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ROLE OF COMPUTATIONAL METHODS FOR ARTIFICAL INTELLIGENCE BASED HEALTHCARE ENGINEERING – A SYSTEMATIC REVIEW

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ABSTRACT

Background: Health care has changed because of technological developments, which have improved patient care and diagnoses through telemedicine and diagnostic support systems. These technologies lower costs and improve the quality of care. Healthcare is starting to use artificial intelligence (AI) and associated technologies, which are becoming increasingly common in society and business. Numerous studies have already shown that AI can perform critical healthcare jobs, such as disease diagnosis, on par with or even better than humans. These days, computers are already better than radiologists at identifying dangerous tumors and helping researchers create cohorts for expensive clinical studies. However, we think it will be several years before AI takes the role of humans in many medical process sectors due to several factors. In this article, we discuss AI in healthcare, as well as the potential of AI to automate certain aspects of care.

Material and Methods: Major databases such as Medline were explored detailed literature search in resulting in a systematic review pertaining to Computational methods for AI-based healthcare Engineering.

Results: Nine original research scientific articles dated between 2020 – 2024 pertaining to mentioned topic were highlighted.

Conclusions: In every aspect of healthcare, the use of AI has shown great promise. Additionally, it makes disease diagnosis, decision-making, therapy, and surgery easier for both patients and professionals. The creation of straightforward, reasonably priced, and easily accessible AI-based health solutions could eliminate this disparity. A system like this would aid in achieving the Sustainable Development Goal of encouraging everyone to lead healthy lives. Detailed information regarding the Computational methods for AI-based healthcare Engineering is discussed in this systematic review.

KEYWORDS: computational intelligence, machine learning, medical application, precision, artificial intelligence-based application, diagnosis, treatment, drug development

INTRODUCTION

In numerous fields, particularly biomedical engineering, computational models are vital instruments, enabling researchers to precisely replicate complex biological systems. These models—mathematical and algorithmic representations of real-world phenomena—forecast behaviour, illuminate underlying principles, and guide experimental and therapeutic strategies. Simultaneously, Information and Communication Technology (ICT) is fundamental to digital businesses, enhancing competitive advantage and performance. The ongoing Fourth Industrial Revolution emphasizes advanced digital devices and technologies for value creation across all industries, including medicine. The concept of "AI," coined by McCarthy in the 1950s, describes computer science utilizing algorithms to mimic human cognition, encompassing machine learning (ML), deep learning (DL), natural language processing (NLP), and computer vision (CV). Healthcare globally is actively integrating these digital technologies to boost care quality and efficiency. Healthcare systems face the challenge of achieving in improving population health, enhancing patient/caregiver experiences, and reducing costs. Rising global healthcare expenses, aging populations, and chronic illnesses pressure all stakeholders to innovate and transform current healthcare delivery models.

MATERIAL AND METHODS

“computational” AND “machine learning” AND “artificial intelligence’’ were the words used in MEDLINE database using advance search strategy targeting different article categories between 2020 to 2024. The result was 85 articles, out of which we selected 9 articles based in the inclusion criteria. Inclusion criteria was of case studies and scientific literature between 2020-2024. Exclusion criteria was of scientific literature irrelevant to the specific search. This systematic review was conducted to determine importance of computational methods for AI-based healthcare engineering following the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). PubMed, Lilacs, Embase, Scopus, and Web of Science were the source of electronic databases. The search strategy used Boolean operators (AND and OR): [ALL ("computational") AND (AI OR diagnosis OR machine learning OR treatment OR digital OR health) AND (clinical practice)]. The following data were collected: first author, year, country of study, type of study and outcome. The quality of studies was assessed using the STROBE (Strengthening the Reporting of Observational Studies) checklist.

RESULTS

Nine articles were included in this systematic review based on the selection criteria. We analyzed and mentioned in the nine articles reviewed. This included only relevant research articles and excluded articles pertaining to nonspecific search terms.

Table 1 – An overview

Author	Title	Journal	Outcome
Alaa Abd-alrazaq, Israa Abuelezz, Asma Hassan, AlHasan AlSammarraie, Dari Alhuwail, Sara Irshaidat, Hashem Abu Serhan, Arfan Ahmed, Sadam Alabed Alrazak, Mowafa Househ	Artificial Intelligence–Driven Serious Games in Health Care: Scoping Review	Abd-Alrazaq A, Abuelezz I, Hassan A, AlSammarraie A, Alhuwail D, Irshaidat S, Serhan HA, Ahmed A, Alrazak SA, Househ M. Artificial intelligence–driven serious games in health care: Scoping review. JMIR serious games. 2022 Nov 29;10(4):e39840. doi: 10.2196/39840	The last decade with an increase in the development of AI-driven health care purposes, targeting various health conditions
Jiamin Yin, Kee Yuan Ngiam, Hock Hai Teo	Role of Artificial Intelligence Applications in Real-Life Clinical Practice: Systematic Review	Yin J, Ngiam KY, Teo HH. Role of artificial intelligence applications in real-life clinical practice: systematic review. Journal of medical Internet research. 2021 Apr 22;23(4):e25759. doi: 10.2196/25759	The research on the clinical implementation of AI applications is still at an early stage despite the great potential
Moustafa Laymouna, Yuanchao Ma, David Lessard, Tibor Schuster, Kim Engler, Bertrand Lebouché	Roles, Users, Benefits, and Limitations of Chatbots in Health Care: Rapid Review	Laymouna M, Ma Y, Lessard D, Schuster T, Engler K, Lebouché B. Roles, users, benefits, and limitations of chatbots in health care: rapid review. Journal of medical Internet research. 2024 Jul 23;26:e56930. doi: 10.2196/56930	Health care chatbots offer a wide spectrum of applications
Junaid Bajwa, Usman Munir, Aditya Nori, Bryan Williams	Artificial intelligence in healthcare: transforming the practice of medicine	Bajwa J, Munir U, Nori A, Williams B. Artificial intelligence in healthcare: transforming the practice of medicine. Future healthcare journal. 2021 Jul 1;8(2):e188-94.doi: 10.7861/fhj.2021-0095	AI have the potential to transform many aspects of healthcare, enabling a future that is more personalised, precise
Ayumu Asai, Masamitsu Konno, Masateru Taniguchi, Andrea Vecchione, Hideshi Ishii	Computational healthcare: Present and future perspectives	Asai A, Konno M, Taniguchi M, Vecchione A, Ishii H. Computational healthcare: Present and future perspectives. Experimental and Therapeutic Medicine. 2021 Dec;22(6):1351. doi: 10.3892/etm.2021.10786	AI-based applications would be useful for the future utilization of novel approaches in healthcare

Hafsa Habehh, Suril Gohel	Machine Learning in Healthcare	Habehh H, Gohel S. Machine learning in healthcare. Current genomics. 2021 May 1;22(4): 291-300.doi:10.2174/1389202922666210705124359	Many of the current machine learning advancements in healthcare aim to support the physician’s or specialist's ability to provide a more effective treatment
DonHeeLee and SeongNoYoon	Application of Artificial Intelligence-Based Technologies in the Healthcare Industry: Opportunities and Challenges	Lee D, Yoon SN. Application of artificial intelligence-based technologies in the healthcare industry: Opportunities and challenges. International journal of environmental research and public health. 2021 Jan;18(1):271. doi: 10.3390/ijerph18010271.	The hospitals are, at present, using AI-enabled systems to augment medical staff in patient diagnosis and treatment activities for a wide range of diseases
Hariharasakthisudhan Ponnarengan, Sivakumar Rajendran , Vikas Khalkar, Gunapriya Devarajan, Logesh Kamaraj5	Data-Driven Healthcare: The Role of Computational Methods in Medical Innovation	Ponnarengan H, Rajendran S, Khalkar V, Devarajan G, Kamaraj L. Data-Driven Healthcare: The Role of Computational Methods in Medical Innovation. CMES-Computer Modeling in Engineering & Sciences. 2025 Jan 1;142(1). DOI 10.32604/cmes.2024.056605	This covers such as computational modelling, bioinformatics, machine learning in medical diagnostics
Geetha Narasimhan, Akila Victor	Analysis of computational intelligence approaches for predicting disease severity in humans: Challenges and research guidelines	Narasimhan G, Victor A. Analysis of computational intelligence approaches for predicting disease severity in humans: Challenges and research guidelines. Journal of Education and Health Promotion. 2023 Sep 1(1):334. doi: 10.4103/jehp.jehp_298_23	Machine-learning techniques are useful especially in the field of health care in extracting information from healthcare data.

DISCUSSION

Artificial intelligence (AI) is not a novel concept in the healthcare sector, its integration is increasing in healthcare delivery, in enhancing diagnostic precision, treatment efficacy, and overall patient care.1

AI algorithms can be trained to analyse medical images like X-rays and CT scans, creation of personalised medicine, assist in understanding genetics, environment, and lifestyle affect their health by analysing medical data.2

AI can be used to extract patient medical records and that can make it easier for healthcare practitioners.3

Evolution of ai in healthcare - Medical AI applications have developed substantially since their beginning in several medical operations. These advanced through three main factors - faster computers, bigger medical databases, and better algorithm capabilities.4

Rule-based expert systems brought AI technologies into healthcare during the 1970s and 1980s for aiding physicians with medical diagnosis and treatment decisions.5

Stanford University developed MYCIN as an early AI system that allowed it to identify bacterial infections, later they developed Internist-1 that offered support for identifying complex internal medicine situations.6

During the 1990s together with the initial years of the 2000s machine learning (ML) emerged as AI systems gained the capacity to extract knowledge from data are widely available.7

The first recognizable ML incorporated statistical models that forecasted patient results from past information, which used both decision trees and logistic regression to determine disease evolution chances and treatment responses.8

In recent years explosive growth in AI healthcare progress because deep learning brought momentum to ML through neural networks that process sophisticated medical information.9

Deep learning provides maximum effectiveness when applied to medical imaging because convolutional neural networks (CNNs) can now match human-level performance in diagnosing.10

AI has become instrumental to precision medicine and drug discovery while it provides diagnostic support. Deep learning through AI enables to create drug discovery platforms which minimize costs of conventional research.11

AI made significant contributions to COVID-19 during the year 2020. Deep learning examined viral protein structures, which is medical breakthroughs demonstrate that AI speeds up the process of scientific discovery and quickens global pandemic response.12

These technologies have the potential to transform many aspects of patient care, as well as administrative processes within provider, payer, and pharmaceutical organisations.13

Table 2: Types of AI

Subfields of AI	**description**
Machine learning	Algorithm to learn from data
Natural language proc	Understanding and processing human language
Computer vision	Analyzing and interpreting visual content
Cognitive computing	Mimicking human thought and decision making

Types of AI (table 2) of relevance to healthcare, Artificial intelligence is not one technology, but rather a collection of them.14

Machine learning is a statistical technique for fitting models to data and to 'learn' by training models with data. It is one of the most common forms of AI; and is a broad technique at the core of many approaches to AI and there are many versions of it.15

In healthcare, the most common application of traditional machine learning is precision medicine – predicting what treatment protocols are likely to succeed on a patient.16

The great majority of machine learning and precision medicine applications require a training dataset for which the outcome variable is known; this is called supervised learning.17

A more complex form of machine learning is the neural network – a technology that has been available since the 1960s has been well established in healthcare research for several decades.18

Neural networks structure computational systems to mimic the processing patterns observed in biological organisms, including humans. Among the many types, convolutional neural networks (CNNs) and artificial neural networks (ANNs) are the most notable.19

In healthcare, neural networks power a range of smart applications, including wireless body sensors, mobile health applications, accelerator chips, as well as tools for decision-making and disease prediction.20

It views problems in terms of inputs, outputs, and weights of variables or 'features' that associate inputs with outputs. Also has been likened to the way that neurons process signals, but the analogy to the brain's function is relatively weak.21

Deep learning is increasingly being applied to radiomics, or the detection of clinically relevant features in imaging data beyond what can be perceived by the human eye.22

Deep learning is also increasingly used for speech recognition and, as such, is a form of natural language processing (NLP), making sense of human language has been a goal of AI researchers since the 1950s.23

This field, NLP, includes applications such as speech recognition, text analysis, translation, and other goals related to language. There are two basic approaches to it: statistical and semantic NLP.24

In healthcare, the NLP involve the creation, understanding and classification of clinical documentation and published research. This can analyse unstructured clinical notes on patients, prepare reports, transcribe patient interactions, and conduct conversational AI.25

Expert systems based on collections of 'if-then' rules were the dominant technology for AI in the 1980s. In healthcare, they were widely employed for 'clinical decision support' purposes over the last couple of decades.26

Physical robots have become more collaborative with humans and are more easily trained for desired task.27

Surgical robots, provide 'superpowers' to surgeons, improving their ability to see, create precise and minimally invasive incisions, stitch wounds and so forth.28

Also, common surgical procedures using robotic surgery include gynaecologic surgery, prostate surgery and head and neck surgery.29

Robotic process automation performs structured digital tasks for administrative purposes, those involving information systems. Compared to other forms of AI they are inexpensive, easy to program and transparent in their actions.30

In healthcare, they are used for repetitive tasks like prior authorisation, updating patient records or billing. They can be used to extract data from, for example, faxed images in order to input it into transactional systems.31

Cognitive computing, a subset of artificial intelligence, empowers computing systems to emulate human intelligence for problem-solving.32

In healthcare, cognitive computing has facilitated the development of AI-based Clinical Decision Support Systems (CDSSs), which play a crucial role in aiding diagnosis, treatment, and surgical procedures.33

Computer vision focuses on improving a computer's ability to identify and recognize visual images, it analyzes image data to achieve highly accurate results in detection and interpretation.34

Its applications are particularly promising in microscopy, where it can be used to study cell morphology, detect pathogens such as malaria, and even identify microscopic cancers.35

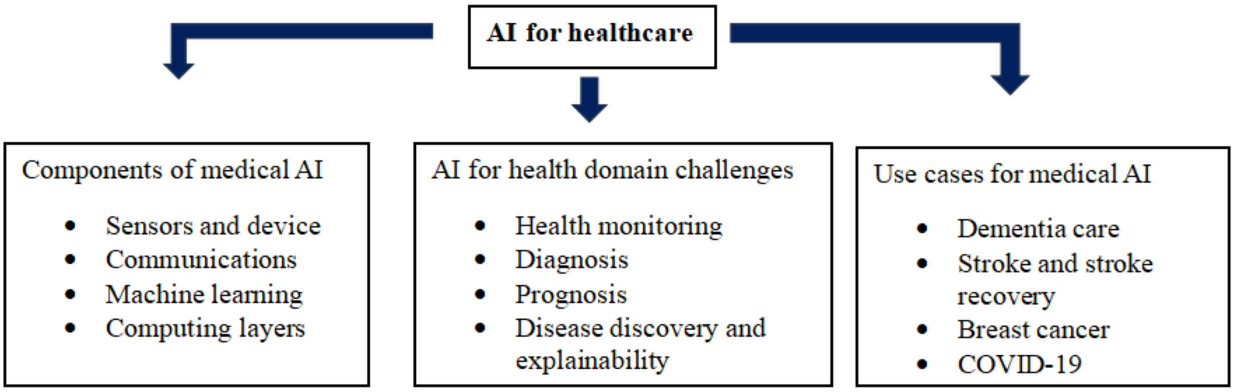

Figure 1: AI in healthcare36

Artificial intelligence and Computational Intelligence (CI) are changing healthcare, the most experience impact may be observed in medical imaging / diagnostic support.37

Role of AI in Radiology: Fracture and Lesion Identification: With thousands of annotated images per class, systems can detect fractures, haemorrhages, and other lesions with high precision.38

Digital Pathology: Whole slide imaging (WSI) digitizes pathology slides which are subsequently read by AI algorithms to find cells with cancer potential or anything weird.39

Early Disease Detection: AI systems analyse retinal scans for the indication of diabetic retinopathy so that early intervention and vision saving are possible. Other include: Alzheimer's and Neurological Condition, Cardiovascular Risk Prediction.40

Integration with Clinical Workflows: AI imaging tools produce reports, raise alerts on abnormal findings, and guide the consultation for further imaging/molecular testing to radiologists/Physicians.41

Precision and personalized medicine is a paradigm shift in healthcare where the treatment, prevention strategies are individualized to every unique aspect of patient.42

Role of Computational Intelligence in Personalization - Using complex datasets computational intelligence approaches like, machine learning, deep learning, genetic algorithms extract patterns & relationships that are often beyond human comprehension.43

These models can be used to combine genomic sequences, biomarker profiles, environmental exposures, and electronic health records (EHR).44

Genetic and Molecular Data Analysis, CI systems could be trained to study DNA sequencing data for detection mutations, gene expressions and biomarkers linked to diseases like cancer, rare genetic disorders, or cardiovascular conditions.45

Tailored Treatment Plans, Using AI insights, the doctors could build personalized treatment plans for the patient considering not only her genetic data but also her age, medical history, lifestyle and even relocation.46

Disease Prevention and Early Detection, with genetic susceptibilities and early biomarkers examined, healthcare providers could take prevention- oriented actions.47

Drug Development and Clinical Trials, it accelerates drug discovery, as well as predicting how individuals would respond to various compounds in silico.48

Improving Administrative Efficiency, Hospitals process large amounts of administrative work every day, AI processes automate them to avoid human errors and time saving.49

Automated Scheduling: Provides scheduling of appointments using historical data to identify no- shows, therefore increasing availability for doctors & staff and reduces last minute drudgery.50

Medical Billing and Coding: With the help of AI, you can give diagnosis and procedures to claim and increase insurance approval time.51

Optimizing Resource Allocation, Efficient resource management is fundamental for high- quality patient care as well as operational cost minimization in hospitals.52

Decision Support for Hospital Management, AI as a decision-making tool for hospital administrators and C suites allows them to run the hospital by helping analyse terabytes of operational clinical data to provide strategic insights.53

AI Performance Dashboards show critical metrics such as patient satisfaction, average days in hospital, readmission rates, and financial performance to management.54

Data Privacy and Security, AI for Healthcare require access to huge amounts of patient data which is very sensitive, like histories, genetic enhancements, and diagnostic results.55

Inadequate Handling or Breach could lead to disclosure of sensitive personal health information, eroding patient trust and legal protections.56

Informed Consent and Transparency, Patients have a right to knowledge when AI is playing a part in the decision-making process of medicine and what exactly does the AI do. Consent must inform not only of the treatment itself but also what AI tools are to be used.57

Regulatory Compliance and Accountability, AI Health Applications must adhere to medical device regulations and be certified to be used. In several countries regulatory bodies are formulating guidelines on AI based tools.58

CONCLUSION

AI is poised to fundamentally transform future healthcare services, primarily as the engine behind precision medicine through machine learning. While early efforts in generating diagnostic and treatment suggestions faced hurdles, AI proficiency in these areas is anticipated. Rapid advancements in imaging analysis suggest most pathology and radiology images will eventually be computer-analyzed. Furthermore, the use of speech and text recognition for clinical notes and patient communication is already prevalent and expanding. The primary challenge for AI in healthcare is not technological capability, but successful integration into routine clinical practice. Widespread adoption requires overcoming significant hurdles: regulatory approval, seamless integration with standardization across similar products, comprehensive clinician training, viable funding models by payers, and ongoing field updates. Though these issues are solvable, the process of implementation and integration will likely lag far behind the pace of technological innovation.

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