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Revolutionizing Healthcare: A Comprehensive Review Of AI Applications, Benefits, And Risk Mitigation Strategies

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Abstract

The revolutionary impact of artificial intelligence (AI) on the healthcare industry is demonstrated through an exciting combination of diverse technologies, algorithms, and state-of-the-art techniques. Medical and administrative procedures in healthcare organisations are rapidly being revolutionised by AI technologies. The general consensus is that AI tools will prove to be beneficial adjuncts to healthcare practitioners, not a replacement for them, despite concerns about job displacement. AI is positioned to help healthcare workers with a variety of duties, including clinical documentation, patient outreach, administrative processing, and advanced support in areas like image analysis, patient monitoring, and diagnostics.

The numerous uses of AI in healthcare are described in this thorough analysis, which goes beyond its direct use in patient care to include drug discovery and ambient assisted living, among other areas of the healthcare value chain. The main objective is to create a solid body of information that will guide the creation of risk-reduction plans. In order to ensure the safe and successful integration of AI technology into standard healthcare procedures, several measures are essential.

Understanding the need of researching the hazards associated with AI in healthcare, this work becomes essential to both improving AI systems and developing technology in general. The focus is not just on accepting the possible advantages but also on taking proactive steps to reduce any hazards that may arise, which will help AI in healthcare develop responsibly.

Key words: Artificial intelligence, Application, risk reduction strategy, direct health care application, challenges.

1 Introduction

Artificial intelligence (AI) is at the cutting edge of technological innovation, having a significant and disruptive impact on the healthcare sector. AI systems are altering administrative and medical procedures inside healthcare organisations by compellingly incorporating innovative technology, complex algorithms, and novel methodologies. This introductory part seeks to offer a complete overview of AI's revolutionary influence in healthcare, emphasising its function as a catalyst for innovation and efficiency improvement. This section lays the context for a more in-depth analysis of AI's possible advantages, problems, and risk mitigation techniques by evaluating its varied applications across many healthcare areas. Furthermore, it emphasises the critical need for a comprehensive understanding of AI's role in healthcare reform and the urgency of responsible adoption.(1)

1.1 The Potential for Artificial Intelligence In Healthcare

These tools can help with challenging medical diagnosis in addition to automating time-consuming administrative tasks. Massive database analysis, medical image interpretation, and conversational interface patient interaction are all made possible by AI-powered systems. AI has the potential to revolutionise healthcare, but in order to have the greatest possible impact and ensure patient safety, ethical considerations and legal frameworks must control its application.(2)

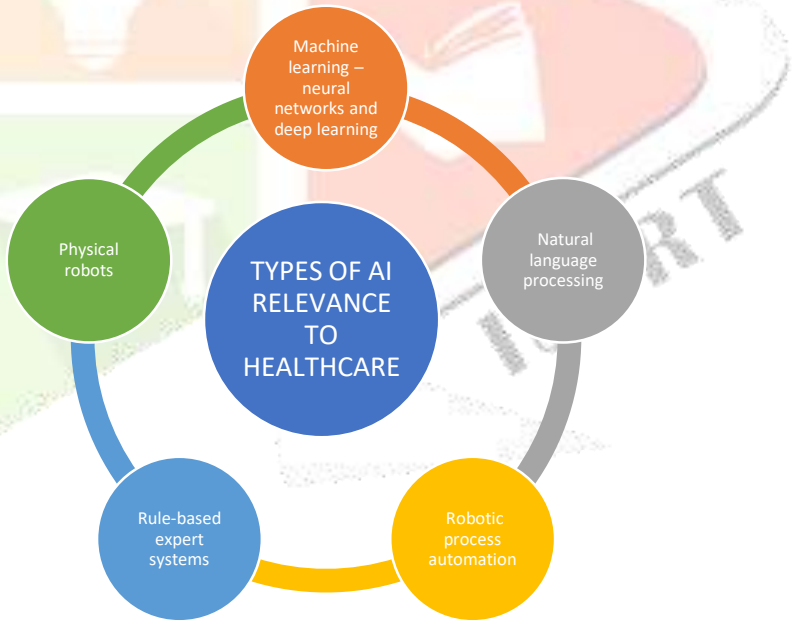

Figure 1Potential of AI in healthcare

1.2 Evolution of Artificial Intelligence in Healthcare (3,4)(5)

Artificial intelligence was there since long ago, but it was not known or openly used. Use of AI in healthcare system give rise to comfort and safe healthcare system. Technological innovations and conceptual upheavals have characterised the extraordinary journey of artificial intelligence (AI) inside the healthcare industry. To guarantee the appropriate and equitable application of AI technology in healthcare, considerable ethical, legal, and societal ramifications accompany these developments that need to be properly addressed.

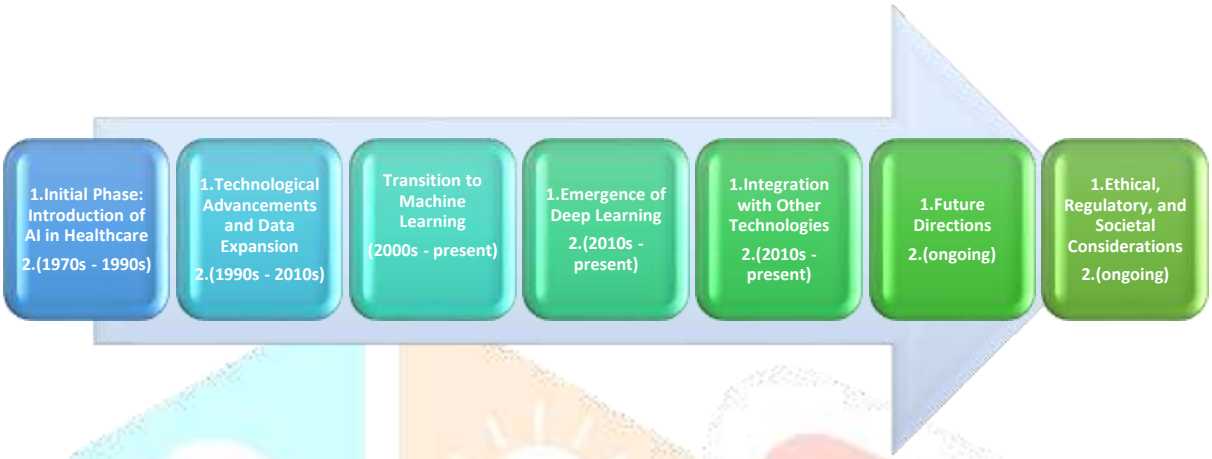

Figure 2 Evolution of AI in healthcare

1.3 Artificial Intelligence Applications in Healthcare(6)

Application of AI in healthcare system and management is vast like use of AI in drug development stage to the disease treatment with robotic surgery.

In 2018, Forbes declared that administrative processes, image analysis, robotic surgery, virtual assistants, clinical decision support, cybersecurity, and dose mistake reduction will be the most crucialsectors. According to a McKinsey analysis from 2019, targeted and personalised medicine, robotics-assisted surgery, electroceuticals, and linked and cognitive gadgets are crucial sectors.

Historically, patient-specific features were often absent from personal health records, which were primarily focused on physicians. By promoting self-management, the implementation of a patient-centric personal health record can improve outcomes. The goal is to give patients autonomy over their conditions so that carers may concentrate on more crucial tasks.

Application of AI sometimes directly related to patient or sometimes related to optimization of work flow processes, so overall application of AI is divided into direct healthcare applications and healthcare value chain application respectively.

Figure 3 Application of AI in healthcare system

1.4 Direct Healthcare Application Of AI

Direct Healthcare Applications relate to the use of AI technology in patient care, diagnosis, treatment, and monitoring. In these applications, AI systems communicate directly with patients or aid healthcare workers in providing treatment. They focus on improving patient outcomes, strengthening care quality, and optimising healthcare delivery systems.

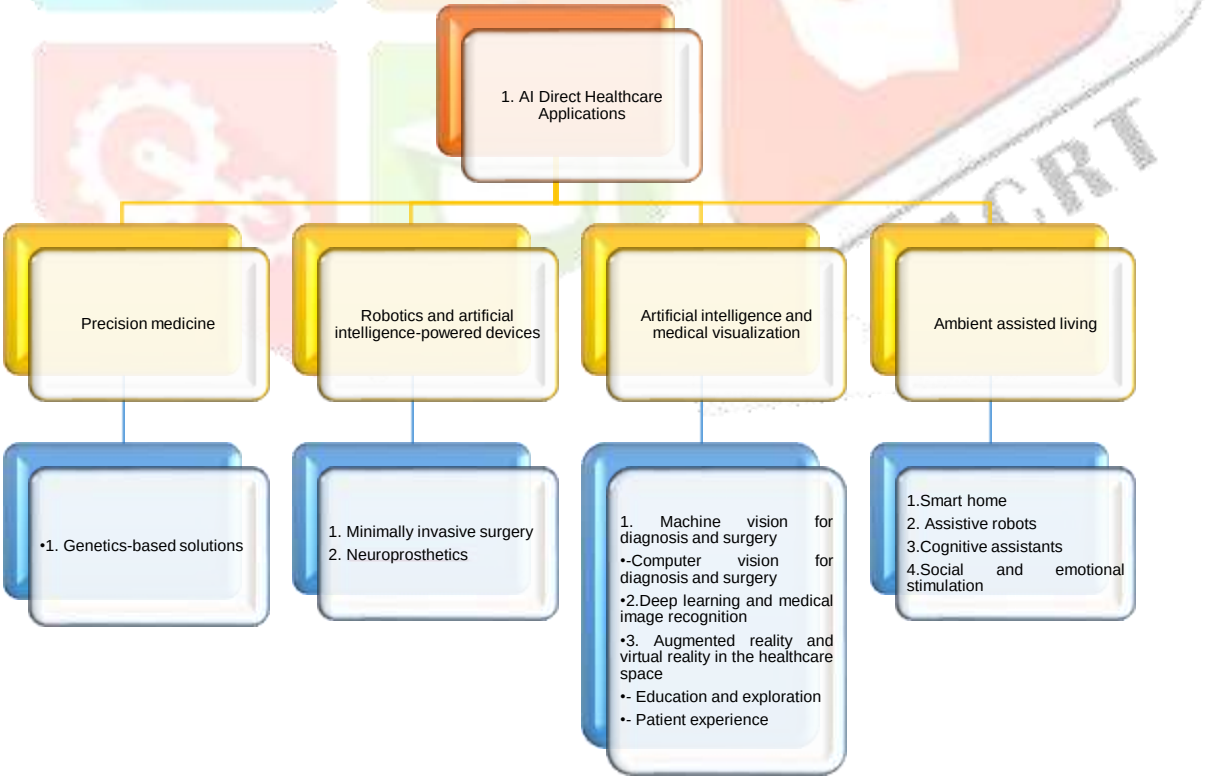

Figure 4Direct healthcare application of AI

1.4.1 Precision medicine

Throughout a patient's treatment process, precision medicine seeks to use individual biology rather than population biology. This means collecting personal data from patients, such as genetics, EMR data, or physiological monitoring data, and utilising advanced algorithms to tailor their treatment.(7)

Reduced medical expenses, less adverse drug responses, and more effective drug activity are just a few benefits of precision medicine.

Various attempts are being made in precision medicine, which may be generally categorised into three clinical areas: Digital health applications, intricate algorithms, and testing based on "omics"(1,8)

1.4.1.1 Genetics-based solutions

Through the application of AI and whole genome sequencing, precision medicine can enable techniques to enhance the discovery of genetic variants.

Deep Genomics, a health tech business, is looking for patterns in both the massive DNA dataset and EMRs in an attempt to link the two in terms of disease indicators. This company looks at these connections to identify therapeutic targets, whether they are new therapeutic possibilities or pre-existing therapeutic targets, in order to develop tailored genetic drugs. AI is used in all phases of their drug research and development process, including toxicity analysis, lead optimisation, target identification, and innovative trial design.(9)

1.4.2 Robotics and AI-powered gadgets.

Robots are replacing, augmenting, and assisting human healthcare workers in several fields. Robots are utilised for a variety of purposes, including surgical procedures, rehabilitation and patient support, implant and prosthetic integration, and assisting physicians and healthcare workers.

Numerous companies are creating devices to boost communication between patients and healthcare machines. Robotics is using AI technology more and more to improve its performance in areas like image processing, language recognition, and classification.(19)

1.4.2.1 Minimally invasive surgery

Surgical technology is evolving to reduce invasiveness through smaller incisions, open operations, and the use of flexible instruments and cameras. Minimally invasive surgery is considered as the way ahead, although it is still in its early stages with numerous improvements to make it "less of a big deal" for patients while reducing time and expense.

Minimal invasive surgery necessitates different motor skills compared to traditional surgery due to less tactile feedback from instruments and less direct touch. Sensors are being developed to offer surgeons with finer tactile sensations. Tactile data processing is used to convert sensor input into perceptible data. Tactile data processing often involves AI, notably artificial neural networks, to improve signal translation and interpretation.(20)

1.4.2.2 Neuroprosthetics

Neuroprosthetics are devices that support or supplement the nervous system, providing input and output. Electrical stimulation is commonly used to address neurological deficits experienced by patients.

These disorders can cause hearing, visual, cognitive, sensory, and motor impairments, as well as comorbidities. Movement disorders, such as multiple sclerosis or Parkinson's, can cause slow and painful declines in these skills, with patients being aware of each change.

Brain-machine interfaces (BMIs) may store and learn subjects' voluntary goal-directed desires (electro-encephalogram, EEG) when a user "trains" an intelligent controller (AI).(21)

1.4.3 Artificial intelligence and medical visualization

Interpreting data presented as images or videos can be tricky. Experts in the area undergo extensive training to identify medical occurrences and continuously learn new information as research advances. Artificial intelligence is becoming increasingly used in healthcare applications. Despite rising demand, there remains a substantial scarcity of specialists in the industry. AI offers a promising solution to address the demand gap.

1.4.3.1 Machine Vision for Diagnosis and Surgery

The interpretation of images and videos by computers that is on par with or better than human ability, including object and scene recognition, is known as computer vision. Applications of computer vision are widely used in guided surgery and image-based diagnostics.(10)

Utilising Computer Vision to Diagnose and Operate

Artificial neural networks are being employed more and more for learning, even though statistical signal processing has long been the basis of computer vision.

DL is used in the development of computer vision algorithms that categorise pictures of lesions in the skin and tissue. In the long run, video data may have a higher data value since it is anticipated to include 25 times more data than high-resolution diagnostic imaging, such CT scans.

Although video analysis is still in its early stages, it has significant promise to enhance clinical decision-making.

AI and computer vision can improve surgical abilities, including suturing and knot-tying, like the Johns Hopkins University-developed smart tissue autonomous robot (STAR) outperforms human surgeons in some surgical operations, including intestinal anastomosis in animals.

While completely autonomous robotic surgeons are not yet a reality, researchers are interested in applying AI to assist many elements of surgery. (11)

The algorithm assesses the probability of the intervention and the particular body part such as when a dissection or cutting is performed on a patient's tissues or organs. For difficult surgical procedures or emergency surgeries requiring inexperienced surgeons, algorithms based on video training could be helpful. A major contribution to the development of high-quality, clinically applicable technologies that facilitate the transfer from lab to clinic is made by surgeons.(12)

1.4.3.2 Deep learning and medical image recognition

The adjective "deep" alludes to machine learning's multi-layered structure. Because of its multi-layered nature, CNNs have become the most promising deep learning method for picture recognition. The system's theoretical foundation was created in the 1980s by renowned French computer scientist Yann LeCun, who created LeNET, an automated technique enabling financial systems to recognise handwriting. These networks have shown encouraging pattern recognition performance.(5)

1.4.3.3 Augmented and Virtual Reality in Healthcare

Augmented and virtual reality (AR and VR) may be integrated into every Stage of a healthcare system. Implementing these methods can benefit medical students, specialists, and seasoned surgeons at all phases of their education. However, these technologies can have both positive and bad effects on patients(13)

Education and exploration

Early in medical school, students are taught principles without real-world experience. Virtual and augmented reality (VR and AR) have the potential to improve medical and health education. Medical students may study anatomy and intricate surgical procedures using augmented reality technology without having to perform autopsies or interact with patients in real life. The goal is to begin training early and cut costs later, even though these students will interact with actual patients in the workplace.

In healthcare contexts, augmented reality technology is more suited for precise and practical implementation. Wearing lightweight equipment (like Google Glass or Microsoft HoloLens) that projects pertinent images or video into areas of interest frees users' visual fields from distracting images, allowing them to concentrate on work without interruption.

Patient experience

In a study of chronic stroke patients, immersive VR technology was found to improve their condition. During the VR experience, patients are encouraged to return a virtual ball into the virtual environment.

By involving patients in upper limb movement many times a day, this immersive experience can act as a personal rehabilitation physiotherapist. This can encourage neuroplasticity and help afflicted regions progressively regain normal motor function.(14)

1.4.4 Ambient assisted living

As society ages, more persons with chronic diseases are able to live independently until they reach old age. Assistive technologies promote patient independence by utilising ICT tools to provide remote care and notify healthcare professionals. To enable people to live in their chosen environments and improve their quality of life, AAL seeks to improve security, support, and productivity; to boost autonomy and mobility for the aged; and to encourage a healthy lifestyle for those who are at-risk. AAL applications create intelligent systems by utilising AI methods to process input from cameras and sensors. Assistive robots or smart homes are two ways that AAL can be used.(15)

1.4.4.1 Smart home (Intelligent dwelling)

A smart house is a residential home that has been enhanced with sensors and monitoring systems to improve the lives of its people. AAL applications include remote monitoring, reminders, alert creation, behaviour analysis, and robotic help, which may be integrated into smart homes or utilised independently. Several studies have explored how smart home technologies might benefit dementia sufferers. Low-cost sensors in IoT architectures may identify anomalous behaviour.

To ensure safety, sensors are placed thoughtfully around the house, including in the bathrooms, kitchens, and bedrooms. The oven has a sensor that may detect use and notify the patient if it is not properly switched off. If the patient leaves the window open in the rain, a rain sensor can be placed close to it to alert them. To stop lights in the bathroom from being left on, install bath and lamp sensors. Sensors provide data for processing using machine learning methods to adjacent computers or the cloud. When necessary, alerts can also be issued to family members or medical professionals.

Collecting daily patient data helps define daily activities and identify deviations from the pattern. Smart home applications employ machine learning algorithms such as Naive Bayes classifiers, Hidden Markov Models, Support Vector Machines, and Artificial Neural Networks.(16)

1.4.4.2 Assistive robots

Assistive robots support the physical constraints of the aged and disabled, helping with everyday activities and functioning as an additional set of hands or eyes. Assistive robots can aid with movement, cleaning, medication administration, feeding, grooming, bathing, and social communication.

Similar to smartphone apps, the system has speech recognition, controllers, and interfaces to manage several robotic applications on a single platform. The robotic applications concentrate on social interaction, cognitive stimulation, and health assessment. Applications with AI capabilities analyse robot data for a variety of purposes, such as language processing, object identification, facial recognition, and diagnostic support.

(17)

1.4.4.3 Cognitive Assistants

Cognitive decline is a common issue among the elderly, causing difficulties with memory, focus, and problem-solving skills. Cognitive stimulation is a popular treatment for minor cognitive impairment as well as brain injuries such strokes, multiple sclerosis, or traumas. It has been demonstrated that cognitive stimulation, which assistive robots may be trained to deliver, reduces cognitive deterioration.

1.4.4.4 Social and emotional stimulation.

Companion robots for social and emotional stimulation are a popular use of assistive robots that have been extensively researched. Robots can help elderly people manage stress and depression by providing emotional support, social engagement, and everyday duties. The robots range from pet-like to peer-like, and are interactive, providing psychological and social consequences. (18)

1.5 Healthcare value chain applications

Healthcare Value Chain Applications involve the application of AI technology to improve procedures, workflows, and outcomes across the whole healthcare system. These applications aim to improve efficiency, lower costs, and improve decision-making across the whole healthcare value chain, from research and development to patient care delivery and post-treatment monitoring.(22)

Drug Discovery and Development	Predictive Analytics for Population Health
• Drug property and activity prediction • De-novo design through deep learning • Drug target interactions	Leveraging AI-driven predictive analytics models to forecast disease outbreaks, identify at-risk populations, and allocate healthcare resources effectively to improve population health outcomes.

Table 1 Application of AI

1.5.1 Drug discovery and development

The drug development process involves a number of tasks that may be made more efficient with the application of machine learning. Drug-receptor interactions, de novo drug compound creation, drug compound property and activity prediction, and drug response prediction are all included in this

.

To make them readable by learning systems, the drug compounds and related attributes that are utilised in the in-silico models are converted into vector format. Simplified molecular input line entry system (SMILES) strings and convolutional neural network (CNN) grids are among the data typically employed here, along with molecular fingerprints (molecular structure) and descriptors (e.g., physicochemical qualities).(23)

1.5.1.1 Drug property and activity prediction

Understanding a drug's characteristics and action is necessary to assess how it behaves in the human body. Drug compounds' physicochemical qualities, biological activity, and absorption, distribution, metabolism, and excretion (ADME) features have all been assessed using machine learning-based methods.

Many chemical and biological data repositories, such as ChEMBL and PubChem, have made information on millions of compounds for different disease targets available in recent years.

Utilising DeepTox, a DL-based model for assessing the toxic effects of compounds based on a dataset comprising several drug molecules, is one example of how machine learning has been applied to evaluate the toxicity of chemicals [19]. Two-dimensional chemical structures are also translated into unique features/descriptors using a different platform called MoleculeNet. These features/descriptors may then be utilised to forecast the toxicity of the specific molecule.(24)

1.5.1.2 De novo design through deep learning

The creation of novel chemical structures using neural networks is known as DL in the drug development process.

Utilising vast datasets of medicinal compounds as a fit for the design model, variational and adversarial autoencoders are frequently employed in this context to automatically create novel molecules. An example of an autoencoder is a neural network used for unsupervised learning that may also be used to create fake human faces in photos.(25)

For instance, the programme druGAN employed adversarial autoencoders to produce novel molecular fingerprints and drug designs that included characteristics like solubility and absorption based on established anticancer drug attributes. Autoencoders are trained on a variety of drug molecule configurations. These findings point to a significant increase in the effectiveness of developing novel medication designs with certain characteristics.(26)

1.5.1.3 Drug target interactions

The assessment of drug target interactions is an important part of the drug design process.(18)

- **Role of Ai In Healthcare Personnel: Support Mechanisms Vs. Job Displacement**

Artificial intelligence (AI) has a number of benefits over conventional analytics and clinical decision-making techniques. Artificial intelligence (AI) algorithms enhance system precision by gaining the capacity to comprehend training data. This, in turn, facilitates people in gaining unparalleled insights into treatment variability, care procedures, diagnostics, and patient out

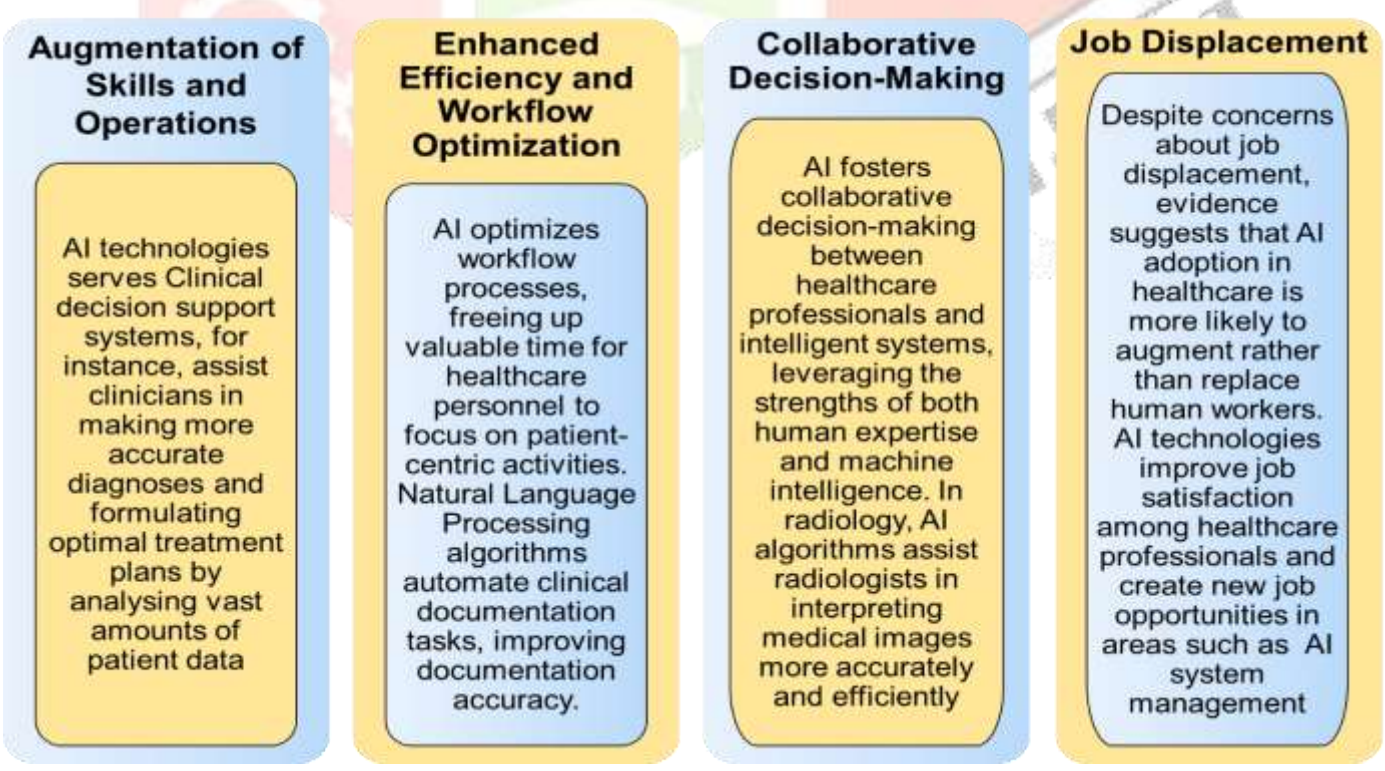

Figure 5 Role of AI in healthcare personnel

It is clear that AI is a useful tool for enhancing human skills rather than completely replacing them in healthcare staff when the support mechanisms and job displacement features of AI are distinguished.

2 Challenges in AI Implementation(27–29)

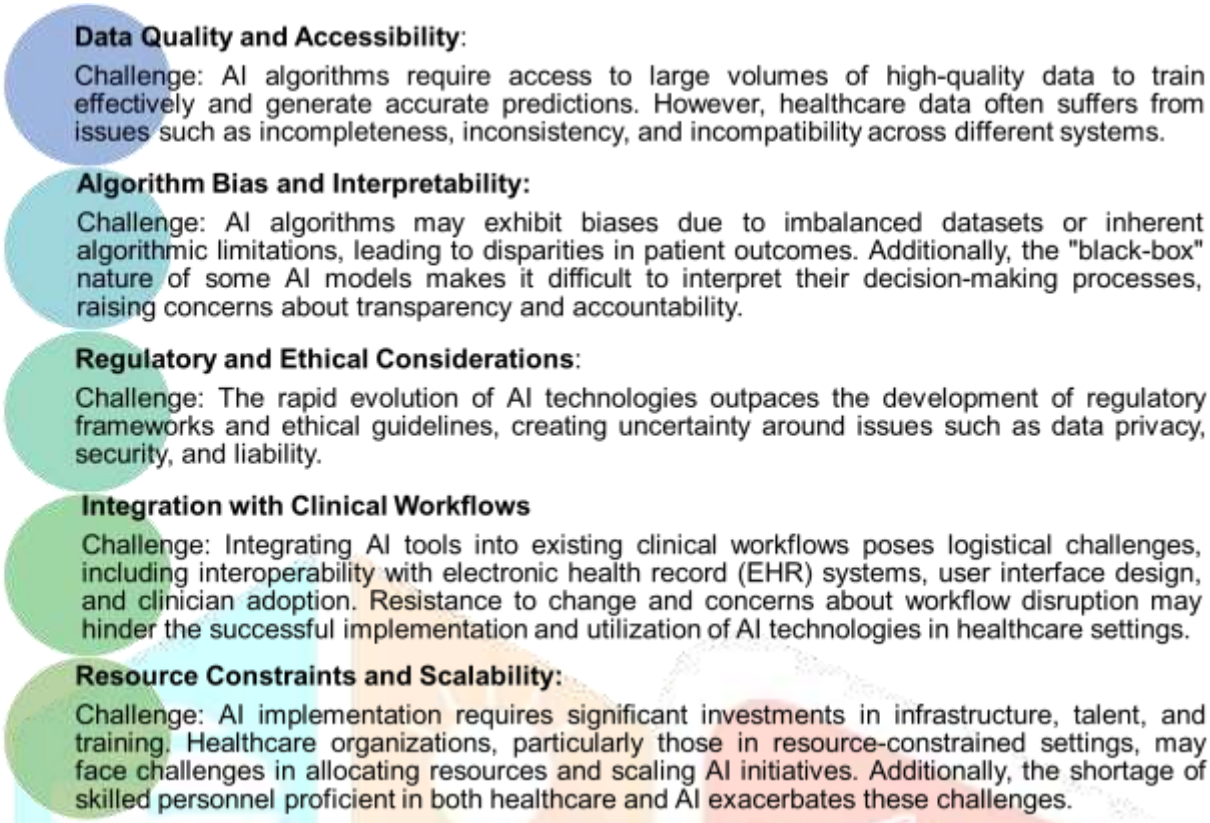

Figure 6

Challenges in implementation of ai in healthcare system

3 Risks and Ethical Considerations(7,30)

There is various risk and ethical considerations are there like data privacy and security risk for implementations of AI.

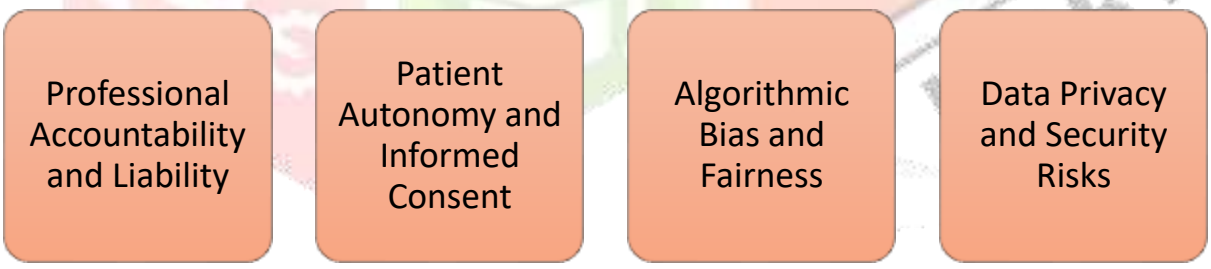

Figure 7 Risk and ethical consideration in implementation of AI

4 Methodologies for Risk Mitigation

Risk mitigation strategies like strict regulatory compliance for implementations of AI in healthcare system is necessary we need dedicated robust guidelines for the use of AI along with strict rules and punishment for violations of such guideline. It will reduce the risk related to misuse of AI

Here are some risk mitigation methods by implementing or adapting them we can ensure right use of AI in healthcare system.

Figure 8 Methodologies for Risk Mitigation

5 Ensuring Safe Integration of AI in Healthcare(31,32)

We can ensure safe use of AI in healthcare system by considering this factors.

Continuous Monitoring and Improvement
Human-Centric Design and User Training
Transparent and Interpretable AI Systems
Clinical Validation and Evidence-Based Practice
Regulatory Compliance and Standards

Table 2 Ensuring Safe Integration of AI in Healthcare

6 Conclusion

The evolution of AI in healthcare announces a new age of innovation, with the potential to transform patient care across the healthcare value chain. However, practical obstacles, biases, and ethical considerations must be addressed for safe incorporation into therapeutic practice. Methodologies for risk mitigation, including robust data governance and transparent AI systems, offer promising solutions.

7 Future direction

Leveraging AI technology has enormous potential, from reducing patient wait times to improving hospital efficiency, and may contribute considerably to the world economy by 2030, as seen by the estimated USD$15.7 trillion effect. Anticipating and avoiding chronic diseases using AI-driven insights might result in significant benefits in public health, with rates of ailments such as diabetes and congestive heart failure predicted to fall. However, ongoing research and collaboration among stakeholders are required to develop AI systems.

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