Healing with Machines:
Advancements, Challenges, and Ethical Considerations of AI in Healthcare

Aadya Bansal

Abstract

As the presence of artificial intelligence (AI) and automation increases in healthcare, many questions are raised about the balance between technological advancements in the fields and the quality of patient care. This paper explores the extent to which healthcare should be automated so that it improves the quality of care and while minimizing harm to the patient. AI powered tools bring many advantages to the healthcare field such as a more accurate and faster diagnosis and treatment recommendations, higher surgical precision, and the ability to reduce administrative burden by managing repetitive tasks. However, there are many concerns regarding the ethical implications of such technology, a lack of patient trust and transparency and the risk of skill degradation among healthcare professionals. In this paper we evaluate both the benefits and risks of automation to conclude how AI can best human healthcare professionals instead of completely replacing them in patient care. By analyzing AI's existing use in medical fields, future trends, and ethical dilemmas, this paper emphasizes the need for a balanced approach for implementing AI in healthcare in which AI's strengths are leveraged with proper human oversight.

1. Introduction

The integration of AI in healthcare has been transformative for many medical practices. AI systems show promise in helping increase the accuracy of diagnoses, treatment plans and helping streamline repetitive administrative tasks. Sophisticated AI systems show promise in enhancing the precision of diagnoses, treatment plans and streamlining many administrative tasks (Grenier et al., 2022). Healthcare, independent of AI use, is largely reliant on the expertise of professionals, their empathy and the speed of real-time decision-making. However, rising patient loads, medical errors, and inefficiencies in healthcare delivery have necessitated technological intervention (David Cutler et al., 2020). AI has shown its ability to process huge and complex datasets, identify patterns, and make decisions at unprecedented speeds (Liang & Hu, 2015). When applied to medicine, AI presents many opportunities but also risks regarding its lack of transparency and confusion about accountability related to medical decisions (Ueda et al., 2024).

This paper will examine the current applications of automation and AI technologies in healthcare, like AI-assisted diagnostics, robotic surgery, and remote patient monitoring. Next, it will explore the future uses of AI, upcoming technologies and their potential to become more autonomous in a healthcare setting. This will then lead to a discussion addressing the issues relating to different ethical, legal, accountability and trust. Finally, the paper will evaluate how

much automation can be implemented responsibly without compromising patient security and care.

2. Current Automation in Healthcare

Automation in healthcare has started to become sophisticated, especially with a variety of AI-driven devices and systems. These technologies are prominently being used in data-intensive fields such as dermatology, oncology, radiology, pathology, and ophthalmology. Currently, their primary function has been to assist doctors by suggesting a diagnosis, detecting findings and recommending treatments. By processing vast amounts of data quickly and accurately, these systems help in human decision-making, improving the care delivered. They also support doctors in other clinical tasks such as triage, by assisting with prioritizing time-sensitive cases and monitoring a patient's trajectory. As of now, most systems are assistive and present in acute care settings in high-income countries. Over time, though, they are expected to become autonomous by going beyond giving just a recommendation, to operating closed-loop machines like ventilators and insulin pumps. Immediate effects on medical professionals using AI include a significant workload to review and confirm AI output and a reduction in time spent per patient. The long-term effects are predicted to be situational awareness and skill degradation, which are well-documented effects of automation in other industries.

AI in Clinical Decision Support

One of the biggest applications of AI is helping clinicians make a faster and a more accurate diagnosis and provide treatment plans. During times of a high patient workload, they can reduce the workload on clinicians by helping analyze a patient's medical history and any other related data.

For example, in radiology, AI systems can assist doctors by acting as a second pair of eyes in analyzing medical images such as X-rays, CT scans, and MRIs, to catch any abnormalities that may have been missed, such as lung nodules, cardiovascular calcifications, and degenerative spinal changes. Siemens Healthineers recently developed a deep learning model called AI-RAD Companion that can be used by radiologists. By having a quick second reading, radiologists gain confidence in their diagnosis, shorten turnaround time, provide better patient outcomes, and eventually reduce costs (Grenier et al., 2022). Similarly, in ophthalmology, Gulshan et al. (2016) describes how Google's AI system was developed and validated for the detection of diabetic conditions such as diabetic retinopathy and age-related macular degeneration. Deep learning was also used in this model so that the algorithm could analyze retinal images and identify early signs of the disease, resulting in quick intervention. In dermatology, applications (apps) are becoming more prominent for diagnosing different conditions. Apps like VisualDx provide patients with easy to understand personalized answers, while apps like Miiskin help

patients keep track of their skin and moles and store the data so that it can be shown in-person later.

Robotic Surgery

Robotic systems represent another significant area of automation in the healthcare industry. Most robotics is used mostly for surgery since it provides high-quality treatment by bringing higher accuracy and precision compared to human surgeons. If the current trend of robotics being used continues in healthcare, the global medical robotics market systems are projected to grow from $16.0 billion (2024) to $33.8 billion in 2029, growing at a CAGR rate of 16.9% (MarketsandMarkets, 2024).

In Verma et al.'s (2018) review of IoT and robotics, they lay out many recent advancements in the field. Robotics has been deeply intertwined in healthcare, prominently through surgery, since the 1990s. Today, surgical robots comprise more than 64% of all medical robotic systems. Currently, most robots assist surgeons and have proved that robotic surgery can reduce surgical trauma and loss of healthy tissue, leading to a quicker recovery of the patient. They achieve this by working with micro-precise movements and without tremors. There are two main systems in robotics that assist in surgery, called Robotic assisted surgery (RAS) and computer assisted surgery (CAS). RAS is a motorized system controlling the motion of intervention. It consists of a robot which can be manipulated by the surgeon. RAS provides human dexterity and ergonomics while reducing tremors and resisting human errors, making it more reliable. CAS is a computer interface that assists the doctor in controlling the intervention site manually. It is generally used for detection tools, motion planning, identification, cancer cells etc.

The da Vinci Surgical System is one of the most well-known RAS systems. It consists of a console where the surgeon sits and controls the robot's arms, which hold surgical instruments. The system also provides a high-quality, 3-D view of the surgical site and the robot's arms can make micro-precise movements, which are often more stable than a human hand and reduce the risk of errors during surgery. Another RAS system is the Mako Robotic-Arm Assisted Surgery System, which is used in orthopedic procedures. This system also provides the surgeon with a 3D model of the patient's anatomy, like the da Vinci system, which allows them to plan the surgery better and conduct it with more precision. A more precise surgery means better patient results, such as reduced pain and a quicker and faster recovery. Robotic systems are also making advances in neurosurgery. The Robotic Stereotactic Assistance (ROSA) system is designed to assist neurosurgeons in performing brain surgeries with minimal invasiveness. It helps in the precise placement of instruments during procedures such as biopsies, electrode implantation, and other neurosurgical interventions which are important for such a delicate organ.

Internet of Things (IoT) in Healthcare

The Internet of Things (IoT) is a series of connected devices and key players in driving healthcare automation by helping patients collect and monitor data. Patients can do this by using new devices and services being created by IoT startups and many tech giants like IBM, Google, Apple, and Samsung. These devices are gaining traction in this area by commercializing devices and services that assist in user health by helping patients get their health data on a daily basis.

One of the most prominent applications of IoT in healthcare is remote patient monitoring. IoT enabled devices such as smartwatches, wearable electrocardiogram (ECG) monitors and continuous glucose monitors, allow doctors to monitor their patient's data without needing to call them in, saving both time and money (Park et al., 2020). For example, in 2017, Apple installed an FDA-approved deep learning algorithm in their smartwatch that detects atrial fibrillation (a common type of arrhythmia). Using photoplethysmography and accelerometer sensors, it learns the user's average heart rate at rest and at activity, and sends a warning signal if the heart rate becomes abnormal (Nguyen et al., 2018). Another IoT application is medication management. Smart pill dispensers, for example, can be programmed to release the correct dosage on time, reducing the number of missed or incorrect doses. Since economic advantages are the main driving factors of IoTs in healthcare, their implementation results in better outcomes, disease and drug management with cheaper cost of treatments.

3. Future of AI in Healthcare

Detection

AI algorithms like recurrent CNNs– a type of CNN that uses recurrent connections within its layers which allow the network's units to evolve over time, making them suitable for tasks that require contextual information, like object recognition (Liang, Hu, 2015)– can be used to analyze diseases like coronary atherosclerotic plaques which usually require an invasive and demanding procedure like (Zachariadis, Leligou, 2024). A newer, less invasive technique of testing for abnormalities in blood flow and diagnosing cardiovascular diseases is coronary computed tomography angiography (CCTA). CCTA is non-invasive and creates 3D images of the heart (Ramjattan et al., 2024) that doctors can use with a possibility of overestimating the degree of narrowing of the artery lumen (Zachariadis, Leligou, 2024). To improve its diagnostic accuracy, Federate Learning (FL) has been applied in this context. FL helps institutions collaborate to train AI models on a diverse range of patient data without any direct sharing of sensitive patient data which significantly affects CCTA's diagnostic performance (Di Cosmo et al., 2023). By incorporating data from multiple sources, FL can reduce biases in the model that stem from training a model on a single dataset, which leads to models that are better adapted for different demographics.

Similarly, in musculoskeletal imaging, AI matches or surpasses human expertise in detecting fractures and degenerative conditions. The Sytin model (VGG-16) was trained on hip X-rays and achieved a sensitivity of 95% and an overall accuracy of 92.8% in diagnosing hip osteoarthritis from X-rays, making it comparable to physicians who have atleast 10 years of experience (Zachariadis, Leligou, 2024). AI's capabilities can go beyond osteoarthritis detection. For example, faster RCNN models have shown an accuracy of 88% in detecting interochanteric than orthopedic specialists, who had an accuracy of 84% (Liu et al., 2022). Additionally, ResNet18 has shown an accuracy of 98.1% in identifying distal radius fractures, (Tobler et al., 2021), further proving AI's ability to assist radiologists in high-precision musculoskeletal assessments. However, while AI excels in detecting fractures, it performs moderately in complex classification tasks such as evaluating joint involvement and fragmented displacement with an accuracy ranging from 58.9% to 85/1% in the task (Yoon et al., 2020).

Deep Learning Applications in Surgery

Deep learning (DL) is another tool for enhancing surgical practices by helping increase precision, introducing robot-assisted interventions and automated procedural recognition. An application of DL is automated phase recognition in which models like EndoNet identify different surgical stages to provide real-time feedback that helps improve surgical safety and give skill assessments to residents (Yang et al., 2024). Region-based CNNs have the capability to localize surgical instruments while deep reinforcement learning can refine robotic techniques through continuous feedback, leading to improved precision and efficiency (Morris et al., 2022).

DL can be applied to various surgical specialties: in orthopedics, DL models have a high accuracy in diagnosing fractures and detecting orthopedic implants from radiographs (Bozzo et al., 2024); in neurosurgery, it can identify anatomical structures and track the surgical phases to minimize the risk of a complication during the surgery, thereby improving patient safety (Morris et al., 2022). Similarly, in plastic surgery, DL can assess and evaluate multiple postoperative results. Applications like DL4Burn analyze visual data to help in burn surgery, providing more effective treatment strategies (Morris et al., 2024).

IoT

The integration of IoT into healthcare also has a huge scope for improving patient outcomes, especially through real-time monitoring. By interconnecting different devices and systems, IoT can help establish a seamless connection between medical tools, wearables, and healthcare providers (Zaman et al., 2024). IoT in healthcare would operate across multiple layers which would manage data collection, transmission and application. In the perception layer, there would be technologies like RFID tags, medical sensors, and GPS devices to collect real-time health data. These tools would be responsible for converting physical phenomena into digital signals that would go to the patient and potentially the devices of their healthcare providers, who would then be able to analyze the metrics (Zaman et al., 2024). For example, devices with biometric

sensors that can track heart rate, blood pressure, and oxygen levels allow for non-stop monitoring without hospital visits.

The network layer would primarily be used to manage the transmission of the collected data from the perception later using Bluetooth and Wi-Fi. A strong network layer is necessary in cases of emergency situations where real-time data can help in rapid decision-making and intervention. However, data storage and security are two main concerns in the area. Even though cloud-based storage is flexible and scalable, there are significant concerns raised regarding patient data privacy during potential security breaches. To address these concerns, technologies like edge computing and blockchain technology are being explored to create a decentralized approach. Edge computing would allow real-time data processing closer to the source, which also reduced latency and bandwidth usage. On the other hand, blockchain is more focused on patient autonomy and reducing risks related to centralized data breaches (Nguyen et al., 2024). Lastly, the application layer would use AI to interpret and analyze the health data. AI algorithms can analyze electronic health records, data and other patient information to assist healthcare professionals in making a diagnosis (Kelly et al., 2020).

Apart from diagnosis, IoT technologies could also play a role in increasing healthcare accessibility in underserved areas. By using monitoring and telemedicine, patients would be able to receive medical consultations and follow-ups without physically having to visit a hospital or clinic (Pullimamidi et al., 2022). Wearable health trackers and mobile applications would promote a disease prevention approach by allowing individuals to monitor their own health and be alert in case of any abnormal changes (Kelly et al., 2020). The integration of IoT can help healthcare shift towards a more efficient and accessible patient care model. However, strong data security measures are needed to ensure safe use and trust in the technology.

4. Advantages and Limitations

In the healthcare system, the integration of technology has both significant advantages and limitations.

Automation can significantly reduce the time needed by clinicians and staff to do time-consuming and repetitive administrative tasks, which improves both efficiency and the quality of patient care. In the U.S., about one quarter of the total healthcare expenditure is used for administration, such as getting authorizations, eligibility inquiries and managing billing processes (David Cutler et al., 2020). Automation through technologies like RPA can streamline these processes that traditionally require a large amount of manual labor. For example, in a case study from National Taiwan University Hospital, the time to process medical claims was reduced by 380 minutes through the implementation of RPA, bringing up the cycle efficiency to 95.54% from 69.07%. Therefore, this integration would help healthcare professionals give more

attention to achieving faster turnaround times and patient centered care instead of on non-value steps like filtering and manual data entering (Huang et al., 2024).

The integration of AI also shows promise in being able to enhance operational efficiency. Tools like clinical decision support systems help in improving diagnostic accuracy and optimizing workflows. For example, since AI-driven tools can rapidly analyze a patient's data and provide suggestions on a diagnosis and treatment plans, clinicians can make informed decisions faster, which in turn reduces wait times. Moreover, these predictive tools can help identify a high-risk population early by analyzing risk factors, genetics, lifestyle choices, environmental exposures, and existing health conditions (Khalifa, Albadawy, 2024), giving them the opportunity for early proactive interventions which can also reduce hospital admissions and a sudden increase in workload (Kasula, 2023).

Increased diagnostic accuracy is another benefit of automation technologies. Because they can perform an analysis of vast amounts of patient data, AI algorithms are excellent at identifying subtle patterns that might be missed by clinicians, especially when they're under a heavy workload. For example, if there is an AI continuously monitoring vitals, it can flag small abnormalities that could indicate a patient's deteriorating condition (Yelne et al., 2023). Therefore, using these technologies to minimize human errors would lead to timely and accurate diagnosis, and ultimately, take patient care to another level (Venigandla, 2022).

While automation brings clear advantages to healthcare, these benefits come with certain challenges. The biggest concerns are caused by the lack of human interaction that the increased implementation of AI technologies would cause and the "black box" nature of AI algorithms. These factors then raise questions about transparency, accountability and trust, especially when critical patient decisions are based on opaque, automated inhuman algorithms.

The reduction in human interaction can negatively affect the patient's experience. As technology increasingly handles tasks that take place through interaction with doctors, such as making a diagnosis, patient monitoring and decision-making, the human elements – empathy and real-time communication – diminish. This can lead to a feeling of isolation or even distrust among patients, who may need reassurance and interaction rather than blind trust in an algorithm. Moreover, algorithms are more likely to overlook context-driven factors in patients that only humans can detect (Abad et al., 2010). A study by Digby et al. (2024) indicates the importance of human interaction in patient care, especially when it comes to those who are in isolation. Many negative patient experiences stem from a lack of interaction during their treatment which affects their physical and mental health and may lead to increased levels of depression, anxiety and fear. So, as the duration of their isolation lengthens, the negative emotional states also intensify, which is proved by a worsening Hospital Anxiety and Depression Scale over time. Even though some individuals prefer increased privacy, the overall impact is

overwhelmingly detrimental, highlighting the need for a way to address the mental health of patients when they have fewer interactions with their healthcare providers (Abad et al., 2010).

The “black box” problem with deep learning AI technologies may arise because it is impossible to know how the system came to its conclusion, which hinders their acceptance in clinical settings. The lack of transparency in their decision-making leads to skepticism and diminished trust in both healthcare providers and patients despite the statistics regarding AI’s high performance in diagnostic accuracy. Medical practitioners require transparency on matters like clinical performance, safety and risks because they are liable when using AI tools on their patients. On the other hand, patients want transparency because they have a right to know whether the predictions made by the AI software are safe for them (Fehr et al., 2024). In a survey conducted by Tyson et al. (2023), six in ten U.S. adults stated that they would feel uncomfortable if their doctors relied on AI for diagnosing them and recommending treatments. There are a variety of factors that lead to this distrust. There is a major concern about AI’s impact on the relationship between the patient and their healthcare provider: 57% say that the relationship will only get worse. The security of health records is another concern, with 37% believing that AI would increase the security risk.

This lack of clarity among the public makes it nearly impossible to understand how these models arrived at their conclusion, which affects the safety of the patient. Moreover, the earlier use of any ML-based model may disproportionately affect certain patient populations, since the models could be trained on datasets that are inherently biased. A study by Obermeyer et al. (2019) highlights how racial bias was identified in an algorithm used to predict a patient’s healthcare needs. The algorithm used healthcare costs as a proxy for medical needs and consistently overestimated the severity of the illness in white patients compared to black patients. It only recommended enhanced care for 17.7% of Black patients compared to the 46.5% of white patients, even though both were at the same risk level. This bias originates because the algorithm uses healthcare costs as a proxy for health needs, but Black patients have historically spent less on medical expenses than white patients for their health needs. This problem arises from systemic issues like different socioeconomic backgrounds, difficulty in accessing healthcare, and direct or indirect racism in the healthcare system, and it is hard to address this discrepancy without insight into the model’s internal workings (Jhaveri et al., 2022).

5. Impacts

Building on the advancements of AI, it is also crucial to address the broader impact of the automation of healthcare delivery. These innovations promise early disease detection, lowering clinical loads, and help in times of resource shortages to help get better patient outcomes. These innovations do promise better patient outcomes through early disease detection, lower clinical loads and addressing other resource shortages in the healthcare system. However, it will likely face major challenges related to patient trust in technology, data privacy and a lack of

transparency. The following sections examine ways AI and automation will change healthcare on a broader level.

Enabling Faster Diagnoses

AI-driven systems can enhance patient care quality by speeding up making a diagnosis. For example, they can help analyze medical images which usually take 24–48 hours to analyze and diagnose. They can also act as a second pair of eyes to help clinicians catch any missed details in time-constrained environments (Grenier et al., 2022). This early detection and treatment can enable prompt interventions, therefore contributing to improved long-term health outcomes, because the conditions are managed before they have a chance to progress to severe stages.

Automation Creates More Personalized Healthcare

Another way that automation technologies can greatly improve patient care is by helping create more personalized care plans by analyzing a patient's health-related data such as their health records, genetic data and data from wearable devices. For example, the Apple Watch has FDA approved deep learning algorithms to detect atrial fibrillation, monitor heart health and alert the user to any abnormalities it detects(Nguyen et al., 2018). Similarly, Continous Glucose Monitors (CGMs) help diabetic patients maintain glucose levels by giving them their blood sugar trends (Park et al., 2020). Therefore, personalized healthcare can help improve patient outcomes by addressing their individual needs, but strong security measures are needed to make sure that the patient's data is kept safe.

At-Home Care Expands Access to Treatment

Automation and AI-powered devices are also making at-home care more available to expand the range of access to treatments for patients. Devices like wearable ECG monitors, CGMs, and smart pill dispensers allow healthcare providers to monitor their patients' health remotely, which reduces the need for frequent hospital visits. This makes patient care more convenient and continous, which is helpful for patients with chronic conditions that need constant monitoring. But there are challenges in scaling at-home care, such as the digital divide due to which patients in low-income or in areas that lack access to such devices or a reliable connection that can connect them to their doctors; or a patient's lack of knowledge about the proper usage of specific devices can be an obstacle in them getting proper care because these devices rely on proper usage and care which can vary widely (Park et al., 2020).

Automation Reshapes Healthcare Roles

The introduction of healthcare will have a huge impact on healthcare professionals by changing their roles and requirements. While automation can handle mundane and repetitive tasks like data entry, imaging analysis and scheduling, the clinicians will be able to spend more time working on complex cases and patient interaction. However, this transformation will also raise concerns regarding workforce displacement. Since some redundant tasks will be taken over,

there will be the need to reskill or upskill the workforce that took care of them before. On the other hand, the effect of a shortage of healthcare professionals in certain fields like radiology and pathology can be reduced by supporting clinicians in diagnosing and monitoring patients. For example, AI tools can assist overburdened radiologists by acting as a second pair of eyes to ensure that no details are missed. Similarly, in areas that lack specialists, these tools can assist general physicians or lower-level healthcare workers in making a diagnosis.

6. Ethics

As AI technologies are increasingly integrated into the healthcare system, ethical questions surrounding its liability, lack of transparency, and regulation rise. This section explores the ethical dilemmas related to AI and the current efforts to establish guidelines for its responsible implementation.

One major issue is determining liability for when AI systems cause harm while operating is an ethical and legal gray area. The dominant view is that the developers and manufacturers of the product should be held responsible in this case. This is also consistent with product liability laws such as the Restatement (Third) of Torts: Product Liability, which holds the manufacturers accountable for any harm caused by defects in their products such as design flaws and inadequate instructions (H. Silverglate, 2001). If the AI system makes an incorrect diagnosis due to flawed training data or programming, the developers may be held responsible as well. According to a poll conducted by the AI Policy Institute, 73% of voters believe that AI companies should be held responsible for the harms caused by their technologies (Colson, 2023), highlighting the public support for this approach.

Another approach to the problem is to hold healthcare providers using AI systems equally responsible. According to malpractice laws, clinicians should exercise their judgement and evaluate the AI recommendations before applying them to the patient. The Health Information Technology for Economic and Clinical Health (HITECH) Act emphasizes the shared accountability of healthcare providers in managing and applying any technology. But many critics of this approach argue that not all clinicians may have the necessary knowledge to fully understand the reasoning behind an AI model and AI's "black box" characteristics would only make it harder for them to do that, and therefore cannot.

This issue of liability becomes more pressing when an AI tools recommendation or results conflict with those of a human professional. The view that the medical professional's decision should be final stems from the common belief that they are more equipped to take into account a patient's contextual factors like their preferences, mental state and culture. This also aligns with the idea of a patient-centered healthcare system in which human understanding and empathy play a huge role. In a 2023 survey by Tyson et al. 60% of U.S. adults said that they would feel somewhat or very uncomfortable about their healthcare provider relying on AI for

diagnosing and recommending treatments, underscoring a strong public preference for human oversight in medical decisions.

On the other hand, since AI systems base their recommendations on vast datasets and evidence that clinicians might not have the time or capability to process, they are more capable of having a higher accuracy and identifying early signs of a disease. For example, AI systems in radiology have outperformed human clinicians in identifying early stages of cancers (Grenier et al., 2022). In cases like this, a clinician's decision might be detrimental to a patient. Therefore, it becomes important to balance both judgements. And to achieve a proper balance, there is a need for structured protocols and rules like the ones in the UK's National Health Service. The NHS recommends the implementation of an environment in which AI is a tool for decision support, but the clinician has the final accountability.

7. Conclusion

The integration of AI into healthcare is one of the most significant technological shifts in medicine to date. While AI has already enhanced diagnostics, treatment planning and administrative tasks, there is constant debate over the extent to which this should be continued. Therefore, the challenge isn't deciding whether AI and automation technologies should be implemented but how they can be used best to support human expertise while upholding ethical integrity.

One of the concerns is the risk of automation eroding human aspects of patient care such as human empathy and clinical judgement, which take contextual factors into account. An overreliance on AI could lead to skill degradation among healthcare professionals, which makes it crucial to have a balance between technological efficiency and the current medical institution. Additionally, the effects of the integration of such technologies on employment in healthcare, regulatory policies and data security are all areas of concern.

Therefore, the success of AI and automation technologies in healthcare rests on policymakers, medical professionals and AI developers, who need to continuously work on establishing frameworks to mitigate AI's risks to patients and enhance its benefits as technology evolves. So, rather than replacing human decision-making, which has been imperative in healthcare, AI should function as an assistive tool for them to expand access to high-quality care. The future of healthcare automation will be dependent not just on technological advancement but on the ethical decisions made to ensure patient safety and trust.

8. References

[1] Bozzo, A., Tsui, J. M. G., Bhatnagar, S., & Forsberg, J. (2024). Deep Learning and Multimodal Artificial Intelligence in Orthopaedic Surgery. *The Journal of the American Academy of Orthopaedic Surgeons*, *32*(11), e523–e532. https://doi.org/10.5435/JAAOS-D-23-00831

[2] Colson, D. (2023, September 13). *Poll shows voters oppose open sourcing AI models, support regulatory representation on boards, and say AI risks outweigh benefits*. Artificial Intelligence Policy Institute. https://theaipi.org/poll-shows-voters-oppose-open-sourcing-ai-models-support-regulatory-representation-on-boards-and-say-ai-risks-outweigh-benefits/

[3] Cutler, D. M. (2020). Reducing administrative costs in US health care. *The Hamilton Project Policy Proposal*, *9*, 3-25.

[4] Di Cosmo, M., Migliorelli, G., Francioni, M., Muçaj, A., Maolo, A., Aprile, A., ... & Moccia, S. (2023, September). A Federated Learning Framework for Stenosis Detection. In *International Conference on Image Analysis and Processing* (pp. 211-222). Cham: Springer Nature Switzerland.

[5] Grenier, P. A., Brun, A. L., & Mellot, F. (2022). The potential role of artificial intelligence in lung cancer screening using low-dose computed tomography. *Diagnostics*, *12*(10), 2435.

[6] Gulshan, V., Peng, L., Coram, M., Stumpe, M. C., Wu, D., Narayanaswamy, A., ... & Webster, D. R. (2016). Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. *jama*, *316*(22), 2402-2410.

[7] Kelly, J. T., Campbell, K. L., Gong, E., & Scuffham, P. (2020). The Internet of Things: Impact and implications for health care delivery. *Journal of medical Internet research*, *22*(11), e20135.

[8] Liu, P., Lu, L., Chen, Y., Huo, T., Xue, M., Wang, H., ... & Ye, Z. (2022). Artificial intelligence to detect the femoral intertrochanteric fracture: the arrival of the intelligent-medicine era. *Frontiers in Bioengineering and Biotechnology*, *10*, 927926.

[9] MarketsandMarkets. (2024). *Medical robotic systems market - Global forecast to 2029.* Retrieved from https://www.marketsandmarkets.com/Market-Reports/medical-robotic-systems-market-2916860.html

[10] Ming Liang and Xiaolin Hu, "Recurrent convolutional neural network for object recognition," *2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Boston, MA, 2015, pp. 3367-3375, doi: 10.1109/CVPR.2015.7298958.

[11] Morris MX, Rajesh A, Asaad M, Hassan A, Saadoun R, Butler CE. Deep Learning Applications in Surgery: Current Uses and Future Directions. The American SurgeonTM. 2022;89(1):36-42.
[12] Nguyen, T., Nguyen, H., & Gia, T. N. (2024). Exploring the integration of edge computing and blockchain IoT: Principles, architectures, security, and applications. *Journal of Network and Computer Applications*, 103884.

[13] Park, C. W., Seo, S. W., Kang, N., Ko, B., Choi, B. W., Park, C. M., ... & Yoon, H. J. (2020). Artificial intelligence in health care: current applications and issues. *Journal of Korean medical science*, *35*(42).

[14] Pulimamidi, R., & UI, S. (2022). Leveraging IoT devices for improved healthcare accessibility in remote areas: an exploration of emerging trends. *Internet of Things and Edge Computing Journal*, *2*(1), 20-30

[15] Ramjattan, N. A., Lala, V., Kousa, O., & Makaryus, A. N. (2017). Coronary CT angiography.

[16] Silverglate, S. H. (2001). THE RESTATEMENT (THIRD) OF TORTS Products Liability—The Tension Between Product Design and... *Florida Bar Journal*, *75*(11).

[17] Tobler, P., Cyriac, J., Kovacs, B. K., Hofmann, V., Sexauer, R., Paciolla, F., ... & Hirschmann, A. (2021). AI-based detection and classification of distal radius fractures using low-effort data labeling: evaluation of applicability and effect of training set size. *European Radiology*, *31*, 6816-6824.

[18] Ueda, D., Kakinuma, T., Fujita, S., Kamagata, K., Fushimi, Y., Ito, R., ... & Naganawa, S. (2024). Fairness of artificial intelligence in healthcare: review and recommendations. *Japanese Journal of Radiology*, *42*(1), 3-15.

[19] Verma, V., Chowdary, V., Gupta, M. K., & Mondal, A. K. (2018). IoT and robotics in healthcare. In *Medical big data and internet of medical things* (pp. 245-269). CRC Press.

[20] Yang, H. Y., Hong, S. S., Yoon, J., Park, B., Yoon, Y., Choi, G. H., ... & Kim, S. H. (2024). Deep learning-based surgical phase recognition in laparoscopic cholecystectomy. *Annals of Hepato-Biliary-Pancreatic Surgery*, *28*(4), 466-473.

[21] Zachariadis, C. B., & Leligou, H. C. (2024). Harnessing Artificial Intelligence for Automated Diagnosis. *Information*, *15*(6), 311.

[22] Zaman, M. F., Elsayed, S. M., Ray, T., & Sarker, R. A. (2015). Evolutionary algorithms for dynamic economic dispatch problems. *IEEE Transactions on Power Systems*, *31*(2), 1486-1495.