Scientific Research Publishing

Engineering, 2026, 18(3), 107-122
https://www.scirp.org/journal/eng
ISSN Online: 1947-394X
ISSN Print: 1947-3931

The Miracle of AI in Healthcare

Cynthia Silvia[1], Karolina Kopczynski[2]

[1]School of Business, American Public University System, Charlestown, WV, USA
[2]School of Arts, Humanities and Education, American Public University System, Charlestown, WV, USA
Email: cynthia.silvia@mycampus.apus.edu, karolina.kopczynski@mycampus.apus.edu

How to cite this paper: Silvia, C. and Kopczynski, K. (2026) The Miracle of AI in Healthcare. *Engineering*, **18**, 107-122.
https://doi.org/10.4236/eng.2026.183008

Received: January 15, 2026
Accepted: March 21, 2026
Published: March 24, 2026

Abstract

This paper on artificial intelligence in the healthcare industry explains its impact, the role of Artificial Intelligence, and its role in advancing medical research and patient care in new drug development, which is accelerated by predicting molecular behavior and identifying AI potential drug candidates by optimizing pharmacodynamic and pharmacokinetic properties, resulting in lower drug costs and lessening the need for animal experimentation. Artificial intelligence in predictive analytics uses AI to predict disease outbreaks, patient outcomes, and treatment responses. AI can tailor treatments based on a patient's genetics, environment, and lifestyle. AI-enhanced diagnostic accuracy is achieved by analyzing medical images, laboratory results, and patient data. Predictive analytics leverages AI to forecast disease outbreaks, patient outcomes, and treatment responses. Robotic surgery benefits from AI through increased precision, reduced recovery times, and fewer complications. AI tools for mental health facilitate the early detection and treatment of conditions. AI-powered telemedicine expands healthcare access, while AI-driven chronic disease management provides personalized care plans. Addressing health disparities, AI ensures equitable care for underserved populations. Lastly, AI enhances medical education and training through simulations and virtual reality. This paper highlights the transformative power of AI in revolutionizing healthcare treatments and enhancing patient outcomes.

Keywords

AI in Healthcare, Robotic Surgery, Early Detection, AI in Telemedicine

1. Introduction

AI, data science, and informatics are accelerating new drug development, reducing costs, and decreasing the need for animal experimentation. The discovery of new drugs requires optimizing properties related to pharmacodynamics, pharma-

cokinetics, and clinical outcomes. As early as 2000, AI was used to screen for diseases such as diabetic retinopathy and skin cancer. The FDA has approved 900 AI-enabled medical devices [1]

Johnson & Johnson has been at the forefront of developing digital video capture technology for use in the operating room. The technology is known as the Polyphonic digital ecosystem. It is a beta program that uses AI algorithms to generate a highlights snippet from a surgical procedure, allowing surgeons to review their performance during surgery. This Polyphonic digital ecosystem allows surgeons and residents to review surgical procedures via telepresence, creating shared learning experiences and opportunities [1]. Polyphonic digital ecosystems are a valuable data source for hospitals. Surgical innovations, such as the Polyphonic digital ecosystem, are improving surgical outcomes, reimagining solutions that save lives, and creating smarter, less invasive, and personalized solutions [1].

2. Personalizing Healthcare with Precision Medicine and AI

Precision medicine and artificial intelligence (AI) have enabled the tailoring of medical treatments to the specific needs of individual patients. Precision medicine enables physicians to make informed decisions by using artificial intelligence to identify patients who do not respond to standard therapies or have unique needs. Precision medicine enables clinicians to tailor medical treatments to individuals based on both nongenomic and genomic determinants, in conjunction with patient-specific information, clinical history, and lifestyle factors [1].

According to [1], the successful adoption of AI in healthcare depends upon three principles: data and security, analytics and insights, and shared expertise [1]. Precision medicine requires massive amounts of data and a healthcare ecosystem that focuses on individualized strategies. AI can combine data from multiple sources and utilize that input to assist healthcare professionals in making informed decisions when diagnosing, creating care plans for patients, or helping a social services agency develop care plans for elderly patients [1].

3. Predictive Analytics and Healthcare

Today, artificial intelligence and predictive analytics have made major strides in improving patient health outcomes, particularly in disease progression, treatment responses, and recovery rates. AI's predictive capabilities have enabled the prediction of disease progression, the optimization of treatment plans, and improvements in patient recovery rates by analyzing large datasets, including electronic health records, genetic, and imaging data. Machine learning and deep learning techniques enable personalized medicine by predicting disease early, allowing treatments to be tailored to patients' needs.

4. AI in Diagnostics

AI can enhance diagnostic precision when analyzing medical imaging and lab results. It is performed more quickly and accurately. AI systems serve as a second

set of eyes to help medical practitioners analyze complex datasets, including medical imaging, lab results, and patient histories. The National Institutes of Health's PRIMED-AI [2] suggested using AI to assist clinicians in their decision-making.

The AI tools enable clinicians to achieve accurate diagnoses and provide more personalized patient care. According to the Cleveland Clinic, AI, along with the expertise of medical clinicians, is already demonstrating its value in areas such as radiology, pathology, and cardiology, helping with the interpretation of X-rays and MRIs and identification of specific conditions such as tumors, fractures, and neurological disorders (health.clevelandclinic.org).

Cleveland Clinic notes that AI is being used to diagnose complex conditions and streamline workflows, ultimately increasing efficiency and enabling personalized patient care. As noted, AI is evolving daily, providing enhanced diagnostic capabilities across the healthcare system, making early detection and intervention more accessible and practical [3].

5. Precision Medicine with AI: Integrating Imaging with Multimodal Data

The Precision Medicine with AI: Integrating Imaging with Multimodal Data (PRIMED AI) program is a National Institute of Health initiative designed to advance the next generation of clinical decision support tools by integrating medical imaging with diverse health data. The program recognizes that while imaging plays a key role in diagnosis and treatment, integrating it with other patient information, such as clinical records, lab results, and physiological data, remains a major challenge. PRIMED AI aims to harness rapidly evolving artificial intelligence technologies to merge these data streams, enabling accurate, efficient, and personalized medical decision-making that clinicians could not achieve through manual review alone.

To accomplish this, PRIMED AI focuses on four foundational components: integrating imaging and non-imaging data, developing advanced AI tools, implementing these tools in real-world clinical settings, and strengthening trust and collaboration among researchers, clinicians, and patients. The program will support efforts to create AI models that address unmet clinical needs, accelerate the translation of multimodal AI tools into practice, and foster academic-industry partnerships that enhance commercialization potential. It will also establish rigorous validation frameworks to ensure reliability and develop shared software tools and standards to support the emerging field.

Ultimately, PRIMED AI seeks to transform personalized medicine by enabling AI-powered tools that deliver patient-specific insights at the point of care. By coordinating research, clinical implementation, and community engagement, the program aims to improve health outcomes across a wide range of conditions and lay the groundwork for a more integrated, data-driven healthcare ecosystem. Funding opportunities for PRIMED AI are expected to begin in early 2026, with

updates available through the program's listserv and strategic planning resources.

6. AI in Healthcare: Benefits and Examples

Artificial intelligence is rapidly transforming the healthcare sector, increasing efficiency, accuracy, and the patient experience. AI tools and machine learning are being integrated into chatbots, virtual assistants, smart patient rooms, diagnostic tools, and research workflows to help clinicians streamline patient care. They can analyze large datasets, spot patterns humans might otherwise overlook, and assist health care providers in their decision-making. The sector is expected to expand rapidly, and global AI in healthcare is forecast to be worth $188 billion by 2030, according to the Cleveland Clinic [3].

Practical examples currently in use are also underscored in the article. AI-enabled chatbots assist patients with symptom management and appointments, and machine learning algorithms help interpret imaging studies and predict health risks. In hospitals, AI systems can automate routine tasks, optimize workflows, and support personalized treatment planning. Cleveland Clinic tells us these tools are designed to complement, not replace, professional expertise in clinical knowledge, ultimately aiming to improve innovation, discovery, and patient outcomes.

7. Predicting Outbreaks and Managing Diseases

AI plays a crucial role in predicting and controlling disease outbreaks by analyzing diverse data streams, including social media data and health records [4]. AI can detect the slightest changes in patterns and signals that may not be readily visible to the human eye. AI algorithms can predict and analyze a patient's symptoms, enabling more precise diagnoses that save time and improve accuracy. AI chatbots are available 24/7 and provide immediate answers to health-related questions. They can also provide answers and guidance when needed [4]. AI can personalize treatment plans based on a person's previous health data and genetic background, enabling patients to lead healthier lives.

AI plays a significant role in predicting and managing disease outbreaks by providing timely response strategies that enable better tracking and pattern identification to prevent further spread. AI plays a key role in process improvement and diagnostic *accuracy* [4]. AI can analyze symptoms in real time, enabling doctors to diagnose and treat patients accurately. The earlier an outbreak is identified, the sooner preventive measures can be implemented, such as vaccine campaigns and quarantines [4].

Monitoring enables health systems to detect epidemics early, allocate resources effectively, and develop a timely response plan. AI-powered data collection tools can quickly analyze large amounts of data from multiple sources, including social media, health records, and environmental data [4]. Machine learning models can analyze data and identify patterns that can predict outbreaks quickly. Algorithms can learn through continuous improvement, thereby enhancing their predictive ability over time [4].

8. Predicting Patient Outcomes

AI is enhancing diagnostics and improving health outcomes by increasing accuracy and enabling earlier disease detection. AI leverages algorithms and data-driven insights to detect and forecast disease, fostering a global approach to healthcare that addresses access, outcomes, and the adoption of innovative technologies while ensuring early and accurate detection.

AI enhances patient outcomes by slowing and preventing disease progression. A perfect example is Omdena's AI-powered app in Liberia, which predicts outbreaks and identifies high-risk areas, enabling health officials to take proactive measures and prevent the spread of disease. AI is also making significant improvements in oncology through genomic testing, which identifies mutations and customizes therapies to a patient's unique cancer profile.

Recently, AI has been utilized for the early detection and prevention of cardiovascular disease, achieving an accuracy rate of 93% [5]. These studies have improved the accuracy of heart disease diagnosis, offering patients noninvasive treatment options that could potentially save lives. As AI continues to evolve, the ability to treat, diagnose, and predict disease will lead to significantly healthier populations [5].

9. AI in Mental Health

[6] used artificial intelligence-powered social media analysis to detect early signs of mental health crises. Together, they developed a multimodal deep learning model that integrated natural language processing and temporal analysis techniques using standard metrics validated against expert psychiatric assessments [6]. The AI model demonstrated 89.3% accuracy with a 7.2% lead time before expert psychiatric assessment [6]. In this case, performance was consistent across all languages and platforms. The model showed different accuracy rates for different types of crises; for example, depressive episodes were rated at 91.2%, manic episodes at 88.7%, suicides at 93.5%, and anxiety cases at 87.3% [6].

The application of AI to social media data for mental health has gained popularity recently. There remain questions regarding its accuracy, privacy, and ethical concerns. This model employed a multimodal approach, providing a comprehensive analysis of social media across languages, including English, Spanish, Mandarin, and Arabic [6].

10. AI in Telemedicine

AI-enabled telemedicine is central to expanding health care access for patients, particularly in rural and underserved communities. Incorporating AI into virtual care systems will enhance personalized services, including automated triage, symptom screening, and diagnostic assistance. Now, AI-based tools allow providers to cut wait times and concentrate on delivering higher-quality care. The broad rollout of telehealth during the COVID-19 pandemic showed us its promise as a lifeline for patients, and AI is already augmenting that potential by making care at a dis-

tance more intelligent and scalable [7].

AI-generated tools support remote monitoring and personalized care by leveraging sensors and predictive analytics to enable early detection of health issues. The Cleveland Clinic points to this early evidence in the application of AI to help streamline diagnostics, optimize treatment plans, and enhance patient engagement, and ultimately, an increase in a more proactive and inclusive healthcare system [3].

According to [8], permanent expansion of telehealth access is critical to bolstering the U.S. public health infrastructure, particularly for rural and underserved communities. During the COVID-19 public health emergency, temporary federal flexibilities allowed telehealth to function as a "literal lifeline," allowing patients to receive care without exposure risks and without the geographic barriers that traditionally limit access to physicians, the American Medical Association said. The AMA characterizes these temporary measures as a natural experiment demonstrating telehealth's capacity to mitigate clinician shortages, reduce travel burdens, and maintain continuity of care. For this reason, the organization urges Congress to institutionalize these flexibilities to prevent regression in access and to support a more equitable distribution of healthcare resources.

This Cleveland Clinic piece details how artificial intelligence is rapidly changing the face of health care: by improving diagnosis and accelerating research; by increasing health access [3]. In contemporary settings, artificial intelligence (AI) and machine learning systems can analyze large datasets, detect subtle patterns in medical images that are invisible or only partially discernible, and aid clinicians in making more rapid decisions. For example, in radiology, AI tools detect bone fractures, breast cancer indicators, or stroke-related irregularities with greater accuracy, serving as a "second pair of eyes" that can supplement human expertise [3]. These systems also support triage of urgent cases, such as stroke, by rapidly reviewing scans and notifying medical teams to deploy critical resources promptly.

In addition to diagnosis, AI is redefining biomedical research, enabling scientists to access genetic, cellular, and clinical data at scales and resolutions previously unattainable [3] Cleveland Clinic's collaborations, such as the Discovery Accelerator with IBM, are intended to accelerate drug discovery and enhance understanding of complex diseases, including epilepsy. AI also facilitates operational improvements, such as automatically recording appointments in the office, chatbots that interact directly with patients, and remote monitoring tools that support continuity of care. Technology advances rapidly, but the article emphasizes the importance of doing so ethically and safely, aligning with international best-practice recommendations to ensure that AI benefits patients while preserving trust and safety [3].

Taken as a whole, the AMA's push for permanent telehealth and the Cleveland Clinic's success in developing AI-enabled technologies indicate a confluence of transformations in healthcare today. Telehealth, as a technology, removes geographic and logistical barriers to extending the reach of healthcare, while AI im-

proves care quality and effectiveness through advanced analytics and automation [7] [3]. Both technology solutions address systemic issues such as clinician shortages, rising patient demand, and access disparities, but they also pose significant challenges related to infrastructure, regulation, and ethical application. Integrating these perspectives, we suggest the future of healthcare will necessarily depend not on a single innovation but on the coordinated deployment of the increase in telehealth and AI-driven clinical intelligence to form a more ubiquitous, efficient, and more robust healthcare system [3] [7].

11. AI in Chronic Disease Management

AI tools provide personalized care through intelligent monitoring systems and data-driven insights. For patients with conditions such as heart disease, COPD, and diabetes, the use of such systems to track medication intake, vital signs, and lifestyle factors can be beneficial. This also alerts clinicians to potential problems. According to the Mayo Clinic, AI is being employed to automate more complex diagnostic tasks and to predict disease progression, such as assessing the decline in kidney function in polycystic kidney disease, using imaging data [9]. As the Cleveland Clinic notes, with the help of its AI tools, early intervention and custom treatment plans can be developed, resulting in improved patient outcomes and fewer hospitalizations. In addition, AI enhances personalized patient engagement through mobile and virtual assistant applications that help individuals monitor and self-manage their health. AI is already employed across the care continuum, from diagnosis to aftercare, to better guide clinicians across multiple levels of care and enhance access to care for every patient [9].

12. AI in Health Equity

The tools offered by AI support health equity by using algorithms and large datasets to identify patterns of inequality in healthcare access, outcomes, and treatment, helping providers and policymakers design more equitable interventions. The [10] emphasizes that AI can improve population health by targeting high-priority clinical needs and eliminating inequities rooted in systemic discrimination affecting marginalized communities, including racial minorities, low-income populations, and rural residents.

The American Medical Association's vision for health care AI is underpinned by the Quadruple Aim, which centers on patient care, population health, provider well-being, and system affordability [11]. AI should strengthen the quality of patient care by protecting patients' rights, supporting informed decision-making, and demonstrating, through rigorous research, improvements in clinical outcomes, quality of life, and satisfaction [12]. It should also support population health by addressing critical clinical priorities, as well as the inequities that derive from historical and ongoing injustices that impacted marginalized community and population backgrounds like, but not limited to, Black, Indigenous, and other communities of color, women, people with disabilities, low income and rural populations,

and other populations that have not gained access to the health system [13] [14].

AI in its best sense should enhance the work life of health care providers through physician engagement both in the design and delivery of clinically validated tools to enhance their capacity to provide high-quality care, and in the removal of barriers, including limited AI education, liability concerns, and payment challenges [15] [16]. At the system level, AI should minimize costs through oversight and regulatory frameworks that balance risks and benefits, maintain legal and evidence-based adherence, and foster access and affordability [17]. Developing this vision requires clearly defined roles and responsibilities for clinical AI system developers, health care organizations, leaders promoting AI integration in clinical settings, and physicians leveraging AI for patient-centered, personalized care.

In practice, AI-driven tools are being used to enhance access to care for underserved populations through predictive analytics, language translation services, and remote monitoring technologies. The AI tools help identify patients at risk due to social determinants of health and guide personalized outreach or resource allocation. Research published in Frontiers in Digital Health highlights how AI can accelerate health disparities research by uncovering hidden biases in healthcare delivery and supporting the development of targeted solutions.

13. AI in Health Education

AI provides medical students with numerous realistic, practical learning experiences, including simulations and virtual reality, enabling them to practice in realistic scenarios. The [18] emphasizes that AI can improve learning outcomes by analyzing complex assessment data and tailoring educational content to each learner's zone of proximal development [18].

In addition to providing medical students with realistic learning experiences, it also helps educators by allowing them to focus more on mentoring and offering personalized feedback. Furthermore, AI-powered virtual patients and VR environments are revolutionizing how future healthcare providers practice clinical decision-making and procedural skills. At Harvard Medical School, tools such as the Virtual Integrated Patient (VIP) are used to simulate diverse patient interactions, helping students develop diagnostic reasoning and empathy in a risk-free setting [19]. These technologies also support equity in education by providing consistent, high-quality training experiences regardless of geographic or institutional limitations. The AI tools, combined with professional expertise, enable medical education to produce more competent, confident, and compassionate healthcare professionals [18].

Artificial intelligence has made great strides in medical imaging. Traditionally, physicians have been trained to assess and detect abnormalities. With the aid of artificial intelligence, detecting and monitoring complex patterns has become significantly easier [20]. Artificial intelligence and big data are two recent innovations shaping medical diagnosis, imaging, and patient care. The enthusiasm surrounding AI in medical imaging stems from the performance of ML and DL algo-

rithms, which produce lower error rates and greater accuracy in disease identification [20]. The combination of these two components has enabled early disease detection and diagnosis, informed custom treatment plans, and improved patient outcomes. Medical imaging techniques, such as computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET), provide physicians with detailed, comprehensive, and visual information about the human body. These imaging techniques generate large amounts of data that require analysis and interpretation. This is where AI's deep learning algorithms and datasets can recognize complex patterns that may not be easily discerned by the human eye [21] [22].

Using AI to detect abnormalities, such as tumors, blood vessels, or cells, in their earliest stages can result in timely treatments that potentially save lives and lead to improved treatment outcomes. Merging AI and imaging can result in personalized treatment plans. AI can be used to detect, screen, diagnose, and grade retinal diseases, including diabetic retinopathy, retinopathy of prematurity, and age-related macular degeneration. Extensive research has also been done on the use of AI in lung imaging, mainly because lung cancer is very aggressive and often leads to higher mortality rates in those with cancer. Lung CT for COVID-19 has proven effective and can be readily adapted to other imaging modalities.

Breast cancer is another cancer that must be detected early for the best results. [23] evaluated two computer-aided detection strategies for digital mammograms that differentiated between malignant and benign breast cancers, using two state-of-the-art approaches based on radionics and deep transfer learning. The findings of this study indicate that deep transfer learning can extract meaningful features from medical images, providing more informative insights. Radiomics and AI play important roles in advancing breast cancer imaging, providing insights into breast cancer treatments and decisions [23].

14. AI in Surgery

Today, artificial intelligence is being trained to analyze medical images to detect the most minute abnormalities that often go undetected by humans. This has led to greater accuracy in the diagnosis of diseases like breast cancer, lung nodules, and even signs of Alzheimer's disease [24]. AI can improve patient care by delivering faster, more accurate results. AI can detect and distinguish between organs and tumors, significantly reducing time to diagnosis and reducing errors. AI can also assess risk factors associated with medical conditions, enabling healthcare providers to improve their decision-making and make informed choices about which treatment is most effective, thereby reducing the risk of adverse outcomes [24]. The most significant advantage of AI is its ability to analyze large volumes of data quickly and accurately, enabling physicians to base their decisions on all available information [24] [25].

AI, CT scans, and MRI images can be utilized to create three-dimensional models, which enhance accuracy when complex medical procedures are necessary

[26]. 3D printing technology, combined with imaging and 3D modeling techniques, can be used to create physical replicas of the patient's anatomical structures, allowing surgeons to hold and examine them. This enables them to anticipate potential challenges and refine surgical procedures. Surgical procedures can be tailored to each patient's unique anatomy [26].

15. AI In Spinal Cord Injuries

A Rutgers team of scientists has discovered how a combination of AI and robotics can assist patients in recovery. The team determined that the enzyme Chondroitinase ABC (ChABC) can degrade scar tissue in spinal cord injuries and promote tissue regeneration [27]. Previously, the enzyme was active for only a few hours at body temperature; now it remains active for more than a week, sufficient to degrade scar tissue from spinal cord injuries, thereby promoting tissue regeneration [27].

Researchers used machine learning to identify artificial polymers that would remain in the body longer. This was the first time AI and robotics were combined to produce therapeutic proteins for tissue regeneration. Scientists can now use algorithms to create new therapies that would be too time-consuming to identify under normal circumstances and might otherwise never have been discovered.

16. What Are the Ethical and Legal Considerations of AI in Healthcare

AI and big data continue to span the healthcare continuum, encompassing payers. As healthcare expenditure grows globally, it is unfortunate that not all funds are spent in the most effective ways. As global expenditure grows, it is unfortunate that not all funds are spent in the most effective ways. According to [28], 10% of healthcare expenditures are wasted due to fraud and abuse, totaling billions of dollars annually. Healthcare losses have been identified in cases involving fraud and error, affecting patients, healthcare professionals, medical staff, management, and contractors.

The legal and ethical issues arising from artificial intelligence encompass privacy, surveillance, bias, discrimination, and the impact on human judgment [29]. There is considerable concern that AI could become inaccurate and misleading, leading to errors in procedures or protocols and resulting in devastating consequences, particularly for patients on the receiving end. According to [29], no defined regulations are in place to address the ethical and legal issues directly attributed to artificial intelligence. AI has the potential to transform healthcare through the vast amounts of data collected during healthcare delivery. There are concerns that AI could introduce inaccuracies and lead to data breaches. These errors could have negative consequences for patients who are the victims in this case. AI solutions have the potential to significantly impact clinical decision-making, potentially creating a new healthcare paradigm [29].

17. Data Privacy and Security

Ensuring the protection of patient data in AI systems is crucial to safeguarding the healthcare ecosystem against cyber threats. A ransomware attack on Change Healthcare in 2024 underscored the need for sustained efforts to safeguard medical billing in the United States. This ransomware attack brought medical billing across the United States to a complete standstill and precipitated the bankruptcy of many health systems and medical practices. This breach affected the cash flow of organizations that today account for a fifth of the U.S. economy, compromising 85 million patient records and resulting in trillions of dollars in losses [30]. Recovery remains a work in progress, and it may take years for the full extent of the damage to be fully understood.

We must adopt a new approach to cybersecurity risk protection that analyzes the functions of hospitals, medical practices, health insurance plans, payers, pharmacies, drug manufacturers, medical labs, medical technology companies, healthcare IT vendors, contractors, and governments. The risks of each sector must be thoroughly assessed to determine where the ecosystem requires the most robust line of defense [30].

To ensure the protection of the healthcare ecosystem, five key strategies must be in place, including:

1) The first line of defense is establishing a baseline security system. A baseline security system makes it more difficult for attackers to breach the ecosystem and cause harm. Essential cyber protection can be established through joint efforts between the Department of Health and Human Services and the Health Sector Coordinating Council, an advisory group that works with agencies on healthcare cybersecurity policy [30]. Together, these two agencies help organizations establish and maintain cybersecurity performance goals, such as addressing operational vulnerabilities and implementing backup planning and preparedness systems [30].

2) To ensure that the connections between the two systems are secure. One-way connections between organizations are less likely to be used to launch a cyberattack than bidirectional connections. An example is an HVAC company that requires a private connection to a hospital to control the environment in areas such as operating rooms, laboratories, and patient rooms.

3) Healthcare organizations must identify areas of high risk and take action to report a breach within 72 hours. They must also establish criteria for determining whether a breach is material. Most organizations can withstand a short-term disruption; however, a full-scale cyberattack can last anywhere from 30 to 60 days.

4) Today, organizations are required to report significant cyberattacks under the federal Cyber Incident Reporting for Critical Infrastructure Act of 2022. Key sectors must report these attacks within 72 hours. In the case of Change Healthcare, HHS took 13 days to issue a public statement [30].

5) The healthcare ecosystem must collaborate with the federal government to establish government oversight and formal recognition of critical organizations

[30]. The government must also help identify the ecosystems present. In this case, both the company and the hospital must have detection methods that enable the hospital to defend itself against intrusion. While the government cannot entirely remove the risk, it can have a plan of action in place should a breach occur.

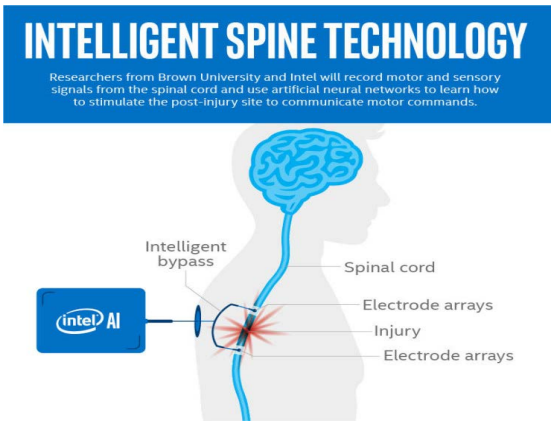
18. Virtual Health Assistants

Virtual Health Assistants were introduced with the chatbot ELIZA, which paved the way for the chatbots in use today [31]. Today's virtual assistants can be integrated with electronic health record systems (EHR), enabling them to manage patient information. The pandemic has led to the proliferation of digital and virtual platforms. Healthcare has seen a rise in virtual nursing chatbots to address the nursing shortage. Virtual health assistants have significantly contributed to improved health outcomes and enhanced patient-provider relationships. Virtual chatbots have improved healthcare accessibility, particularly in remote areas. The use of virtual assistants enables remote consultations, thereby improving the quality and equity of healthcare for all.

As healthcare virtual assistants continue to evolve, healthcare providers must be mindful of technological advancements and the ethical responsibilities surrounding the security and privacy of patient data generated by their use. To address these concerns, healthcare systems must use encryption protocols and implement strict data protection measures. Addressing these issues will help the healthcare industry mitigate potential risks, leading to advancements that will revolutionize patient care.

19. Case Studies

19.1. Intelligent Spine Technology



(Credit: Intel.com/officia. 2022.)

David Borton, an Assistant Professor of Engineering at Brown University, and his team have discovered that a combination of AI and robotics can assist patients in recovering from spinal cord injuries. The team determined that the enzyme Chondroitinase ABC (ChABC) can degrade scar tissue in spinal cord injuries and pro-

mote tissue regeneration [27]. Restoration of tissue around the injury site can be used to rehabilitate and restore lost functions, correct spinal cord function, and potentially alleviate paralysis [27].

19.2. Surgical Robots

Robot-assisted surgeries employ AI and collaborative robots together. One such robot is the Da Vinci Surgical System, which assists surgeons in the operating room with procedures requiring precision and repetition, such as laparoscopic surgery. The Da Vinci Surgical System can execute predefined movements with high precision and without fatigue. This reduces human error and shortens recovery times, thereby enabling surgeons to perform even complex procedures with high accuracy [32].

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Johnson and Johnson (2024) 6 Ways Johnson & Johnson Is Using AI to Help Advance Healthcare. https://www.jnj.com/innovation/artificial-intelligence-in-healthcare?utm_source=bing&utm_medium=cpc&utm_campaign=BI-USA-ENG-PS-Corporate+Equity-GP-PH-RN-NB_STORIES_ARTIFICIAL+INTELLIGENCE&utm_content=AI+-+Healthcare&utm_term=ai+medicine&gclid=a3ceedc26e3e1d74292d8afdab946523&gclsrc=3p.ds&msclkid=a3ceedc26e3e1d74292d8afdab946523

[2] National Institutes of Health, Common Fund (n.d.) Precision Medicine with AI: Integrating Imaging with Multimodal Data (PRIMED-AI). https://commonfund.nih.gov/primed-ai

[3] Cleveland Clinic (2025) How AI Is Being Used in Healthcare and What It Means for You. https://health.clevelandclinic.org/ai-in-healthcare

[4] Health (2024) The Role of AI in Predicting and Managing Disease Outbreaks. https://www.innovationnewsnetwork.com/the-role-of-ai-in-predicting-and-manag-

ing-disease-outbreaks/49277/?form=MG0AV3

[5] World Economic Forum (2024) How AI Is Improving Diagnostics and Health Outcomes, Transforming Healthcare. https://www.weforum.org/stories/2024/09/ai-diagnostics-health-outcomes/

[6] Mansoor, M. and Ansari, K. (2024) Early Detection of Mental Health Crises through Artificial-Intelligence-Powered Social Media Analysis: A Prospective Observational Study. *Journal of Personalized Medicine*, **14**, Article 958. https://doi.org/10.3390/jpm14090958

[7] Ehrenfeld (2024) Permanently Expanding Telehealth Access Will Improve Public Health. https://www.ama-assn.org/about/leadership/permanently-expanding-telehealth-access-will-improve-public-health

[8] AMA (2024) Is Telemedicine Here to Stay? The Future of Telehealth Services and the Benefits of Telemedicine. https://www.ama-assn.org/practice-management/digital-health/telemedicine-here-stay-future-telehealth-services-and-benefits

[9] Mayo Clinic (2024) AI in Healthcare: The Future of Patient Care and Health Management. https://mcpress.mayoclinic.org/healthy-aging/ai-in-healthcare-the-future-of-patient-care-and-health-management

[10] American Medical Association (2025) Advancing Health Care AI through Ethics, Evidence and Equity. https://www.ama-assn.org/practice-management/digital-health/advancing-health-care-ai-through-ethics-evidence-and-equity

[11] Bodenheimer, T. and Sinsky, C. (2014) From Triple to Quadruple Aim: Care of the Patient Requires Care of the Provider. *The Annals of Family Medicine*, **12**, 573-576. https://doi.org/10.1370/afm.1713

[12] Topol, E. (2019) Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again. Basic Books.

[13] Bailey, Z.D., Krieger, N., Agénor, M., Graves, J., Linos, N. and Bassett, M.T. (2017) Structural Racism and Health Inequities in the USA: Evidence and Interventions. *The Lancet*, **389**, 1453-1463. https://doi.org/10.1016/s0140-6736(17)30569-x

[14] Obermeyer, Z., Powers, B., Vogeli, C. and Mullainathan, S. (2019) Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations. *Science*, **366**, 447-453. https://doi.org/10.1126/science.aax2342

[15] Shanafelt, T.D. and Noseworthy, J.H. (2017) Executive Leadership and Physician Well-Being: Nine Organizational Strategies to Promote Engagement and Reduce Burnout. *Mayo Clinic Proceedings*, **92**, 129-146. https://doi.org/10.1016/j.mayocp.2016.10.004

[16] Shortliffe, E.H. and Sepúlveda, M.J. (2018) Clinical Decision Support in the Era of Artificial Intelligence. *Journal of the American Medical Association*, **320**, 2199-2200. https://doi.org/10.1001/jama.2018.17163

[17] U.S. Food and Drug Administration (2021) Artificial Intelligence and Machine Learning in Software as a Medical Device. https://www.fda.gov

[18] American Medical Association (2023) Advancing AI in Medical Education through Ethics, Evidence, and Equity. https://www.ama-assn.org/practice-management/digital-health/advancing-ai-medical-education-through-ethics-evidence-and

[19] McPherson, S. (2025) Master's Student Empowers Medical Educators with AI Tools. https://hms.harvard.edu/news/masters-student-empowers-medical-educators-ai-tools

[20] Currie, G. and Rohren, E. (2021) Intelligent Imaging: Applications of Machine Learning and Deep Learning in Radiology. https://onlinelibrary.wiley.com/doi/epdf/10.1111/vru.13144

[21] Ahsan, M.M., Luna, S.A. and Siddique, Z. (2022) Machine-Learning-Based Disease Diagnosis: A Comprehensive Review. *Healthcare*, **10**, 541. https://doi.org/10.3390/healthcare10030541

[22] Hosny, A., Parmar, C., Quackenbush, J., Schwartz, L.H. and Aerts, H.J.W.L. (2018) Artificial Intelligence in Radiology. *Nature Reviews Cancer*, **18**, 500-510. https://doi.org/10.1038/s41568-018-0016-5

[23] Danala, G., Maryada, S.K., Islam, W., Faiz, R., Jones, M., Qiu, Y., *et al.* (2022) A Comparison of Computer-Aided Diagnosis Schemes Optimized Using Radiomics and Deep Transfer Learning Methods. *Bioengineering*, **9**, Article 256. https://doi.org/10.3390/bioengineering9060256

[24] Open Medscience (2024) Revolutionizing Medical Imaging with AI and Big Data Analytics. https://openmedscience.com/revolutionising-medical-imaging-with-ai-and-big-data-analytics/

[25] Pinto-Coelho, L. (2023) How Artificial Intelligence Is Shaping Medical Imaging Technology: A Survey of Innovations and Applications. *Bioengineering*, **10**, Article 1435. https://doi.org/10.3390/bioengineering10121435

[26] Wang, S., Cao, G., Wang, Y., Liao, S., Wang, Q., Shi, J., *et al.* (2021) Review and Prospect: Artificial Intelligence in Advanced Medical Imaging. *Frontiers in Radiology*, **1**, Article 781868. https://doi.org/10.3389/fradi.2021.781868

[27] Fingas (2022) AI Discovery Could Advance the Treatment of Spinal Cord Injuries. https://www.engadget.com/ai-robotics-spinal-cord-injury-treatment-151507175.html

[28] Gee, J. and Button, P.M. (2014) The Financial Cost of Healthcare Fraud 2014. https://fullfact.org/wp-content/uploads/2014/03/The-Financial-Cost-of-Healthcare-Fraud-Report-2014-11.3.14a.pdf

[29] Naik, N., Hameed, B.M.Z., Shetty, D.K., Swain, D., Shah, M., Paul, R., *et al.* (2022) Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility? *Frontiers in Surgery*, **9**, Article 862322. https://doi.org/10.3389/fsurg.2022.862322

[30] Decker, E., Glaser, J. and Guptill, J. (2024). Preventing the Next Big Cyberattack on U.S. Healthcare. https://hbr.org/2024/05/preventing-the-next-big-cyberattack-on-u-s-health-care

[31] Farquharson, A. (2024). How Virtual Healthcare Assistants Are Changing the Face of Healthcare. https://www.vivian.com/community/industry-trends/how-virtual-healthcare-assistants-are-changing-the-face-of-healthcare/#:~:text=

[32] Da Vinci Surgical System (n.d) https://logodix.com/logo/1062240.png

Video References

Bloomberg Originals. (2025, April 18). *How AI is revolutionizing medicine* [Video]. YouTube. https://www.youtube.com/watch?v=FqsvgFTQv8w

AI in Diagnosing Diseases, Predicting Outbreaks, and Personalizing Treatments. (2025). *YouTube*. https://www.youtube.com/watch?v=ERQ1rgQn3Us

Track Health & AI News. (2025). *AI / LLMs analyze EHR data to predict patient outcomes* [Video]. YouTube. https://www.youtube.com/watch?v=x4-sL9fLN6I

UCL Brain Sciences Faculty. (n.d.). *How AI is shaping the future of mental health diagnosis and treatment* [Video]. YouTube. https://www.youtube.com/watch?v=s5B_SKwcij8

Smart Health with Dr. Saab. (2024, October 17). *How AI is revolutionizing telemedicine* [Video]. YouTube. https://www.youtube.com/watch?v=Eg9bBdhEbC4

Stanford CME. (2024). *Lightning demos: AI tools for medical education/AI in medical education symposium* [Video]. YouTube. https://www.youtube.com/watch?v=svPXLcrzU-w

Grant Thornton US. (2025, June 13). *Empowering Healthcare Providers: What is the Future of AI?/Chronic Disease Management/AI Tech*. YouTube. https://www.youtube.com/watch?v=VtFrv0TW3Mo

Afsar, N. (2024). *Unify. Understand. Empower: The AI blueprint for health* [Video]. TEDxUWMadison. YouTube. https://www.youtube.com/watch?v=Yn3Zkada8-8

UC San Francisco (UCSF). (2023). *How a brain implant and AI gave a woman with paralysis her voice back* [Video]. YouTube. https://www.youtube.com/watch?v=iTZ2N-HJbwA

Shachar, C. (Guest). (2024). *Understanding the Legal and Ethical Implications of AI in Healthcare with Carmel Shachar* [Video]. The RegulatingAI Podcast. YouTube. https://www.youtube.com/watch?v=0mxlgDF8tGg

IBM Technology. (2025, July 8). *Protecting Data in AI: Strategies for Security & Governance* [Xillium®. (2020, March 17). *What is a Virtual Medical Assistant?* [Video]. YouTube. https://www.youtube.com/watch?v=dujSyycZ0YIVideo]. YouTube. https://www.youtube.com/watch?v=LyfG7SGRiZA

Xillium®. (2020, March 17). What is a Virtual Medical Assistant? [Video]. YouTube. https://www.youtube.com/watch?v=dujSyycZ0YI

Prince EA. (2025, July 16). Scientists install the world's first electronic spine to restore movement after paralysis. Retrieved from: https://princeea.com/electronic-spine-restores-movement-after-paralysis/