TEENS IN HEALTH SUMMER 2023 INTERNSHIP

AI IN HEALTHCARE ARTICLE WRITING

Teens In Health

Teens in Health AI in Healthcare Summer 2023 Journal

Teens in Health is a teen led organization that aims to provide open access to biological research skill development through researching and writing articles. This session, students spent 5 weeks working on individual articles, on all different topics of AI in Healthcare

Director/Reviewer/Mentor: Charlotte Lungren

Authors:

Abdullah Malik
Alex Lungren
Angel Yeung
Anvita Bhogadi
Ayran Tummala
Ava LeFevre
Danat Beyene
Diya Patel
Diya Patel
Eniola Karim
Fariha Sneha
Hana Ahmed
Iman Iqbal
Jenny Wu
Kaitlyn Yainna
Iayan Essam
Monika Mp
Sahana Sankaran
Sean Gee
Sebastian Ribault
Shakthi Rao
Victoria Nelms
Vienna Li
Zara Chaudhary
Rachel Weng
Adwin Sujin
Keertana Raghavendra
Esther Morataya
Lauryn Singh
Queenie Hwang

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AI in Healthcare: Revolutionizing Patient Care and Diagnostic Accuracy

Abdullah Malik, Charlotte Lungren (advisor), Anika Shah (advisor), Michelle To (advisor)
Delran High School

Abstract:

This research paper explores the applications of artificial intelligence (AI) in healthcare and its impact on patient care and medical diagnosis. It discusses the benefits of AI, including improved diagnostic accuracy, enhanced efficiency, and personalized medicine. Real-world examples, such as IBM Watson for Oncology and Google DeepMind's AI in ophthalmology, demonstrate the effectiveness of AI technologies in improving patient outcomes. However, challenges like data privacy, algorithmic bias, and human-AI collaboration need to be addressed. By examining the potential of AI in healthcare, this research paper provides insights into its role in shaping the future of medicine and highlights the need for responsible integration to ensure patient well-being.

Introduction:

The emergence of artificial intelligence in healthcare has been groundbreaking and it has reshaped the way we diagnose patients. This technology is drastically improving healthcare research and outcomes by producing more accurate diagnoses and enabling more personalized treatments. AI in healthcare's ability to analyze various clinical documentations helps medical professionals identify diseases and trends that would otherwise be overlooked. It started with IBM's launch of a healthcare-specific version of Watson in 2011 that focused on using natural language processing to understand human communication. Today, alongside IBM, other tech companies like Apple, Microsoft and Amazon are increasingly investing in AI technologies for the healthcare sector. By using artificial intelligence in healthcare, medical professionals can make more informed decisions based on more accurate information - saving time, reducing costs and improving medical records management overall. From identifying new cancer treatments to improving patient experiences, AI in healthcare promises to lead the way towards a future where patients receive quality care and treatment faster and more accurately than ever before. This poses the question: How does artificial intelligence improve diagnostic accuracy and enable personalized treatments?

Discussion:

AI in Patient Care:

AI technology plays a transformative role in enhancing patient care across various aspects of healthcare delivery. According to a Foresee Medical article about AI in healthcare, a key application of AI in patient care is in patient monitoring (Barth 2022). AI algorithms continuously analyze patient data, including vital signs and sensor data, to detect patterns, identify anomalies, and predict potential adverse events. This proactive monitoring enables healthcare professionals to intervene early, providing timely and targeted interventions. For example, AI-based predictive analytics can identify patients at high risk of sepsis, allowing for prompt intervention and potentially saving lives. Additionally, AI-powered remote monitoring systems enable real-time tracking of patient health conditions, facilitating personalized care and reducing the need for frequent hospital visits. Another important aspect of AI in patient care is medication management. AI systems leverage patient data and medical records to prevent medication errors and improve medication adherence. By analyzing patient information, including medical history, drug interactions, and patient-specific factors, AI algorithms can provide personalized medication recommendations and dosage adjustments. AI-powered medication adherence tools can remind patients to take their medications, monitor adherence, and provide educational resources. This technology helps ensure that patients receive the right medications at the right time, improving medication safety and treatment effectiveness. Furthermore, AI-driven chatbots and virtual assistants contribute to patient care by providing 24/7 access to healthcare information and guidance. Patients can interact with these AI-powered tools to obtain information about symptoms, medications, and general healthcare advice. AI chatbots can promote patient inquiries, offering preliminary assessments and appropriate recommendations for further care. This accessibility to healthcare information empowers patients to make informed decisions and promotes self-care. Overall, the integration of AI in patient care has the potential to revolutionize healthcare delivery. By leveraging advanced algorithms, AI systems can enhance patient monitoring, medication management, and patient education. This technology empowers healthcare professionals to provide proactive, personalized care, improving patient outcomes and overall healthcare experience. However, it is important to address challenges such as data privacy, algorithmic bias, and maintaining a balance between human expertise and AI automation to ensure responsible and ethical implementation of AI in patient care.

AI in Medical Diagnosis:

AI plays a crucial role in medical diagnosis by assisting healthcare professionals in making accurate decisions. In the field of medical imaging, AI algorithms can analyze radiological images such as X-rays, CT scans, and MRIs by detecting abnormalities. A study explores the application of AI in medical imaging analysis, specifically focusing on lung cancer detection (Daley 2018). The research highlights the

effectiveness of deep learning algorithms in analyzing chest CT scans to identify lung nodules and assess their malignancy. The AI system achieved a high level of accuracy, demonstrating its potential as a valuable tool for early lung cancer detection. Another domain where AI contributes to medical diagnosis is clinical decision support systems. These systems utilize AI algorithms to analyze patient data, medical records, and scientific literature to provide healthcare providers with evidence-based recommendations for diagnosis and treatment planning. A review article discusses the current state of clinical decision support systems and their potential impact on healthcare delivery (Barth 2022). The study emphasizes how AI can assist healthcare professionals by offering insights and recommendations based on comprehensive data analysis, ultimately leading to improved diagnostic accuracy and treatment outcomes. AI-powered diagnostic tools also offer promising solutions for early disease detection. For instance, AI algorithms can analyze medical data and identify patterns that may indicate the presence of certain diseases. Another study discusses the potential of AI in predicting cardiovascular diseases by analyzing electronic health records. The research showcases how AI models can leverage various clinical parameters to predict the risk of developing cardiovascular diseases accurately (Ahuja 2019). By leveraging AI in medical imaging analysis, clinical decision support systems, and early disease detection, healthcare professionals can enhance their diagnostic capabilities and improve patient outcomes.

Benefits and Challenges

The integration of AI in healthcare brings a range of benefits that have the potential to significantly improve patient care and enhance medical diagnosis. Numerous studies have demonstrated the advantages of AI in different healthcare domains. A study showed that a deep learning algorithm trained on a large dataset of chest X-rays achieved performance comparable to expert radiologists in detecting pneumonia (Daley 2018). This highlights the potential of AI to assist in radiological interpretations and enhance diagnostic accuracy. AI also enhances the efficiency and productivity of healthcare professionals. AI-enabled clinical decision support systems led to improved clinical outcomes and increased efficiency in healthcare delivery (Barth 2022). These systems analyze patient data to provide evidence-based recommendations, aiding healthcare providers in optimizing treatment strategies. However, the integration of AI in healthcare is not without its challenges. Data privacy and security are major concerns, and measures must be taken to protect patient information and maintain confidentiality. Algorithmic bias is another challenge, where AI systems may produce biased results due to underlying biases in the data or algorithm training. Striving for transparency and fairness in AI algorithms is important to avoid perpetuating healthcare disparities. Finding the right balance between human expertise and AI automation is crucial, as AI should support clinical decision-making rather than replace it, ensuring a patient-centered approach to care. By addressing these challenges, healthcare systems can responsibly implement AI,

leveraging its benefits to enhance patient care, optimize resource utilization, and drive advancements in medical practices.

Examples of AI in Healthcare

An example of AI in healthcare is the IBM Watson for Oncology system, which applies AI to assist oncologists in treatment decision-making. This system utilizes natural language processing and machine learning algorithms to analyze patient data, medical literature, and treatment guidelines. A study evaluated the performance of IBM Watson for Oncology in breast cancer treatment recommendations (Foster 2007). The research found that the system provided treatment options aligned with expert recommendations in the majority of cases. This proves how AI can enhance clinical decision-making by providing evidence-based guidance and aiding healthcare professionals in formulating treatment strategies. Another example is Google DeepMind's AI technology applied to ophthalmology. Google DeepMind's AI has been utilized to detect and diagnose eye diseases by analyzing retinal images. This technology aids ophthalmologists in identifying conditions such as diabetic retinopathy and age-related macular degeneration, allowing for earlier detection and intervention. These systems demonstrate how AI has the potential to enhance diagnostic accuracy, support treatment planning, and improve patient outcomes. Moreover, AI has proven valuable in improving healthcare operations and resource allocation. Hospital readmission prediction models powered by AI algorithms analyze patient data to identify those at high risk of readmission. By identifying high-risk patients, healthcare providers can implement proactive interventions, such as post-discharge monitoring and care coordination, to prevent unnecessary readmissions. Furthermore, AI has shown promise in the field of genomics and precision medicine. Genomic sequencing generates massive amounts of data that require sophisticated analysis. AI algorithms can efficiently process and interpret genomic data, identifying genetic variations and their potential implications for disease diagnosis and personalized treatment plans. This enables healthcare professionals to deliver targeted therapies based on an individual's unique genetic makeup, leading to more effective and personalized care. Lastly, AI is being applied in the field of robotic surgery. Robotic-assisted surgical systems utilize AI algorithms to assist surgeons in performing precise and minimally invasive procedures. These systems can analyze real-time data, provide enhanced visualization, and offer guidance to surgeons, resulting in improved surgical outcomes.

Conclusion:

The integration of artificial intelligence (AI) in healthcare can transform patient care and medical diagnosis. The research question of how AI is utilized in healthcare to improve patient care and enhance medical diagnosis has been explored and answered through an analysis of various subtopics. The findings emphasize the benefits of AI, such as improved diagnostic accuracy, enhanced efficiency, and personalized medicine. Real-world examples demonstrate the effectiveness of AI technologies in improving patient outcomes. However, challenges related to data privacy, algorithmic bias, and human-AI collaboration need to be addressed for responsible integration. The significance of this research lies in its implications for the future development of AI in healthcare, paving the way for improved healthcare delivery, optimized treatment strategies, and the potential for groundbreaking advancements in medicine. With continued progress in AI technology and ethical considerations, AI has the power to reshape the future of healthcare.

Works Cited:

Ahuja, A. S. (2019). *The impact of artificial intelligence in medicine on the future role of the physician.* PeerJ, 7(7702), e7702. https://doi.org/10.7717/peerj.7702

Barth, S. (2022). *Artificial Intelligence (AI) in Healthcare & Hospitals.* ForeSee Medical. https://www.foreseemed.com/artificial-intelligence-in-healthcare

Daley, S. (2018). *Surgical robots, new medicines and better care: 32 examples of AI in healthcare.* Built In. https://builtin.com/artificial-intelligence/artificial-intelligence-healthcare

Foster, E. M., Porter, M. M., Ayers, T. S., Kaplan, D. L., & Sandler, I. (2007). *Estimating the Costs of Preventive Interventions.* Evaluation Review, 31(3), 261–286. https://doi.org/10.1177/0193841x07299247

Literary Review

Who Is Matthew Lungren, And What Are His Impacts On AI?

Alex Lungren, Charlotte Lungren (advisor), Anika Shah (advisor), Michelle To (advisor)

Abstract:

This article explores the work of Dr. Matthew Lungren, a leading figure in the integration of Artificial Intelligence (AI) in healthcare. As a physician, researcher, and educator, Dr. Lungren's work is making huge strides in understanding and using the incredible potential of AI in healthcare. His impact extends from his research on applications of AI in medicine to his efforts in educating the public about AI through his online course.

Introduction:

Artificial Intelligence (AI) is a quickly evolving field, transforming various sectors, including healthcare. This advanced technology is helping with diagnosing diseases, developing treatments, and improving patient care. A key figure in this transformation is Dr. Matthew Lungren, who is a physician and a researcher in machine learning, a type of AI. This article will delve into Dr. Lungren's contributions to the field of healthcare AI and why they matter.

Discussion:

Dr. Lungren is not just a practicing physician, but also a scholar at well known academic institutions such as Stanford and Duke. His experience in medicine strengthens his research in AI, as he can identify real problems and look for solutions using AI. Before joining Microsoft's company, Nuance Communications, Dr. Lungren was a known figure in leading the Stanford Center for Artificial Intelligence in Medicine and Imaging (AIMI). He also worked at Amazon Web Services, where his focus was on using AI to improve public healthcare services. With over 100 scientific articles written, Dr. Lungren's research spans various features of healthcare AI. He has worked on combining different types of health data for improved patient care and developed new methods for predicting health outcomes using AI. Dr. Lungren's belief in open medical data as a public good and his exploration of machine learning for public health applications demonstrate his commitment to the societal benefits of AI. In addition to his doctoral and research roles, Dr. Lungren is also an educator. He offers a course on Coursera about AI in healthcare, designed for people without much background in technology. This course has been completed by more than 15,000 students globally, underscoring his impact on AI education.

Conclusion:

So, who is Dr. Matthew Lungren, and what are his impacts on AI? Dr. Lungren is a doctor, researcher, and educator who contributes to a better understanding of AI's capabilities and future possibilities in

healthcare. With his prestigious background and knowledge of AI and healthcare, his 100+ research papers, and his course helping others learn the potential of AI, it is no wonder why Dr. Matthew is a leading figure in the development and implementation of AI in healthcare.

Sources Cited:

EHR National Symposium. (n.d.). *Matt Lungren*. EHR National Symposium. https://med.stanford.edu/ehr/2019_speakers/matt-lungren.html

Matthew Lungren md mph | linkedin. linkedin. (2023). https://www.linkedin.com/in/mattlungrenmd

Matthew Lungren, instructor. Coursera. (2023). https://www.coursera.org/instructor/~10223366

Matthew Lungren, instructor. Coursera. (n.d.). https://www.coursera.org/instructor/~10223366

Matthew Lungren at Microsoft Research. Microsoft Research. (2023). https://www.microsoft.com/en-us/research/people/mlungren/

Literary Review

AI in surgery

Yam Yeung, Charlotte Lungren (advisor), Anika Shah (advisor), Michelle To (advisor)
Lake Washington high school

Abstract:
This research essay explores the question of whether AI can replace surgeons in the field of medicine. It provides a comprehensive analysis of the current advancements in AI technology and its potential implications for surgical practice. The essay discusses the benefits of AI in surgical procedures, including its ability to analyze medical images, assist in surgical planning, and provide real-time feedback during operations. It also examines the challenges and limitations associated with AI in surgery, such as data quality, generalization to diverse patient populations, interpretability, integration with clinical workflow, safety concerns, surgeon training, and ethical considerations. Furthermore, the essay emphasizes the critical role of surgeons in healthcare, highlighting their expertise, complex decision-making abilities, physical capabilities, social connection, and irreplaceable contributions to patient care. While AI has made significant contributions to surgical procedures, it is argued that surgeons play an essential role that cannot be fully replaced by AI technologies alone. The essay concludes by emphasizing the importance of collaboration between surgeons and AI technologies to harness their respective strengths and achieve optimal surgical outcomes.

Introduction:

As technology begins to play a bigger part of humans' daily lives,it forever changed various industries, including healthcare. As AI emerged in healthcare, it began to replace and take over many healthcare employees' careers, creating the fear of future med students becoming jobless. With its advancement of computer vision, machine learning, and more; allowing many capabilities of AI. The question arises: Could AI replace surgeons? This article would explore the capabilities and challenges of AI in surgery; more importantly, AI's potential of replacing surgeons.

Discussion:

Current AI use in surgery:

AI has already shown its potential to greatly benefit surgical procedures by leveraging its capabilities to analyze medical images, assist in surgical planning, and provide real-time feedback during operations. With the ability to accurately detect anomalies in medical scans, AI algorithms contribute to early diagnosis and more effective treatment. Additionally, surgical robots like the da Vinci Surgical System have enhanced precision and introduced minimally invasive techniques, ultimately leading to improved surgical outcomes. However, it is designed to assist surgeons, who retain full control and responsibility throughout the procedures. But these advancements in AI technology highlight the promising role it can play in enhancing the overall quality of surgical care and patient outcomes.

Capabilities:

AI algorithms can perform repetitive and precise tasks with minimal error, potentially reducing the risk of human error in surgical procedures. For example, AI can assist in the precise placement of surgical instruments or sutures, leading to improved surgical outcomes. In the Da Vinci system, the

robotic arms allowed a high level of precision with complicated maneuvers minimally invasively; allowing less postoperative pain, shorter recovery time, and reduced trauma. According to a study by JAMA surgery in 2020, usage of Da Vinci system in robot assisted surgeries results in a lower rate of complication, reduced blood loss, and shorter hospital stay compared to traditional open surgeries. In addition with its advanced diagnostic capabilities, it can analyze vast amounts of patient data, including medical records, lab results, and imaging scans. By applying machine learning algorithms, AI systems can identify patterns, correlations, and anomalies that may not be readily apparent to human surgeons. This can assist in preoperative planning, leading to more accurate diagnoses and personalized treatment plans. In addition, AI systems can process real-time data during surgery, providing surgeons with valuable insights and aiding in critical decision-making. For instance, AI can analyze data from sensors and imaging devices to provide real-time feedback on tissue health, blood flow, or nerve integrity. This information can help surgeons adapt their approach during the procedure. Along with the potential to improve access to healthcare in remote or underserved areas, where expert surgeons may not be readily available. Telemedicine platforms, coupled with AI algorithms, can connect patients with skilled surgeons remotely, enabling timely diagnosis and access to surgical expertise. According to the Lancet commission estimates that 81 million deaths could be prevented each year if timely access to surgical care is available globally.

Limitations and Challenges:

Despite many advantages with the integration of AI in surgery, it still faced obstacles in the surgical setting. One is the requirement of complex decision-making in surgery, as surgeries often require intricate decision-making based on nuanced patient factors, individual circumstances, and unexpected complications. The complexity of these decisions poses challenges for AI algorithms, which currently lack human-like intuition and adaptability. The lack of human intuition, common sense reasoning, and contextual understanding that allows many to handle unexpected scenarios, which is crucial in surgery, makes it dangerous for AI to operate independently in surgeries. AI systems primarily rely on patterns and correlations learned from training data, limiting their ability to handle or adapt unforeseen scenarios. And during surgeries, surgeons rely on their tactile feedback and dexterity to manipulate tissues and organs during surgery. The ability to detect subtle changes in tissue texture, tension, or response to surgical maneuvers is critical for successful outcomes. AI lacks the physical capability to replicate the fine motor skills and sensitivity of human surgeons. As it lack the ability to directly perceive tactile sensations, typically perform with sensors and cameras that isn't as precise as the Human's tactile feedback, when comes to sensing. AI also lacks the fine motor skills of surgeons, which allows surgeons to perform with eye and hand coordination, and delicately maneuver instruments to perform successfully in complicated tasks. While AI could mimic those movements, it couldn't posses the same level of sensitively or finesse as those human hands. More importantly, surgical procedures involve ethical dilemmas, requiring a nuanced understanding of patient preferences, cultural context, and moral considerations. As decisions in surgery often extend beyond analytical reasoning, also involving the balance between ethical principles and patient values. The accountability and responsibility associated with surgery necessitate human oversight. AI systems may lack the ability to make morally nuanced decisions and adhere to ethical guidelines. Similar to the trust and patient-doctor relationship, that AI couldn't replicate. As surgeons establish trust with patients through face-to-face interactions, communication, and empathy. They provide emotional support, answer questions, and alleviate concerns. As in surgical settings patients often experience anxieties and stresses with the procedures, and it could be emotionally and psychologically

challenging for them at most times. More importantly, it's crucial for surgeons to get to connect and know about the patients personally, to understand their preferences, values, and goals; to provide the desired care. The human connection between surgeons and patients is a crucial aspect of healthcare that AI cannot replicate, potentially affecting patient experience and outcomes.

The Role of Surgeons:

Surgeons possess a unique combination of medical expertise, technical skills, and empathy that is currently irreplaceable by AI. They bring years of education, training, and experience to the operating room. Surgeons can analyze complex patient factors, make informed decisions based on clinical judgment, and adapt their approach during surgery. Furthermore, they can address patient concerns, explain procedures, and provide personalized care. The human element in surgery is essential for building trust, ensuring patient satisfaction, and delivering holistic healthcare.

The Future of AI and Surgery:

While AI has the potential to revolutionize surgical practices, replacing surgeons entirely remains a distant possibility. The future lies in a collaborative approach, where AI assists and augments the skills of human surgeons. Surgeons will leverage AI's capabilities for improved diagnostics, surgical planning, and enhanced precision during procedures. This symbiotic relationship between AI and surgeons can lead to safer, more efficient, and personalized surgical care.

Conclusion:

While AI has demonstrated significant potential in augmenting surgical procedures, replacing surgeons entirely remains unlikely. Surgeons possess unique qualities, including complex decision-making, tactile feedback, and patient interaction, that make their role indispensable in surgical settings. The future lies in harnessing the power of AI to enhance surgical outcomes, empowering surgeons with cutting-edge tools and technologies to provide the best possible care to patients. A collaborative approach that combines the strengths of AI and human surgeons will pave the way for transformative advancements in surgical care, ultimately benefiting patients and healthcare systems worldwide.

Sources Cited:

Catherine Graham // Photos Courtesy Of Axel Krieger And Jin Kang. (2022, May 31). Star of the show in Laparoscopic Surgery. JHU Engineering Magazine. https://engineering.jhu.edu/magazine/2022/05/star-of-the-show-in-laparoscopic-surgery/

George, E. I., Brand, T. C., LaPorta, A., Marescaux, J., & Satava, R. M. (2018). Origins of robotic surgery: From skepticism to standard of care. JSLS : Journal of the Society of Laparoendoscopic Surgeons. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6261744/#:~:text=In%201996%2C%20Computer%20Motion%20announced,system%2C%20ZEUS%2C%20in%201996.

Hashimoto, D. A., Rosman, G., Rus, D., & Meireles, O. R. (2018, July). Artificial Intelligence in surgery: Promises and perils. Annals of surgery. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5995666/

International Director, & Internationaldirector. (2018, June 26). Ai errors vs. human errors. International Director. https://internationaldirector.com/technology/ai-errors-vs-human-errors/#:~:text=AI%20errors%20are%20far%20more,(unlike%20that%20of%20humans).

Quick facts. UCLA Health System. (n.d.). https://www.uclahealth.org/departments/surgery/research/investigators-research-staff/events/about-us/d-sine-africa/news-and-media/our-team/quick-facts

U.S. Department of Health and Human Services. (n.d.). Robot performs soft tissue surgery with minimal human help. National Institute of Biomedical Imaging and Bioengineering. https://www.nibib.nih.gov/news-events/newsroom/robot-performs-soft-tissue-surgery-minimal-human-help

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ROLE OF AI IN IDENTIFICATION AND REHABILITATION OF RHEUMATOID ARTHRITIS

Anvita Bhogadi, Charlotte Lungren (advisor), Anika Shah (advisor)
Delhi Public School Hyderabad

Abstract

The paper discusses the utilization of artificial intelligence (AI) in the diverse department of healthcare - Arthritis. It includes the current applications, trends and on-going research in the field
while covering the changes that need to be brought about. The different types of AI applications in this particular sector include, machine learning, deep learning models and imaging teaching.
AI is already being employed in a few hospitals to help medical professionals make efficient diagnoses and treatment plans, and has a lot of potential to be implemented in the field of Arthritic study with specialized developments in Rheumatoid and Psoriatic Arthritis.
However, accurate data collections and pattern recognitions along with availability of technologies are concerns posing significant challenges to adoption of AI in the arthritic scope

Introduction

Arthritis is a medical condition which includes various inflammatory diseases that affect different parts of the body such as joints, bones, and muscles. It can be of several types such as Osteoarthritis (OA), Rheumatoid Arthritis (RA) and psoriatic arthritis, which can result in stiffness, pain, redness and swelling in the joints. With 20 million occurrences worldwide as of 2019, Rheumatoid Arthritis (RA) is the second most prevalent autoimmune illness. It affects both minor and major joints and results in excruciating pain, incapacity, and a shorter life span. Untreated RA can result in more serious joint problems. Additionally, a higher mortality risk is recorded in patients with rheumatoid arthritis as compared to the general population. AI can help physicians apply AI-based models in clinical practice and identify robust models as well as customize medical services and treatments based on patients' biological profiles and illness status.. AI-enhanced data analysis can help with early diagnosis and more effective utilization of human resources. Early diagnosis of RA is crucial for early therapies and improved prognosis but it faces several barriers. The advancements and the rate of integration of AI in healthcare make it clear that AI has the

potential to greatly influence the current methods of diagnosis and treatment which causes us to further understand the different instances of implementation of AI and machine learning methods in the article.

Discussion

Diagnosis and Treatment of Rheumatoid Arthritis:

Artificial intelligence (AI) is a field that focuses on enhancing machine capabilities through various interdisciplinary approaches. These systems could make use of almost any available data, including demographic information, medical imaging, electronic health records (EHRs), data from wearable technology and sensors, as well as laboratory findings. Experiments and specifically data analysis led to the development of modern-day medicine. Therefore, utilizing the data currently available to its maximum potential becomes extremely important. Since it would prove exceptionally challenging for individuals to evaluate the entirety of this data, Artificial Intelligence enables us to accomplish this objective by combining machine-like precision and human-like comprehension. Currently, autoantibodies such anti-citrullinated protein (ACPAs) or rheumatoid factor (RF) are used to measure pre-clinical rheumatoid arthritis (RA). These, however, do not forecast outcomes well. Single nucleotide polymorphisms (SNPs) associated with RA development risk and their epistatic connections have been found in numerous investigations. As early therapies in the disease's course may inhibit inflammatory degradation of the joints and improve prognosis, early detection of RA is crucial. Additionally, imaging findings—such as synovitis evidence—along with clinical information and sensor data are crucial for the diagnosis, monitoring, and management of RA. AI-enhanced data analysis can help with disease early diagnosis and more effective utilisation of human resources. Several machine learning methods have been applied to the diagnosis of RA using omics, imaging, clinical, and sensor data. Early diagnosis in rheumatoid arthritis (RA) faces barriers such as differential diagnosis, heterogeneous disease presentation, symptom onset differences, and no specific laboratory test. Delayed diagnosis is also a problem in patients with ankylosing spondylitis and psoriatic arthritis, with an average delay of ≥8 years between symptom onset and disease diagnosis. Earlier diagnosis is crucial to prevent irreversible structural damage. Understanding AI concepts helps physicians apply AI-based models in clinical practice and identify robust models.By taking into account aspects like dataset size, external validation, clinical problem significance, performance, and availability on public repositories, guidelines ensure accurate models. These elements make it possible for independent model validation and reproducibility. The

conclusions drawn from these inputs may help us gain useful understanding of a disease's pathogenesis and epidemiologic characteristics, besides other issues. They have the capability to assist researchers in identifying novel biomarkers and diagnostic techniques, enabling more rapid and more precise diagnoses. Further, owing to "precision-medicine" and its numerous advantages, Artificial Intelligence (AI) algorithms are now able to customise medical services and treatments for each patient based on their particular biological profile and illness status.

The goal of RA treatment is to lessen joint damage and inflammation. Non-steroidal anti-inflammatory medicines (NSAIDs) and corticosteroids are used as initial treatments, followed by disease-modifying anti-rheumatic drugs (DMARDs). Patients with RA may be able to get off their medication once they enter remission by gradually decreasing their dosage. In patients who have endured in sustained remission for at least six months, current recommendations involve decreasing DMARDs. Tapering may lessen side effects and the burden of medications. Additionally, it is possible to make savings in the health system and distribute resources more fairly. On the other side, for certain patients, tapering increases the likelihood of flare-ups.

Application of AI in Differentiation Diagnoses:

Recently, in an interdisciplinary research project, computer scientists and physicians from the FAU and Universitätsklinikum Erlangen have now taught artificial neural networks to differentiate between different types of arthritis (rheumatoid arthritis and psoriatic arthritis) and healthy joints.

The main objectives of this research were to answer the following questions 1) Can artificial intelligence (AI) recognize different forms of arthritis based on joint shape patterns? 2) Is this strategy useful for making more precise diagnosis of undifferentiated arthritis? 3)Is there any part of the joint that should be inspected more carefully during a diagnosis?

Since there are numerous types of arthritis, it can be challenging to identify the exact inflammatory condition that is harming a patient's joints. Currently, it is difficult to appropriately identify the relevant form of arthritis due to a lack of biomarkers. Additionally, the two-dimensionality of X-ray images used to aid in diagnosis makes them less reliable and susceptible to interpretation. This is in addition to the difficulty of positioning the joint for X-ray imaging.

The research team based their investigation on the metacarpophalangeal joints of the fingers, which are frequently damaged early in the course of autoimmune disorders like rheumatoid arthritis or psoriatic arthritis in patients. Using finger scans from high-resolution peripheral quantitative computed tomography (HR-pQCT), a network of artificial neurons was taught to distinguish between "healthy" joints and those

of people with rheumatoid or psoriatic arthritis. HR-pQCT is currently the best quantitative method of producing three-dimensional images of human bones in the highest resolution. Therefore, in the case of arthritis, changes in bone structure can be precisely identified, allowing for reliable classification. While HR-pQCT is limited in clinical routine, the neural network's heat maps reveal disease-specific characteristics. Hotspots in psoriatic arthritis are found in articular entheses; thereby, other imaging modalities like ultrasound can be used to identify bone alterations in this region.

The artificial network's competence was then tested using a total of 932 HR-pQCT images from 611 patients to address the question of whether it could accurately assess the previously categorised finger joints. The findings indicated that AI accurately identified 82% of healthy joints, 75% of rheumatoid arthritis patients, and 68% of psoriatic arthritis cases—an extremely high probability in the absence of any further information. It could result in a significantly more accurate diagnosis when paired with a professional's knowledge. In addition, the network successfully identified cases of undifferentiated arthritis when it was presented with them.
To summarise, medical professionals can now identify significant disease-specific traits that can be investigated using sonography in clinical practice utilising the combination of HR-pQCT and neural networks.

Application of AI in Treatment of RA:

Rheumatoid arthritis treatment choices have frequently depended on trial and error. Researchers at the Mayo Clinic are currently investigating the use of pharmacogenomics and artificial intelligence (AI) to anticipate how patients will respond to prescription medications and personalised care.
The goal of the study was to predict how patients would react to methotrexate, one of the most widely used treatments for rheumatoid arthritis. AI was utilised to assess the preliminary response to methotrexate in patients with early-stage rheumatoid arthritis using patient data that comprised genomic, clinical, and demographic details.

Similarly, a new gaming application has been designed to help with regaining operation of the RA affected hand. The Visual Studio environment, version 2019, and the C# programming language serve as the foundation for the technologies used in the development of the Virtual Arthritis Rehabilitation application. The user interface is minimal to make it as simple as possible for the doctor and therapist to use. With the aid of digital technologies and multimodal interaction—leap motion, serious gaming, and neuronal networks—this programme aims to restore function to the RA hand. The neural network

provides assistance to patients who want to do their exercises at home by classifying the right movement with a 95% accuracy rate.

Machine learning and glycomics have also recently demonstrated significant promise for screening potential blood markers in RA patients, which is certain to assist clinicians acquire an improved understanding of RA.
For example, twoXAR Inc., an AI-driven biopharmaceutical company, developed an integrative bioinformatics drug discovery platform for rapid identification and validation of novel RA drug candidates. This platform could help expand alternative treatment strategies by targeting new targets and improving understanding of RA pathophysiology.

Contribution of Machine Learning to the field of RA:

Machine learning algorithms can be classified into supervised and unsupervised learning. In supervised learning, models determine classes or labels by examining the relationship between input and output variables. While unsupervised learning finds patterns and structure in data without class labels, supervised learning trains models using labelled data. Common approaches include the following:

1. Supervised Techniques:

    1.1. K-Nearest Neighbours
    It is used to predict a new sample through ‘K’-closest samples from the training set. The output varies accordingly depending on whether it is used for classification or regression

    1.2. Support vector machine
    It involves training samples as input and separates them into different categories which are used for classification of tasks. capable of assigning categories to newer samples and discover the best probable separation of distinct categories

    1.3. Decision trees
    This consists of decisions and their likely consequences. Decision trees combine classification functions and feature collection within a single model, unlike other machine learning methods.

    1.4. Random Forest

A machine learning ensemble classifier which combines classifiers from regression trees and other local classifiers. It is employed to evaluate distinct predictors and choose the top-performing models. This technique addresses the correlation and interaction between variables while reducing predictors and associated variables. However, it is challenging to create precise classification rules and comprehend the model's predictions.

1.5. Artificial neural networks

Artificial neural networks (ANNs) have been scientifically defined as computational models which are inspired by human biological nervous systems which contain parts like neurons and have a layered structure. A vast majority of supervised learning tasks, such as organisation of labelled data, use ANN. Regression tasks can also be carried out by artificial neural networks. Artificial Neural Networks have been shown to yield better outcomes in contrast to more conventional techniques like Logistic Regression and Support Vector Machines,

2. Unsupervised Techniques:

2.1. K-Clusters

Data is grouped into k clusters, which reduces the inconsistent separation space between each cluster through classification based on the distance between centroids and adjacent data.

2.2. Reinforcement Learning

In this technique, agents who learn by means of trial and error methodologies may be rewarded or punished according to how they perceive and interpret their environment.

2.3. Deep Neural Networks

Deep Neural Networks are used in the field of deep learning to further enhance the abilities of ANNs by mapping input data to the intended outcomes.The deep neural network has significantly boosted the performance of image processing techniques in particular because it can distinguish and label a broad variety of images and objects. DL and ANN differ in that DL is composed of multiple hidden layers.

Various DL techniques include:

A. *Auto-Encoder* - Neural networks that can be utilised to compress and reconstruct data. Input undergoes compression by the encoder, and the decoder undertakes restoration of the data from the compressed version.
B. *Convolutional Neural Networks* - It is a widely known structure for most photo recognition, categorisation, and monitoring tasks. It has been employed to identify bone erosions and improve the treatment of rheumatoid diseases
C. *Fully Convolutional Network* - It is helpful in cases where the semantic segmentation of images is required
D. *U-Net* - Medical image segmentations primarily use the U-Net architecture which has performed more favourably than template matching techniques used for tasks of image localization.
E. *RetinaNet* - It is a prevalent technology which has been implemented for collaborative localization. It is quite effective at precisely positioning the bounding boxes to detect joints.

Problems with AI

Nowadays, several intriguing and novel designs and structures have been synthesized to address the prevailing problems of the arthritis diagnosis and treatment.
Despite this progress, there are still some research obstacles which need to be addressed such as:

1. *Deep Learning Models*

   Although deep neural networks produce results with a high degree of accuracy, it is crucial to generalise these models in order to prevent one of the main problems, overfitting. The model must therefore be meticulously modified for generalizability. Deep neural networks can also be viewed as a mystery by medical professionals, leading them to doubt their validity and technique.

2. *Data Scarcity*

   Due to patient privacy concerns and a number of other variables, including ethical authorizations, data scarcity is a severe problem in the field of medical research. There isn't yet a publicly accessible database for the training of deep learning models. Large size datasets are preferable for

deep learning algorithms, and the availability of large RA datasets can aid in the early diagnosis of diseases and enhance the performance of the diagnostic system as a whole..

3. *Data Imbalance*

Another difficulty in using machine learning to diagnose rheumatoid arthritis is data imbalance. The datasets that are currently accessible are imbalanced, and research publications do not discuss as to how this problem is addressed. A balanced dataset with information on how to deal with the disproportionate medical datasets would prove to be insightful.

Conclusion

Various programmes and applications introduced by seasoned researchers have formed the base of diagnosis and treatment of arthritic diseases, especially rheumatoid arthritic issues.
However, rheumatic diseases are chronic, fluctuating, and have unclear etiologies, complicating treatment. Despite biological and synthetic treatments, only a small subset of patients experience a decrease in disease progression. Current applications of AI though helpful do not offer significant contribution to the field of rheumatology. However this is likely to change due to future developments in the field which are collaborations between multiple disciplines and is likely to bring out high quality testing methodologies.

Sources Cited

Chocholova, E., Bertok, T., Jane, E., Lorencova, L., Holazova, A., Belicka, L., et al. (2018). Glycomics Meets Artificial Intelligence - Potential of Glycan Analysis for Identification of Seropositive and Seronegative Rheumatoid Arthritis Patients Revealed. *Clin. Chim. Acta* 481, 49–55. doi:10.1016/j.cca.2018.02.031
https://www.sciencedirect.com/science/article/pii/S0009898118301001

Emmarayner. (2021, August 16). *Artificial Intelligence in Rheumatic Diseases: Can It Solve the Treatment Management Puzzle? - European Medical Journal*. European Medical Journal. https://www.emjreviews.com/rheumatology/symposium/artificial-intelligence-in-rheumatic-diseases-can-it-solve-the-treatment-management-puzzle-j170121/

Folle, L., Simon, D., Tascilar, K., Krönke, G., Liphardt, A., Maier, A., Schett, G., & Kleyer, A. (2022). Deep Learning-Based Classification of Inflammatory Arthritis by Identification of Joint Shape Patterns—How Neural Networks Can Tell Us Where to "Deep Dive" Clinically. *Frontiers in Medicine*, *9*. https://doi.org/10.3389/fmed.2022.850552

Imtiaz, M., Shah, S. a. A., & Rahman, Z. U. (2022). A review of arthritis diagnosis techniques in artificial intelligence era: Current trends and research challenges. *Neuroscience Informatics*, *2*(4), 100079. https://doi.org/10.1016/j.neuri.2022.100079

Maind, S. B., & Wankar, P. (2014). Research paper on basics of artificial neural network. *International Journal on Recent and Innovation Trends in Computing and Communication*, *2*(1), 96-100. https://ijritcc.org/index.php/ijritcc/article/view/2920

Momtazmanesh, S., Nowroozi, A., & Rezaei, N. (2022). Artificial Intelligence in Rheumatoid Arthritis: Current Status and Future Perspectives: A State-of-the-Art Review. *Rheumatology and Therapy*, *9*(5), 1249–1304. https://doi.org/10.1007/s40744-022-00475-4

Myasoedova, E., Athreya, A. P., Crowson, C. S., Davis, J. M., Warrington, K. J., Walchak, R. C., Carlson, E., Kalari, K. R., Bongartz, T., Tak, P. P., Vollenhoven, R. F., Padyukov, L., Emery, P., Morgan, A., Wang, L., Weinshilboum, R. M., & Matteson, E. L. (2022, April 6). Toward Individualized Prediction of

Response to Methotrexate in Early Rheumatoid Arthritis: A Pharmacogenomics‐Driven Machine Learning Approach. *Arthritis Care & Research*, *74*(6), 879–888. https://doi.org/10.1002/acr.24834

Varga, G., Stoicu-Tivadar, L., & Nicola, S. (2021, May 27). Serious Gaming and AI Supporting Treatment in Rheumatoid Arthritis. *Studies in Health Technology and Informatics*. https://doi.org/10.3233/shti210262

Literary Review

AI and Robotics in Surgical Procedures

Aryan Tummala, Charlotte Lungren (advisor), Anika Shah (advisor)
BASIS Independent Silicon Valley

Abstract

Artificial Intelligence has become an integral part of healthcare, including surgical procedures and in the operating room. AI algorithms are versatile and applicable in various aspects of healthcare, from administrative tasks to precision medicine and health monitoring. In the field of surgery, AI algorithms analyze patient data, such as medical scans and health records, to assist with diagnosis, treatment planning, and prescription recommendations. AI also plays a crucial role in surgical planning, optimizing the surgical approach and improving efficiency. The integration of AI with robotics has further enhanced surgical procedures, allowing for precise and accurate movements. Robotic surgical systems, such as the Da Vinci surgical system, combine robotic arms with AI algorithms to provide surgeons with real-time image analysis, instrument control, and feedback during surgeries. This collaboration between robotics and AI leads to improved surgical outcomes, reduced human error, and increased precision. The use of AI in surgical procedures has the potential to revolutionize healthcare by optimizing surgical processes, improving patient safety, and advancing personalized medicine. As AI continues to evolve, its impact on the field of surgery is expected to grow, transforming the way surgeries are performed and ultimately improving patient outcomes.

Introduction

Artificial Intelligence (AI) has become very prevalent in our society today, used almost everywhere from social media to autonomous vehicles. AI is best used in fields that produce large amounts of data, which can be analyzed and used by AI and similar Machine Learning models to produce meaningful results. The availability of easily accessible large datasets to train and test AI models and advances in computing powers to run large algorithms for a low cost. AI is praised for its elimination of human error with increases in precision and accuracy depending on the training process, and it is used to reduce costs and optimize resources. AI is starting to replace menial human tasks, such as working with robotics in factories, or performing administrative tasks. AI's use in the medical field revolves around the idea of helping the medical professional through suggestions and improvements. The large amounts of medical data collected from patients through the form of electronic health records, medical scans, or research publications. AI is starting to be implemented side by side with doctors in the operating room by helping with difficult surgeries performed by professionals. AI can be used to train surgeons and assist them inside and outside the operating room, and its ability to quickly and correctly analyze information can greatly increase the success rate of important surgeries. AI has the potential to revolutionize the entire healthcare industry, especially inside the operating room.

Discussion

Applications of Artificial Intelligence in Hospitals

Due to its extreme versatility in performing a wide range of tasks, AI is applicable in many sectors of healthcare. AI algorithms can be used in more administrative and patient related tasks such as storing data

and graphs into easily accessible places, functioning as chatbots for any patients with questions, and managing medical records. According to an article published by the NIH, some major uses of AI include the following: precision medicine and health monitoring. Precision medicine is creating drug molecules and medicines specific to a patient. The treatment considers the patient's medical history, personal information, genetic information, and other details to administer a medicine specific to the patient instead of specific to the disease. Precision medicine focuses on the patient's biology instead of the population's biology and can lead to lower costs and increased effectiveness of the medicine. Since lots of data about the patient is required for this approach, Artificial Intelligence is perfect for analyzing the collected data and suggesting a path for doctors to take in the treatment. AI is being implemented in health monitoring devices such as EKG's in the hospital and exercise monitors outside the hospital. Phones and watches are able to monitor many features in your body such as heart rate, exercise levels, blood pressure, and other details. AI can use this data to make predictions about your health, such as detecting when you are showing symptoms of a heart stroke.

The Use of Artificial Intelligence with Surgeries

There are many applications of AI in hospitals and AI has proven to produce accurate results about patients through the vast amounts of medical data it receives about any patient. Any medical scans, such as MRI or X-ray scans, and health records are used to train AI about patients in general, but also about a specific patient. AI can recognize trends in data, such as consistently rising blood sugar levels and make a prediction that the patient has diabetes. AI algorithms can analyze scans to assist surgeons and physicians with diagnosis and prescription. An AI algorithm can recognize through an X-ray scan that a patient sprained their ankle, and recommend prescriptions or other measures for the physician. Before a surgery, anesthesiologists are required to administer small doses of anesthesia to keep the patient unconscious while the surgery is happening, and many calculations are required on the part of the anesthesiologist to make sure that an overdose does not occur. AI is able to assist the anesthesiologist with these quantitative calculations which can greatly speed up the pre surgery process. Furthermore, lots of planning and routing is required before a surgery and AI is able to help by being able to identify the optimal surgical approach for a required surgery, which saves lots of time and effort for the surgeon. Outside of the operating room, AI can use data on a patient to detect a disease before surgery is even required. For example, Peripheral Artery Disease (PAD) is difficult to detect and often requires surgical amputation, but AI can detect PAD using trends and data on previous patients with PAD to prevent surgery.

Merging Robotics with AI for surgery

Robotics and AI have merged to revolutionize surgical procedures, combining the precision of robotics with the intelligent decision-making capabilities of AI. One of the most well-known and widely used robotic surgical systems is the Da Vinci surgical system. This system consists of robotic arms equipped with instruments that are controlled by surgeons from a device. The console provides a simulation of the surgical site, while the surgeon manipulates the robotic arms using master controls. AI Algorithms are used in this technology to analyze images quickly, control the different instruments and provide feedback and suggestions for the surgeon. The integration of AI in robotic surgical systems enhances surgeries in several ways. AI algorithms analyze and interpret imaging data, such as X-ray scans or MRI scans, to visualize the patient's anatomy and condition. Surgeons can recreate the operating site inside the system and start planning the route for the surgery through the device. AI also plays a crucial role in instrument control since it allows precise movement of the robotic arms. The robotic hands can learn how the surgeon is operating and improve the stability of the hands making the surgery even more precise. The AI can also provide suggestions and feedback during surgeries. For instance, they can analyze what the

surgeon is doing and his planned route of the surgery to assist them. AI also monitors factors such as heart rate, blood pressure and blood flow, alerting surgeons to abnormalities that shouldn't be happening. The incorporation of AI in robotic surgery has resulted in several benefits. The flexibility and precision of the robotic arms allows surgeons to do procedures that wouldn't have been possible with their hands. Using robotics with AI benefits patients by having a more effective surgery and possibly reducing any side effects from the surgery. AI-powered robotics eliminates human error and increases consistency with the results of surgeries. Robotics with AI can improve surgical outcomes by using machine learning and data analysis. By analyzing large datasets of surgical cases and outcomes, AI algorithms can identify patterns, ideal methods, and challenges to contribute to more effective and quick surgery. This approach can also use precision medicine to specialize the surgery to each patient, further increasing accuracy and effectiveness.

Conclusion

There exist numerous implementations of Artificial Intelligence in the vast field of healthcare, from simple administrative tasks, to storing medical data, to directly helping surgeons with procedures. AI has evolved from performing small simple tasks to managing complex procedures that change lives. AI can do many things in hospitals including analyzing data and scans to detect diseases early and help doctors with diagnosis for patients. AI can assist a surgeon in developing the optimal route for a surgery and the different algorithms can streamline the whole process. AI is merging with robotics through technologies such as the Da Vinci surgical system to change the surgical process for surgeons. Precise robotic hands and a simulation of the patient and the operating room allow the surgeon to easily perform the surgery. AI is improving how surgeries are done and they have the capability to evolve into a technology that can change the healthcare field.

Sources Cited

About the daVinci Surgical System. UC Health. (n.d.). https://www.uchealth.com/services/robotic-surgery/patient-information/davinci-surgical-system/

Bohr, A., & Memarzadeh, K. (2020, June 26). The rise of Artificial Intelligence in healthcare applications. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7325854/

Davenport, T., & Kalakota, R. (2019, June). The potential for artificial intelligence in Healthcare. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6616181/

Hashimoto, D. A., Rosman, G., Rus, D., & Meireles, O. R. (2018, July). Artificial Intelligence in surgery: Promises and perils. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5995666/

Javaid, S. (2022, December 22). 4 ways AI is revolutionizing the field of surgery in 2023. AIMultiple. https://research.aimultiple.com/ai-in-surgery/

Kwo, L. (2021, November 24). Contributed: The power of AI in surgery. MobiHealthNews. https://www.mobihealthnews.com/news/contributed-power-ai-surgery

McCartney, J. (2023, June 7). AI is poised to “revolutionize” surgery. ACS. https://www.facs.org/for-medical-professionals/news-publications/news-and-articles/bulletin/2023/june-2023-volume-108-issue-6/ai-is-poised-to-revolutionize-surgery/

Robotic-Assisted Surgery with da Vinci Systems. Intuitive.com. (n.d.). https://www.intuitive.com/en-us/patients/da-vinci-robotic-surgery

Literary Review

Ethical and Explainable AI In Healthcare: Ensuring Transparency and Trust

Ava LeFevre, Charlotte Lungren (advisor), Anika Shah (advisor)
Teens In Health

Abstract:

This paper explores the significance of ethical and explainable AI in healthcare, with a focus on ensuring transparency and trust in AI systems. The discussion begins by highlighting the ethical considerations in healthcare AI, including data privacy and consent, bias and fairness, and accountability and responsibility. The importance of explainability and interpretability of AI is then examined, covering rule-based systems, model interpretability techniques, and post-hoc explanation methods. Ensuring transparency and accountability is discussed, emphasizing open access to algorithms and data sources, as well as the need for auditing, certification, and ongoing monitoring. The role of standardized frameworks and standards, such as ethical guidelines, data governance protocols, and AI ethics review boards, is also explored. In conclusion, the article emphasizes the necessity of ethical and explainable AI in healthcare to maintain transparency, trust, and accountability, and highlights its significance for the future of AI and healthcare advancements.

Introduction:

Artificial Intelligence (AI) has emerged as a powerful tool in healthcare, revolutionizing various aspects of medical diagnosis, treatment, and research. AI systems have demonstrated remarkable capabilities in analyzing complex medical data, detecting patterns, and providing valuable insights to support healthcare professionals. However, as AI systems become increasingly sophisticated and pervasive in healthcare settings, concerns arise regarding their ethical implications and lack of transparency. The deployment of AI in healthcare raises important questions about how these systems make decisions, the potential biases they may exhibit, and the impact they have on patient care and outcomes. Transparency and trust are critical factors in ensuring the responsible and ethical implementation of AI in healthcare. Healthcare professionals, patients, and society at large need to have confidence in the decisions made by AI systems and understand the underlying reasoning. This paper delves into the importance of ethical and explainable AI in healthcare, aiming to shed light on the key issues and potential solutions. It explores how ethical considerations can guide the development and deployment of AI systems, ensuring they align with

established ethical principles and protect patient rights. Additionally, this paper investigates the significance of explainability and interpretability in AI algorithms, allowing healthcare providers and patients to understand the decision-making process. To provide insights and recommendations for the responsible integration of AI in healthcare, this paper aims to examine subtopics such as ethical considerations in healthcare AI, the importance of explainability and interpretability of AI, strategies for ensuring transparency and accountability, and the role of regulatory frameworks and standards. Ethical and explainable AI not only foster transparency and trust but also serve as critical safeguards against potential risks and biases. The findings of this article contribute to the ongoing dialogue on the responsible development and deployment of AI in healthcare, with the ultimate goal of improving patient care, enhancing healthcare outcomes, and ensuring the ethical advancement of this transformative technology. The central question being answered in this article is: How can ethical and explainable AI be implemented in healthcare to ensure transparency and maintain trust in AI systems?

Discussion:

Ethical Considerations in Healthcare AI:

AI systems in healthcare heavily rely on patient data, raising concerns about privacy and consent. Ensuring that data is collected, stored, and used in compliance with relevant regulations and ethical principles is crucial. Robust data governance frameworks and clear consent protocols should be in place to protect patient privacy and maintain trust. AI algorithms can inadvertently perpetuate biases present in the data they are trained on, potentially leading to unfair outcomes. AI applications have changed rules and policies related to healthcare practice and work ethics. (ScienceDirect, 2023) Recognizing and mitigating biases is essential to ensure equitable healthcare delivery. Proactive steps such as diverse and representative training datasets, continuous monitoring for biases, and bias-mitigation techniques should be implemented. AI systems must be designed with clear lines of accountability and responsibility. Stakeholders, including developers, healthcare providers, and policymakers, should establish protocols for addressing issues that arise from AI system decisions. Transparent reporting, error analysis, and post-implementation evaluations can help identify and rectify potential shortcomings.

Explainability and Interpretability of AI:

Rule-based AI systems utilize predefined rules and logical reasoning to generate recommendations or decisions. These systems provide high interpretability, allowing healthcare providers and patients to understand the underlying rules and logic guiding the AI's actions. Complex AI models, such as deep learning neural networks, can be difficult to interpret. Model interpretability techniques, such as saliency maps, attention mechanisms, and feature importance analysis, help uncover the factors contributing to AI

system outputs, enhancing transparency and trust. Post-hoc explanation methods aim to provide explanations for AI decisions after they are made. Techniques such as rule extraction, surrogate models, and natural language generation help generate understandable explanations, aiding in the interpretation of AI-driven recommendations.

Ensuring Transparency and Accountability:

Transparency can be promoted by ensuring open access to AI algorithms and data sources used in healthcare. Making algorithms publicly available for scrutiny, along with detailed information about the data used, helps identify potential biases, errors, or ethical concerns, fostering trust in the system. Regular auditing and certification processes should be established to evaluate the performance, safety, and ethical compliance of AI systems. Ongoing monitoring of AI algorithms in real-world healthcare settings enables the detection of biases, errors, or unforeseen consequences, allowing for timely corrective actions.

Regulatory Framework and Standards:

Governments, regulatory bodies, and professional organizations should collaborate to develop comprehensive ethical guidelines and principles specific to AI in healthcare. These guidelines should address the responsible development, deployment, and use of AI systems, emphasizing principles such as beneficence, non-maleficence, autonomy, and justice. Clear regulations on data governance and consent protocols should be established to protect patient privacy and ensure data is used in a responsible and ethical manner. These protocols should encompass informed consent procedures, data anonymization, secure data storage, and patient rights to access and control their health data. The establishment of an AI ethics review board can provide an independent assessment of AI systems' ethical implications. This board would evaluate the ethical considerations, potential biases, and transparency measures employed by AI developers, ensuring adherence to ethical standards and promoting trust in healthcare AI.

The Future Implications of Ethical and Explainable AI in Healthcare:

Looking ahead, the implementation of ethical and explainable AI in healthcare holds immense potential for shaping the future of healthcare and AI advancements. As AI continues to evolve and become more integrated into healthcare systems, addressing ethical considerations and ensuring transparency and trust will be paramount in realizing the full benefits of AI while mitigating risks. Ethical and explainable AI practices not only enhance patient care and outcomes but also contribute to the overall development and acceptance of AI technology in society. Considering the stereotypes and fears associated with AI, allowing AI to mitigate and handle tasks that were recently held by humans is a significant transition that will require trust, understanding, and transparency. By establishing robust data governance frameworks, clear consent protocols, and accountability mechanisms, we can build a foundation of trust and confidence in AI systems. This, in turn, encourages wider adoption of AI in healthcare, fostering innovation and driving positive changes in healthcare delivery. Moreover, as regulatory frameworks and

standards specific to AI in healthcare are established, they provide guidance and a common set of principles for developers, healthcare providers, policymakers, and other stakeholders. These guidelines help ensure that AI is developed and deployed responsibly, emphasizing ethical principles such as beneficence, non-maleficence, autonomy, and justice. By proactively addressing the ethical and explainability challenges in healthcare AI and implementing measures to promote transparency and accountability, we can pave the way for a future where AI is harnessed responsibly to improve patient care, enhance medical research, and contribute to the overall advancement of healthcare systems worldwide.

Conclusion:

In conclusion, the ethical and explainable implementation of AI in healthcare is essential for maintaining transparency, trust, and accountability. By considering ethical implications, ensuring explainability, promoting transparency, and establishing regulatory frameworks, the potential of AI in healthcare can be harnessed responsibly. Moving forward, this topic is of paramount importance for shaping the future of AI and healthcare, as it lays the foundation for ethical advancements and safeguards against potential risks. By striving for ethical and explainable AI, we can unlock the full potential of this technology while addressing societal concerns, fostering trust, and ultimately improving patient care and outcomes.

Works Cited:

Amann, J., Blasimme, A., Vayena, E., Frey, D., Madai, V. I. (2020, November 30). Explainability for artificial intelligence in healthcare: a multidisciplinary perspective. *National Library of Medicine*. https://doi.org/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7706019/

Rigby, M. J. (2019, February). Ethical Dimensions of Using Artificial Intelligence in Health Care. AMA Journal of Ethics. https://doi.org/https://journalofethics.ama-assn.org/article/ethical-dimensions-using-artificial-intelligence-health-care/2019-02

Albahri, A. S., Duhaim, A. M., Fadhel, M. A., Alnoor, A., Baqer, N. S., Alzubaidi, L., Albahr, O. S., Alamoodi, A. H., Bai, J., Salhi, A., Santamaría, J., Ouyang, C., Gupta, A., Gu, Y., Deveci, M. (2023, August). A systematic review of trustworthy and explainable artificial intelligence in healthcare: Assessment of quality, bias risk, and data fusion. ScienceDirect, 96, 156-191. https://doi.org/https://www.sciencedirect.com/science/article/abs/pii/S1566253523000891

Rasheed, K., Qayyum, A., Ghaly, M., Al-Fuqaha, A., Razi, A., Qadir, J. (2022, October 1). ACM Digital Library, 149(C). https://doi.org/https://dl.acm.org/doi/abs/10.1016/j.compbiomed.2022.106043

Durán, J.M., Sand, M. & Jongsma, K. The ethics and epistemology of explanatory AI in medicine and healthcare. Ethics Inf Technol 24, 42 (2022). https://doi.org/10.1007/s10676-022-09666-7

Asan, O., Bayrak, A. E., Choudhury, A. (2020, June). Artificial Intelligence and Human Trust in Healthcare: Focus on Clinicians. National Library of Medicine, 22(6). https://doi.org/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7334754/

Kiseleva, A., Kotzinos, D., De Hert, P. (2022, May 30). Frontiers, 5. https://doi.org/https://doi.org/10.3389/frai.2022.879603

Bernal, J., & Mazo, C. (2022, October 11). Transparency of Artificial Intelligence in Healthcare: Insights from Professionals in Computing and Healthcare Worldwide. MDPI, 12(20). https://doi.org/https://www.mdpi.com/2076-3417/12/20/10228

Ross, P., & Spates, K. (2020, August 9). Considering the Safety and Quality of Artificial Intelligence in Health Care. National Library of Medicine. https://doi.org/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7415213/

Pazzanese, Christina. "Ethical concerns mount as AI takes bigger decision-making role in more industries." The Harvard Gazette, 26 Oct. 2020, https://doi.org/https://news.harvard.edu/gazette/story/2020/10/ethical-concerns-mount-as-ai-takes-bigger-decision-making-role/.

Literary Review

AI: Invasive or Beneficial?

Danat Beyene, Charlotte Lungren (advisor), Anika Shah (advisor)

Kirkwood High School

Abstract:

This Article provides perspective on the use of AI in healthcare, specifically focusing on the potential dangers of patient information safety. Questions on whether sensitive patient or hospital information will be protected are being raised within healthcare. In some nations, laws and healthcare rules are set in place to avoid any future issues, tackling the threat that AI could pose in health spaces.

Introduction:

As the age of AI and technology progresses, its use has been seen in many unexpected fields. The cohesion of human producers and consumers is growing stronger, not excluding those in healthcare. With the integration of Artificial Intelligence into healthcare and examining as well as giving feedback on patient data, many have noticed the potential dangers of its closeness with patient information. Beginning in the 1970's, scientists and doctors have explored the possibility of incorporating this technology into everyday healthcare, however with its spike in advancement over the years, people have grown wary of who exactly will be handling this data, and how sensitive patient information can remain private.

Discussion:

Faster results:

In the world of healthcare, many small details are put into complicated procedures and completion of tasks. Teams full of specialized doctors, multiple manual checks of paperwork and lab results, dealing with emergencies and patients head on, are all part of the job. Naturally, humans are bound to make mistakes that could prove to be harmless, or dire. However, with the introduction of AI into many different fields in healthcare, the amount of human mistakes when handling lives could drop drastically. With a large 60% of U.S citizens living with chronic health issues and having to deal with constant evaluations and trips to the hospital, AI can put an end to the struggle for both workers and patients. Medical Economics proves the use of AI in healthcare to be extremely efficient, stating that, "AI algorithms can monitor patients' health data over time and provide recommendations for lifestyle changes and treatment options that can help manage their condition" (Jon Moore, 2023). With this, Patients can enjoy quicker evaluations, accurate suggestions of lifestyle changes, and ease the workload/ time spent for both doctors and patients.

Risks of usage:

Despite the use of AI in healthcare seeming to be only beneficial, there are many instances that could show otherwise. The rise of a successful app known as DeepMind Technologies performed as an AI app and research company that would partner with many studies, handling the sensitive information of patients who suffer from illnesses. Context on their race, ethnicity, and backgrounds would be handled by the Scientists carefully. But with its recent ownership being passed to google, user safety has been placed in more danger. As writer Blake Murdoch describes, "Google subsequently took direct control over DeepMind's app, effectively transferring control over stored patient data from the United Kingdom to the United States [27]. The ability to essentially "annex" mass quantities of private patient data to another jurisdiction is

a new reality of big data and one at more risk of occurring when implementing commercial healthcare AI"(Blake Murdoch, 2021). This open display of the selling and passing of sensitive patient information has alarmed the public, making people wary of ever trusting the partnership between AI and healthcare. However the use of AI apps and AI technology in workplaces is vastly different.

Present solutions:

Although there are multiple current concerns, they are all met with a large amount of solutions and changes to AI in healthcare. The understanding of technology and how AI works is still growing, but by keeping an open mindset and allowing changes to be made, healthcare could undergo serious beneficial changes. The threat of AI taking user information without any knowledge, and working against healthcare workers/scientists is stopped abruptly by rules and regulations. For example, "... the European Union's (EU) General Data Protection Regulation (GDPR), implemented throughout the EU since May 2018, requires companies to gain explicit consent before processing personal information"(Vatsal Ghiya, 2023). Laws and boundaries will prevent any sensitive user information from being sold, leaked, or handled in any illegal ways, opening the door for the future of healthcare workers and AI coexisting in the future.

Conclusion:

With AI's rapid encroachment into multiple different work fields, people have raised a number of concerns. Will AI replace all the coders, graphic designers, radiologists, teachers, and many more? Along with the fear of replacement, people have grown increasingly worried about the safety of users and how protected patient information might be in healthcare. With constant scandals surrounding social media and the bidding of private user information, AI could pose a large threat. However, stricter guidelines and

healthcare laws like the EU AI Act ensure that the future of patients and workers alike remain safe, respected, and protected from data theft. AI and healthcare working alongside each other is a large step that may seem dangerous, but in the end will benefit workers and patients with technological aid.

Works Cited:

Moore, J. (2023, March 14). *Ai in health care: The risks and benefits*. MedicalEconomics. https://www.medicaleconomics.com/view/ai-in-health-care-the-risks-and-benefits

Murdoch, B. (2021, September 15). *Privacy and artificial intelligence: Challenges for protecting health information in a new era - BMC medical ethics*. BioMed Central. https://bmcmedethics.biomedcentral.com/articles/10.1186/s12910-021-00687-3

Expert, I. (2023, April 7). *Data Privacy and security in healthcare AI: Challenges and solutions*. Health IT Answers. https://www.healthitanswers.net/data-privacy-and-security-in-healthcare-ai-challenges-and-solutions/

Bak, M., Madai, V. I., Fritzsche, M.-C., Mayrhofer, M. Th., & McLennan, S. (2022, May 23). *You can't have AI both ways: Balancing Health Data Privacy and Access Fairly*. Frontiers. https://www.frontiersin.org/articles/10.3389/fgene.2022.929453/full

Literary Review

Is AI Really Worth It?: The Benefits & Risks Associated With AI in Healthcare

Diya Patel, Charlotte Lungren (advisor), Anika Shah (advisor), Michelle To (advisor)
Maggie L. Walker Governor's School

Abstract:

This paper discusses the benefits and risks associated with the integration of artificial intelligence (AI) in healthcare. It includes discussion on the four main types of AI (machine learning, natural language processing, and physical robots) in healthcare as well as examples of how AI is used to aid healthcare professionals and improve fields of medicine, including oncology, pathology, and biomedical research and education. Additionally, the paper discusses current challenges and ethical issues associated with implementation, including lack of transparency, unfamiliarity with AI technology, and poor data management. Ultimately, artificial intelligence in healthcare can prove to be extremely helpful, but many obstacles in the path of integration must be addressed before the widespread adoption of AI in the world of medicine.

Introduction:

The impact that artificial intelligence has on various aspects of modern life, including entertainment, commerce, and healthcare, has increased over the past few years. AI in healthcare, in particular, has expanded immensely since its first use in the 1950s, when researchers began to use computers to analyze medical data and make diagnostic decisions. Later on, during the early 1970s, researchers developed an AI program known as MYCIN, which was used to help identify blood infection treatments (XSOLIS, 2021). Throughout the 1980s and 1990s, AI began to be used in a broader range of medical applications, such as imaging analysis, assistance in more precise surgical procedures, and drug discovery. In the early 2000s, the role of AI further expanded with the development of deep learning algorithms, which helped develop AI-powered medical systems that could analyze medical data and make predictions with high accuracy (King, 2022). Since then, the prevalence of AI has continued to expand in numerous fields of medicine, including oncology and pathology, along with biomedical research and medical education, developing into something incredibly powerful. Though it has the potential to be extremely

beneficial in its application, this powerful technology creates a set of ethical challenges and risks that must be addressed to ensure patient safety as well as preference. When discussing the integration of AI, one must consider the risk factors along with the benefits to determine whether artificial intelligence will be worthy in the field of medicine.

Discussion:

Types of AI in Healthcare, Applications, & Benefits:

The demand for healthcare services continues to increase while many countries experience a shortage of healthcare professionals, resulting in burnout among many physicians. Due to the existence of such a problem, the healthcare ecosystem has realized the importance of AI-powered tools. There is optimism that artificial intelligence will bring about substantial improvements in numerous areas of healthcare all while not replacing the pre-existing healthcare staff. AI is said to support healthcare personnel with a range of tasks, including clinical documentation, patient outreach, and image analysis. In 2018, *Forbes* stated that the most important task areas are administrative workflows, image analysis, robotic surgery, virtual assistants, and clinical decision support (Bohr & Memarzadeh, 2020).

AI in healthcare can be categorized into four subtypes: machine learning, natural language processing (NLP), robotic process automation (RPA), and physical robots. Oftentimes, these types can be seen working together during the performance of certain tasks. The first type, machine learning, uses an algorithm to examine previous data, current information, and interactions to help predict the most ideal treatment for patients. Machine learning is often used in the field of radiology to help analyze CT and MRI scans and detect tumor cells more accurately, allowing doctors to create a diagnosis and treatment plan quickly (R, 2021). It plays an important role in optimizing and streamlining healthcare procedures and administration. AI can be used to schedule appointments and process insurance claims, which can help reduce costs while increasing overall efficiency. Similarly, NLP, another type of AI, can help analyze patient records and give suggestions to improve methods of treatment. By doing so, sickness can be detected sooner and combatted efficiently. Furthermore, AI can be used to examine the effectiveness and side effects of drugs, which can aid in developing new treatments. The most common use of natural language processing is for understanding and classifying medical records. On average, it takes medical practice staff around two minutes and 36 seconds to review each

medical document and input relevant data into patient records. With the assistance of machine learning and NLP, this time has been reduced to one minute and 11 seconds. With this level of efficiency, over 3 million hours of work have been eliminated for healthcare staff (Bush, 2018). Another example of machine learning and NLP at work is chatbots or virtual assistants. Chatbots use algorithms to assist patients by providing them with answers to their questions and suggestions for treatments. Likewise, AI-powered nursing assistants can be used instead of human nursing assistants. They can engage in a range of duties, including conversing with patients and providing patient care. The world's first virtual nursing assistant was Care Angel (R, 2023). By performing the scut work, the implementation of AI allows physicians to regain their love for doing their job as they now have the opportunity to focus on serious matters that are more of their concern. The third type, robotic process automation (RPA), can be used alongside machine learning and NLP to record early authorizations, update patients' medical records, and for billing.

Unlike the other types, physical robots, which were first created to deliver hospital supplies, are not merely computer programs. Since their original use, these robots have been developed to collaborate with human beings and perform a variety of tasks, including aiding in surgical procedures. The smart tissue autonomous robot (STAR) from Johns Hopkins University has demonstrated that it can outperform human surgeons in some surgical procedures, such as bowel anastomosis in animals (Bohr & Memarzadeh, 2020). Not only is artificial intelligence helpful by aiding healthcare professionals with many tasks, but it can be implemented at the early stages of education for medical students. Medical students can be provided with and taught surgical procedures through augmented and virtual reality without ever needing to interact with patients at an early stage. This ultimately lowers the cost of training, while still allowing students to pick up the required skills. AI in healthcare has endless possibilities and can be something worth investing in as it provides patients with the most efficient, accurate care and assists healthcare professionals in times of need.

Ethical Challenges & Other Roadblocks:

Although AI has the potential to be extremely helpful in the field of healthcare, many risks must be addressed prior to its implementation as AI technology has tremendous capability to threaten patient preference, safety, and privacy. There is much work to do to lay down the

proper ethical foundation for using AI technology safely and effectively in healthcare. The added risk to patient privacy and confidentiality, boundaries between the physician's and the machine's role in patient care, and adjustment to the education of future physicians to confront the changes occurring in healthcare must all be addressed. One of the biggest hurdles when discussing AI integration in healthcare is data management. Patient's health information is protected by law as private and confidential. Therefore, healthcare providers are obligated to not share such information with any third party. However, training AI systems requires large amounts of patient data. If AI developers are not granted access to such data, they are unable to train healthcare machine learning models. For developers to use patient data, they must ensure that the data is protected and patients still have control over their data, which can prove to be challenging at times. Since AI systems are trained on certain sets of data, the data is not always representative of the entire population the system will be serving. If the data is biased or discriminatory, then the system will also be biased or discriminatory. This can result in inaccurate or unfair results among certain marginalized groups, such as those of color or women. In an empirical study, three researchers: Irene Y. Chen, Peter Szolovits, and Marzyeh Ghassemi, demonstrated that machine learning algorithms might not provide equally accurate predictions of outcomes across race, gender, or socioeconomic status (Rigby, 2019).

Another issue that is common with the use of artificial intelligence is the lack of transparency. Legal issues are likely to arise with the use of "black-box" algorithms because users are not provided with a logical explanation as to how the algorithm arrived at its given output. This may result in patients questioning if the technology is trustworthy. There are currently no clear regulations or guidelines set for the use of AI in healthcare, making it difficult for healthcare organizations to know how to use it properly and making it difficult for patients to trust AI. Furthermore, many healthcare practitioners and patients are unfamiliar with how to operate complex AI models. AI systems must be simple in terms of their features and functionality for patients and practitioners to operate AI-powered machines and applications efficiently. With the increased use of AI in healthcare, medical education needs to be geared toward training professionals on how to deal with such models. In fact, in their published journal, Steven A. Wartman and C. Donald Combs claimed that, given the rise of AI, medical education should be reframed from a focus on knowledge recall to a focus on training students to interact with and manage artificially intelligent machines (Rigby, 2019).

The use of AI in this field is powerful, but not perfect. AI is not meant to fully take over the role of healthcare professionals, but there is a risk that doctors as well as other members of the medical community may over-rely on AI systems. If doctors solely base their decisions on what AI believes to be correct without considering the limitations and potential errors of such technology, it can lead to poor medical decisions and therefore harm to patients. By addressing ethical issues and challenges that may arise with the use of artificial intelligence, it would help individuals gain a better understanding of AI; one that is more realistic.

Conclusion:

As technologies continue to advance, the role of AI in medicine will likely continue to expand and develop in complex ways. AI is expected to transform the way the community approaches healthcare as it will provide more effective solutions to challenges that face the medical industry. The medical community can expect to see improvements in many subfields, including oncology, pathology, and biomedical research. AI creates the opportunity to improve the efficiency of healthcare delivery and the quality of patient care. However, there is a need to reduce the ethical risks and challenges associated with AI implementation to ensure smooth delivery by AI operating systems. There is no doubt that artificial intelligence will bring about large positive change in the healthcare community, but not without solutions to the challenges facing AI implementation today.

Works Cited:

Bohr, A., & Memarzadeh, K. (2020, June 26). *The rise of artificial intelligence in healthcare applications*. NCBI. Retrieved July 9, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7325854/

Brown, R. (2022, October 30). *Challenges to Successful AI Implementation in Healthcare - DataScienceCentral.com*. Data Science Central. Retrieved July 9, 2023, from https://www.datasciencecentral.com/challenges-to-successful-ai-implementation-in-healthcare/

Bush, J. (2018, March 5). *How AI Is Taking the Scut Work Out of Health Care*. Harvard Business Review. Retrieved July 9, 2023, from https://hbr.org/2018/03/how-ai-is-taking-the-scut-work-out-of-health-care

King, M. (2022, December 26). *The Future of AI in Medicine: A Perspective from a Chatbot*. Springer Link. Retrieved July 9, 2023, from https://link.springer.com/article/10.1007/s10439-022-03121-w

R, R. (2021, December 13). *Main Types Of AI And Their Applications In Healthcare*. Managed Outsource Solutions. Retrieved July 9, 2023, from https://www.managedoutsource.com/blog/what-are-main-types-of-ai-and-applications-in-healthcare/

Rigby, M. (2019, February). *Ethical Dimensions of Using Artificial Intelligence in Health Care*. AMA Journal of Ethics. Retrieved July 9, 2023, from https://journalofethics.ama-assn.org/article/ethical-dimensions-using-artificial-intelligence-health-care/2019-02

Rosen, H. (2023, February 7). *Top Five Opportunities And Challenges Of AI In Healthcare*. Forbes. Retrieved July 9, 2023, from

https://www.forbes.com/sites/forbesbusinesscouncil/2023/02/07/top-five-opportunities-and-challenges-of-ai-in-healthcare/?sh=208ee8c92805

XSOLIS Insights. (2021, February 2). *The Evolution of AI in Healthcare*. XSOLIS. Retrieved July 9, 2023, from https://www.xsolis.com/blog/the-evolution-of-ai-in-healthcare

Literary Review

Nanotechnology in Healthcare

Diya Patel, Charlotte Lungren (advisor), Anika Shah (advisor)
Gatlinburg-Pittman High School

Abstract:

The study addresses how nanotechnologies and nanoparticles (NPs) are being used in healthcare. It discusses historical, present, and potential future applications, as well as the obstacles and hazards associated with successfully incorporating nanotechnology into healthcare operations. Gene therapy, drug delivery, brain ailments, psychological disorders, cancer, and many more forms of nanotechnology applications in healthcare are explored in this paper. Nanotechnology is already being utilized in hospitals to help doctors target and combat specific regions of the body and diseases, and it has enormous potential for usage in cardiology, surgery, therapy, and other fields. Toxicology, risk, and ethical concerns about patient safety, as well as the morale of human decision making, represent substantial barriers to the broad application of nanotechnology in healthcare.

Introduction:

As technology evolves, the incorporation of Artificial Intelligence (AI) and nanotechnology in a variety of industries around the world is becoming more prevalent. Richard Feynman, a physicist from the United States, is widely regarded as the founder of nanotechnology. He discussed the principles and concepts underlying nanotechnology in a 1959 talk titled "There's Plenty of Room at the Bottom." Feynman did not use the term "nanotechnology," but rather outlined a technique that would allow scientists to alter and control individual atoms and molecules. Until the mid-1980s, when MIT-educated engineer K Eric Drexler released "*Engines of Creation*," a book to popularize the promise of molecular nanotechnology, Feynman's theory went mostly unnoticed. It is a new multidisciplinary discipline that uses cell therapy and tissue engineering approaches to repair, enhance, and maintain cells, tissues, and organs. Nanotechnology enables interaction with cell components, manipulation of cell proliferation and differentiation, and synthesis and organization of extracellular matrices. Modern nanotechnology genuinely began in 1981, when scientists and engineers were able to observe and manipulate individual atoms using a scanning tunneling microscope. Despite some promising early advances in nanotechnology, it did not make major progress for several decades, particularly in healthcare. Nanotechnology has been a critical area of research over the last thirty years, owing to the unique chemical, electrical, optical, biological, and magnetic properties of nanomaterials. Nanotechnology has gotten a lot of attention

because it is well known that when nanotechnology and biotechnology come together, they create a platform with enormous potential and importance in terms of application diversity. Nanotechnology products have been more beneficial in healthcare, leading in the development of revolutionary nanotechnologies for the diagnosis, imaging, and treatment of a wide range of diseases, including cancer, cardiovascular disease, ophthalmic disease, and neurological disorders. Along with these breakthroughs, the incorporation of nanotechnology in healthcare is becoming more popular, and it is obvious that nanotechnology has the potential to increase the accuracy and efficiency of diagnostics and therapies for certain diseases that humans are unable to cure. The future of nanotechnology in healthcare, as well as the obstacles it may present, begs the question: Is nanotechnology too risky to continue developing?

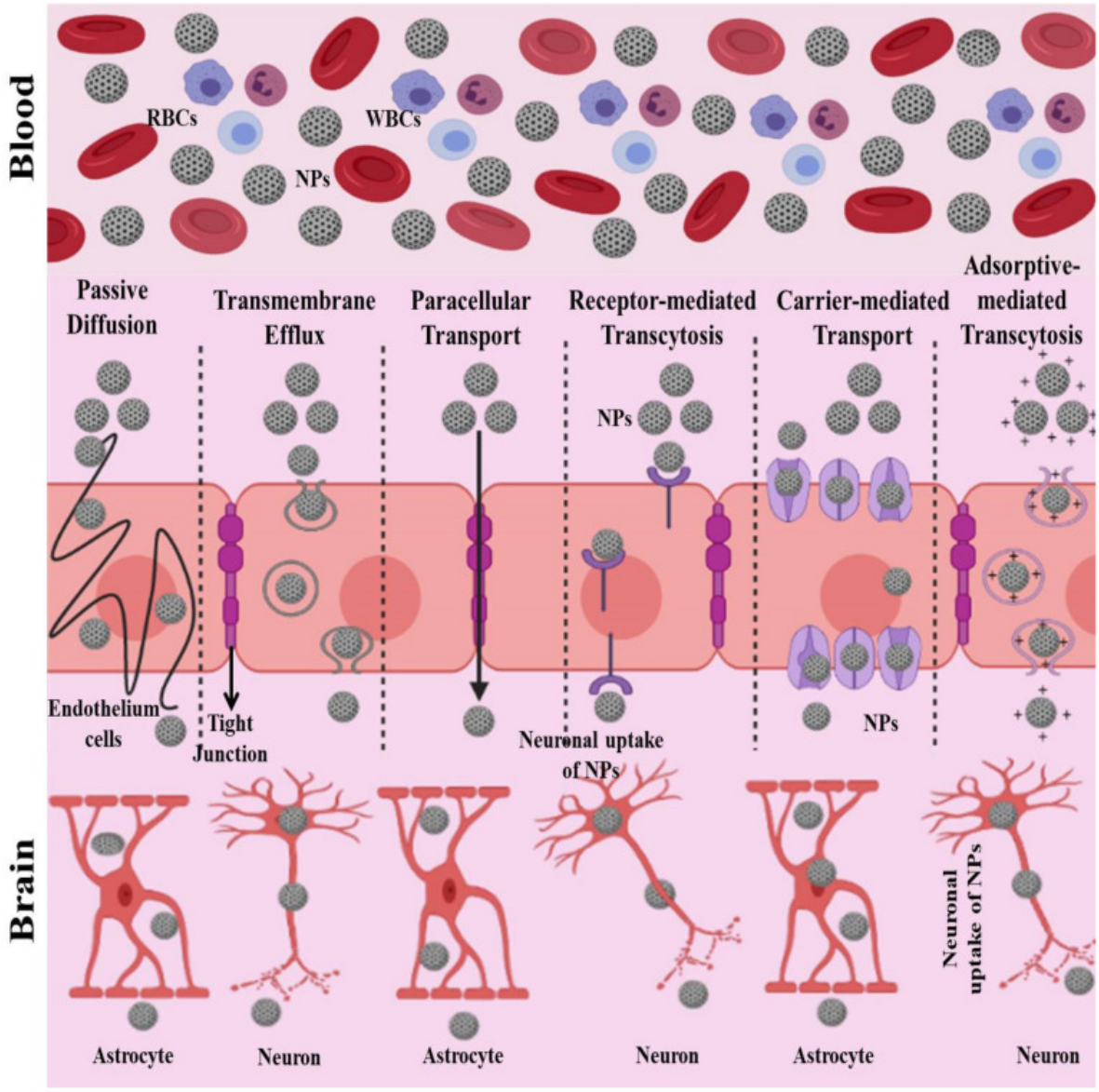
Discussion:

Types of Applications:

Nanotechnology has multiple applications in healthcare, and it is continually evolving and helping doctors attain more precise outcomes more efficiently. Gene therapy is one example of such application. Gene therapy is a treatment in which a disease-causing defective gene in the DNA is replaced with a normal one. To implant the gene into the stem cells, a vector is commonly utilized. Stem cells are the ideal candidates for gene therapy since they have extended lifetimes and the ability to self-renew. When the gene is properly integrated into the cells, it inhibits and corrects the mutant gene's effects while also generating normal cell activity. Nanovectors have significant potential for drug delivery to specific targets in the treatment of a wide range of illnesses. It is critical to use targeted medication delivery, especially if the solvents of hydrophobic medicines are toxic. If these solvents are discharged somewhere other than the target cell, they may contaminate the bloodstream or other body fluids. Nanostructures enable a constant controlled release of the right dosage of drugs. Drug doses are also reduced when drugs are delivered specifically and locally. Nanoparticles' small size allows them to penetrate deep into tumor cells, making them valuable in improving cancer treatments.

Brain disorders can also be effectively treated if we can solve the blood-brain barrier (BBB) problem. The BBB is a barrier that separates circulating blood from brain neural tissues. The presence of the BBB is a crucial barrier in the treatment of brain illnesses because it prevents medications from entering the CNS and preserves homeostasis in the brain. Any disruption to the BBB produces neuro-inflammatory and neurodegenerative illnesses such as Alzheimer's disease, Parkinson's disease, and others, but even a broken BBB prevents medications from entering the brain. However, different forms of NPs (nanoparticles) can cross the BBB and hence efficiently transport medications to injured brain areas. To

enter the BBB, NPs use organic and inorganic elements as a core. Organic materials that can be employed include PLA, PLGA, and trehalose, while inorganic materials include silica, molybdenum, cerium, iron, and gold. The unique properties of NPs that allow them to treat neurodegenerative illnesses are their tiny size, high drug loading ability, and efficient imaging capability (especially for inorganic NPs). To cross the BBB, NPs can take a variety of routes. The suggested paths for NPs to penetrate the BBB are depicted in the picture below.



As seen by the applications described above, there are numerous benefits to adopting nanotechnology in healthcare that outweigh some of the concerns. Thus, nanotechnology is not deemed too dangerous to use, and further research is being conducted to improve both the efficacy and quality of health care.

Current Nanotechnology Effects, and Applications by Healthcare Professionals:

Nanotechnology is being implemented to predict and prevent errors quicker than any healthcare professional. Nanotechnology has the potential to make medical tools and treatments more personalized, portable, less expensive, safer, and easier to administer. Silver nanoparticles, for example, put into bandages, suffocate and kill dangerous microbes. This is notably beneficial in the treatment of burns. Nanotechnology is also furthering advances in disease treatments. Researchers are working on ways to deliver drugs directly to specific cells using nanoparticles. This is especially promising for cancer treatment because chemotherapy and radiation treatments can harm both healthy and diseased tissue. Dendrimers, nanomaterials with numerous branches, may improve drug delivery speed and efficiency. Dendrimers, which carry medications that inhibit the spread of cerebral palsy-like symptoms in rabbits, have been tested by researchers. Fullerenes can be engineered to have anti-inflammatory properties, which can be used to slow or even stop allergic reactions. Nanomaterials have the potential to minimize bleeding and accelerate coagulation. By organizing nanoparticles to detect and attach themselves to certain proteins or damaged cells, diagnostic tests and imaging can be improved. Nanotechnology can generate precise answers to problems by focusing on specific issues and resolving them before they worsen. By targeting and fixing the condition at hand, nanotechnology benefits both the patient and the healthcare professionals who use it. Whether it's a minor scrape on the knee or a growing tumor, nanotechnology can target and combat it, potentially saving a life.

The Future Of Nanotechnology:

There is growing hope that nanotechnology applied to medicine will lead to significant advancements in illness diagnosis, treatment, and prevention. Growing interest in future medical applications of nanotechnology is spawning a new area known as nanomedicine. Nanomedicine must overcome application difficulties in order to increase understanding of disease pathophysiology, provide more advanced diagnostic opportunities, and generate more effective therapeutics and preventive qualities. When doctors get access to medical robots, they will be able to quickly cure the majority of known diseases that afflict and kill people today, as well as quickly repair the majority of physical damage our bodies can sustain, and substantially prolong the human health span. Molecular technology is destined to become the foundational technology underlying all of 21st century medicine. To target specific tissues

and organs, modern nanomedicine employs finely organized nanoparticles such as dendrimers, carbon fullerenes (buckyballs), and nanoshells. These nanoparticles have the potential to be used as diagnostic and therapeutic antiviral, antitumor, or anticancer medicines. Complex nanodevices and even nanorobots will be created in the coming years, first from biological materials and then from more lasting materials such as diamond to attain the most potent outcomes. Because the human body is made up of molecules, the availability of molecular nanotechnology will allow for dramatic improvements in addressing medical problems and using molecular understanding to maintain and improve human health at the molecular level. Within the next 10-20 years, it should be possible to build micrometer-scale devices out of nanometer-scale parts. Nanorobotic devices that can be programmed would allow doctors to execute precise interventions at the cellular and molecular levels. Medical nanorobots have been proposed for gerontological applications such as pharmacological research, clinical diagnosis, improved respiratory capacity, near-instantaneous homeostasis, immune system supplementation, rewriting or replacing DNA sequences in cells, and brain damage treatment. Hichan Fenniri, a chemistry professor, attempted to make artificial joints behave more naturally. Fenniri has developed a nanotube coating for titanium hip or knee that is a very good imitation of collagen. As a result of the coating, more bone cells, osteoblasts, which aid in bone growth, are attracted and attached, resulting in faster bone growth than uncoated hip or knee. When delivered into the body through the circulatory system or cavities, a surgical nanorobot programmed or led by a human surgeon could function as a semiautonomous on-site surgeon. A built-in computer might coordinate the device's operations, such as searching for pathology and then detecting and fixing lesions by nanomanipulation while keeping contact with the supervising surgeon via coded ultrasonic signals. A 'smart pill' is another possible future application of nanotechnology. The term 'smart pills' refers to nano-level electronic devices that are formed and designed like pharmaceutical pills but perform more advanced tasks like sensing, imaging, and medication delivery. Previously, nanotechnology aided in the development of smart pills such as the PillCam, a capsule with a miniature video camera, and dose-tracking pills. The 'Atmo Gas Capsule,' a more advanced smart pill in development, analyzes the gasses in the human gut after ingestion and reports any abnormalities. Its sensors can detect the presence of dangerous compounds as well as the levels of oxygen and carbon dioxide in the body. Its applications include detecting cancerous digestive organs, diagnosing gastrointestinal problems, and tracking food sensitivities to enable individualized diet and nutrition plans. Meanwhile, MIT is working on 'Smart Sensor Capsules,' which will eliminate the need to inject medications into the stomach. It unfolds before resting on the organ when taken orally, recording vital signals for diagnostic and therapeutic monitoring. It also features chambers for pre-loading medications that will be released into certain regions of the body. Nanotechnology will not only prevent thousands of deaths, but also save billions of dollars and hours of doctor's time.

Current Challenges and Risks:

One of the biggest challenges with using nanotechnology in healthcare is the risks that are associated with using it. Approximately 2 million Americans are exposed to significant levels of nanoparticles.
One of the most serious issues with nanotechnology is the risk to one's health. Small particles can easily penetrate the body (especially the lungs) and create a variety of health problems, cancer being one of the most serious. Working with such products, or being in areas where they are dispersed, can be hazardous to one's health. That is why nanotechnology safety is such a critical issue. Furthermore, a disturbing number of people in the United States are exposed to nanoparticles, a figure that some experts estimate may rise to 4 million in the near future. Nanoparticles are potentially hazardous for three reasons:

1. Nanoparticles have the potential to harm the lungs. We know that 'ultra fine' particles from diesel engines, power plants, and incinerators can harm human lungs significantly. This is due to their size (they can get deep into the lungs) in addition to the fact that they carry other compounds in with them such as metals and hydrocarbons.
2. Nanoparticles enter the body via the skin, lungs, and digestive system. This may contribute to the formation of 'free radicals,' which can cause cell damage and DNA damage. There is also concern that nanoparticles will be able to breach the blood-brain barrier once they enter the bloodstream.
3. The human body has evolved tolerance to the majority of naturally occurring elements and molecules with which it comes into contact. It lacks inherent immunity to novel compounds and is more likely to be poisonous to them.

These arguments can be supported by further research and experiments on animals. The dangers of coming into contact with nanoparticles are not just speculation. Concerns grow as more research is conducted. Here are some recent discoveries:

- In rats, certain nanoparticles induce lung injury. Several studies have indicated that carbon nanotubes, which resemble asbestos fibers in form, cause mesothelioma in rats' lungs.
- Other nanoparticles have been linked to neurological impairment in fish and dogs.
- A German study found solid evidence that if discrete nanometer-sized particles were placed in the nose region (in this instance, in mice), they completely got around the blood-brain barrier and proceeded right into the brain via the olfactory neurons.
- Inhaled nanotubes containing carbon are capable of suppressing the body's immune system by intervening with the function of T cells, which are a type of white blood cell that organizes the immune system to attack infectious diseases.

Toxicology is a key barrier to the deployment of nano-based products in living systems for healthcare services. Various nanomaterials have caused unintended allergy and other reactions that may be damaging to the body. Toxicity is a complicated notion in and of itself because it is affected by numerous aspects such as morphology, size, dose, surface area, route, and duration of administration. This brings us to another point, which is the need to standardize or personalize the use of nanomaterials. Furthermore, another issue that has to be worked on is the dependability and repeatability of research employing NPs. Controlling their activities in sensitive situations is similarly difficult due to their small size. Other constraints include their high cost, the prevalence of contaminants, the environmental effect, and so on. If these threats are not addressed appropriately, they can have fatal consequences. The most pressing difficulty in nanotechnology is learning more about materials and their behavior at the nanoscale. Universities and organizations throughout the world are conducting extensive research into how atoms come together to form larger structures. We're still discovering how quantum physics affects material at the nanoscale. Because elements behave differently at the nanoscale than they do in their bulk form, there is fear that some nanoparticles may be harmful. Some doctors are concerned that because the nanoparticles are so small, they could readily breach the blood-brain barrier, which protects the brain from dangerous chemicals in the bloodstream. We also need to consider if nanotechnology is an ethical option for people to improve their bodies if they do not have a critical ailment that requires immediate attention. Is it ethical to use nanotechnology in medicine to enhance our physical capabilities? In theory, medical nanotechnology may make us smarter and stronger, as well as provide us with additional talents such as quick healing and night vision. Should we pursue such objectives? Could we still call ourselves human, or would we evolve into “transhumans,” the next step in man's evolution? We don't know the answers to these concerns, but numerous organizations are asking nanoscientists to think about them now, before it's too late. Eric Drexler, the guy who invented the term nanotechnology, gave a horrific apocalyptic image of self-replicating nanorobots malfunctioning and reproducing themselves a trillion times over, swiftly consuming the entire earth as they extract carbon from the environment to construct more of themselves. The "gray goo" scenario is one in which a synthetic nano-size gadget replaces all organic substances. Another scenario involves organic nanodevices wiping out the Earth – the "green goo" scenario. These scenarios also emphasize the risks associated with using nanotechnology in healthcare by showing what can happen if humans continue on this road of technological innovation.

Conclusion:

Nanotechnology research has developed tremendously in the last few decades, as has the emphasis on healthcare sectors. However, nanomedicines and nanodevices are still in the early stages of development,

and one option to speed up this process is to direct research investigations so that researchers work on inventing new methods to overcome the associated limits. The progressive development of nanotechnology-based technologies has given rise to the optimism that life-threatening and disabling illnesses may be efficiently treated in the near future. The gaps caused by insufficient efficacy and preclinical safety studies must be bridged as soon as possible so that we can fully and timely fulfill the enormous potential of nanotechnology. Although nanotechnology provides solutions to numerous problems, this does not mean that it is without challenges or restrictions. We urgently need to develop standardized techniques for synthesizing these nanomaterials that ensure not only high yields, stability, and purity, but also compliance with the stated security criteria. There is also a need to establish techniques that will allow us to completely understand the outcomes of NPs after they have been used. These questions include how long they stay in the body, what conditions influence the duration of deterioration, how to make them stay for longer and shorter periods, what their long-term and short-term effects are, how the body behaves towards these outsider entities on a micro and macro level, what their characteristics and mechanisms of action are, and how we can standardize these particles to ensure experiment reproducibility. These should be addressed before introducing nanotechnologies into the healthcare sector. Furthermore, in order to obtain the safest and most effective therapy regimen, the numerous nanomedicines and nanoformulations targeting specific diseases must be carefully created. Even if it doesn't appear to be so right now, nanotechnology has the potential to profoundly transform daily life, both within and outside of healthcare. While nanotechnology is not currently deemed dangerous, and most likely will not be until more study is conducted, this does not mean that the use of nanotechnology in healthcare should be discouraged. Nanotechnology has saved lives and will continue to do so in the near future with new advancements. If we can overcome the major hurdles and threats that nanotechnology development is currently confronting, virtually anything will be possible to treat and accomplish.

Sources Cited:

- Anjum, S., Ishaque, S., Fatima, H., Farooq, W., Hano, C., Abbasi, B. H., & Anjum, I. (2021, July 21). *Emerging applications of nanotechnology in healthcare systems: Grand Challenges and Perspectives*. Pharmaceuticals (Basel, Switzerland). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8401281/#B1-pharmaceuticals-14-00707
- Bonsor, K., & Strickland, J. (2023, March 8). *How nanotechnology works*. HowStuffWorks Science.

https://science.howstuffworks.com/nanotechnology5.htm#:~:text=The%20most%20immediate%20challenge%20in,together%20to%20form%20larger%20structures.

- Johansson, M., & Boholm, Å. (2017). *Scientists' understandings of risk of nanomaterials: Disciplinary culture through the ethnographic lens*. Nanoethics. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5712326/#CR16
- Mrkonjić, E. (2023, May 20). *Nanotechnology statistics: State of the industry and jobs*. SeedScientific. https://seedscientific.com/nanotechnology-statistics/
- *Nanotechnology - a new hazard*. OHS Reps. (n.d.). https://www.ohsrep.org.au/nanotechnology_-_a_new_hazard#:~:text=Nanoparticles%20can%20get%20into%20the,cross%20the%20blood%2Dbrain%20barrier.
- *Nanotechnology in healthcare: 4 ways its changing the future*. Netscribes. (2023, June 21). https://www.netscribes.com/nanotechnology-in-healthcare/
- *Nanotechnology*. Education. (n.d.). https://education.nationalgeographic.org/resource/nanotechnology/#
- Patil, M., Mehta, D. S., & Guvva, S. (2008, May). *Future impact of nanotechnology on medicine and Dentistry*. Journal of Indian Society of Periodontology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2813556/#:~:text=There%20is%20increasing%20optimism%20that,a%20new%20field%20called%20nanomedicine.

Literary Review

Redefining the Art of Patient Care: Human Touch and AI

Eniola Karim, Charlotte Lungren (advisor), Anika Shah (advisor)
Edmond Santa Fe High School

Abstract

This paper will explore the implementation of Artificial Intelligence (AI) into healthcare, while also highlighting the importance of maintaining human touch and patient-provider interactions. AI technologies are rapidly evolving and advancing, and their potential to improve how physicians provide healthcare is becoming increasingly apparent. However, this revelation does not come without concerns, a major consideration being the loss of human interaction and empathy during integration. This paper examines relevant literature to better inform about the ethical challenges connected with implementing AI into healthcare. Furthermore, this paper highlights solutions and strategies to address those challenges and preserve human-centered care. This is achieved by emphasizing using AI to assist and support physicians, rather than replacing them completely. The significance of achieving a balance between AI integration and human touch is emphasized. Finally, the paper concludes that advanced technologies should be embraced by the healthcare system while simultaneously providing compassion and empathy and ensuring personalized patient care.

Introduction

While advancements are being made in Artificial Intelligence technology at a fascinating pace and level, questions arise over the extent to which AI should be implemented into different industries, specifically medicine. Artificial Intelligence refers to the ability of systems and machines to perform tasks typical of human capabilities. AI is much more complex, branching off into many specialized areas like Natural Language Processing, which allows systems to communicate and interact with the human language and Expert Systems, which are designed to replicate the decision making capabilities of humans in a certain field. This type of machine learning has the ability to provide data driven decisions to physicians. The drawbacks and benefits of AI to the healthcare industry are vast and complex that pose a question: What is the Future of Patient Care? AI is most certainly here to stay and a sure sign of the changing times as seen in the development of FitBits and virtual health assistants but to what extent should the technology evolve within the industry? It is no doubt that the heart of a routine check up is the *interaction* with your physician, the empathy and understanding they provide is essential to healing and is simply something that cannot be replicated with technology. To further enhance patient care, a balance must be struck between AI and preserving human interactions.

Discussion

Applications of AI

Utilizing AI to do the administrative tasks can increase productivity within healthcare and increase a medical professional's ability to perform efficient patient care. Diagnosis and imaging analysis will be improved significantly, a current application seen in the company PathAI. The technology used ensures

accurate diagnosis with results specialized toward an individual, offering treatment solutions and detecting cancer within patients in its early stages, preventing fatality. Another application, BERG, has the capability to identify and treat rare diseases. The biotech platform utilizes research and interrogative biology that assists doctors in treating patients with rare diseases. The application is making significant headway in treating Parkinson's disease. Digital health startup, Thymia created a video game infused with AI technology that offers objective mental health assessments in 2020. The AI technology analyzes facial features and audio to detect depression and determine severity. As discussed in Harvard Business Review (HBR) , it's becoming evident that AI technology can drastically improve diagnostic and imaging evaluations, " In 2011, researchers from NYU Langone Health found that this type of automated analysis could find and match specific lung nodules (on chest CT images) between 62% to 97% faster than a panel of radiologists." (Kalis). Another technology, HBR examines is a type of robot-assisted surgery created by Mason Robotics that uses data, like medical records, to guide a surgeon during surgery. The results of this technology prove to be promising as the HBR's analysis found that, "AI-assisted robotic surgery could also generate a 21% reduction in patients' length of stay in the hospital following surgery, as a result of fewer complications and errors" (Kalis). It is becoming increasingly clear that emerging technologies alike to the ones mentioned above have the potential to improve prognosis on various patients.

Ethical Concerns

AI has the potential to revolutionize the healthcare system, but the first step towards this revolution is addressing the ethical dilemmas that come with integration. Key considerations include privacy and data security and bias and accessibility. In regards to privacy and data security, HIPAA remains a safeguard to a patient's privacy, but for AI to work, its inherent need is *data*. As stated in a publication by the American College of Surgeons, "AI cannot exist without data. This creates a paradox where demands are made to conceal data for the sake of confidentiality and release data to AI developers in order to create better algorithms" (AlHassan). To combat this problem, AlHassan suggests strict laws to regulate the design and implementation of AI to ensure patient security. AlHassan goes further to assert that physicians and AI developers must work together to develop an ethical code of conduct that guarantees a patient's civil rights and dignity. Additionally, bias and discrimination are another major issue, an article by the American Civil Liberties Union (ACLU) notes that, "While the FDA suggests that device manufacturers test their devices for racial and ethnic biases before marketing to the general public, this step is not required" (Grant). This does not completely ensure that AI technologies will use objective reasoning in diagnosis and treatment, posing a risk to patients. This can lead to AI technologies misdiagnosing marginalized individuals who don't have the same access to healthcare compared to their counterparts. This poses a major risk to life and death medicinal decision making. To combat the subconscious bias AI technology might inherit, it is important to ensure that the data AI uses is representative of different demographics, socioeconomic backgrounds, and geographic regions of each patient. This allows the technology to have an unlimited range of data at its disposal that will hopefully reduce bias. By monitoring and evaluating AI systems, the risks posed to data, privacy, and bias can be reduced, paving the way for a peaceful transition of AI technology into medicine.

Combining Human Touch and AI

A report by Pew Research Center found that 60% of Americans would be uncomfortable with their physician relying solely on AI. The respondents cited concerns of worsening patient-physician relationships by using AI to diagnose and recommend treatments (57%). The apprehension by everyday

Americans is to be considered and a balance must be achieved to ensure patient care has reached its full potential, and AI is how we facilitate that goal. Integrating AI into medicine can only be successful with limiting the role of AI in treatment, an analysis by health leaders supports this, “Artificial intelligence should be used to support, not supplant, the healthcare provider” (Vanderknyff). Within this analysis, Vanderknyff, the chief integration and informatics officer for Proactive MD, asserts using AI to enhance a provider's ability and provide support to decision making. Dr. Vanderknyff goes on to highlight the importance of human empathy and compassion in patient care, “Nothing can replace the compassionate care of a provider. They can see you, hear your stories, grieve with you, rejoice with you, and offer a human experience that can never be replicated—even with all the knowledge in the world at their fingertips” (Vanderknyff). The medicine world should not be apprehensive of emerging technologies, especially if it can improve patient care. However, it remains that the heart of a patient-provider interaction is the empathy and understanding a physician can give that can help patients cope and recover. Using AI can allow a physician to do their job better and more efficiently, but human-centered care should never be forgotten, it is integral to patient recovery and treatment.

Conclusion

All in all, the revolution that AI can bring to healthcare has its advantages and drawbacks that are to be considered in the future of medicine. AI offers many possibilities that can transform healthcare. However, it is evident that it is crucial to maintain human interactions in healthcare. Allowing AI to dominate patient interactions can be detrimental to a patient's health. It is imperative to ensure empathy and patience in patient care, and human emotions like those simply cannot be expressed with technology. This paper has highlighted key considerations and insights from various sources that point towards reaching a middle ground with human touch and AI to ensure patient benefit significantly from the integration. Using AI as a supportive tool can easily benefit the physician and lead to improved outcomes for various patients. AI technology can revolutionize medicine in the best way possible if done correctly and thoroughly.

Works Cited

AlHassan, A. (2023, February 8). Ethical concerns grow as AI takes on greater decision-making role. ACS. https://www.facs.org/for-medical-professionals/news-publications/news-and-articles/bulletin/2023/february-2023-volume-108-issue-2/ethical-concerns-grow-as-ai-takes-on-greater-decision-making-role/

Gordon, C. (2022, November 2). Ai in Healthcare is Making Our World Healthier. Forbes. https://www.forbes.com/sites/cindygordon/2022/10/31/ai-in-healthcare-is-making-our-world-healthier/

Grant, C. (2023, February 24). Algorithms are making decisions about health care, which may only worsen medical racism: ACLU. American Civil Liberties Union. https://www.aclu.org/news/privacy-technology/algorithms-in-health-care-may-worsen-medical-racism#:~:

text=A%20Lack%20of%20Transparency%2FBiased%20Data&text=Another%20study%20found%20AI%20tools,have%20access%20to%20medical%20care.

Kalis, B., Fu, R., & Collier, M. (2021, January 20). 10 Promising AI Applications in Health Care. Harvard Business Review. https://hbr.org/2018/05/10-promising-ai-applications-in-health-care

Tyson, A. (2023, February 22). 60% of Americans would be uncomfortable with provider relying on AI in their own health care. Pew Research Center Science & Society. https://www.pewresearch.org/science/2023/02/22/60-of-americans-would-be-uncomfortable-with-provider-relying-on-ai-in-their-own-health-care/

Vanderknyff, J. (2023, May 13). The Age of AI: Keeping the Human Touch in Healthcare. HealthLeaders Media. https://www.healthleadersmedia.com/innovation/age-ai-keeping-human-touch-healthcare

Literary Review

AI's Integration in Healthcare and its Effects on Marginalized Racial Groups

Fariha Sneha, Charlotte Lungren (advisor), Anika Shah (advisor)

Bronx Early College Academy

Abstract

This paper examines the pros and cons of integrating artificial intelligence into healthcare through the lens of race. To centralize the data, the AI-related close studies and applications discussed in this journal are derived from the United States. The analysis of US residents' encounters with AI-operated health-related resources and lack thereof will be used to determine how stakeholders will be affected as AI is utilized further in the medical community. The adoption of Artificial Intelligence in the US medical system has grown more common by the day and has shown great success aiding in patient care. However, the promising prospects can be compromised by prejudice as it can use proxy variables to reach conclusions. The paper highlights how artificial intelligence can perpetuate as well as subdue racial disparities accompanied by measures to take to avoid such fatal errors.

Keywords:

Artificial intelligence, machine learning, healthcare, race, bias, Generative Adversarial Networks, algorithm transparency

Introduction

The field of artificial intelligence is vigorously expanding into different industries. The healthcare industry and big pharma are expected to benefit primarily as the “market size [is] expected to grow from just under $5 billion in 2020 to $45.2 billion by 2026” (Talby, 2021). Without a doubt, deploying AI into healthcare has great outcomes for profits but how does the mechanized human intelligence affect its patients? In 1956, the term ‘artificial intelligence” was introduced at the Dartmouth Conference, and in a matter of nearly two decades, AI made its presence in the healthcare system. The earliest groundbreaking use of AI in healthcare was the MYCIN system, created by Stanford professor Edward Shortliffe. He and his team incorporated medical expertise into AI systems to diagnose and recommend treatments for bacterial infectious diseases (Press, 2020). The pioneers of early artificial intelligence showcased the revolutionary potential it can offer in aiding physicians and patients. The field was relatively new and so the lack of momentous progress led to investors withdrawing their funds which discouraged in-depth research. Artificial intelligence’s usage especially in healthcare skyrocketed by the 2nd decade of the 21st century but the hesitancy towards AI now comes from patients who distrust the ability of AI especially from people of color. According to the survey conducted by PEW Research, “Black adults are especially likely to say that bias based on a patient’s race or ethnicity is a major problem in health and medicine (64%). About four-in-ten Hispanic (42%) and English-speaking Asian adults (39%) also say this. A smaller share of White adults (27%) describe bias and unfair treatment” (Tyson et al., 2023). Racial bias, whether explicit or implicit, is an epidemic to the progress in the United States healthcare system and brings out the question of whether artificial intelligence can ameliorate the racial disparities that exist within healthcare or facilitate further distrust amongst people of color.

Discussion

Benefits of AI

Generative AI is a system that emulates real-time data which is a recourse for analyzing authentic patient data. An example widely used is Generative Adversarial Networks and the framework consists of a generator network and a discriminator network. The latter “could improve performance of classifiers when limited labeled data is available” while the generator “uses a fixed noise distribution, learning slows dramatically after the model has learned even an approximately correct distribution over a small subset of the observed variables. Finally, some techniques do not involve defining a probability distribution explicitly, but rather train a generative machine to draw samples from the desired distribution. This approach has the advantage that such machines can be designed to be trained by back-propagation” (Goodfellow et al., 2014). The generator produces synthetic data that is adjacent to real-life patient data and it aims to be indistinguishable. The discriminator on the other hand actively seeks to categorize the realistic generated data and actual data. With both networks working against each other, the feedback loop assures that the synthesized data is feasible for real-life use. To certify that it works near-accurately, autoregressive models should be considered but the recent most cases undoubtedly need to be taken into reckoning for the neuron networks to be up-to-date. G.A.N. can aid an equitable approach and uphold patients' privacy. For instance, Hereditary ATTR Amyloidosis is a disease caused by the excess accumulation of a protein called amyloid which can lead to organ dysfunction and failure (“Hereditary amyloidosis” n.d.). One of its mutations Val122Ile is highly prevalent among African Americans and is extremely difficult to diagnose. According to an epigenomic article by Gita A. Pathak, it stated: “The carriers have an increased risk of congestive heart failure, peripheral edema, and several other noncardiac phenotypes such as carpal tunnel syndrome, and arthroplasty which are top reasons for ambulatory/outpatient surgeries (OSs) in the country.” The epigenome study conducted by Pathak and her team used “protein to protein interaction” network to find the relation between symptoms of the Val122Ile mutation and the nature of the amyloid proteins (Pathak et al., 2021). Given that it is a rare disease, the

G.A.N. can create synthetic reports so additional tests can be conducted. Researchers will have ample data to draw out anomalies and design treatments. The poor prognosis for African Americans can be dealt with if the data is handled with adequate levels of skepticism.

African Americans are disproportionately subjected to higher knee pain and inadequate treatment for osteoarthritis likely because many doctors still assume that black people have higher pain tolerances compared to other races. This harmful generalization can be combatted through AI-enabled systems as they can validate patients' pain levels. Ziad Obermeyer and his team's "algorithmic severity measures better capture underserved patients' pain, and severity measures influence treatment decisions, algorithmic predictions could potentially redress disparities in access to treatments like arthroplasty" (Pierson et al., 2021). This system "accounted for 4.7x more of the racial disparities in pain relative to standard measures of severity graded by radiologists" ("Racial Bias in Health Care Artificial Intelligence," 2021). The algorithm predicted the knee pain levels based on X-ray scans which matched patients' descriptions of their pain nearly accurately. This algorithm can bridge the gap between satisfactory treatments across patients of any racial and ethnic identity, especially African Americans.

Where AI can go wrong

Contrary to popular and ill-informed belief, race is not a determining factor for genetic differences and in itself does not dictate a person's health. Certain diseases can be prevalent in particular ethnic groups due to genetic similarities, but race is a social construct categorizing phenotypic differences. When sorting out data, diagnosing health issues, and designing treatment plans, AI can take race into account without being given the green light to do so. Moreover, it can predict patients' self-reported races through radiological images in a way that scientists do not understand and the team that conducted the study stated, "This capability is extremely difficult to isolate" (Gichoya et al., 2022). This can exacerbate the issue of unequal outcomes based on patients' races, especially due to the absence of social context within AI-enabled systems which can spin its analysis in any direction and stimulate bias in its way.

AI systems process highly quantitative information and when developed properly, they can be equipped to do administrative tasks such as billing, allocating resources, and detecting and deterring fraudulent activities within the medical system in an efficient and methodical manner. A risk-prediction algorithm called Impact Pro was developed by Optum which caters to its innovations for health industry uses. Impact Pro measures patients' risk for management which arrived at its conclusion by analyzing the costliness of healthcare. The data revealed that "the care provided to black people cost an average of US$1,800 less per year than the care given to white people with the same number of chronic health problems" (Ledford, 2019). As white patients seemingly spent more money on healthcare, they were assigned as high-risk patients because according to the algorithm's logic, if the patients' cost towards medical needs is high, they must have more ailments. However, the positive correlation of the two factors did not account for the fact that many marginalized groups of color, especially African Americans do not obtain or seek medical treatment in the first place due to a lack of faith in the healthcare system. It stems from innumerable reasons but considerably due to an alarming rate of misdiagnosis, inadequate medical attention, and inaccessibility due to socioeconomic factors. In 2021, the uninsured rate for nonelderly Black people and non-elderly Hispanic people was 10.9% and 19.0% respectively, which is the nation's highest uninsured rate (Artiga, Hill, Damico, 2022). Historically speaking, the reluctance towards receiving medical help also derives from being experimented upon. Such factors were prolonged in place before artificial intelligence began integrating into the healthcare system. According to studies, "hospitals and insurers use the algorithm and others like it to help to manage care for about 200 million people in the United States each year" (Ledford, 2019). In the process of allocating the resources to those in need, it paradoxically diverted resources away from equally ill black individuals. Developers must consider many factors but when AI is intuitively learning like human beings, they can exclude other factors which can have severe repercussions.

Solution

Increasing algorithm transparency was proposed as one of the solutions to combat bias within AI because "trust and transparency are closely linked, as the more transparent a system, the more trust it is likely to inspire" (Obermeyer, 2019). With algorithms displayed, it can allow developers and researchers to assess faultiness. However, many machine learning algorithms are “black boxes” which is a technical jargon defined as "a model or algorithm that generates accurate predictions without any clear rationale for its outputs" (Weller, 2017). Like the human brain, AI’s neural network is ridden with complexity: it can process various factors, be easily condensed, and consider them but the decision-making aspect is rather inexplicable. Individual variability within artificial intelligence also makes it difficult to pinpoint the defects such as racial bias within AI as it can learn and adapt from its users. Hence why it is important to opt for interpretable AI models with traceable origins of their reasoning. When it is traced back, the variables can be adjusted. For instance, after the extensive bias was detected in the risk-prediction algorithm, Ziad Obermeyer and his team at UC Berkeley “collaborated with the company to find variables other than health-care costs that could be used to calculate a person’s medical needs, and repeated their analysis after tweaking the algorithm accordingly. They found that making these changes reduced bias by 84%... Obermeyer says that using cost prediction to make decisions about patient engagement is a pervasive issue” (Ledford, 2019).

Although it is important to incorporate diverse datasets, Leo Anthony Celi, a principal research scientist in IMES at MIT stated, “Just because you have representation of different groups in your algorithms, that doesn’t guarantee it won't perpetuate or magnify existing disparities and inequities. Feeding the algorithms with more data with representation is not a panacea” (Gordon, 2022). This is not to advise against diversifying datasets but to emphasize that a clear and cautious approach is necessary. Hence why it is important to bridge the racial gap that exists among AI developers as they are aware of the disparities and can devise algorithms that can aid people of color. According to the Computing Research Association, “In 2019, 45% new U.S. resident AI Ph.D. graduates were white—by comparison, 2.4%

were African American and 3.2% were Hispanic" (Mishra, 2021). Celi stresses the importance of increasing diversity as he stated, "They need to have more investigators representing underrepresented groups of people, to provide that lens to come up with better designs of health products" (Bender, 2023). AI developers must also collaborate with well-versed social scientists so they can analyze the causes and consequences of AI when socioeconomic factors are available. The intersection between the two fields is needed to reverse the bias and increase proactivity.

Conclusion

A rising issue in artificial intelligence appears to be how this insentient technology possesses bias. This issue can further plague the healthcare system in the US which has long discriminated against people of color, especially African Americans. It is important to note that artificial intelligence only amplifies the extensive societal bias reflected through the data and may be unwittingly or deliberately woven into the AI system. The AI lacks the intent to discriminate but its inclination towards the inadvertent unequal distribution of health outcomes can be dealt with because, "a lack of fairness in AI can be systematized and quantified in a way that makes it more transparent than human decision-making, which is often plagued by unconscious prejudices and myths" (Townson and Zeltkevic, 2023). Without a doubt, the harm done by human bias cannot amount to artificial intelligence however human supervision is necessary to rectify any errors to come. Despite the dystopian depiction of artificial intelligence in science fiction, AI has an encouraging outlook in tackling systemic bias in the healthcare industry when meticulously programmed with inclusive factors. To devise optimal solutions for patients through equitable means, AI, physicians, data scientists, and social scientists must work collectively.

Sources Cited

Artiga, S., Hill, L., & Damico, A. (2022, December 20). *Health Coverage by Race and Ethnicity, 2010-2021* | KFF. www.kff.org/racial-equity-and-health-policy/issue-brief/health-coverage-by-race-and-ethnicity/

Bender, E. (2023, May 16). *Joining the battle against health care bias.* MIT News. https://news.mit.edu/2023/joining-battle-against-health-care-bias-leo-anthony-celi-0516

Gichoya, J. W., Banerjee, I., Bhimireddy, A. R., Burns, J. L., Celi, L. A., Chen, L. C., Correa, R., Dullerud, N., Ghassemi, M., Huang, S. C., Kuo, P. C., Lungren, M. P., Palmer, L. J., Price, B. J., Purkayastha, S., Pyrros, A. T., Oakden-Rayner, L., Okechukwu, C., Seyyed-Kalantari, L., Trivedi, H., … Zhang, H. (2022). *AI recognition of patient race in medical imaging: a modelling study.* The Lancet, 4(6), e406–e414. https://doi.org/10.1016/S2589-7500(22)00063-2

Godwin, C. (2021, February 6). *Can AI tackle racial inequalities in healthcare?* BBC. www.bbc.com/news/technology-55940112

Gordon, R. (2022, May 20). *Artificial intelligence predicts patients' race from their medical images*. MIT News. https://news.mit.edu/2022/artificial-intelligence-predicts-patients-race-from-medical-images-0520

Hereditary amyloidosis. (n.d.). Genetic and Rare Diseases Information Center. https://rarediseases.info.nih.gov/diseases/6611/hereditary-amyloidosis

Ledford, H. (2019, October 24). *Millions of black people affected by racial bias in health-care algorithms.* Nature, *574*(7780), 608-609. 10.1038/d41586-019-03228-6

Mishra, S. (2021, April). *The AI Index: Emerging Trends in AI Education.* Computing Research Association, *33*(4), 2. https://cra.org/crn/2021/04/the-ai-index-emerging-trends-in-ai-education/

Obermeyer, Z., Powers, B., Vogelli, C., & Mullainathan, S. (2019, October 25). *Dissecting racial bias in an algorithm used to manage the health of populations.* Science Magazine, 366(6464), 447-453. 10.1126/science.aax2342

Pathak, G. A., Wendt, F. R., De Lillo, A., Nunez, Y. Z., Goswami, A., De Angelis, F., Fuciarelli, M., Kranzler, H. R., Gelernter, J., & Polimanti, R. (2021). *Epigenomic Profiles of African-American Transthyretin Val122Ile Carriers Reveals Putatively Dysregulated Amyloid Mechanisms*. AHA Journals, 14(1), e003011. doi.org/10.1161/CIRCGEN.120.003011

Pierson, E., Cutler, D. M., Leskovec, J., Mullainathan, S., & Obermeyer, Z. (2021). *An algorithmic approach to reducing unexplained pain disparities in underserved populations.* Nature, 27(1), 136–140. https://doi.org/10.1038/s41591-020-01192-7

Press, G. (2020, April 27). *12 AI Milestones: 4. MYCIN, An Expert System For Infectious Disease Therapy*. Forbes. www.forbes.com/sites/gilpress/2020/04/27/12-ai-milestones-4-mycin-an-expert-system-for-infectious-disease-therapy/?sh=4d29c1f76e51

Racial Bias in Health Care Artificial Intelligence. (2021, September 30). NIHCM. https://nihcm.org/publications/artificial-intelligences-racial-bias-in-health-care

Talby, D. (2021, April 28). *The Current State Of The Healthcare AI Revolution*. Forbes. https://www.forbes.com/sites/forbestechcouncil/2021/04/28/the-current-state-of-the-healthcare-ai-revolution/?sh=2c8c0e0d2980

Townson, S., & Zeltkevic, M. (2023, June 30). *AI bias may be easier to fix than humanity's.* The World Economic Forum. www.weforum.org/agenda/2023/06/why-ai-bias-may-be-easier-to-fix-than-humanity-s/

Tyson, A., Pasquini, G., Spencer, A., & Funk, C. (2023, February 22). *How Americans View Use of AI in Health Care and Medicine by Doctors and Other Providers*. Pew Research Center. https://www.pewresearch.org/science/2023/02/22/60-of-americans-would-be-uncomfortable-with-provider-relying-on-ai-in-their-own-health-care/

Literary Review

Applications of Artificial Intelligence in Healthcare

Hana Ahmed, Charlotte Lungren (advisor), Anika Shah (advisor)
St. Christopher's School, Bahrain

Introduction

Artificial intelligence is the new buzzword and just like the internet took everything by storm, AI will also do the same. AI is the intelligence demonstrated by machines. It is the ability of computer systems to learn, to reason, to infer and use the information in order to carry out a range of activities. As we move forward into a more connected digital world, using AI in the healthcare sector will become an invaluable asset and reshape how doctors treat patients and deliver care. In this article I will be discussing how Artificial intelligence is playing and will continue to play a crucial role in the healthcare sector.

Discussion

Telehealth

Telehealth is a type of AI that allows people to connect with medical professionals via their devices. It includes access to patient portals, video and phone appointments, accessible health records, and much more. Its use surged during the COVID-19 pandemic since it slowed down the COVID-19 transmission by keeping doctors and patients out of waiting rooms and healthcare facilities. Moreover, it allowed non-COVID-related patients to continue receiving care, which was particularly beneficial for at-risk older people during the pandemic. Studies show that the use of virtual care now is 38 times higher than before the COVID-19 pandemic. Likewise, a German study involving 2,700 doctors and nurses, thought telehealth during the COVID-19 pandemic was high in its level of positive impact throughout the medical field.

Medical Research

AI is being widely used in medical research as researchers are able to assess vast amounts of patient outcome data to identify substances that are more likely to be effective against certain diseases. At the same time, they can also screen compounds that are safe for human consumption and cheap and easy to make. For example, Al can be used in drug discovery and development research, which is another aspect of healthcare. The process of creating new medications is expensive, time-consuming, and frequently requires years of study and clinical testing. Al's ability to analyze and anticipate the efficacy and safety of medicinal substances allows them to speed up this procedure.

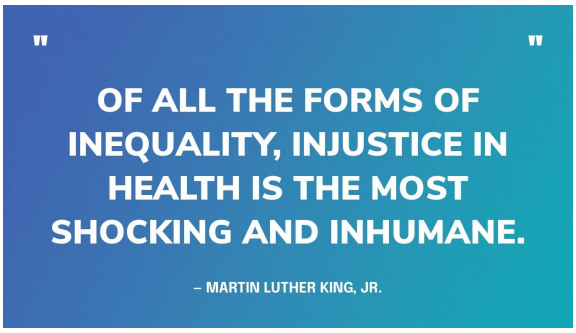
Radiology

AI technology is being extensively used by radiologists as they are able to add more confidence to their diagnosis. The machinery used eases their work as it enhances image analysis for practicing radiologists. These models formed by the AI technology offer radiologists a second opinion regarding analysis and they may even point out anomalies that may not be obvious to the naked eye.

Personalized Treatment plans

Another application of AI in healthcare is in the development of personalized treatment plans. To find the best course of treatment, AI systems can examine a patient's medical background, genetic information, and other data. This can result in more precise and efficient treatments, lowering the possibility of adverse outcomes and enhancing patient results.

AI in healthcare in developing countries



Artificial intelligence can also help people who don't have access to efficient healthcare systems in developing countries. Majority of poor nations struggle and lack access to basic healthcare systems and services. The world health organization estimates that the 18 year difference in life expectancy seen between the world's richest and poorest countries is caused by insufficient or no access to healthcare. With effective use of AI technology, these disadvantaged places can benefit as there are programs specifically designed to support cooperation among international and national healthcare groups in providing individuals in need with the aid they require without them having to travel.

Conclusion

In summary, although the use of AI in healthcare is still in its early stages, it has the potential to completely change how we approach patient care, diagnosis, and treatment as it has the ability to transform healthcare and improve patient outcomes.

Sources Cited

Artificial Intelligence in Healthcare - AI Applications & Uses. (2023, March 29). Intellipaat. Retrieved June 29, 2023, from https://intellipaat.com/blog/artificial-intelligence-in-healthcare/?US#no16

Bresnick, J. (2018, October 30). *Top 5 Use Cases for Artificial Intelligence in Medical Imaging*. HealthITAnalytics. Retrieved July 4, 2023, from https://healthitanalytics.com/news/top-5-use-cases-for-artificial-intelligence-in-medical-imaging

Flynn, S. (2022, September 30). *10 top artificial intelligence (AI) applications in healthcare*. VentureBeat. Retrieved June 29, 2023, from https://venturebeat.com/ai/10-top-artificial-intelligence-ai-applications-in-healthcare/

Pifer, R. (2021, July 12). *Telehealth use stabilizing at 38 times pre-COVID-19 levels, McKinsey says*. Healthcare Dive. Retrieved July 2, 2023, from https://www.healthcaredive.com/news/telehealth-use-stabilizing-at-38-times-pre-covid-19-levels-mckinsey-says/603153/

Sienel, R., & Jing, J. (n.d.). *Artificial intelligence in the healthcare sector – A few brief examples - qinnovativ medtech*. Qinnovativ. Retrieved July 4, 2023, from https://qinnovativ.de/artificial-intelligence-in-the-healthcare-sector/

Uneven access to health services drives life expectancy gaps: WHO. (2019, April 4). World Health Organization (WHO). Retrieved July 4, 2023, from https://www.who.int/news/item/04-04-2019-uneven-access-to-health-services-drives-life-expectancy-gaps-who

Literary Review

Implications of AI in Cancer

Iman Iqbal, Charlotte Lungren (advisor), Anika Shah (advisor)
Clements High School

Abstract:
Artificial Intelligence is a powerful tool in various different parts of healthcare, and this includes the field of cancer research care. Its numerous applications will be discussed in this article, as well as its potential future positive and negative implications. Overall, AI holds great promise in revolutionizing cancer detection, treatment, and research, but these advancements come with challenges that cannot be left unaddressed.

Introduction:

"AI will transform medicine. It will have an enormous impact. It will empower physicians and enable them to better focus on their patients" (Topol).

In the seemingly impossible battle against cancer, artificial intelligence has emerged as a transformative force. What knowledge previously took humans numerous years of education to attain can now be regurgitated in seconds by AI systems. In its early stages, artificial intelligence was trained to differentiate between seemingly disparate categories, such as distinguishing images of brown dogs with curly fur from those of fried chicken. Now, artificial intelligence has shown remarkable performance in analyzing far more complex images. These major advancements in AI are slowly allowing doctors and scientists to push the boundaries of current medical knowledge, especially in the field of oncology. Its most significant impact can be observed in the increased accuracy and efficiency of cancer research, diagnosis, and treatment strategies, as AI has the ability to analyze vast amounts of data and identify patterns that were perhaps previously undetectable by the human eye. From early detection to precision medicine, artificial intelligence has the capacity to revolutionize the entirety of the cancer care continuum and optimize patient outcomes.

Discussion:

AI in Early Detection and Diagnosis

AI can now assist in the early detection of various cancerous cells and lesions through analyzing mammograms, CT scans, MRIs, and tissue samples. This includes numerous types of cancer such as breast, lung, prostate, skin, and brain cancer, showing how advantageous AI can be in radiomics. It can, in fact, even increase the accuracy of cancer detection because it has the ability to identify patterns and anomalies in these medical images that may have been too subtle for humans to recognize. There are several instances of AI already making noteworthy impacts. A study published in Nature Medicine found that an AI algorithm developed for breast cancer detection demonstrated a 94.5% sensitivity, surpassing the average sensitivity of 88.2% among

human radiologists. Another study published in The Lancet Oncology reported that AI-based algorithms analyzing CT scans were able to detect lung cancer at an earlier stage with a higher accuracy rate compared to traditional methods. It can also detect specific biomarkers associated with different types of cancers which only helps cancer diagnosis be more targeted and efficient. It can help reduce both false positives and negatives regarding cancer diagnosis, helping reduce unnecessary invasive procedures while simultaneously calling attention to patients who require further scrutiny. Additionally, artificial intelligence has been observed to have exponential progress. Thus, by continuously learning from vast datasets and through the integration of multiple data sources, such as medical images, patient history, and genetic information, AI systems can continue to diagnose cancer with even more alarming accuracy.

AI in Personalized Treatment

As mentioned previously, AI algorithms have the ability to analyze diverse patient data, ranging from genomics, imaging, clinical records, and more. This can not only help in cancer detection and diagnosis but also assist in personalizing cancer treatment plans for individuals based on their unique traits and circumstances. AI can use specific genetic mutations or biomarkers to target therapies for different types of cancer, and it can also help predict the consequences and possible side effects of these treatments, providing adjustments accordingly. Moreover, precision in radiation therapy planning is and will continue to be greatly improved due to AI's aid in optimizing treatment delivery while minimizing radiation exposure to healthy tissue. Besides predicting treatment responses, AI algorithms can also estimate prognosis and survival rates, which can help patients and healthcare professionals make more informed decisions. The Mayo Clinic implemented an AI-driven algorithm called the Patient Journey Analytics, which successfully reduced the average length of hospital stays by 25%, according to a study published in The BMJ. A similar AI-powered clinical decision support system, IBM Watson for Oncology, was utilized to provide treatment recommendations based on patient data, medical literature, and clinical guidelines, and help oncologists make informed decisions about treatment options. Along with creating specialized treatments, AI support systems also have the ability to assist in monitoring treatments and any potential disease progression, as well as providing these cancer patients with the support and resources necessary for their needs. For example, AI's assistance with chemotherapy management can allow for the constant monitoring of drug interactions, patient characteristics, and treatment response at a level that healthcare professionals would not be able to achieve otherwise.

AI in Cancer Research

AI systems can not only analyze vast amounts of data to detect and treat cancer, but also to research its origins. Through analyzing scientific literature, research papers, and clinical trial data at a massive scale, AI can continue to identify relevant patterns in cancer research and assist in the characterization and classification of cancer cells and tissues to help researchers as well as pathologists come to conclusions at a more efficient rate. These pathologists can then collaborate with other healthcare professionals, such as oncologists and surgeons, to guide treatment decisions and contribute to patient care. AI can also aid in the discovery of biomarkers for

different types of cancer and novel drug combinations. In other words, it can stimulate the effects of different drugs, which accelerates the drug discovery process for cancer researchers and reduces the immense time and resources that would be needed otherwise. By screening existing drugs and identifying potential new uses and combinations for cancer treatment, AI helps increase treatment options for patients. Additionally, as AI powered systems have the ability to compile and integrate data from various sources quickly, they help facilitate a comprehensive understanding of cancer biology for cancer researchers on a global scale. The availability of AI as a resource fosters an increase in knowledgeable individuals, leading to enhanced research opportunities in the field of cancer. The reciprocal relationship between AI and researchers enables them to mutually benefit from each other's strengths, thereby advancing the progress in cancer research.

Ethical Considerations and Challenges

As AI is still a relatively new concept, it's only natural that many people are apprehensive of its capabilities. In order to harness its power responsibly and efficiently, it is crucial that healthcare professionals involved with AI implementation possess the necessary competence, training, and knowledge to understand the strengths, limitations, and potential biases of AI systems. The automation of certain tasks through AI may lead to job displacement of healthcare professionals, so while AI can enhance efficiency, it is important to consider the potential impact on the workforce and ensure that appropriate training and support is provided for professionals to adapt to evolving roles. In addition, regularly assessing the performance, reliability, and safety of AI algorithms to ensure they meet standards and expectations is absolutely necessary. Furthermore, despite its benefits, AI can come with a plethora of its own challenges that need to be addressed. Foremost among these are privacy and security, and bias and fairness. For AI to do its job efficiently, it requires access to sensitive healthcare data, including patient records, medical images, and genetic information. This raises concerns about unauthorized access, potential misuse, and data breaches. This is why protecting patient data and ensuring confidentiality when using AI that analyzes sensitive medical data is crucial. Additionally, AI can have biases due to various factors such as training data bias or a lack of diversity in development teams. One study that illustrates the presence of bias in AI systems is the Gender Shades project conducted by Joy Buolamwini, a researcher at the MIT Media Lab. The Gender Shades study found that facial recognition systems from prominent technology companies exhibited higher error rates in classifying the gender of darker-skinned and female faces compared to lighter-skinned and male faces by up to 35%. In the context of cancer, if the training data for an AI system is not diverse or representative of different populations, it can lead to biased predictions, diagnoses, or treatment recommendations that disproportionately impact certain groups. It is vital that biases like such are addressed and avoided, through ongoing research and evaluation, and that equitable access to AI-driven cancer care, especially for underserved populations, is guaranteed. "Artificial intelligence has the potential to democratize healthcare by bridging the gap between expert knowledge and underserved populations, leading to more equitable access to quality care" (Shah).

Future Implications and Direction

Future implications of AI in cancer are still unfolding, and there are many further applications of AI that can be implemented through continuous research, development, and ethical considerations. For example, AI-assisted surgical platforms, including robotic surgery and image-guided interventions may become more advanced. This could minimize invasiveness and enhance surgical precision, therefore improving patient safety. AI algorithms may also come to more precisely analyze real-time imaging data during surgery, providing guidance and assistance to surgeons who need to make quick yet informed decisions. Additionally, as data sharing and collaboration becomes more enhanced, AI can facilitate the secure sharing and analysis of healthcare data across institutions. This collective data can allow for large-scale studies that include diverse patient populations and a more comprehensive understanding of cancer. However, while AI in cancer care does hold great promise, there are potential negative implications to consider. As reliance on AI increases on a massive scale, critical evaluation by healthcare professionals may be compromised. AI systems should predominantly only assist in decision-making, but final treatment decisions should be made in collaboration between patients and their healthcare providers so individual circumstances and preferences are taken into account. On the same note, the lack of direct human interaction between healthcare providers and patients may be worrisome. AI can certainly enhance efficiency and accuracy, and help mitigate human error in the grave context of cancer, but it is important to strike a balance between human empathy and personalized care for patients. "Artificial intelligence in healthcare is not a replacement for physicians; it's an augmentation of human expertise" (Li).

Conclusion:

The integration of artificial intelligence into cancer research and care has brought about significant advancements and will continue to do so in the future. From early detection to personalized treatment, AI has demonstrated its ability to enhance accuracy, efficiency, and patient outcomes. By leveraging the power of machine learning, data analysis, and predictive modeling, AI enables precise diagnosis, optimal treatment selection, and improved prognostic capabilities. Despite the many advantages, ethical issues and difficulties must be carefully considered. To guarantee patient confidentiality and equal access to AI-driven technology, strong frameworks and rules are needed to address privacy and security concerns as well as potential biases. Additionally, the involvement of healthcare professionals in the integration of AI is still crucial because effective interpretation and use of AI-generated insights depend on human skill and judgment. By harnessing the power of AI, we can advance our understanding of cancer, improve patient outcomes, and ultimately work towards a future where cancer is better controlled and managed.

Sources:

Bera K;Braman N;Gupta A;Velcheti V;Madabhushi A; (n.d.). ***Predicting cancer outcomes with radiomics and artificial intelligence in Radiology*****. Nature reviews. Clinical oncology. https://pubmed.ncbi.nlm.nih.gov/34663898/**

Bi WL;Hosny A;Schabath MB;Giger ML;Birkbak NJ;Mehrtash A;Allison T;Arnaout O;Abbosh C;Dunn IF;Mak RH;Tamimi RM;Tempany CM;Swanton C;Hoffmann U;Schwartz LH;Gillies RJ;Huang RY;Aerts HJWL; (n.d.). ***Artificial Intelligence in cancer imaging: Clinical challenges and applications*****. CA: a cancer journal for clinicians. https://pubmed.ncbi.nlm.nih.gov/30720861/**

K;, Z. K. (n.d.). ***Artificial Intelligence: Opportunities in lung cancer*****. Current opinion in oncology. https://pubmed.ncbi.nlm.nih.gov/34636351/**

Niu PH;Zhao LL;Wu HL;Zhao DB;Chen YT; (n.d.). ***Artificial Intelligence in gastric cancer: Application and future perspectives*****. World journal of gastroenterology. https://pubmed.ncbi.nlm.nih.gov/33024393/**

O;, B. B. C. N. (n.d.). ***Artificial Intelligence in Cancer Research and Precision Medicine*****. Cancer discovery. https://pubmed.ncbi.nlm.nih.gov/33811123/**

Ostherr, K. (2022, June). ***Artificial Intelligence and medical humanities*****. The Journal of medical humanities. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9242900/**

O'connor, A. (2019, March 11). ***How artificial intelligence could transform medicine*****. The New York Times. https://www.nytimes.com/2019/03/11/well/live/how-artificial-intelligence-could-transform-medicine.html**

Shah, P. (n.d.). ***How ai is making it easier to diagnose disease*****. Pratik Shah: How AI is making it easier to diagnose disease | TED Talk. https://www.ted.com/talks/pratik_shah_how_ai_is_making_it_easier_to_diagnose_disease?language=en**

Literary Review

AI in Drug Discovery: Revolutionizing the Search For Novel Treatments

Jenny Wu, Charlotte Lungren (advisor), Anika Shah (advisor)
Hsinchu County American School

Abstract

This article emphasizes how artificial intelligence (AI) has revolutionized drug research. AI algorithms improve drug repurposing and de novo drug design by evaluating enormous amounts of data, enabling quicker and more effective identification of new candidates. Successful applications show enhanced virtual screening, image analysis, data integration, and protein structure prediction. Despite its shortcomings, AI has advantages over traditional methods in terms of effectiveness and success rates. The use of AI in drug discovery has a lot of potential for overcoming current obstacles and promoting innovation in the field of pharmaceutical research.

Introduction

From historical records found on ancient clay tablets that offer valuable insights into the early use of natural products, to the involvement of high-end technology like nuclear magnetic resonance (NMR) in drug discovery, the process remains a complex challenge. Through the focused refinement of technological progress and the integration of artificial intelligence (AI), there is a promising opportunity to surpass current constraints and accelerate the exploration and creation of novel pharmaceutical drugs, including those needed to combat global health crises like the COVID-19 pandemic. This, in turn, has the potential to bring about significant benefits for patients across the globe. Researchers have developed a generative AI model capable of designing novel molecules to block SARS-CoV-2, the virus that causes COVID-19, according to Science Advances (AAAS). As technology rapidly advances, AI poses a question in the field of healthcare: Do the advantages of AI outweigh the disadvantages, justifying its inclusion and integration in drug discovery?

Discussions

Limitations of Traditional Drug Discovery

While humans have made phenomenal advancements in discovering new pharmaceutical drugs to treat illnesses, there are intrinsic challenges that researchers face. The process of drug discovery has been a

complex and arduous venture. Target identification, chemical screening, preclinical and clinical trials, and regulatory approvals are a few of the processes that must be completed before a medicine may be commercialized. These phases can take an extended period and require an abundance of resources; they frequently last for more than a decade and are fairly costly. Additionally, only a small percentage of potential pharmaceuticals succeed in reaching the market due to the high failure rate of drug candidates throughout development. Finding the disease's mechanisms is one of the biggest hurdles. On the other hand, the traditional trial and error method in the early stages of drug discovery has been proven to be laborious and inefficient. The process of screening extensive collections of compounds to find potential drug candidates can be overwhelming and often resulting in low success rate. Moreover, this method fails to consider certain categories of compounds that could potentially possess therapeutic properties. Consequently, the process of traditional drug discovery is often defined as “costly, inauspicious, and ineffective.” To tackle these obstacles, scientists are progressively embracing cutting-edge technologies such as AI to revolutionize the field of drug discovery. The ability of AI algorithms to examine vast quantities of data, detect complex patterns, and make predictions is crucial for identifying novel drug candidates, improving trial procedures, and repurposing existing treatments. By utilizing AI's capabilities, researchers can accelerate the drug discovery process, improve success rates, and develop safer and more effective medicines. According to The Actuary Magazine, “Most experts expect AI tools to become more prevalent and more frequently used in the drug discovery process, thereby leading to quicker, cheaper and more effective drug discovery.” Although AI has its drawbacks, such as algorithm-dependent predictions in the 'gray zone' of interpretation, potential algorithm bias affecting objectivity, and the need for human scientist verification, it has proven its place in drug discovery as a great assistant alongside human expertise.

Drug Repurposing

Drug repurposing is the first stage of the drug development flow that pinpoints new substances with strong potential to fight a targeted disease, according to Altexsoft. Through data mining and analysis, drug-target prediction, virtual screening, side effect prediction, clinical trial design optimization, medication combination prediction, and personalized medicine, AI plays a crucial role in drug repurposing. AI is able to predict drug efficacy, swiftly screen drugs against a variety of targets, evaluate drug safety profiles, optimize clinical trial designs, suggest synergistic drug combinations, and personalize treatment plans based on patient-specific data by analyzing enormous amounts of data. Drug repurposing includes coming up with novel uses for already-approved medications, experimental treatments, and unapproved drug prospects. By relying on the safety of substances that have previously been proven, this method minimizes the development process. The success rate of repurposed

pharmaceuticals is about 30%, which is significantly higher than the 10% success rate of conventional methods. In the past, finding new targets for medicines that already existed was frequently an accident or was based on theories, like in the instance of Viagra, which Pfizer first developed to treat angina but later repurposed to treat erectile dysfunction as a result of an unforeseen side effect. By leveraging knowledge graphs and graph neural networks, AI is essential in enabling researchers to investigate polypharmacology and forecast unidentified relationships, offering insightful data for efforts to repurpose drugs.

De Novo Drug Design

De novo drug design is a methodology that creates novel chemical entities based only on the information regarding a biological target (receptor) or its known active binders. (Varnavas D. Mouchlis et al., 2021) De novo design uses AI techniques to accelerate the discovery and design of molecules and materials by combining various computational approaches. Predicting the properties of molecules or materials is made possible through the use of machine learning or deep learning algorithms. The discovery of molecules that display particular desirable traits is made possible by these models, which learn patterns from training data comprising molecular descriptors, physicochemical characteristics, and structural aspects. Researchers can choose potential candidates for additional study based on traits like drug-likeness, bioactivity, or material performance with the help of these predictive capabilities. By using acquired information from current datasets to produce completely new and previously undiscovered chemical or material structures, generative models like generative adversarial networks (GANs) and variational autoencoders (VAEs) contribute to de novo design. These models capture underlying patterns and correlations by training on vast databases of well-known structures, and they can produce novel structures that follow chemical laws and limitations. By enlarging the design area, this presents special opportunities for creating molecules or materials with desired qualities. In order to efficiently explore the enormous chemical or material, AI optimization methods are essential. These algorithms explore through the possibilities of combination and configuration of atoms, functional groups, or building blocks using a variety of search techniques, such as evolutionary algorithms, genetic algorithms, or Monte Carlo methods. They direct the design process and choose the most viable candidates for experimental validation by optimizing particular characteristics or goals, such as stability, reactivity, or efficacy. Since optimization is iterative, molecule or material structures can be improved and refined over time, incrementally enhancing desired attributes or resolving particular design limitations. AI-enabled virtual screening is another useful de novo design method. It is possible to computationally filter huge databases of molecules or materials to find prospective candidates that have the needed attributes. Huge amounts of data can be rapidly analyzed and filtered through by AI algorithms, which helps to focus the search on the most promising choices. Before experimental validation, virtual screening serves as a helpful

pre-screening phase that considerably cuts down on the time and expense needed to find viable candidates. AI helps with design optimization when used in de novo design. It can make knowledgeable recommendations for changing or combining structural elements to improve desired qualities or adhere to certain design constraints by integrating generative models, property prediction models, and optimization algorithms. Researchers can adjust chemical or material structures using this iterative optimization approach to accomplish the intended goals, resulting in the development of novel compounds or materials with specialized features. In general, AI methods in de novo design provide strong computational tools for generative modeling, design optimization, and virtual screening. By utilizing these methods, scientists can hasten the discovery and creation of molecules or materials with exact features, enabling developments in a number of scientific areas like chemical synthesis, materials science, and drug discovery.

Successful Applications and Case Studies

DeepMind's AlphaFold

It can be challenging to determine protein structures using conventional techniques like X-ray crystallography and cryo-electron microscopy, which are essential for comprehending their function and creating medications. These methods demand a lot of time, energy, and resources, and they frequently have trouble adequately capturing the intricate 3D structure of proteins. Furthermore, some proteins are challenging to investigate experimentally using these techniques. However, the AI-driven system AlphaFold successfully handles these difficulties. The deep learning models and innovative AI algorithms used by AlphaFold were taught using enormous volumes of protein structural data. This large dataset's analysis allows AlphaFold to predict protein structures with remarkably high accuracy. The AI system has mastered the ability to spot relationships and patterns in the data, which enables it to produce precise models of protein structures. This method greatly shortens the prediction process, which in the past may take years to determine a single protein structure. The predictions provided by AlphaFold offer useful information for drug development and research. Scientists can better comprehend a protein's function and find possible therapeutic targets by knowing the structure of the protein. This information helps in the development of medications that interact with particular proteins and modify their function, resulting in the creation of more potent treatments. Drug discovery and the creation of novel therapeutics could be revolutionized by AlphaFold's ability to quickly and precisely anticipate protein structures using AI.

BenevolentAI

The AI platform from BenevolentAI uses machine learning techniques to combine and examine data from many biomedical sources. The platform uses AI algorithms to automatically sift through enormous volumes of data rather than merely relying on manual inspection and sparse data integration. Thus, it can spot trends, correlations, and patterns that humans might have missed otherwise. BenevolentAI can find possible therapeutic concepts and insights that could result in the creation of effective medicines thanks to its automated analysis. The platform from BenevolentAI uses AI to solve the drawbacks of conventional drug development methods. The platform can effectively and efficiently process massive amounts of data by utilizing machine learning techniques. It can identify novel relationships, find links between various datasets, and produce fresh drug discovery hypotheses. This AI-driven method speeds up the drug discovery process and may help identify interesting candidates much more quickly than using conventional techniques. By revealing the depth of knowledge concealed within biomedical data, BenevolentAI's AI platform offers the ability to find effective medications. Researchers can make better conclusions and discover new therapeutic options by utilizing AI's capabilities, which solve the shortcomings of manual review, biases, and data restrictions. The use of AI in the drug development process has the potential to advance research, increase the likelihood of developing successful therapies, and ultimately aid people who are in need.

Atomwise

The computer analysis of molecular structures is a common practice in the traditional drug discovery process. These techniques create predictions about the interactions between chemicals and target proteins using physics-based models or chemical principles. These methods, however, have downsides because they rely on simplified approximations that may leave out treatment options. Atomwise, an AI and deep learning-focused biotechnology company that specializes in drug discovery. on the other hand, adopts a different strategy by using virtual screening powered by AI and deep learning models to evaluate chemical structures. Atomwise circumvents the drawbacks of conventional techniques by training their models on substantial datasets. Atomwise can increase prediction accuracy by using AI because of its capacity to recognize intricate patterns and connections in data. The effectiveness of virtual screening is increased by AI's better capacity to predict the binding affinities of compounds to target proteins. Accordingly, Atomwise can find compounds that are more likely to interact with the target proteins in a desirable manner, which raises the possibility that they will be effective therapeutic choices.

Insilico Medicine

The AI platform from Insilico Medicine combines the potency of GANs with reinforcement learning to create and optimize distinctive chemical compounds with desired attributes for particular therapeutic targets. In order to create novel compounds with the potential to have the desired therapeutic effects, GANs are used. The quality of these created compounds is then assessed using reinforcement learning, a method that employs iterative optimization and refinement to improve the compounds. Insilico Medicine can more effectively and efficiently explore the chemical space by employing AI. The drug development process is considerably accelerated by AI algorithms' fast generation and evaluation of many molecules. This enables scientists to find prospective therapy possibilities that might not have been found using traditional trial-and-error techniques. The strategy taken by Insilico Medicine benefits from the application of AI in a number of ways. First, since AI algorithms can quickly develop and assess chemical compounds, it saves time and money compared to the traditional trial-and-error method. This quickening of the drug discovery process may enable the quicker identification of qualified candidates. Additionally, Insilico Medicine may investigate a wider variety of chemical spaces by utilizing AI approaches, improving the probability of discovering new and potent medication candidates. The possibility of finding compounds with advantageous features for particular therapeutic targets is increased by the ability to scan a larger chemical space. In summary, Insilico Medicine revolutionizes the drug discovery process by expediting the search for promising therapeutic options. This is made possible by the application of AI, notably GANs and reinforcement learning. Insilico Medicine can more effectively explore the enormous chemical space by utilizing AI algorithms, cutting down on the time, money, and resources needed for drug development. This AI-driven methodology has a lot of potential for developing novel, efficient treatments for a range of ailments. Traditional drug discovery methods rely on manual interpretation of cellular and molecular images, which takes time and is subject to human bias. Automation and AI are used by Recursion Pharmaceuticals to get beyond these limitations. AI systems examine high-resolution cellular images, collecting valuable information on cellular and molecular interactions on a huge scale. By automating image analysis, Recursion Pharmaceuticals can uncover promising disease-modifying medications with ease. Researchers can now analyze enormous numbers of pictures and extract relevant data in a fraction of the time it once took them to do so using human procedures thanks to AI's expediting capabilities.

Recursion Pharmaceuticals

To understand how medications interact with cells and molecules, scientists manually evaluate photographs of cellular and molecular structures in traditional drug discovery approaches.

However, this procedure takes a while and is susceptible to bias on the part of the user. Recursion Pharmaceuticals uses automation and AI techniques to get around these constraints. High-resolution cellular photos can be examined using AI methods that Recursion Pharmaceuticals has created. These algorithms efficiently and automatically extract important information regarding cellular and molecular interactions. Recursion Pharmaceuticals can quickly find possible disease-modifying medications by automating the study of these photos. There are various advantages of using AI for picture analysis. First off, the process of finding new drugs is greatly accelerated. In a fraction of the time needed by manual procedures, researchers can analyze massive amounts of photos and extract useful data. They can investigate a wider range of medication candidates and swiftly spot interesting options thanks to this faster analysis. Additionally, AI-based analysis lessens the possibility of prejudice on the part of humans. Recursion Pharmaceuticals can get objective and reliable results from the image analysis process by relying on algorithms rather than arbitrary human interpretation. This raises the validity of their findings and the likelihood that potent disease-modifying medications will be discovered.

Conclusion

Through applications like medication repurposing and de novo drug design, AI has considerably revolutionized the field of drug research. In drug repurposing, massive datasets are analyzed by AI algorithms to forecast therapeutic efficacy, screen candidates, improve trial designs, and tailor treatment plans. This uses less resources than conventional approaches and yields higher success rates. De novo drug design, which expands the design space and speeds up development, uses AI to generate novel compounds based on biological targets using generative models and optimization algorithms. AI has been successfully used in drug discovery by companies like DeepMind's AlphaFold, BenevolentAI, Atomwise, Insilico Medicine, and Recursion Pharmaceuticals, modernizing procedures including protein structure prediction, biomedical data integration, virtual screening, and image analysis. The use of AI in drug creation has the potential to increase success rates, lower costs, and create safer medications. Although AI has its limitations, its benefits in efficiency and discovery surpass these drawbacks, making it a field tool that is becoming increasingly vital to advancing healthcare.

References

AltexSoft. (2022, August 27). *Ai in drug discovery and repurposing: Benefits, approaches, and use cases*. AltexSoft. https://www.altexsoft.com/blog/ai-drug-discovery-repurposing/

Barrie, R. (2023, May 9). *Recursion plans $87.5m acquisitions to shore up AI drug discovery -*. Pharmaceutical Technology. https://www.pharmaceutical-technology.com/news/recursion-plans-87-5m-acquisitions-to-shore-up-ai-drug-discovery/

Benevolentai unveils strategic plan to position the company for a new era in Ai. Business Wire. (2023, May 25). https://www.businesswire.com/news/home/20230524005926/en/BenevolentAI-Unveils-Strategic-Plan-to-Position-the-Company-for-a-New-Era-in-AI

Buntz, B. (2023, May 3). *Benevolentai exploring novel AI-Driven Drug Discovery Methods*. Drug Discovery and Development. https://www.drugdiscoverytrends.com/benevolentai-is-pioneering-ai-driven-drug-discovery-methods/

Dias, D. A., Urban, S., & Roessner, U. (2012, April 16). *A historical overview of natural products in Drug Discovery*. Metabolites. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3901206/#:~:text=The%20earliest%20records%20of%20natural,colds%20and%20inflammation%20%5B3%5D.

Editorial. (2021, April 12). *Ai in drug discovery - benefits, drawbacks, and challenges*. RoboticsBiz. https://roboticsbiz.com/ai-in-drug-discovery-benefits-drawback-and-challenges/

Field, H. (2023, June 29). *The first fully a.i.-generated drug enters clinical trials in human patients*. CNBC. https://www.cnbc.com/2023/06/29/ai-generated-drug-begins-clinical-trials-in-human-patients.html

Hagan, K. (2020, July 17). *Traditional drug development process*. The Actuary Magazine. https://www.theactuarymagazine.org/traditional-drug-development-process/#:~:text=Reasons%20for%20failure%20could%20be,funding%20to%20complete%20a%20trial.

Heller, S. R., Reker, D., Hammett, L. P., Salt, D. W., Goodfellow, I., Ching, T., Saleem, T. J., Weininger, D., Hochreiter, S., Vaswani, A., Rogers, D., Duvenaud, D., Kearnes, S., Coley, C. W., Feinberg, E. N., Lim, J., Gilmer, J., Smith, J. S., Faber, F. A., … Lyu, J. (2020, August 17). *Current methods and challenges for deep learning in Drug Discovery*. Drug Discovery Today: Technologies. https://www.sciencedirect.com/science/article/abs/pii/S1740674920300081?via%3Dihub

Insilico Medicine successfully explores the advantages of quantum generative adversarial networks in Generative Chemistry. United States. (2023, May 17). https://www.prnewswire.com/apac/news-releases/insilico-medicine-successfully-explores-the-advantages-of-quantum-generative-adversarial-networks-in-generative-chemistry-301827125.html

Kennedy, S. (2023, June 29). *Generative AI may accelerate drug discovery for COVID antivirals*. HealthITAnalytics. https://healthitanalytics.com/news/generative-ai-may-accelerate-drug-discovery-for-covid-antivirals

ltd, R. and M. (2023, January). *Drug Discovery Technologies: Global Strategic Business Report*. Research and Markets - Market Research Reports - Welcome. https://www.researchandmarkets.com/reports/347959/drug_discovery_technologies_global_strategic?utm_source=GNOM&utm_medium=PressRelease&utm_code=3gjb4r&utm_campaign=1674436%2B-%2BGlobal%2BDrug%2BDiscovery%2BTechnologies%2BMarket%2BReport%2B2022%3A%2BMarket%2Bto%2BReach%2B%2480.2%2BBillion%2Bby%2B2026%2B-%2BLate-Stage%2BDrug%2BFailures%2BDrives%2BDemand%2Bfor%2BDrug%2BDiscovery%2BTechnologies&utm_exec=chdo54prd

Mabey, B., Alfa, R., & Matsumoto, C. (n.d.). Recursion pharmaceuticals case study | google cloud. Google. https://cloud.google.com/customers/recursion

Recursion accelerates drug discovery with new data ... - confluent. Recursion Accelerates Drug Discovery with New Data Pipelines Based on Confluent Cloud. (2020). https://assets.confluent.io/m/592ee9b1c81dd0f6/original/20191024-CS-Recursion_Pharmaceuticals.pdf

Smith, W. (2020, August 12). *How atomwise uses Artificial Intelligence for Drug Discovery*. Technology Magazine. https://technologymagazine.com/ai-and-machine-learning/how-atomwise-uses-artificial-intelligence-drug-discovery

Smyth, M. S., & Martin, J. H. (2000, February). *X ray crystallography*. Molecular pathology : MP. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1186895/

Sparkes, M. (2022, August 4). *DeepMind's protein-folding AI cracks biology's biggest problem*. New Scientist. https://www.newscientist.com/article/2330866-deepminds-protein-folding-ai-cracks-biologys-biggest-problem/

Waldron, J. (2022, August 17). *Sanofi signs $1.2B pact with atomwise in latest high-value AI Drug Discovery deal*. Fierce Biotech. https://www.fiercebiotech.com/biotech/sanofi-signs-12b-pact-atomwise-latest-high-value-ai-drug-discovery-deal

Literary Review

AI’s Ability to Personalize Medical Treatments

Kaitlyn Yainna (author), Charlotte Lungren (advisor), Anika Shah (advisor)
Capistrano Valley High School

Abstract:
Artificial intelligence (AI) has revolutionized the healthcare industry by enabling personalized medical treatments tailored to individual patients. Through advanced analytics, machine learning algorithms, and access to extensive patient data, AI can identify patterns and correlations that lead to personalized treatment strategies. This article explores the potential of AI in optimizing healthcare interventions, enhancing patient outcomes, and addressing the challenges of personalized care. Additionally, the role of real-time monitoring in conjunction with AI is examined, emphasizing its ability to track a patient's health status continuously and generate personalized medical plans based on real-time data analysis. However, ethical concerns surrounding data privacy, transparency, algorithmic bias, and the doctor-patient relationship need to be addressed to foster trust and acceptance of AI in healthcare. By addressing these concerns, AI has the potential to usher in a new era of patient-centered healthcare, transforming the way medical treatments are delivered and improving patient care

Introduction:
Artificial intelligence (AI) has quickly become a disruptive force in the healthcare industry, altering the way that individual individuals' medical treatments are tailored to them. Healthcare practitioners can now customize therapies in ways that were previously impossible because of the power of AI, which has given them unprecedented access to advanced analytics, machine learning algorithms, and massive volumes of patient data. The amazing potential of AI to personalize medical treatments is examined in this article along with its ability to optimize healthcare interventions, enhance patient outcomes, and address the difficulties of providing personalized care. AI's capacity to tailor medical treatments holds great potential for ushering in a new era of patient-centered healthcare, from patient profiling and precision medicine to real-time monitoring and adaptive interventions.

Discussion:

Patient Data Recognition:

Firstly, AI algorithms can identify patterns and correlations in patient data that may not be immediately apparent to human clinicians. This allows for the discovery of personalized treatment strategies tailored to specific patient characteristics. For example, AI can analyze genetic information to determine a patient's susceptibility to certain diseases or predict their response to different medications. By considering these factors, AI can assist healthcare providers in developing personalized treatment plans that maximize the likelihood of positive outcomes. AI algorithms have the remarkable ability to identify complex patterns and correlations in patient data that may not be immediately apparent to human clinicians. This is achieved through several key mechanisms. AI algorithms can process and integrate vast amounts of patient data from various sources, including electronic health records, medical imaging, genetic information, and real-time monitoring. By consolidating this diverse data, AI algorithms can uncover subtle relationships and patterns that may not be evident when considering individual data points in isolation. Additionally, AI algorithms utilize machine learning techniques to recognize and learn from patterns within the data. Through training on large datasets, these algorithms can identify hidden correlations, associations, and trends that humans may overlook. By detecting these patterns, AI algorithms can provide valuable insights into patient characteristics, disease progression, treatment responses, and potential risk factors. They can also perform complex data analysis, such as clustering, classification, and predictive modeling, to uncover intricate relationships within patient data. For example, they can identify clusters of patients with similar characteristics or predict the likelihood of certain outcomes based on specific variables. By analyzing multiple dimensions of patient data simultaneously, AI algorithms can reveal patterns that human clinicians might find challenging to identify due to the volume and complexity of the information. Deep learning algorithms, a subset of AI, employ artificial neural networks inspired by the human brain's structure and function. These networks can learn hierarchical representations of data, progressively extracting more abstract features and capturing intricate relationships within the data. This allows AI algorithms to detect nuanced patterns and correlations that may be deeply embedded within the patient data. This pattern recognition is key, as it is quick, the patient’s treatment plan develops much faster.

Real-Time Monitoring:

Real-time monitoring plays a crucial role in the creation of personalized medical plans for patients, especially when combined with artificial intelligence (AI) technologies. Real-time monitoring involves the continuous collection and analysis of data related to a patient's health status, such as vital signs, physiological parameters, and even behavioral patterns. This data is gathered using various sensors, wearables, and connected devices, allowing healthcare providers to gain valuable insights into a patient's condition and respond proactively. By leveraging AI algorithms and machine learning techniques, real-time monitoring enables the development of personalized medical plans tailored to each patient's specific needs. AI can analyze the vast amounts of data collected from the monitoring devices, identify patterns, and generate meaningful insights. These insights can include early warning signs, deviations from normal health parameters, or potential risks and complications. With this information, healthcare professionals can intervene promptly, make informed decisions, and adjust treatment plans accordingly. The advantages of real-time monitoring for AI in creating personalized medical plans are numerous. Firstly, it allows healthcare providers to track a patient's health in real-time, providing a comprehensive and up-to-date understanding of their condition. This continuous monitoring helps identify subtle changes that might not be apparent during intermittent check-ups, enabling early detection and intervention. Consequently, potential health issues can be addressed promptly, minimizing the risk of complications and improving patient outcomes. Secondly, real-time monitoring combined with AI facilitates the collection and analysis of large volumes of data, surpassing what traditional manual methods can achieve. AI algorithms can process this data rapidly, identifying correlations, trends, and predictive patterns that may not be evident to human observers. This enhanced analytical capability helps AI systems generate personalized medical plans that are tailored to an individual's unique health profile, considering factors such as genetic predispositions, lifestyle choices, and environmental influences. Furthermore, real-time monitoring enables remote patient care and telemedicine. Patients can wear wearable devices or use mobile applications that transmit their health data to healthcare providers in real-time, regardless of geographical location. This accessibility improves the continuity of care, especially for patients with chronic conditions or those who live in remote areas with limited access to healthcare facilities. AI algorithms can then process the data and generate personalized medical plans, which can be shared with the patient and their healthcare

team for ongoing monitoring and collaboration. In summary, real-time monitoring, when integrated with AI technologies, revolutionizes the creation of personalized medical plans. It empowers healthcare providers with timely and accurate information about a patient's health status, enabling proactive interventions and individualized care. With the ability to analyze vast amounts of data, AI algorithms can uncover patterns, predict outcomes, and generate tailored medical plans that consider an individual's unique health characteristics. As real-time monitoring continues to evolve, it holds tremendous promise for improving patient care, enhancing medical decision-making, and ultimately saving lives.

Patient-AI Trust:

As the integration of artificial intelligence (AI) in healthcare continues to expand, a critical question arises: Can patients trust AI with their treatment plans? Recent statistics shed light on patient perceptions and acceptance of AI in healthcare decision-making. According to a survey conducted by Accenture, 74% of patients express a willingness to use AI for personalized treatment recommendations. Additionally, a study published in the Journal of Medical Internet Research found that 72% of patients were comfortable with AI systems assisting healthcare providers in making treatment decisions. These statistics indicate a growing level of trust and acceptance among patients regarding AI's role in their treatment plans. However, it is essential to acknowledge that trust in AI varies across different demographic groups and medical contexts. A survey conducted by Rock Health revealed that while 59% of millennials were comfortable with AI-generated treatment plans, only 30% of baby boomers expressed the same level of trust. Furthermore, patient trust may be influenced by the specific medical condition or complexity of the treatment involved. For instance, a study published in JAMA Network Open found that patients were more willing to trust AI for radiology interpretations compared to surgical procedures. In conclusion, the statistics indicate a positive trend in patients' willingness to trust AI with their treatment plans. However, it is crucial to recognize that patient trust may vary among different demographic groups and medical contexts. As AI continues to evolve and demonstrate its effectiveness in improving healthcare outcomes, building patient trust through transparent and explainable AI systems, informed patient education, and open communication between healthcare providers and patients will be crucial for fostering a strong partnership between patients and AI in their treatment journey. Knowing that their doctors are verifying the accuracy of the outputs and recommendations produced by AI systems may make patients feel

more at ease. While AI can help healthcare professionals make treatment decisions and give insightful data, human oversight and knowledge are still necessary to guarantee patient safety and individualized care. Patients may feel more trusting and confident if there are doctors present who can critically assess and validate the data produced by AI systems. Doctors may make sure that the treatment plans adhere to their clinical judgment, the preferences of the patients, and the most recent medical guidelines by actively fact-checking the AI-generated recommendations. Doctors may validate the accuracy and suitability of AI-generated insights in the context of each patient's particular circumstances using this collaborative approach, where AI acts as a supportive tool rather than as a replacement for human decision-making. Knowing that their doctors are actively engaged in their care and utilizing their knowledge of medicine to supplement and verify the data offered by AI systems may reassure patients and improve the overall quality and safety of their healthcare experience.

Ethical Setbacks:

While the ability of AI to personalize medical treatments holds immense potential, it also raises ethical concerns that may lead to doubts and reservations among people. One ethical setback revolves around the issue of data privacy and security. AI algorithms require access to extensive patient data, including sensitive health information, to generate personalized treatment plans. However, ensuring the privacy and protection of this data becomes crucial to prevent unauthorized access, breaches, or misuse. Patients may be skeptical about sharing their personal information, fearing potential data breaches or loss of control over their sensitive medical data. Another ethical concern lies in the transparency and explainability of AI algorithms. Complex machine learning models may generate recommendations that are difficult to interpret or comprehend, making it challenging for healthcare providers to explain the rationale behind personalized treatment plans to patients. Patients may question the trustworthiness and reliability of AI-generated suggestions if they are unable to understand the underlying decision-making process. Additionally, algorithmic bias is a potential concern, as AI systems can inadvertently perpetuate or amplify existing biases in healthcare, such as disparities in treatment based on race, gender, or socioeconomic status. These biases may undermine the fairness and equity of personalized treatment plans and erode patient trust in AI. Furthermore, the role of AI in the doctor-patient relationship is another ethical consideration. Patients may worry about the potential dehumanization of healthcare interactions when AI plays a dominant role in treatment

decisions. The reliance on AI-generated recommendations may lead to a perceived lack of empathy or personalized care from healthcare providers, potentially undermining the patient's sense of trust and connection with their doctors. In summary, ethical setbacks associated with AI's ability to personalize medical treatments include concerns related to data privacy, transparency, algorithmic bias, and the potential impact on the doctor-patient relationship. These ethical considerations can contribute to people's doubts and hesitations about fully embracing AI in healthcare. Addressing these concerns through robust data protection measures, transparent AI algorithms, and maintaining the human element in healthcare interactions is crucial to fostering trust and acceptance of AI in personalized medical treatments.

Conclusion:

In conclusion, the integration of artificial intelligence (AI) in healthcare has the potential to revolutionize personalized medical treatments. AI algorithms can analyze patient data to identify patterns and correlations that may not be immediately apparent to human clinicians, enabling the development of personalized treatment strategies. Patient trust in AI is growing, although it can vary among different demographic groups and medical contexts. Real-time monitoring combined with AI allows for continuous tracking of a patient's health, early detection of changes, and proactive interventions. This integration also facilitates the collection and analysis of large volumes of data, surpassing manual methods, leading to the generation of tailored medical plans. However, ethical setbacks such as data privacy, transparency, algorithmic bias, and the impact on the doctor-patient relationship need to be addressed to build patient trust and acceptance of AI in healthcare. Yet, by educating the public on AI’s capability and ensuring it is fact checked, AI has the potential to enhance patient outcomes and usher in a new era of patient-centered, personalized care.

Works Cited:

Accenture Executive Survey on AI in Healthcare, UK. Accenture. (n.d.). https://www.accenture.com/gb-en/insights/health/ai-injecting-intelligence-into-healthcare

Artificial Intelligence and personalized medicine - PMC. (n.d.). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7580505/

HealthSnap, Inc. (2023, March 17). *Ai in healthcare: Trends we saw in 2022.* https://healthsnap.io/ai-in-healthcare-trends-we-saw-in-2022

Paranjape, K., Schinkel, M., & Nanayakkara, P. (2020, July 7). *Short Keynote Paper: Mainstreaming Personalized Healthcare–Transforming Healthcare Through New Era of Artificial Intelligence*. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7169508

Payne, A. (2020, September 22). *The role of AI in Advancing Personalized Healthcare*. TechRadar. https://www.techradar.com/news/the-role-of-ai-in-advancing-personalized-healthcare

Pennic, J. (2023, May 2). *45% of U.S. adults say AI in healthcare is trustworthy.* 45% of U.S. Adults Say AI In Healthcare Is Trustworthy. https://hitconsultant.net/2023/05/03/45-of-u-s-adults-say-ai-in-healthcare-is-trustworthy/

Schork, N. J. (2019). *Artificial Intelligence and personalized medicine.* Cancer treatment and research. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7580505/

Literary Review

Exploring Mental Health Chatbots

Leyan Al Dabbagh (Author), Charlotte Lungren (Advisor), Anika Shah (Advisor)

Abstract:
This paper explores and describes mental health chatbots, an emerging technology that is experiencing a noteworthy rise. The paper delves into the underlying mechanisms of mental health chatbots, investigating how they employ artificial intelligence and Natural Language Processing (NLP) techniques. It also examines the benefits of mental health chatbots and the potential they have to assist the mental healthcare field. Along with that, the paper discusses challenges associated with mental health chatbots and how important it is to address these concerns for the sake of the successful implementation of the technology.

Introduction:

Artificial Intelligence (AI) refers to intelligence demonstrated by machines that can perform tasks that usually would require human intelligence, such as speech recognition, problem-solving, and decision-making. With its high efficiency and profitability, it comes as no surprise that artificial intelligence is being implemented in numerous industries including healthcare. AI is being introduced to disease diagnosis, medical imaging, and branches of medicine such as radiology. We have also observed its integration into the mental health field with the rapidly growing therapy chatbots: computer programs created to provide mental health support. Mental health conversational agents have great potential; however, before integrating this highly compelling technology into the mental health field, further exploration is required. The substantial rise of therapy bots prompts certain questions: what is the technology behind mental health chatbots and what are the benefits and challenges associated with them?

Discussion:

Mechanism:

The infamous Turing Test was born after Alan Turing, a British computer pioneer, envisioned a future where a computer would have the ability to express itself similarly to humans (Bibault, J. E., Chaix, B., Nectoux, P., Pienkowski, A., Guillemasé, A., & Brouard, B. 2019). The creation responsible for therapy bots, Conversational Agents (CAs), is a software program that uses artificial intelligence to simulate a conversation with a user through text or voice. This same software is behind popular digital assistants such as Alexa, Siri, and Cortana. The first example of this technology used in healthcare was ELIZA, a program created by MIT professor Joseph Weizenbaum in the 1960s. As described by its creator, "ELIZA is a program which makes natural language conversation with a computer possible." ELIZA mimicked a Rogerian psychotherapist and provided the patient with prerecorded answers selected based on the user's input (Weizenbaum, J. 1966). In this day and age, Artificial Intelligence (AI) has enabled conversational agents to become a technology that we utilize daily. By using Natural Language Processing (NLP), a field of artificial intelligence, therapy bots are capable of imitating human conversation. NLP uses speech recognition, sentiment analysis, and optical character recognition to enable computers to understand and interpret human language (Graham, S. A., Lee, E. E., Jeste, D. V., Van Patten, R., Twamley, E. W., Nebeker, C., ... & Depp, C. A. 2020). Along with NLP, Sentiment Analysis (SA) plays a fundamental role in functioning therapy bots. SA is a process of categorizing views expressed in a part of the text as positive, negative, or neutral (Aqlan, A. A. Q., Manjula, B., & Lakshman Naik, R. 2019). Those two features ensure the flow of a sophisticated conversation with the chatbot. Empathetic engagement is also another critical design element of mental health chatbots. Empathetic engagement, or empathetic listening, combines active listening skills and empathy in order to understand someone more deeply, intellectually and emotionally (Gearhart, C. C., & Bodie, G. D. 2011). This allows the chatbot to act like a conversational partner who is actively listening to you. Although all users should be aware that they are indeed talking to a bot, these features certainly make the conversation a lot more comforting. One

example is when Woebot, a popular mental health chatbot, received a text about loneliness, it replied “I’m so sorry you’re feeling lonely. I guess we all feel a little lonely sometimes” (Fitzpatrick, K. K., Darcy, A., & Vierhile, M. 2017). Unlike older chatbots, modern mental health chatbots are not mere template phrases. Rather, they are designed under the supervision of medical professionals. Chatbots tend to surprise people with how less “robotic” the conversation is than they initially assumed. Moreover, the general functional framework of therapy bots is a methodology called Cognitive Behavioral Therapy (CBT), a type of therapy that helps patients alter their behavior by changing the way they think. CBT is the most extensively researched psychotherapy; it was also found to be effective for some psychiatric disorders such as depression, anxiety disorders, eating disorders, substance abuse, and personality disorders (Chand, S. P., Kuckel, D. P., & Huecker, M. R. 2022). This enables the bot to not only be a conversation partner, but also an effective tool for mental health support. Another notable mental health chatbot that uses CBT is Wysa. Other than CBT, Wysa also employs a variety of self-help practices such as dialectical behavior therapy, motivational interviewing, positive behavior support, and behavioral reinforcement, among others (Inkster, B., Sarda, S., & Subramanian, V. 2018).

Benefits:

Mental health disorders have been highly prevalent worldwide, significantly altering individuals and societies. According to the UNHCR, approximately more than 1 in 10 people are living with a mental health condition at any one time. These conditions include but are not limited to depression, anxiety disorders, bipolar disorder, schizophrenia, post-traumatic stress disorder (PTSD), and eating disorders. The global burden of mental health disorders is substantial yet treatment has been extremely deficient, especially in low- and middle-income countries. More than 75% of people in these countries receive no treatment, an article by WHO stated. This is due to a multitude of challenges such as the shortage of mental health professionals, the stigma associated with seeking help, and disparities in access to care. In lower-income countries, there are as few as 0.1 for every 1,000,000 people (Oladeji, B. D., & Gureje, O. 2016). This inadequacy in meeting the demand for mental healthcare has led to the proposal of

technology, particularly chatbots, as a solution (Vaidyam, A. N., Wisniewski, H., Halamka, J. D., Kashavan, M. S., & Torous, J. B. 2019). In regards to stigma, therapy is not yet normalized in many communities, and mental health chatbots definitely do provide a safe space for participants. Individuals who struggle to open up about their issues or those who are scared of judgment will surely feel immensely more comfortable utilizing therapy chatbots "AI-based psychotherapy might be an important option for people who experience public stigma and hold more embarrassment during face-to-face interactions with a human therapist." (Aktan, M. E., Turhan, Z., & Dolu, I. 2022) Another advantage to therapy chatbots is remote access to mental health support. Particularly during the COVID-19 pandemic and in isolated areas, face-to-face therapy can be difficult to access. This discourages people from going to therapeutic services. AI-based mental health chatbots provide remote access which increases the rate of participation. Furthermore, therapy bots are currently cheap to use, if not free. According to a survey done by Verywell Mind, cost remains one of the most significant barriers to accessing mental health support. Undoubtedly, therapy bots provide a great cost-effective solution. Finally, it is an obvious advantage to have a virtual therapist that is accessible 24/7, has endless patience, and never forgets what a patient has said (Fiske, A., Henningsen, P., & Buyx, A. 2019).

Challenges:

Utilizing artificial intelligence in mental health support tools poses a series of significant challenges and ethical considerations. To ensure successful and responsible implementation, these concerns must be accounted for and addressed appropriately. Two crucial ethical issues in the development of mental health chatbots are the privacy and security of personal data. As chatbots collect and store big amounts of personal data, private information must remain confidential. There is also a risk of security breaches, such as hacking attacks and data leaks, or data misuse. These concerns particularly cause individuals to stray away from online wellness services. Therefore, developers must ensure that chatbots comply with standards regarding confidentiality, information privacy, and secure management of data in order to adequately protect user information (Körtner, T. 2016). Bots malfunctioning or operating unpredictably is

also an issue that needs to be discussed. As mental health is a complex and sensitive field, inaccurate responses or sudden changes from a chatbot can have serious negative consequences for users' health and overall experience. Another ethical concern relates to the ability of mental health chatbots to handle risk assessment and crisis situations. AI-powered tools engaged in the mental health field will likely also need to be bound by similar ethical guidelines as those that bind mental health professionals (Fiske, A., Henningsen, P., & Buyx, A. 2019). However, how would an AI-powered chatbot refer an individual who, for example, is at high risk for self-harm to appropriate services? While chatbots are arguably better than nothing, they cannot replace human intervention in severe crisis situations. Thus, it is important for chatbots to have crisis detection systems and provide clear information about the scope and limits of their support, redirecting users to mental health professionals when necessary. It is also necessary to note that the algorithms behind AI are vulnerable to existent human biases built into them. This means that mental health chatbots could potentially reinforce inequality. Inherent biases in algorithms can lead to discriminatory responses (e.g. racism or sexism) for certain user groups. There is also the worry that the use of AI-incorporated mental healthcare tools could be a justification for replacing established services (Fiske, A., Henningsen, P., & Buyx, A. 2019). It is therefore crucial to make it known that AI mental health services are not a substitute for therapy, at least currently.

Conclusion:

Therapy chatbots are rapidly growing in the mental health field. However, before utilizing this technology in our daily lives, it is essential to know its functionality, benefits, and associated challenges. Mental health chatbots are computer programs or applications that utilize artificial intelligence and natural language processing to interact with users regarding their mental health. These chatbots typically use cognitive behavioral therapy among other evidence-based techniques to help users manage their mental well-being. Certainly, the rise of artificial intelligence in our daily lives has highlighted the potential for therapy bots to address some obstacles faced in the mental healthcare field. These challenges include a shortage of mental health professionals, the stigma associated with therapy, and inaccessibility. Mental

health chatbots can certainly deliver scalable, cost-effective solutions that can reach individuals in remote areas and customize treatments based on cultural contexts. To enable responsible use, however, privacy and data security, risk of malfunction, risk assessment, algorithm biases, and other ethical concerns must be further researched. It is imperative for developers and mental health professionals to work together to ensure that chatbots become a successful and effective tool in promoting mental health.

Works Cited:

Aktan, M. E., Turhan, Z., & Dolu, I. (2022). Attitudes and perspectives towards the preferences for artificial intelligence in psychotherapy. Computers in Human Behavior, 133, 107273.https://www.sciencedirect.com/science/article/abs/pii/S0747563222000954?via%3Dihub

Aqlan, A. A. Q., Manjula, B., & Lakshman Naik, R. (2019). A study of sentiment analysis: concepts, techniques, and challenges. In Proceedings of International Conference on Computational Intelligence and Data Engineering: Proceedings of ICCIDE 2018 (pp. 147-162). Springer Singapore. https://www.researchgate.net/publication/332451019_A_Study_of_Sentiment_Analysis_Concepts_Techniques_and_Challenges

Bibault, J. E., Chaix, B., Nectoux, P., Pienkowski, A., Guillemasé, A., & Brouard, B. (2019). Healthcare ex Machina: Are conversational agents ready for prime time in oncology?. *Clinical and translational radiation oncology*, *16*, 55-59. **https://www.ctro.science/article/S2405-6308(19)30015-1/fulltext**

Chand, S. P., Kuckel, D. P., & Huecker, M. R. (2022). Cognitive behavior therapy. In StatPearls [Internet]. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK470241/

Fiske, A., Henningsen, P., & Buyx, A. (2019). Your robot therapist will see you now: ethical implications of embodied artificial intelligence in psychiatry, psychology, and psychotherapy. Journal of medical Internet research, 21(5), e13216. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6532335/

Fitzpatrick, K. K., Darcy, A., & Vierhile, M. (2017). Delivering cognitive behavior therapy to young adults with symptoms of depression and anxiety using a fully automated conversational agent (Woebot): a randomized controlled trial. JMIR mental health, 4(2), e7785. https://mental.jmir.org/2017/2/e19/

Gearhart, C. C., & Bodie, G. D. (2011). Active-empathic listening as a general social skill: Evidence from bivariate and canonical correlations. Communication Reports, 24(2), 86-98. https://www.tandfonline.com/doi/abs/10.1080/08934215.2011.610731?casa_token=gtlD2SGSfB4AAAAA:lpVoJuObbbTqRjGoXmlkaQYCH7K5kAN7uCdZ467MHCOYL7gjbXsj3SqKNZVF3NJ5dsUKHdUz-cTB

Graham, S. A., Lee, E. E., Jeste, D. V., Van Patten, R., Twamley, E. W., Nebeker, C., ... & Depp, C. A. (2020). Artificial intelligence approaches to predicting and detecting cognitive decline in older adults: A conceptual review. Psychiatry research, 284, 112732. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7081667/

Ingram, J. (2022, May 9). *Cost remains significant barrier to therapy access, Verywell Mind Survey finds*. Verywell Mind. https://www.verywellmind.com/cost-of-therapy-survey-5271327

Inkster, B., Sarda, S., & Subramanian, V. (2018). An empathy-driven, conversational artificial intelligence agent (Wysa) for digital mental well-being: real-world data evaluation mixed-methods study. JMIR mHealth and uHealth, 6(11), e12106. https://mhealth.jmir.org/2018/11/e12106/

Körtner, T. (2016). Ethical challenges in the use of social service robots for elderly people. Zeitschrift für Gerontologie und Geriatrie, 49(4), 303-307. https://pubmed.ncbi.nlm.nih.gov/27220734/

Mental health and human rights. OHCHR. (n.d.). https://www.ohchr.org/en/health/mental-health-and-human-rights

Oladeji, B. D., & Gureje, O. (2016). Brain drain: a challenge to global mental health. BJPsych international, 13(3), 61-63. https://www.researchgate.net/publication/320812942_Brain_drain_a_challenge_to_global_mental_health

Vaidyam, A. N., Wisniewski, H., Halamka, J. D., Kashavan, M. S., & Torous, J. B. (2019). Chatbots and conversational agents in mental health: a review of the psychiatric landscape. The Canadian Journal of Psychiatry, 64(7), 456-464. https://pubmed.ncbi.nlm.nih.gov/30897957/

Weizenbaum, J. (1966). ELIZA—a computer program for the study of natural language communication between man and machine. Communications of the ACM, 9(1), 36-45. **https://dl.acm.org/doi/10.1145/365153.365168**

World Health Organization. (2023, March 31). Depressive disorder (depression). World Health Organization. https://www.who.int/news-room/fact-sheets/detail/depression

The Ethical Dilemma of AI in Healthcare

Monika , Charlotte Lungren (advisor), Anika Shah (advisor)
Los Gatos High School

Abstract

This paper discusses the ethical dilemma that arises when using AI in healthcare. It incorporates the effect it has on humans, the short and long-term effects, and the effects it has on people's privacy. The daily uses of AI are explained and how they benefit patients as well. However, the consequences of digitally transferring patients' information and data appear to be a big issue along with other things regarding their security.

Introduction

As the digital and computer world rapidly advances a common concern has appeared constantly. Is letting artificial intelligence take care of and treat our patients all across the world ethically correct? But, of course, many of us have different views and ideas of what is ethical and what is not. Before we dive into this let us go over the basics of what artificial intelligence in healthcare is. First, what is it? Artificial intelligence in healthcare is the utilization of many different AI tools working together to treat patients based on their specific issues. It's implemented in many different ways and specializations all across the medical field, such as radiology, pathology, oncology, etc. These AI programs are principal pieces of help in the medical world as they are used for a wide range of jobs from organizing data from scans to early diagnosis of fatal blood diseases. How did the idea of using AI to help in the medical field arise, though? It was first implemented in the 1970s when an AI program was created to help identify treatments for blood infections. And now the use of AI has expanded to many different things such as natural language processing, machine learning, and physical robots. By being able to identify and perform such things, these AI programs and robots provide an immense amount of extra help to those working as doctors, nurses, etc.

Discussion

How does this affect humans?

There are over $11 billion worth of machines being used by doctors and other medical experts daily as of 2021, according to Statista. This emphasizes the importance of them in human life. Many rely on these robots and programs to save their lives. And others rely on it for basic needs and procedures to be performed. And it provides others with a job by giving opportunities to those who create new programs and robots. There are other more common AI systems and programs that everyone has access to such as Fitbits. They can be with you at all times but still keep your health as a top priority. Because some AI systems and programs are so common, this gives a chance to those in lower positions to have access to things that would better their health.

What are the short and long-term consequences?

AI in healthcare has already come so far. It has already advanced so much that it can determine the likeness of mental illness from facial expressions and what video game a person plays, according to insider intelligence. And in hospitals, 20% more of doctors' time can be spent with their patients with the help of AI because the burden of their administrative tasks would be lessened, according to Statista. This increases the efficiency and quality of work at hospitals around the world immensely resulting in better care for patients. On top of this, the costs are also reducing as help becomes more accessible to everyone. The AI systems currently implemented in hospitals are programmed and created to be able to take in a great amount of data which would be difficult for humans to perform. And even if humans did perform it, it would take much more time to do so. But what is in store for the future? Based on the AI we have right now, in the future it is likely that most pathology and radiology images will be examined by a machine at some point, according to the National Library of Medicine. But it is not likely that AI will take over the jobs of humans entirely, as they can't deal with the aspect of giving empathy and comfort when talking to patients and tasks similar to this.

How does this affect people's privacy?

"Personal information includes both private information, such as private conversations that can be digitized through technical processing—this may be categorized as personal information because of its identifiability. At the same time, it also includes non-private information, such as the disclosure of an individual's telephone number without his or her consent. This is personal information that is no longer relevant to personal privacy" (Wang, 2022). One large concern about using AI in healthcare is how it affects people's privacy. With such a large data intake,

there are bound to be problems that arise with it such as data breaches, information leaks, etc. “At the end of the day, healthcare organizations should always prioritize patient safety, security, and privacy. Anything that may pose a threat to those components must be thoroughly evaluated. Until regulations surrounding AI technology become clearer, healthcare organizations should focus on ensuring transparency, asking patients for consent, and assessing third-party vendors before implementing new technologies in to their infrastructure” (McKeon, 2021). Patient security and privacy should be doctors’ number one prime concern when it comes to dealing with their private information, especially of such importance. Many people’s lives could get ruined if their data were to be leaked or hacked into. And even though the benefits of these AI systems outweigh the detriments, the detriments should still be taken into consideration because of how much they can impact a person’s life. And the risk of data breaches and hacking is increased with more of this data being transferred digitally instead of through physical reports, as used before.

Conclusion

Even with all these benefits of AI in healthcare, many people are still concerned with the ethical dilemma of it. So far, there have been more benefits than disadvantages that result from using and taking help from all of these AI programs. “Although, in comparison to the concerns expressed by some potential patients, the majority of health executives believed that investment in AI will lead to both improved health outcomes and patient experience in hospitals and other healthcare settings.” (Stewart, 2023). Perhaps, if some of the uses of AI in healthcare were to be looked over and changed to ensure patient privacy, then it would be a big help. But now, it’s based upon an individual’s views on right and wrong to judge if using AI in healthcare is truly ethical or not.

Sources Cited

Xsolis Insights. (2021, Feb 2). *The Evolution of AI in Healthcare.* Xsolis. https://www.xsolis.com/blog/the-evolution-of-ai-in-healthcare

Conor, S. (2023, May 15). *AI in healthcare - statistics & facts* https://www.statista.com/topics/10011/ai-in-healthcare/#topicOverview

Insider Intelligence. (2023, Jan 11). *how the medical field is benefiting from AI in 2023 and beyond* https://www.insiderintelligence.com/insights/artificial-intelligence-healthcare/#:~:text=Examples%20of%20AI%20in%20Medicine,Thymia%20is%20a%20prime%20example.

Conor, S. (2023, Jun 28). *Artificial intelligence (AI) in healthcare market size worldwide from 2021 to 2030* https://www.statista.com/statistics/1334826/ai-in-healthcare-market-size-worldwide/

Thomas, D. (2019, Jun). *The potential for artificial intelligence in healthcare* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6616181/

Chao, W. (2022, Sep 27). *Privacy Protection in Using Artificial Intelligence for Healthcare: Chinese Regulation in Comparative Perspective* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9601726/

Jill, M. (2021, Dec 1). *Security, Privacy Risks of Artificial Intelligence in Healthcare* https://healthitsecurity.com/features/security-privacy-risks-of-artificial-intelligence-in-healthcare

Literary Review

Legalities of AI in Healthcare: Navigating the Evolution, Implications, and Regulatory Landscape

Sahana Sankaran, Charlotte Lungren (advisor), Anika Shah (advisor)
San Marin High School

Abstract:

The integration of Artificial Intelligence (AI) in healthcare has brought forth significant advancements with the potential to revolutionize diagnostics, treatments, and patient care. However, this technological transformation also introduces complex legal challenges that require careful examination. This research paper explores the legalities surrounding AI in healthcare, including issues of privacy, data protection, liability, intellectual property, and ethical considerations. By analyzing the evolving regulatory landscape, the historical development of AI in healthcare, societal implications, and the ethical dimensions of its implementation, this paper aims to provide insights into the legal framework governing this transformative technology. Furthermore, it emphasizes the need to strike a balance between innovation and regulation, ensuring patient rights, privacy, and the ethical use of AI in healthcare. By understanding and addressing these legal complexities, policymakers, healthcare professionals, and society can harness the potential benefits of AI while mitigating risks and safeguarding patient well-being.

Introduction:

Artificial Intelligence (AI), as a concept, can be traced back to the mid-20th century. However, only in the recent decade has the practical functioning of AI has taken form. This is large-in part due to the exponential growth of computational power and the accumulation of vast amounts of data that AI models have access to. These machines have the ability to perceive, reason, make decisions and learn, leading to a wide range of applications across various industries and sectors. In the healthcare field, we have already seen such possibilities take form. From wearable devices that can be used to monitor health and medical imaging used to diagnose patients, as well as promises of transformative treatment by those in the industry. However, as AI becomes increasingly embedded in healthcare practices, it brings with it a host of legal challenges that require careful consideration. This paper aims to delve into the legalities surrounding AI in healthcare, exploring its development through history, societal implications, and the evolving regulatory landscape. By examining the ethical and legal dimensions of AI implementation, this

paper seeks to shed light on the intricate legal framework surrounding this technology, and the implications it holds for patients and healthcare professionals.

Discussion:

Privacy and Data Protection:

Artificial Intelligence in healthcare relies heavily on accessing and analyzing vast amounts of patient data, which raises significant privacy and data protection concerns. Privacy and data protection are paramount considerations in the utilization of AI algorithms, which often necessitates access to extensive volumes of patient data. (Forbes, 2023) This raises significant legal challenges surrounding the protection of patient privacy and compliance with data protection regulations. Notably, the General Data Protection Regulation (GDPR) has a substantial impact on the use of AI in healthcare within the European Union, requiring robust measures for "*the anonymization, encryption, and secure storage of personal health data.*" (EPRS, 2020) This ensures that healthcare providers and AI developers must navigate complex requirements to obtain informed consent from patients, ensuring they are fully aware of how their data might be used in AI systems. Furthermore, the Health Insurance Portability and Accountability Act (HIPAA) in the United States imposes strict regulations for the privacy and security of protected health information. AI applications must adhere to HIPAA requirements to safeguard patient privacy. Such requirements include: implementing appropriate technical and administrative safeguards to prevent unauthorized access or disclosure of patient data. "*With limited exceptions, the HIPAA Privacy Rule (the Privacy Rule) provides individuals with a legal, enforceable right to see and receive copies upon request of the information in their medical and other health records maintained by their health care providers and health plans.*" (HHS, 2022) Balancing the need for data access and the imperative to protect patient privacy poses ongoing legal challenges in the deployment of artificial intelligence in healthcare. As AI systems continue to evolve and capture increasingly diverse and sensitive data, stakeholders must ensure that robust privacy and data protection measures are in place to preserve patient trust, maintain compliance with regulations, and mitigate the risk of data breaches or unauthorized use of personal health information.

Liability and Accountability:

The integration of AI in healthcare introduces complex questions regarding liability and accountability. Determining who is accountable when adverse outcomes occur due to the involvement of AI can be challenging. The traditional frameworks of liability may need to be reassessed to accommodate the unique characteristics of AI technologies. Typically, accountability and the punishments derived from it, are held using different programs such as Quality Assurance Programs and Accreditation, Regulatory Bodies, Licensing Boards, as well as patients having the option to seek a Medical Malpractice Lawsuit. (American

College of Cardiology, 2017) And while all these may have worked in the past with AI being more robustly used in the medical space, applying the same forms of accountability directly to AI systems presents unique challenges. AI systems often operate using complex algorithms and neural networks, making it challenging to fully understand their decision-making processes. Unlike individual healthcare professionals, AI systems may not be able to provide direct explanations for their decisions or actions, making it difficult to attribute accountability to them. Furthermore, AI systems involve multiple stakeholders, including developers, healthcare providers, and data contributors. Determining who holds primary responsibility for any mistakes or adverse outcomes caused by an AI system can be complex, as it requires untangling the contributions and actions of each involved party. On the other hand, AI developers may be held accountable for the performance and safety of their systems. The legal notion of "explainability" becomes crucial (explainability being how well the process of thinking can be followed), requiring AI systems to provide transparent insights into the factors and considerations that drive their decision-making. As AI technologies adapt and evolve, questions arise regarding who bears responsibility for ensuring the ongoing safety, efficacy, and accuracy of these systems. Existing legal frameworks and liability laws may not explicitly address the unique challenges associated with holding AI systems accountable. The legal and regulatory landscape is continuously evolving, and there is an ongoing debate about how to adapt traditional legal principles to encompass AI accountability. Collaboration among legal experts, policymakers, healthcare professionals, and AI developers is necessary to define the legal frameworks and guidelines that allocate responsibility and mitigate potential legal risks associated with the implementation of AI in healthcare.

Intellectual Property Rights:

Intellectual property in healthcare is of paramount importance as it incentivizes innovation and fosters advancements in medical technology and treatments. It provides a structure for protecting the investments, research, and development efforts of pharmaceutical companies, medical device manufacturers, and other stakeholders in the healthcare industry. By safeguarding intellectual property rights, it encourages continued investment in research and development, ultimately leading to the discovery of new drugs, therapies, and medical technologies that improve patient outcomes and contribute to the overall progress of healthcare. Intellectual property rights also play a significant role in the integration of AI into healthcare, presenting unique challenges and considerations. AI algorithms, particularly those used in drug discovery, diagnostic tools, and medical devices, may generate inventions and innovative solutions that could be eligible for patent protection. However, the collaborative and iterative nature of AI development can complicate the determination of ownership and patentability. Multiple stakeholders, including AI developers, healthcare institutions, and data contributors, may contribute to the creation of AI-generated outputs. This raises questions regarding the allocation of

intellectual property rights and the fair distribution of benefits. Additionally, the rapidly evolving nature of AI technologies poses challenges for the patent system, which often requires fixed and tangible inventions for protection. Determining the appropriate scope and criteria for the patentability of AI-generated innovations, as well as addressing the potential for patent disputes, is a complex legal task. Striking a balance between incentivizing innovation through intellectual property protection and ensuring broader access to AI-driven healthcare advancements is a key consideration. Moreover, intellectual property rights extend beyond patents to include copyrights, trade secrets, and trademarks. Protecting AI algorithms, data sets, and proprietary software under these rights is crucial for fostering innovation while also respecting the intellectual property of developers and organizations. Given the transformative potential of AI in healthcare, establishing clear guidelines and legal frameworks that address intellectual property rights is essential to promote innovations, encourage collaboration, and navigate the evolving landscape of AI-related inventions.

Ethical Considerations:

Alongside legal challenges, the integration of AI in healthcare also raises significant ethical considerations. One critical ethical concern is the potential for bias, fairness, and discrimination in AI algorithms. If AI systems are trained on biased or limited datasets, they may perpetuate existing healthcare disparities and amplify biases based on diagnosis, treatment recommendations, and resource allocations. Ensuring that AI algorithms are developed and validated with diverse and representative datasets becomes essential to mitigate these ethical risks. Transparency and explainability are additional ethical considerations. Patients and healthcare professionals should have access to an understandable explanation of how AI systems make decisions to maintain trust, ensure accountability, and enable meaningful human-AI collaboration. The use of AI in healthcare also raises questions about the impact on the doctor-patient relationship and the dehumanization of care. Striking the right balance between the use of AI as a tool to enhance clinical decision-making and preserving the last human touch, empathy, and ethical responsibilities of healthcare professionals is crucial. Lastly, the ethical collection, use, and protection of patient data in AI systems are paramount. Healthcare institutions and AI developers must prioritize data privacy, security, and informed consent to safeguard patient autonomy, confidentiality, and trust. Robust ethical guidelines, codes of conduct, and institutional review boards (IRBs) need to be established to ensure that AI in healthcare is deployed in an ethically responsible manner, promotes health equity, respects patient autonomy, and upholds fundamental ethical principles.

Conclusion:

In conclusion, the legalities surrounding AI in healthcare are complex and multifaceted, requiring careful consideration of privacy, liability, regulations, intellectual property, and ethical dimensions. While AI

holds immense potential to revolutionize healthcare delivery and improve patient outcomes, it also presents challenges that must be addressed to ensure responsible and ethical implementation. Policymakers, legal experts, healthcare professionals, and AI developers must collaborate to develop robust frameworks that strike a balance between innovation and regulation. By navigating the evolving considerations, we can harness the power of AI in healthcare while upholding societal values, safeguarding privacy, and maintaining trust in the healthcare system. Continued research, adaption of legal frameworks, and interdisciplinary collaboration are essential to foster a regulatory environment that enables the responsible integration of AI, ensuring its benefits are maximized while mitigating potential risks. The legal and ethical landscape surrounding AI in healthcare will continue to evolve, and it is important to remain attentive to emerging challenges and opportunities, ultimately aiming to leverage AI's potential to improve healthcare outcomes and enhance the well-being of individuals and communities.

References

Chavez, S. (2017). *MEDICINE AND PUBLIC ISSUES - Holding Providers Accountable for Health Care Outcomes*. American College of Cardiology. Retrieved July 9, 2023, from https://www.acc.org/~/media/Non-Clinical/Files-PDFs-Excel-MS-Word-etc/Tools%20and%20Practice%20Support/Quality%20Programs/Right%20Measures%20for%20the%20Right%20Care/Session_2/3_Holding_Providers_Accountable.pdf?la=en

Ethical and legal challenges of artificial intelligence-driven healthcare. (2020, June 26). NCBI. Retrieved July 10, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7332220/

Ethical Issues of Artificial Intelligence in Medicine and Healthcare. (n.d.). NCBI. Retrieved July 10, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8826344/

Forbes. (n.d.). *The Dangers Of Using Synthetic Patient Data To Build Healthcare AI Models*. ' - Wiktionary. Retrieved July 9, 2023, from https://www.forbes.com/sites/forbestechcouncil/2023/05/26/the-dangers-of-using-synthetic-patient-data-to-build-healthcare-ai-models/?sh=29a94ce970da

Individuals' Right under HIPAA to Access their Health Information. (2022). HHS.gov. Retrieved July 9, 2023, from https://www.hhs.gov/hipaa/for-professionals/privacy/guidance/access/index.html

Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility? (2022, February 18). Frontiers. Retrieved July 10, 2023, from https://www.frontiersin.org/articles/10.3389/fsurg.2022.862322/full

nicholson, w. (n.d.). *Artificial Intelligence in Health Care: Applications and Legal Implications*. University of Michigan Law School Scholarship Repository. Retrieved July 10, 2023, from https://repository.law.umich.edu/cgi/viewcontent.cgi?article=2932&context=articles

Sartor, P., & Lagioia, F. (n.d.). *The impact of the General Data Protection Regulation (GDPR) on artificial intelligence*. European Parliament. Retrieved July 9, 2023, from https://www.europarl.europa.eu/RegData/etudes/STUD/2020/641530/EPRS_STU(2020)641530_EN.pdf

Transforming healthcare with AI: The impact on the workforce and organizations. (2020, March 10). McKinsey. Retrieved July 10, 2023, from https://www.mckinsey.com/industries/healthcare/our-insights/transforming-healthcare-with-ai

Transforming healthcare with AI: The impact on the workforce and organizations. (2020, March 10). McKinsey. Retrieved July 10, 2023, from https://www.mckinsey.com/industries/healthcare/our-insights/transforming-healthcare-with-ai

Use of artificial intelligence on the rise, but its impact on health still limited, new study finds. (2022, September 27). Use of artificial intelligence on the rise, but its impact on health still limited, new study finds. Retrieved July 10, 2023, from https://www.who.int/europe/news/item/27-09-2022-use-of-artificial-intelligence-on-the-rise--but-its-impact-on-health-still-limited--new-study-finds

Why is AI adoption in health care lagging? | Brookings. (2022, March 9). Brookings Institution. Retrieved July 10, 2023, from https://www.brookings.edu/articles/why-is-ai-adoption-in-health-care-lagging/

The Challenge of Implementing and Adopting AI in Healthcare

Sean Gee, Charlotte Lungren (advisor), Anika Shah (advisor)

San Leandro High School

Abstract:

The paper considers and describes the many challenges facing the rise of artificial intelligence (AI) in healthcare. It focuses on the primary challenge associated with AI, data manipulation, and how overcoming this hurdle is crucial in ensuring AI's operation is as unbiased and as accurate as possible. This, in turn, will allow AI to not only operate optimally but showcase its tangible positive impacts, as evidenced by research findings.

Introduction:

With the rise of technology in all parts of society, it's become no surprise that the implementation of artificial intelligence (AI) in healthcare has become commonplace and developed into one of the biggest markets of innovation in the modern era. Ever since AI's conception in the 1950s, machine learning and programming have evolved into a finely tuned machine that has improved doctors' accuracy in diagnosing illness and customizing treatments to specific needs as well as advanced administrative tasks to ease the workload of healthcare workers. Unfortunately, however, AI is still being limited by human understanding and this shift to AI has left many professionals conflicted. Despite the positive reviews around AI, there still lacks crucial information on actually implementing the technology in real-world situations and how it can influence raw, uncontrolled clinical issues on a greater scale. (Brookings, 2022) The world knows what AI is capable of, but actually applying it to the real world has become the biggest challenge of modern healthcare. This obstacle in AI in healthcare has now transitioned from "what is AI and how can we understand it within healthcare" to "how can we properly and realistically employ AI in the current healthcare system."

Discussion:

Transition:

In order to understand this transition, one has to understand the question: what is AI and what can it do in healthcare? “Simply put, AI refers to the science and engineering of making intelligent machines. which the machine follows to mimic human cognitive functions, such as learning and problem-solving.” (Bajwa, J., Munir, U., Nori, A., & Williams, B. 2021) This ability to mimic human cognitive function is what makes AI so uniquely suited for assisting in healthcare. Through AI’s efficiency and effectiveness, healthcare professionals can make better decisions, understand a patient’s individual concerns more clearly, and most importantly, figure out a solution in a timely manner. And with the development in both technological applications and the growth of databases in the 80s to 90s, AI quickly became more prominent in the world of healthcare and has now become one of the major bases of how technology can be utilized within health (Dupont, 2022). With more and more promise in AI’s ability, questions began being asked about how to implement it and more importantly, whether it will be financially beneficial to all participants. In a recent study, research has shown that AI “could lead to savings between 5% and 10% in healthcare spending, roughly $200 billion to $360 billion a year. The estimates are based on AI use cases employing current technologies that are attainable within the next five years, without sacrificing quality or access.” (Pifer, 2023) In the event that this prediction proves to be accurate, AI in healthcare would become the centerpiece of profit for AI and technology in healthcare. Additionally, this could trickle down to private payers, physician groups, and hospitals, which would not only raise demand for AI but improve confidence in AI’s capability to the public. In fact, AI has topped the charts in investments since 2018 and is still near the top of many investors' portfolios as its versatility and potential have caught many investors’ eyes. (Pharmaceutical-Technology, 2022) However, this kind of saving is still only an estimate as many healthcare professionals are still skeptical over its usage, calling it a “hit or miss.”(Pifer, 2023) AI has come a long way since its conception in the 50s from being an idea to bringing machines

that can actively help specialists in their field to now being the most sought-after possibility in the world of healthcare.

Current Drawbacks:

Without a shadow of a doubt, the biggest drawback in realistically implementing AI in healthcare is accessibility to appropriate data and the security of that data. Due to compatibility issues with healthcare providers and the requirement for a substantial amount of data to operate effectively, AI often takes a secondary role in healthcare (Bajwa, J., Munir, U., Nori, A., & Williams, B. 2021). Furthermore, even with sufficient data, concerns about the authenticity of that data arise as some data may be vulnerable to hackers or viruses. “Because of the advancement of AI, users may mistake artificial systems for people and provide their consent for more covert data collecting, raising serious privacy concerns.” (Fatima, H., Qureshi, A., Kumar, S., Hanan, A., Hussain, J., & Abdullah, S., 2023) Patience and time are key in developing stronger methods of protecting and collecting data, ultimately slowing down the overall implementation of AI. Another major drawback in realistically implementing AI in healthcare is that there's insufficient evidence to adequately validate the effectiveness of AI medications. As previously mentioned, there has been a scarcity of appropriate data for AI, and as such, AI development of medications that can efficiently function in real-life scenarios has been hindered significantly. In a recent article by PubMed Central, they say that a far majority of healthcare AI research has been done in non-clinical settings and that most research results have been controlled, making it difficult to generalize them in real-life scenarios. This has made trusting AI even more difficult as specialists fear that these machines won’t be able to produce accurate results and may even slow down the overall process of assisting patients. In addition, the question of what happens if AI does not work on a certain day or struggles to function properly has been circulating among healthcare specialists. Aside from the technical issues of AI, the other major challenge of AI is its potential biases toward certain social and cultural groups. As a result of being a computer that collects data, AI can unintentionally replicate current prejudice and input them into their algorithms. For example, there was a controversy a few years back when Amazon’s recruitment AI was found to favor more male applicants than females due to the data the

AI had collected. (Dastin, 2018) As a result of these types of bias in general AI, it not only highlights the still undiverse system in our current world but brings down AI's full capabilities in aiding everyone equally. Manipulating data is one of the most important ways AI can be implemented into healthcare, but it is also the most sensitive hurdle researchers must consider when developing a solution for the future.

Successful Applications:

Despite the many obstacles to utilizing AI in current healthcare, the adoption of AI has brought about a revolutionary transformation in the approach of many healthcare providers toward treatments and patient care. For example, during the COVID-19 pandemic, AI was used to dramatically improve researcher diagnoses and predictions as well as solidify researchers' knowledge of models to cure the disease. (Chang, Z., Zhan, Z., Zhao, Z., You, Z., Liu, Y., Yan, Z., Fu, Y., Liang, W., & Zhao, L. 2021). This data was essential in helping scientists make new COVID-19 policies and policy formulations. Using machine learning and deep learning with epidemiology, AI helped predict where COVID-19 would spread to and trace its infection rate. This was all possible due to the overabundant amount of data and learning samples, proving that with enough accurate data, AI implementation can positively work in real scenarios. AI has also been primarily successful in handling patients and management in healthcare. In a recent survey by Insider Intelligence, AI was effective in improving consumer engagement by 45%, operational performance by 58%, and administrative performance by 46%. Moreover, the integration of AI into smart devices has yielded significant benefits for older patients, as the machine learning capabilities of these devices have enabled the development of systems that proactively alert and protect them from potential hazards. (Sanyal, 2018) Through these, AI has demonstrated its reliability and sustainability, garnering trust and acceptance even from demographics such as older individuals who might typically be skeptical of AI. This establishment of trust in AI is paramount for the successful implementation of AI in healthcare and is one of the first steps to realistically implement AI. The potential for successful AI applications is indeed high, as demonstrated through these examples; however, it is crucial to emphasize that the availability of an adequate amount of relevant data for processing is a critical factor in realizing the full potential of AI.

Conclusion:

AI has shown time and time again that it is the next stepping point in healthcare and its potential to improve the lives of others is endless. The challenge, however, is how to properly transition from understanding AI to applying it to the current healthcare system without disrupting the already struggling system. Fortunately, as shown in patient assistance, the transition to AI is not too far in the future as if implemented correctly, can give rise to healthcare's efficiency. For instance, due to the abundant amount of sufficient data, AI can be implemented pretty realistically in mental health services and aiding those in the military. This can not only support those in immediate need nowadays but be used to give confidence for the implementation of AI in healthcare. While AI is still in its early stages in the present era, there is a growing realization that it will soon become fully integrated into healthcare. As the collection of data continues to expand, the utilization of AI will significantly improve, eventually leading to more enhanced healthcare practices and outcomes that could benefit everyone equally.

Works Cited:

Bajwa, J., Munir, U., Nori, A. V., & Williams, B. (2021). Artificial intelligence in healthcare: transforming the practice of medicine. *Future Healthcare Journal*, *8*(2), e188–e194. https://doi.org/10.7861/fhj.2021-0095

Dastin, J. (2018, October 10). Amazon scraps secret AI recruiting tool that showed bias against women. *U.S.* https://www.reuters.com/article/us-amazon-com-jobs-automation-insight-idUSKCN1MK08G

Dupont, X. (2022, April 20) *Everything You Need to Know About AI in Healthcare | TWinFM*. TWinFM. https://www.twinfm.com/article/everything-you-need-to-know-about-ai-in-healthcare#:~:text=It%20wasn't%20until%20over,networks%2C%20and%20hybrid%20intelligence%20systems.

GlobalData Healthcare & GlobalData Healthcare. (2022, November 25). AI will continue to attract investment in near future in the healthcare industry. *Pharmaceutical Technology*. https://www.pharmaceutical-technology.com/comment/ai-investment-healthcare/

Intelligence, I., & Intelligence, I. (2023). Use of AI in healthcare & medicine is booming – here's how the medical field is benefiting from AI in 2023 and beyond. *Insider Intelligence*. https://www.insiderintelligence.com/insights/artificial-intelligence-healthcare/#:~:text=Benefits%20of%20AI%20in%20Healthcare%20%26%20Medicine&text=With%20AI's%20ability%20to%20process,AI%20to%20better%20serve%20patients.

Khan, B., Fatima, H., Qureshi, A., Kumar, S., Hanan, A., Hussain, J., & Abdullah, S. (2023). Drawbacks of Artificial Intelligence and Their Potential Solutions in the Healthcare Sector. *Biomedical Materials & Devices*. https://doi.org/10.1007/s44174-023-00063-2

Pifer, R. (2023, January 26). *Artificial intelligence could save healthcare industry $360B a year*. Healthcare Dive. https://www.healthcaredive.com/news/artificial-intelligence-healthcare-savings-harvard-mckinsey-report/641163/#:~:text=However%2C%20actual%20adoption%20of%20AI,to%20%24360%20billion%20a%20year.

Sanyal, S. (2018, November 1). How Is AI Revolutionizing Elderly Care. *Forbes*. https://www.forbes.com/sites/shourjyasanyal/2018/10/31/how-is-ai-revolutionizing-elderly-care/?sh=30af099ae07d

Stiepan, D. (2022). Using AI in radiology clinical practice. *Mayo Clinic News Network*. https://newsnetwork.mayoclinic.org/discussion/using-ai-in-radiology-clinical-practice/

Why is AI adoption in health care lagging? | Brookings. (2022, March 9). *Brookings*. https://www.brookings.edu/articles/why-is-ai-adoption-in-health-care-lagging/

Zhoulin, C., Zhan, Z., Zhao, Z., You, Z., Liu, Y., Yan, Z., Fu, Y. Q., Liang, W., & Zhao, L. (2021). Application of artificial intelligence in COVID-19 medical area: a systematic

review. *Journal of Thoracic Disease*, *13*(12), 7034–7053. https://doi.org/10.21037/jtd-21-747

Revolutionizing Healthcare: The Role of Artificial Intelligence in Radiology

Sebastian L. Ribault, Charlotte Lungren (advisor), Anika Shah (advisor)
Freedom High School

Abstract

This paper explores the potential of Artificial Intelligence (AI) to transform radiology, with a particular focus on its capacity to reshape the future of medical imaging. As AI's capabilities to swiftly and accurately analyze substantial volumes of medical images are revealed, we foresee a potential surge in the precision and efficiency of diagnosis processes. However, the integration of AI in radiology does come with unique challenges such as fostering trust in AI systems, discerning its most efficacious applications, and preserving data privacy. Notable advancements in AI, such as Rayscape's integration in radiology, serve as exemplary models of how these hurdles can be successfully addressed. As we envision the future of AI-driven radiology, striking the right balance between technological innovation, ethical considerations, and the indispensable human factor becomes vital. The paper argues that with meticulous planning, thoughtful implementation, and continuous research, AI could bring about a revolutionary change in the field of radiology and by extension, significantly reshape the broader healthcare landscape.

Introduction

Artificial Intelligence, commonly referred to as AI, is a cornerstone of modern technological innovation. At its core, AI is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning, reasoning, problem-solving, perception, and language understanding. It offers the ability to quickly and accurately process large amounts of data, identify patterns and trends, and make predictions based on these observations. The application of AI in healthcare is now providing a radical shift in the way we approach different sectors of the medical world. Here, AI is increasingly proving to be a powerful tool that can replicate the capabilities of human practitioners. Its ability to sift through and analyze volumes of medical images quickly and accurately is transformative, potentially leading to earlier and more precise diagnoses. As we delve deeper into this intersection of AI and radiology, it becomes apparent that the integration of this advanced technology into our healthcare systems could redefine the future of medical imaging and, indeed, the broader field of

medicine. However, this transition is not without challenges, requiring a careful balance of technological innovation, ethical considerations, and the invaluable human touch in healthcare.

Discussion

Potential Benefits of Integrating AI into Radiology

The interplay of artificial intelligence (AI) and radiology has the potential to completely transform the realm of medical imaging, bringing forth substantial benefits. Not only does the utilization of AI allow for medical image analysis to be fast and efficient, it can also generate precise 3D models for a comprehensive view of a patient's health status. [2] These emerging improvements “allows surgeons to better plan surgeries, compared to traditional 2D, or paper planning.” [1] The impact of AI extends beyond mere technological advancement; it also pertains to streamlining workflow applications and improving patient care, critical aspects that the radiology community has shown keen interest in. AI is envisioned as an essential tool to assist radiologists in enhancing their diagnostic capabilities. It can assist in identifying suspicious findings in imaging exams, making accurate diagnoses, selecting personalized patient protocols, and tracking a patient's dose parameters. Moreover, AI can even estimate the potential risks of radiation exposure. Diagnostic errors can be minimized as AI helps overcome the limitations of human visual perception and attention. One significant phenomenon that AI can address is "inattentional blindness," [3] a situation where salient events or anomalies are missed due to the observer's focus being engaged elsewhere. Despite a radiologist's advanced ability to rapidly detect abnormalities, including unexpected ones, inattentional blindness can lead to overlooked but clinically significant incidental findings. These are abnormalities seen in medical images unrelated to the primary symptomatology of the patient and may even be observed in asymptomatic patients. Thus, AI can play a pivotal role in identifying such overlooked findings, thereby ensuring a more comprehensive analysis of the patient's health. Further, AI can provide significant support in mitigating radiologists' cognitive fatigue, a common byproduct of their demanding daily medical practice. The use of AI algorithms as aid tools for precision medicine is widely supported by medical professionals. According to a study by Sarwar and colleagues [4], 75% of 487 physicians across 54 countries held positive attitudes towards AI, expressing interest in its capabilities as a diagnostic tool to improve workflow efficiency and quality assurance. Recent studies have shown the promising diagnostic accuracy of AI. A 2018 study, for instance, found that a computer trained to distinguish between cancerous and benign skin lesions outperformed dermatologists with a diagnostic accuracy of 95% compared to 86.6%. [5] However, it's also important to acknowledge that AI's performance may not always surpass human expertise, as shown in another study where AI showed lower diagnostic accuracy than an expert endoscopist in detecting and classifying gastrointestinal tract lesions.

Hence, while AI holds immense potential, its implementation must be balanced with human expertise for optimal patient care and outcomes.

Challenges of Implementing AI into Radiology

As we venture further into the 21st century, artificial intelligence (AI) is increasingly regarded as a crucial tool for advancing healthcare systems. Its potential for revolutionizing diagnosis, treatment planning, and patient care is undeniable. However, the path to this AI-integrated future is strewn with challenges and obstacles, not least of which are establishing trust, selecting the right use cases, and managing massive volumes of data while respecting privacy. Trust is fundamental in healthcare, and this principle is not different in radiology. Traditionally, patients place their trust in radiologists, confident in their expertise and ability to interpret complex imaging data. This human connection is invaluable and can play a crucial role in patient outcomes. AI, while outstanding at processing large volumes of data, lacks this human touch, raising concerns about its capacity to replicate the depth of human radiological expertise. With *"33% of US CEOs cite employee trust as one of the greatest barriers to AI adoption,"* [6] it is evident the transition to the assistance of AI will be a great challenge. Further, the prospect of entrusting AI with the interpretation of critical imaging data can lead to understandable apprehension. An error in AI diagnosis or image interpretation can have serious consequences. Hence, developing AI systems that are not only technically proficient but also transparent in their decision-making processes is essential to earn the trust of radiologists and patients alike. Identifying the most appropriate applications for AI in radiology is another significant challenge. The versatility of AI may make it tempting to implement it across all radiological procedures, from X-rays to MRI scans and patient follow-ups. However, the indiscriminate application of AI could lead to overreliance, misallocation of resources, and potential harm. Given the highly specialized nature of radiology, it's essential to assess where AI can provide the most value. Ideally, it should complement and augment the skills of radiologists, improve workflow efficiency, and generate actionable insights without compromising the precision of diagnosis or treatment planning. This requires a clear understanding of the strengths and limitations of AI, ensuring it is harnessed to best serve the unique demands of radiology. The management of high volumes of radiographic data and respecting patient privacy pose significant challenges. AI systems rely on comprehensive and diverse datasets for training, and radiology is a discipline with a wealth of data, including medical images and associated annotations. However, this data abundance leads to issues concerning storage, management, and security. Ensuring privacy in the age of AI is especially crucial in radiology. Patient confidentiality is a cornerstone of the trust that radiologists and healthcare providers must maintain. The challenge, then, is ensuring AI systems have adequate access to data for learning and improvement while complying with privacy regulations and retaining patient trust. While AI carries substantial promise for transforming radiology, successfully navigating these challenges is key to its

integration. This necessitates an approach that considers technical capabilities, human factors, and ethical concerns. In doing so, we can steer the development of AI in radiology in a way that maximizes its advantages while minimizing potential risks.

Recent Clinical Trials and Studies

In response to recent advancements in AI for radiology, many healthcare corporations are dedicating significant resources to research in this emerging field. They aim to spark innovation through clinical trials and systematic studies. Rayscape is a prime example of such dedication. “We augment radiologists analyzing X-rays and CTs by tapping into 15,000,000 medical images of experience.” [6] Rayscape’s strategy of leveraging a vast repository of medical images to enhance the assistance given by artificial intelligence will transform the landscape of radiology, aiming to improve diagnostic accuracy, expedite patient care, and ultimately, contribute to the betterment of global health outcomes. Furthermore, AI has already made recent strides in the medical scene. According to a professional radiologist, there “are already FDA-approved AI algorithms to detect subtle internal bleeding within the brain or potentially fatal blood clots (“pulmonary embolism”) within the arteries of the lung.” [3] Given the clear endorsement of AI in radiology by the FDA and the medical community, we can anticipate further adoption of this technology in the future. Recently, healthcare corporations are also foreseeing the application of AI in radiology to predict disease progression and response to treatment, adding another layer of precision to personalized medicine. Radiological images can reveal how a patient's body is responding to a specific therapy, for example, by measuring changes in tumor size or characteristics over time. AI can recognize if individuals bodies are not biocompatible with a specific radiotherapy procedure which can support physicians in customizing treatment plans to suit each patient's unique needs and circumstances. This is important to current and future clinical trials as radiotherapy can be often dangerous with “the incidental harm inflicted on healthy, nontarget patient tissues adjacent to tumors or sitting along radiation beam pathways.” [9]

Conclusion

The fusion of AI with radiology is a progressive stride towards reshaping the future of healthcare. It holds the potential to not only accelerate diagnostic processes but also enhance their precision, thereby leading to improved patient care and global health outcomes. Recent advancements, such as those exemplified by Rayscape's AI integration into radiology, provide a glimpse into the transformative power of this technology. However, while the prospects of AI in radiology are highly promising, its integration is not without challenges. These include establishing trust in AI systems, identifying the most beneficial applications, and ensuring data privacy, all of which require careful navigation. As we move forward, it is essential that we strike a balance between technological innovation, ethical considerations, and

maintaining the crucial human touch in healthcare. With strategic planning, meticulous implementation, and continued research, AI can significantly contribute to the advancement of radiology, thus revolutionizing healthcare as we know it.

Sources Cited

Artificial Intelligence Innovation: Leading companies in 3D modelling for surgeries for the medical devices industry. Medical Device Network. (2023, February 16). https://www.medicaldevice-network.com/data-insights/innovators-ai-3d-modelling-for-surgeries-medical-devices/

Medical Image Analysis. Graylight Imaging. (2023, June 22). https://graylight-imaging.com/medical-image-analysis/?gclid=Cj0KCQjw756lBhDMARIsAEI0AgmkyuGqsD_H5nWC5Ygu-DzSGhVwz0jEqo2HHBXSh5mzXcXWQqZxrrEaAkmFEALw_wcB

Hsieh, P. (2023, May 2). *Promises, perils, and predictions for Artificial Intelligence in medicine: A radiologist's perspective*. Forbes. https://www.forbes.com/sites/paulhsieh/2023/04/29/promises-perils-and-predictions-for-artificial-intelligence-in-medicine-a-radiologists-perspective/?sh=6005c2403f50

Neisser, U., & Becklen, R. (2004, August 26). *Selective looking: Attending to visually specified events*. Cognitive Psychology. https://www.sciencedirect.com/science/article/abs/pii/0010028575900195?via%3Dihub

Haenssle HA;Fink C;Schneiderbauer R;Toberer F;Buhl T;Blum A;Kalloo A;Hassen ABH;Thomas L;Enk A;Uhlmann L; ;Alt C;Arenbergerova M;Bakos R;Baltzer A;Bertlich I;Blum A;Bokor-Billmann T;Bowling J;Braghiroli N;Braun R;Buder-Bakhaya K;Buhl T;Cabo H;Cabrijan L;C. (n.d.). *Man against machine: Diagnostic performance of a deep learning convolutional neural network for dermoscopic melanoma recognition in comparison to 58 dermatologists*. Annals of oncology : official journal of the European Society for Medical Oncology. https://pubmed.ncbi.nlm.nih.gov/29846502/

Radiology AI. Rayscape. (n.d.). https://rayscape.ai/

Sarwar, S., Dent, A., Faust, K., Richer, M., Djuric, U., Van Ommeren, R., & Diamandis, P. (2019, April 26). *Physician perspectives on integration of artificial intelligence into diagnostic pathology*. NPJ digital medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6550202/

Young, E. (n.d.). *Global Review 2020*. ey.com.

https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/global-review/2020/ey-global-review-2020-v3.pdf?download

BryantFurlow, B. F. F. (2023, June 6). *Flash radiotherapy promising but faces significant challenges ahead*. Oncology Nurse Advisor. https://www.oncologynurseadvisor.com/home/departments/radiation-and-your-patient/tumor-molecular-response-flash-radiotherapy-promising-faces-significant-challenges/

Literary Review

The implementation of AI in Brain-Computer Interfaces for neurological disorders

Shakthi Rao (author), Charlotte Lungren (advisor), Anika Shah (advisor)
Centennial High School

Keywords: Brain-Computer Interface, BCI, AI, DL, ML, Paralysis, CNS, Neurological Disorder

Abstract:

A common symptom of most neurological disorders includes paralysis. Paralysis prohibits one from operating their limbs or muscles effectively. This research paper intends to explore the role of AI in Brain-computer Interfaces for combating paralysis from neurological diseases. In BCIs, the role of AI centers around data preprocessing, feature extraction, and classification. Although BCIs are in their infancy, BrainGate's first trial in assisting paralytic individuals was successful. Several additional studies prove that with the integration of AI systems, there was a high percentage of accuracy when interpreting brain data. Although ML and DL algorithms lack access to large data sets, the solution proposed for this issue includes a generative adversarial network (GAN). The studies included in this paper evaluate the accuracy levels of AI when interpreting brain data and the effectiveness of cursor controls. In the classification process, 2D cursors prove beneficial in operating prosthetic devices. This research also addresses some limitations and concerns regarding the security and affordability of the technology.

Introduction:

The nervous system is crucial to every movement, gesture, and behavior that the human body performs. Apart from controlling involuntary actions such as sneezing, blinking, or breathing, it controls all voluntary movements like walking or dancing. The central nervous system (CNS) contains the brain and the spinal cord. Several neurological diseases have adverse effects that prevent the nervous system from functioning ordinarily. The most common neurological disorders include Cerebral Palsy, Ataxia, Guillain-Barre syndrome, and Parkinson's disease. All of these diseases result in some form of paralysis in limbs or muscles. Despite the challenges of neurological disorders, technological advancements such as Brain-computer Interfaces restore the ability to function and communicate. Although Brain-computer interfaces have brought neurologists one step closer to combating paralyzation in patients, the technology

has several weaknesses. It is expected that incorporating artificial intelligence (AI) will improve existing defects. This speculation leads one to question the advantages and disadvantages of implementing AI into Brain-computer interfaces for neurological diseases. The results of this research determine whether implementing AI into BCI systems is feasible for the rehabilitation of paralysis in victims of different neurological disorders. It also includes studies that compare the quality, accuracy, and efficiency of AI systems.

Brain-Computer interfaces:

Brain-computer Interfaces (BCI) is a computer-based system that absorbs brain signals by the central nervous system (CNS) and analyzes the neuronal information to perform tasks controlled by an output device. The BCI observes the user's brain signals and then translates the signals into commands. BCIs restore function to those combating neurological disorders that prevent the brain from performing voluntary or involuntary movements. There are two primary types of BCIs: invasive and non-invasive. Invasive BCIs are implanted by surgery into the brain. Non-invasive BCIs involve placing sensors directly on the scalp to uncover EEG (electroencephalogram) signals from the brain. BCIs incorporate assistive actuators that enhance one's ability to communicate and perform actions such as talking or walking. These devices may include touch screens, keyboards, wheelchairs, and robotic limbs. However, BCIs are unable to decode electrical signals from the brain at all times. Currently, they are restricted to basic communication such as sensory-motor functions. This article will discuss how current advances in AI technology can aid in resolving any obstacles that current BCIs face. The findings display the potential of AI in a clinical neurological setting.

Discussion:

Artificial intelligence “[applies] advanced analysis and logic-based techniques, including machine learning, to explicate events, support and automate decisions, and take actions” (Gartner Glossary, n.d). The most generally used form of artificial intelligence includes AI virtual assistants which can be found on several websites including ChaptGPT. The AI used in these websites interprets data based on metadata or personalized databases. AI can also be used to complete the most tedious tasks in clinical settings. Concerning BCIs, (Zhang et al., 2020) states that AI algorithms interpret data provided by internal parameters such as “pulse durations, and amplitudes, simulation frequencies, energy consumption by the device, stimulation or recording densities, and electrical properties of the neural tissues” (par. 4). These

algorithms have also greatly increased processing speeds to decode and encode signals from the brain. As data is processed faster, actuators can perform more complex and elaborate tasks commanded by the brain.

AI in data processing:

A specific type of machine learning (ML) algorithm includes deep learning (DL). DL systems contain neural networks that assist in analyzing human cognition. (Cao, 2020) indicates that in "EEG-based BCI applications, the DL is widely used to extract EEG features and then combine with the traditional ML technology to achieve a…regression task" (p. 166). This system avoids major information loss which further enhances the accuracy and performance of a BCI. The non-invasive EEG evaluates various aspects of the electrical activity in the brain and uncovers real-time psychological data. But the process is typically time-consuming and tedious. (Saeidi et al., 2021) indicates that "High-level features obtained by using the DL model… resulted in a high accuracy of 87.27%" in EEG systems (p. 18). In addition to accurate interpretation levels, the AI algorithms also indicate earlier detections of issues or insights. However, a limitation of training ML or DL models includes having a finite amount of EEG data which affects real-world applications. But (Cao, 2020) reveals that a generative adversarial network (GAN) model was developed to "[learn] the statistical characteristics of the EEG and [increase] the size of datasets by generating synthesis samples to improve classification performances" (p. 167). In other words, by employing data augmentation, the GAN model can generate synthetic data and repurpose real-world data. DL algorithms allow for devices to function with precaution as it is much more efficient in analyzing data and less time-consuming. Another restriction of traditional BCIs is the inability to predict movements accurately at all times. (Mattioli et al., 2022) conducted a study on a type of DL algorithm known as the Convolutional neural network (CNN). The model was tested with motor imagery datasets and received an accuracy score of 99.38% for prediction. (Mattioli et al., 2022) includes that the proposed system outperforms the current model with an accuracy score of 97.28%. These methods can also reduce the need for extensive data training. BCI systems alone fail to enhance the quantity and quality of neuronal information. Therefore by incorporating new DL algorithms, tasks such as analyzing motor imagery have the potential to become advanced.

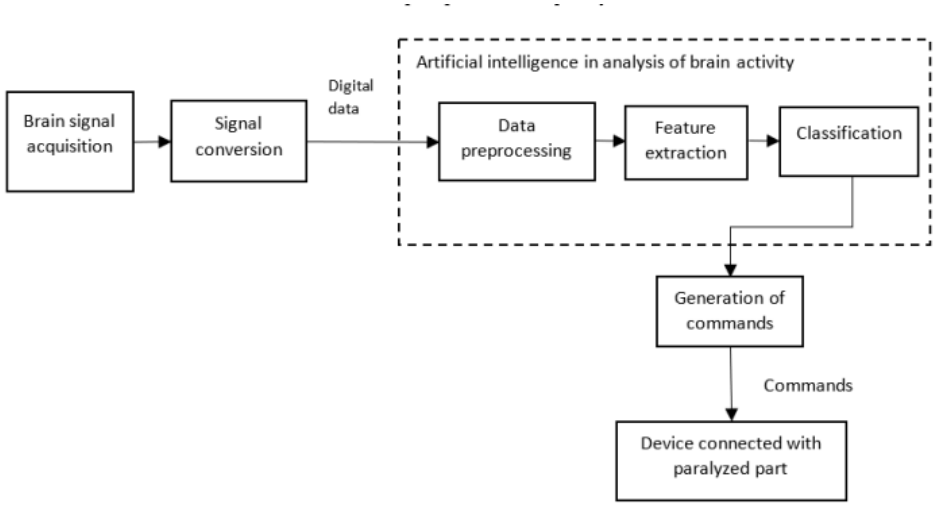
AI in feature extractions:

Although the combination of both systems is relatively new, there have been successes in implementing machine learning systems into BCIs. The types of ML and DL algorithm classifiers that

achieve high accuracy in data analysis include K-nearest neighbors (KNN), Artificial neural networks (ANN), Recurrent neural networks (RNN), and the Convolutional neural network (CNN). A study conducted by (Majumdar et al., 2023), claims that the implementation of the Automated Sensor and Signal processing selection (ASPS) approach results in the most accurate levels for feature extractions of EEG. Feature extractions involve the process of converting raw data into preserving only the most relevant information for ML programs. The ASPS approach selects valuable data for effective communication. In the study, the authors tested to see which ML and DL algorithms would result in the most accurate recognition of 5 human imaginations. As each algorithm was tested 100 times, the average of the results was taken. (Majumdar et al., 2023) reveals that for the two types of ANN used (LVQ and FFN), the ASPS method "attained accuracy between 80% – 100% to recognize five imaginations… [and for 3 imaginations] a 100% accuracy" was achieved (p.10). Those who face Complete Locked-in-Syndrome (CLIS) and Amyotrophic lateral sclerosis (ALS) may not have the ability to function in certain limbs, but they still possess thoughts and imaginations. Instead of only interpreting human cognition, the approach may allow BCI systems to classify complex brain signals to better comprehend a patient's needs, desires, and emotions. The study conveys that with these findings, it is capable for patients who suffer from CLIS or ALS to have the most effective, accurate, and low-cost BCI system. Eventually, this implementation can translate into prosthetic devices for a better understanding of commands to perform various tasks.

AI in classifications:

(Surianarayanan et al., 2023) provides a summarized process of the role of artificial intelligence in BCI systems shown in Fig.1:



According to the graphic, AI centers around Data preprocessing, Feature extraction, and Classification. Classification is an integral part of transforming signals into commands. Its role is composed of separating data into categories making the data interpretation process much simpler for external devices. AI classifiers require either a one-dimensional (1D) or two-dimensional cursor (2D) to navigate and control movements on an external device. 2D cursor controls can operate through Functional Magnetic Resonance Imaging (fMRI) or be EEG-based. The fMRI detects changes in the blood flow according to neural activity. Unlike 1D cursors, 2D cursors can control the vertical and horizontal movements of a cursor at the same time. Therefore, it can execute more complex tasks for real-world applications. Braingate is a brain implant system with a neurotransmitter prosthetic device. It is designed to aid those who experience paralysis or a loss of function in their limbs due to neurological disorders. As Braingate is an invasive BCI, a small chip is inserted into the patient's scalp. It uses cursor controls to send commands to a computer system that translates them into tangible actions. BrainGate conducted a study with a patient suffering from tetraplegia after a cervical spinal cord injury. With the use of an implant, the patient "achieved two-dimensional movement of a cursor on a screen [to] direct the movement of a robotic limb" (Zhang et al., 2020, par. 8). The patient simply has to imagine their movements with their motor cortex and then they can perform various tasks with a prosthetic device. Despite their paralysis, the patient was able to maintain control of their device for a duration of 1,000 days after receiving the implant. This demonstrates the potential of AI algorithms to continue merging with BCI systems as the cursor control process proves beneficial for accuracy in data interpretation and implant longevity.

Privacy and security concerns:

Though the integration of AI into BCIs is quite promising, it is significant to acknowledge the obstacles and constraints that may prevent it from being successful. At this point, it is recognized that AI-based BCIs have the ability to unlock an abundance of information from the brain. This raises some ethical concerns regarding privacy and malpractice. Since AI algorithms are capable of extracting complex data on individuals' thoughts, imaginations, and emotions, it is significant for the host user to be certain of where exactly their data is stored. (Chenna, 2023) suggests that companies should make sure to develop "transparent policies around data collection, storage, and analysis… [or] legal frameworks that establish clear guidelines for data ownership and control" for individuals (p.11). Currently, some companies exploit data gathered by devices commonly used –such as phones or computers– and sell that information to advertising companies. Thus resulting in individuals seeing more ads that are tailored to

their interests. Marketers are already examining the future scope of combining capitalism with BCI technology. (Parida, 2020) explains how in the future, non-invasive BCIs will allow marketers to "track customer journeys, sentiments, and preferences…and send tailor-made ads and experiences to increase sales" (par. 15). It is morally incorrect for companies to begin exploiting sensitive information merely for sales and profit. It is also dangerous as AI-based BCI devices can expose users to be at risk of data breaches. For instance, brain data gathered from the technology can be sold to and taken advantage of by suspicious third parties that lack a direct relationship with the original user. Also, these parties may have the ability to hack a patient's BCI, leading to severe brain damage. Therefore BCI companies should be transparent on where, when, and how information is stored for individuals that seek to use the technology.

Financial obstacles:

Artificial intelligence in a clinical neuroscience setting also proposes financial challenges. Most AI-based BCI technology is expensive. According to (Shih, 2012), both non-invasive and invasive BCIs typically cost around $5000 to $10,000. Furthermore, invasive BCIs are much more expensive due to the costs of surgical implants. But with the addition of AI systems and the need for technical maintenance, the price of BCIs will be far from affordable. This raises the question: How accessible is BCI technology to patients around the world? Those with severe cases of neurological diseases may not have the clinical facilities or access to high-tech devices to aid them. Neurological diseases such as Multiple Sclerosis (MS) or Locked-in syndrome result in severe paralysis. Patients that do not receive the treatments and resources to combat their paralysis are forced to operate despite being unable to perform basic tasks such as walking, eating, or driving. A possible solution to this can be to construct BCIs with low-cost hardware and software, but this would negatively affect the quality of the finished device.

Conclusion:

Is the implementation of AI in BCIs truly revolutionary? Despite the limitations, AI-based BCIs are promising for the future of neurorehabilitation. It plays a crucial part in directing external devices to perform commands by the host. It is essential that prosthetic devices, such as robotic limbs, need an advanced system to carry out various commands. The discussion supports the claim that AI has the capability to combine with neurotechnology successfully. Even though the technology is still in its infancy, integrating the two provides confirmation for advancing BCIs and improving the condition of those with neurological disorders. BCIs are currently used for simple communication and to execute basic tasks. The studies included in this paper serve to present the potential of AI in the near future. Patients can potentially communicate the most complex thoughts or even participate in athletic activities. Apart from neurological disorders, this technology can help the visually impaired, amputees, and those with acquired

spinal injuries. AI's performance is expected to accelerate by 2045, having near human-like intelligence. By then, it is hoped that AI-based BCIs will be the most affordable and convenient option for all victims of paralysis.

Works Cited

Cao, Z. (2020). A review of artificial intelligence for EEG‐based brain−computer interfaces and applications. *Brain Science Advances,* 6(3), 162–170. https://doi.org/10.26599/bsa.2020.9050017

Chenna, S. (2023, May 13). *Exploring the Use of Artificial Intelligence in Brain-Computer Interfaces for Improved Control and Communication. Social Science Research Network.* https://doi.org/10.2139/ssrn.4447601

Bacher, D., Jarosiewicz, B., Masse, N. Y., Stavisky, S. D., Simeral, J. D., Newell, K., Oakley, E. M., Cash, S. S., Friehs, G., & Hochberg, L. R. (2014). *Neural Point-and-Click Communication by a Person With Incomplete Locked-In Syndrome. Neurorehabilitation and Neural Repair,* 29(5), 462–471. https://doi.org/10.1177/1545968314554624

Majumdar, S., Al-Habaibeh, A., Omurtag, A., Shakmak, B., & Asrar, M. (2023). A Novel Approach for Communicating with Patients Suffering from Completely Locked-in-Syndrome (CLIS) via Thoughts: Brain Computer Interface System using EEG Signals and Artificial Intelligence. *Neuroscience Informatics*, 100126. https://doi.org/10.1016/j.neuri.2023.100126

Mattioli, F., Porcaro, C., & Baldassarre, G. (2021). A 1D CNN for high accuracy classification and transfer learning in motor imagery EEG-based brain-computer interface. *Journal of Neural Engineering*, *18*(6), 066053. https://doi.org/10.1088/1741-2552/ac4430

Saeidi, M., Karwowski, W., Farahani , F., Fiok, K., Taiar, R., Hancock , P. A., & Al-Juaid, A. (2021). *Neural Decoding of EEG Signals with Machine Learning: A Systematic Review* [Review of *Neural Decoding of EEG Signals with Machine*

Learning: A Systematic Review]. *11*(11). https://www.mdpi.com/2076-3425/11/11/1525

Shih, J. J., Krusienski, D. J., & Wolpaw, J. R. (2012). Brain-Computer Interfaces in Medicine. *Mayo Clinic Proceedings*, *87*(3), 268–279. https://doi.org/10.1016/j.mayocp.2011.12.008

Stieger, J., Engel, S., Suma, D., & He, B. (2021). Benefits of deep learning classification of continuous noninvasive brain-computer interface control. *Journal of Neural Engineering*. https://doi.org/10.1088/1741-2552/ac0584

Surianarayanan, C., Lawrence, J., Chelliah , P., Prakash, E., & Hewage, C. (2023). Convergence of Artificial Intelligence and Neuroscience towards the Diagnosis of Neurological Disorders—A Scoping Review [Review of *Convergence of Artificial Intelligence and Neuroscience towards the Diagnosis of Neurological Disorders—A Scoping Review*]. *Sensors*, *23*(6). https://www.mdpi.com/1424-8220/23/6/3062

The Rise of Brain Computer Interfaces and the Future of Marketing. (2020, September 8). Future of Marketing Institute. https://futureofmarketinginstitute.com/the-rise-of-brain-computer-interfaces-and-the-future-of-marketing/

Young, M. J., Lin, D. J., & Hochberg, L. R. (2021). Brain–Computer Interfaces in Neurorecovery and Neurorehabilitation. *Seminars in Neurology*, *41*(02), 206–216. https://doi.org/10.1055/s-0041-1725137

Zhang, X., Ma, Z., Zheng, H., Li, T., Chen, K., Wang, X., Liu, C., Xu, L., Wu, X., Lin, D., & Lin, H. (2020). The combination of brain-computer interfaces and artificial intelligence: applications and challenges. *Annals of Translational Medicine*, *8*(11). https://doi.org/10.21037/atm.2019.11.109

Healthcare Data and Algorithms in Artificial Intelligence

Victoria Nelms, Charlotte Lungren (advisor), Anika Shah (advisor)
Batesville High School Charter

Abstract:

This paper discusses the data and processes behind Artificial Intelligence (AI) in the medical field. It delves into the basic workings of AI (machine learning and deep learning), data sharing, privacy and international ethical concerns, and possible future laws pertaining to personal data in AI. AI algorithms are increasingly common in healthcare. They play a significant role in improving diagnosis, treatments, and research. Due to the extensive interworking of this technology with sensitive information, paranoia and mistrust arises. The risks of AI in medical settings do not deter the undeniable benefits it provides.

Introduction:

As Artificial Intelligence (AI) evolves, it continues to spread into every corner of our everyday lives. AI entered healthcare as soon as the early 1970s, and today, we see AI continue to grow in usage and development. (XSOLIS Insights, 2021) The two main "ingredients" for a working AI program are an advanced learning model and supplied data. Without one or the other, AI would be rendered useless. As the technology of AI strengthens, it needs more data to perform to the best of its abilities, but this is where privacy issues arise. These issues have been neglected over the years since many countries, specifically Western, wish to prosper medically to defeat all medical crises. As technology grows, AI immensely changes opportunities in the medical field by improving patient care, diagnosis, and treatment through speed and accuracy. However, safety concerns appear as AI becomes more advanced and spreads across the world.

Discussion:

Artificial Intelligence Algorithms:

AI has to be supplied with data and interpret it to function. The interpreting computer models are machine learning, "an AI technique that teaches computers to learn from experience," and deep learning, a specialized machine learning system. These are two ways data is interpreted and applied in healthcare.

(MathWorks Staff, n.d.) Machine learning and deep learning interfaces provide doctors and patients with quick and often trustworthy results.

The majority of AI programs in Healthcare use machine learning. (Davenport & Kalakota, 2019) Precision medicine (focusing on particular groups of patients) is the most likely to be explored under this model. Tempus is an AI program that uses machine learning architecture with an oncology focus. By compiling health data and research in one database, Tempus can create customized care plans for patients. (Tempus Staff, n.d.) To achieve functionality, the AI becomes accustomed to a training database that provides cases and solutions. This training process is referred to as supervised learning. When presented with a medical case, the AI will shift through the database and present a solution to diagnoses that have appeared in the past. However, machine learning AI will not be able to identify new diagnoses or diagnoses under different circumstances since it uses pattern recognition of smaller databases. (Arm Staff, n.d.) This situation reiterates claims that surface-level AI can only be as intelligent as the humans in charge.

Deep learning is one of the most advanced forms of AI, seeing that it can grasp more data. You can find this in everything from online translators to cancer research. In healthcare, deep learning is faster than any human. It can detect cancer cells automatically. (Sanober, 2022) Deep learning is modeled after the human brain using neural network architectures, also called deep neural networks. (MathWorks, n.d.) The term “deep” refers to the many hidden layers in the man-made brain network. These layers help deep learning work quickly and efficiently, but more is happening than what meets the eye. There can be up to 150 deep layers that users cannot see that the AI uses to get from the input to the desired output. This scenario is called a “black box.” This scenario is where we cannot see exactly how the AI got from point A to point B due to the complex mathematical workings. We know that the program was able to complete the task due to the knowledge provided during its training and the solution provided. (Dashi & Blouin, 2023)

Deep learning and machine learning are used widely in the medical field. These computer systems support programs that aid professionals with diagnoses, research, drug development, discovery, and transcribing medical documents. Researchers from the University of Southern California partnered with the Defense Advanced Research Projects Agency and the U.S. Army and found that people afflicted with post-traumatic stress disorder and similar issues are more comfortable speaking with an AI bot about their concerns and mental anguish. (Basu et al., 2020) Diagnosing and identifying diseases is a quicker process with the application of AI. The algorithms can analyze medical images such as MRIs, X-Rays, and ultrasounds faster and more accurately than their human counterparts. (Al-Antari, 2023) These advanced technologies allow healthcare professionals to save time diagnosing and spend more time on treatment.

Data Sharing and Implementation:

Machine learning and deep learning are trained by receiving data from the developer. This data is applied to pattern recognition programs in AI-driven tools to produce a liable output. Healthcare data is implemented into AI through various sources on both the national and international levels. Laws on data protection vary internationally, so companies have to be increasingly careful they do not create an *ethics shop*.

Data is shared with AI so the program can execute the process of training, testing, and verification. As data is collected, processed, and stored in the developmental pipeline, it may cross international or national borders. (Mörch & Li, 2022) Databanks for medical imaging and other medical data exist, but companies must be careful since different countries have different ethical laws. Most data for developing AI across organizations often fall outside ethical guidelines and agreements. Data protection laws, agreements, values, and ethical laws must be monitored carefully so *ethics shops* (*ethics dumps*), or "the most convenient and least restrictive location to conduct a specific task in the algorithm development pipeline…" is not formed. (Mörch & Li, 2022) This type of database may cause algorithms to be poorly designed and trained, therefore resulting in harm to the patient. The implementation of data from various countries could be dangerous, seeing that medical protocols differ across the world and data from underdeveloped countries may conflict with developed treatments. While large databases full of information seem ideal for performing levels of AI, they may cause damaging treatments and unnecessary mistakes that may lead to lawsuits or violations of the Health Insurance Portability and Accountability Act (HIPAA). (McKeon, 2022)

Fragmented data is a risk that comes with transferring AI data across organizations. When this information is delivered across databases, the AI model must be recalibrated for the transition to work. This also leaves sensitive data in a weak position that is vulnerable to privacy concerns. Healthcare organizations limit sharing data because once the data passes through recalibration, it may become fragmented and less trustworthy. (Basu et al., 2020)

Sharing sensitive data across many geographic and socioeconomic world settings could cause AI to develop a social bias. (Pew Staff, 2021) This does not happen due to AI programming, but rather because of AI databases that contain prejudiced human decisions and historical inequities. (Enikeev, 2022) To avoid bias in AI, it is essential for the provided data to be diverse in race, gender, and nationality. As the AI continues to collect data as it works, it may fuel biases in the provided data since it is using various levels of pattern recognition. (Basu et al., 2020)

Blueprint for an AI Bill of Rights:

In October 2022, the White House of the United States of America released a blueprint for an AI Bill of Rights. While this bill addresses consent and bias, it overlooks how AI does not possess the same fiduciary as medical workers. The blueprint for the AI Bill of Rights is simplified to consent and bias. Consent and anti-bias policies will not protect privacy.

The White House's AI Bill of Rights blueprint addresses privacy by saying citizens' data will be protected using built-in protections to fight abusive systems. (OSTP, 2022) The majority of the data privacy expectations are consent-based. By consenting to your information being used in databases, your privacy is not being shielded from unauthorized access, security breaches, or misuse. AI tools expose patient data to other variables outside of the program, such as software vendors and information service providers that do not possess the same legal obligations. (Evans & Nissenbaum's, 2023) State laws and soft laws would have to be reformed to cover these variables.

One of the most important sections of the blueprint is that human alternatives will still be available outside of AI. (OSTP, 2022) The section outlines that in appropriate situations with sensitive contexts, any consumer will have access to human services outside of AI. Precautions outlawing any type of discrimination or bias are also shown in the plan. While these sections of the bill will protect patients' mental health and comfort, they will not protect them from data breaches or misconduct with information. To properly protect patients and organizations using AI in healthcare, this bill would have to be refined. Policies would have to go beyond consent and become more specific. The blueprint is heavily targeted toward surveillance, agreements, and discrimination, which are topics already addressed in the medical field.

Conclusion:

Artificial Intelligence transforms every realm of the medical field by providing new means of speed and accuracy. There are many ways AI will continue to grow and prosper. Even with drawbacks such as complicated technology, privacy risks, and newly developing laws, healthcare organizations benefit from AI worldwide. Machine learning and deep learning process the implemented data to quickly diagnose patients and get them proper treatment. Security threats cause immense determents in AI sophistication, but as governments catch up with the new developments, laws will be put in place to keep private and sensitive information safe. AI has transformed and will continue to transfer healthcare for the better.

Works Cited

Al-Antari, M. A. (2023, February 12). *Artificial Intelligence for Medical Diagnostics—Existing and Future AI Technology!* NCBI. Retrieved July 9, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9955430/

Arm Staff. (n.d.). *What is pattern recognition – Arm®*. Arm. Retrieved July 8, 2023, from https://www.arm.com/glossary/pattern-recognition

Basu, K., Sinha, R., Ong, A., & Basu, T. (2020). *Artificial Intelligence: How is It Changing Medical Sciences and Its Future?* National Library of Medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7640807/#:~:text=Artificially%20intelligent%20computer%20systems%20are,prescriptions%2C%20and%20remotely%20treating%20patients.

Dashi, V., & Blouin, L. (2023, March 6). *AI's mysterious 'black box' problem, explained*. University of Michigan-Dearborn. Retrieved July 8, 2023, from https://umdearborn.edu/news/ais-mysterious-black-box-problem-explained

Davenport, T., & Kalakota, R. (2019). *The potential for artificial intelligence in healthcare*. NCBI. Retrieved July 8, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6616181/

Enikeev, D. (2022, March 14). *Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility?* NCBI. Retrieved July 9, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8963864/

Evans, B. J., & Nissenbaum's, H. (2023, February 16). *Rules for robots, and why medical AI breaks them*. NCBI. Retrieved July 9, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9934949/

MathWorks. (n.d.). *What Is Deep Learning? | How It Works, Techniques & Applications*. MathWorks. Retrieved July 8, 2023, from https://www.mathworks.com/discovery/deep-learning.html

MathWorks Staff. (n.d.). *What is Machine Learning? | How it Works, Tutorials, and Examples*. MathWorks. Retrieved July 8, 2023, from https://www.mathworks.com/discovery/machine-learning.html

McKeon, i. (2022, October 13). *Key Ways to Manage the Legal Risks of a Healthcare Data Breach*. HealthITSecurity. Retrieved July 9, 2023, from https://healthitsecurity.com/features/key-ways-to-manage-the-legal-risks-of-a-healthcare-data-breach

Mörch, C., & Li, J. (2022). *Governing Data and Artificial Intelligence for Health Care: Developing an International Understanding*. NCBI. Retrieved July 9, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8844981/

OSTP. (2022). *Blueprint for an AI Bill of Rights | OSTP*. The White House. Retrieved July 9, 2023, from https://www.whitehouse.gov/ostp/ai-bill-of-rights/

Pew Staff. (2021, August 5). *How FDA Regulates Artificial Intelligence in Medical Products*. The Pew Charitable Trusts. Retrieved July 9, 2023, from https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2021/08/how-fda-regulates-artificial-intelligence-in-medical-products

Sanober, S. (2022, March 8). *Deep Learning in Healthcare System for Quality of Service*. NCBI. Retrieved July 8, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8906124/

Tempus Staff. (n.d.). Tempus Website. Tempus | AI-enabled precision medicine. Retrieved July 10, 2023, from https://www.tempus.com/

XSOLIS Insights. (2021, February 2). *The Evolution of AI in Healthcare*. XSOLIS. Retrieved June 29, 2023, from https://www.xsolis.com/blog/the-evolution-of-ai-in-healthcare

Literary Review

Artificial Intelligence Effects On Patients and Providers

Vienna Li (author), Charlotte Lungren (advisor), Anika Shah (advisor)
Perkiomen Valley High School

Abstract

The paper discusses the patient and provider's opinions on AI implementation. It discusses two experimental studies: one is patients' different concerns caused by AI and the second is comparing people's different comfortability. This also touches on the advantages and limitations of AI in healthcare. Although AI has already been integrated into AI, there are many raised concerns from patients and providers.

Introduction

Artificial Intelligence (AI) was first introduced during the 1940s-1960s as an invention to better technological developments and combine machines with organic beings. Soon in the 1970s, AI was used for biomedical problems and since then, AI applications have only grown and become accustomed to the healthcare industry. It has benefited healthcare by reducing spending, improving a patient's outcome, and exceeding past efficiencies. Although AI interaction with humans can benefit patients, it is essential to address any concerns that arise to prevent any issues and discomfort.

Discussion

Patients' Opinions on AI

During the experimental study, researchers studied patients' perceptions toward interacting with AI in a healthcare aspect. The health care service encounters and health conditions were major factors that influenced an individual's impressions of trust, privacy, communication barriers, potential risks with liability, and uneasiness about the transparency in regulatory standards. Since patients are one of the main groups that benefit from all the technology interaction, patients' perceptions and opinions can affect clinical AI from becoming a common practice. Through their experiment, they found the reason for the discomfort with AI is due to incompatibility with ethical, technical, or regulatory values. There are also evident concerns with AI being used as a recommendation system under a physician with more wisdom, control, and experience. To further identify the issues that could arise from using AI, the researchers concluded with how there was still a need for studies and experiments. A solution to this crucial concern

is the establishment of standards and evaluation guidelines for AI implementation when collaborating with healthcare institutions. Frequent inspections, monitoring, and reporting of the systems are other important actions to pursue the necessary quality assurance, safety, transparency, and ethical factors for everyone.

Providers with AI

According to Drexel University, AI definitely has made its mark in the industry. For example, AI has aided practitioners in the betterment of operations by simplifying complex procedures and streamlining tasks. Without a doubt, AI has changed the industry, but the technology is still considerably new. With the continuation of AI expansion, there are raised questions and concerns about the advantages and limitations of AI. One limit is the necessity for human surveillance of AI. The example provided is how surgery robots behave in a logical way and not with empathy. A healthcare practitioner could observe a vital or behavioral change to diagnose or prevent any medical complication in contrast to a robot unable to. Ultimately, AI needed human input and evaluation to be considered an effective tool. Even though this is a negative of AI, fortunately, the medical and technology fields maintain communication to advance technology. Professor Christopher C. Yang, PhD of Drexel University Information Science explains how medical professionals are required to complete years of education to operate their fields. Through Subject Matter Experts, crucial information collected enhances the data currently available and builds up the explainable AI to give trusted and significant insights to healthcare workers.

Studies with the Public

Pew Research Center performed a survey that explored the public views on AI in the healthcare and medical field, areas where Americans could gradually encounter more technologies in their patient care. The outcome of their survey is that a higher majority are uncomfortable with the health care provider's relying on AI for their medical care. Through the survey, they concluded that on a personal level, there is considerable discomfort associated with the idea of AI being utilized in their health care among Americans. This is important because AI is becoming increasingly involved in healthcare and if the receivers, the patients, of AI are uncomfortable, people lose trust in the industry and become deterred from healthcare. The results from a second survey done by the Pew Research Center was that six out of ten American adults have stated they would feel uncomfortable if their provider relied on AI with diagnosis and treatment recommendation while 39% of Americans would feel comfortable with AI usage. Another factor that was weighed was how a majority of the public did not believe that using AI in medicine and health would result in any improvement of health outcomes. Results were 38% of U.S. adults said AI used for diagnosis and recommendation of treatment would lead to better health outcomes

while 33% stated it would lead to an inadequate outcome, and 27% of the U.S. stated AI used would not make a significant difference. One of the main concerns with AI is the personal bond and interaction between the patient and provider. 57%, quite a large percentage, stated using AI would only make the patient-provider relationship worse, while only 13% would say it would make it better. This demonstrates how there is a significant concern over the relationship with the practitioner and that the public put a large weight on this. Overall, there are definitely many positives and negatives when considering AI in healthcare and medicine, but there is still an overarching awareness in the eyes of the public. The pacing of AI adoption in healthcare is a widely shared topic discussed across groups whether it is the public and patients or the people who are most familiar with AI technology.

Conclusion

Taking the time to remediate all concerns of the people, the healthcare industry, and patients is important. As AI is increasingly implemented more and more, it is vital to resolve these problems or at least find a way to accommodate if patients are not comfortable with AI. There is still a large percentage of people who are uncomfortable with AI including patients and healthcare providers. Although AI has the ability to streamline tasks making them efficient, they still are machines with no emotions who cannot determine anything with empathy. This is concerning for patients because they still want the emotional bond between provider and patient, and this is concerning for the provider because it is difficult to entrust the care to AI when there are trust issues with security and data. Until these dilemmas are solved, AI may not completely be implemented. Everyone should be ensured that AI clinical applications will not cause harm to them, but instead help them. Even if AI can enhance the outcomes, the many risks and concerns associated with AI must be handled before further inclusion.

References

Esmaeilzadeh, P., Mirzaei, T., & Dharanikota, S. (2021). Patients' Perceptions Toward Human–Artificial Intelligence Interaction in Health Care: Experimental Study. *Journal of Medical Internet Research*, *23*(11), e25856. https://doi.org/10.2196/25856

History of Artificial Intelligence - Artificial Intelligence - www.coe.int. (n.d.). Artificial Intelligence. https://www.coe.int/en/web/artificial-intelligence/history-of-ai#:~:text=1940%2D1960%3A%20Birth%20of%20AI,of%20machines%20and%20organic%20beings.

Nadeem, R. (2023, March 6). *How Americans View Use of AI in Health Care and Medicine by Doctors and Other Providers | Pew Research Center*. Pew Research Center Science & Society. https://www.pewresearch.org/science/2023/02/22/60-of-americans-would-be-uncomfortable-with-provider-relying-on-ai-in-their-own-health-care/

Pros & Cons of Artificial Intelligence in Medicine - College of Computing & Informatics. (2021, July 21). College of Computing & Informatics. https://drexel.edu/cci/stories/artificial-intelligence-in-medicine-pros-and-cons/

XSOLIS Insights. (n.d.). *The Evolution of AI in Healthcare*. https://www.xsolis.com/blog/the-evolution-of-ai-in-healthcare

Tempus: Reshaping the Landscape of Cancer Care with Revolutionary Artificial Intelligence

Zara Chaudhary, Charlotte Lungren (Advisor), Anika Shah (advisor)
San Francisco University High School

Abstract

This paper explores the revolutionizing efforts of Chicago-based healthcare technology company, Tempus, as they thoroughly integrate artificial intelligence (AI) into cancer care and patient treatment. It emphasizes the idea that although applications like Chat GPT have gained public infatuation, AI continues to have vast potential in more practical fields, including healthcare and cancer treatment. The discussion delves deep into Tempus' AI-driven data analysis to detect actionable biomarkers, ordered on their Edge platform, as well as their Tempus One application, which embodies precision medicine and personalized treatment. It also studies Tempus' individual collaborations with biopharmaceutical companies, AstraZeneca and Pfizer, where each partnership is in pursuit of cancer drug discovery, implementing their AI skillset. Finally, the paper ends by underscoring that although cancer is incredibly complex, Tempus has taken these challenges in its stride with a unique approach, the only thing they are missing is global recognition. With the extensive capabilities of artificial intelligence, Tempus is set to transfigure cancer care with immense personalization.

Introduction

When one considers a "revolution", minds often drift to striking periods of time such as 1789s French Revolution, the July Revolution, or the Chinese Revolution of 1949, a handful of significant events deeply rooted in history and change. However, today, a novel and contemporary revolution is brewing among us, and this age of progression begins and ends with the exploration of artificial intelligence, where the surface of its numerous capabilities has just recently been scratched. Though, despite 2023 boasting a technological revelation, beginning with the rapid rise in popularity of OpenAI's Chat GPT, an advanced AI chatbot platform which took the public by storm and won the title of the "fastest-growing consumer application in history", many still have limited knowledge of how much further the potential of artificial intelligence can stretch. In fact, AI has been applied to various fields ranging from education to retail, though, the most beneficial and essential application of such powers occurs within healthcare. Yet, despite such thorough efforts with the practical applications of AI, this progress simply remains underground, as the general public barely knows of such advancements. Nevertheless, the work being done in the background to accelerate AI in healthcare continues to be exceptional, with an abundance of companies, such as Google and Babylon Health, investing ample time and effort into this area. However, it is a startup existing so humbly: Tempus, a leader in the entwinement of artificial intelligence and precision medicine, that has truly made significant strides in the field of healthcare, more specifically, cancer. Founded in 2015 by Eric Lefkofsky, Tempus, with its innovative and personalized approach to patient care, AI-driven data analysis and AI-assisted drug discovery, continues to revolutionize cancer treatment like the masses have never seen before, with none other than artificial intelligence by its side.

Discussion

AI-driven Data Analysis & AI to Identify:

With access to data from various sources, totaling over 100 petabytes, Tempus has excelled in AI-driven healthcare analytics as well as using AI to detect and identify biomarkers, also known as signature molecules. These molecules are especially important as they serve to indicate the existence of or how positively one's body responds to treatment for a certain disease, in this case, cancer. Additionally, with an abundance of de-identified multimodal data, Tempus has been able to develop AI models to understand patterns, make accurate inferences, predictions and classifications, which they have organized on their highly innovative Edge platform. Released in 2022, Tempus' Edge platform, built specifically for pathologists to utilize their evolving AI models, permits the detection of specimens with actionable biomarkers by simply processing the information derived from a single hematoxylin and eosin stain (H&E) slide. With this AI-driven analysis, the company can then determine which cancer patients would be better assisted by additional testing and targeted treatments, alongside the benefit of earlier interventions and outcomes during their cancer care process. Aside from the Edge platform, Tempus also offers a variety of algorithmic AI-powered tests, built on the means of their vast internal database, specifically the Tempus Tumor Origin test. This test, which uses tumor RNA expression results to estimate the patient's most probable cancer types out of 68, applies artificial intelligence to simplify what would be a lengthy process for humans, as each type requires ample data. The test is also unique, as it is to be used in situations where the primary cancer site is unknown or the available diagnostic information is inconclusive. Undeniably, with Tempus' access to extensive amounts of data combined with their practical use of AI, detection and testing, the cancer treatment process is being elevated and transformed like no one has ever seen.

Precision Medicine and Personalized Treatment:

Other than the Edge platform taking an individualistic approach to cancer by identifying patients who would benefit from targeted therapies, the one-size-fits-all attitude has existed for years in healthcare. However, Tempus, titling themselves, "a leader in artificial intelligence and precision medicine", has cracked the code to personalized treatment during the cancer journey using AI to assist them, embodied by their novel Tempus One. To be released in September 2023, Tempus One is a clinical, AI-powered, voice and text assistant, created to simplify and organize the tasks of clinicians. As this assistive platform is available on the Tempus Hub desktop and mobile app, clinicians can conveniently access their patients' complete clinical and molecular profiles as well as a variety of useful datasets to better treat them. Additionally, physicians are also able to benefit from the application as they can examine the ordered information immediately to make correct and informed decisions for their patients. From clinicians being able to easily access summarized patient information, review report information on actionable biomarkers to quickly filtering patient incidence with acute specificity, it is evident that Tempus One has thought of every little thing in the best interests of both the doctor and patient. Furthermore, along with excelling in personalized treatment, Tempus One utilizes generative AI so that clinicians can ask questions such as, "Can you confirm this patient's BRCA2 Germline mutation", and the assistant will provide a detailed response, adding a layer of security to a clinicians duties and providing them with certain insights for a patient. With the AI-based Tempus One platform, cancer care is being transformed to assist doctors further, leading to more focus on the individual needs of their patients.

AI-assisted Drug Discovery:

While it may appear that Tempus has already done it all with their AI skill set (aside from creating physical robots to treat patients), they still remain in the discovery process of developing one of the most significant inventions: the cancer drug. Beginning with their 2021 strategic collaboration agreement with AstraZeneca, a research-based biopharmaceutical company who created a globally recognized COVID-19 vaccine, the two companies have been combining their individual strengths for the advancement of cancer treatment. With Tempus' extensive collection of de-identified multimodal data and AI capabilities to uncover novel insights, AstraZeneca can enhance their research and discovery processes to provide avant-grade therapeutic options for cancer patients. Additionally, in early 2023, for optimal advancement, Tempus announced another collaboration with the top-ranked biopharmaceutical company, Pfizer. In this collaboration, not only are the two focused on Tempus' vast data library, they are also extending their engagement to Tempus' AI-driven companion diagnostic offerings, and their clinical trial matching program. With the diagnostic tests identifying biomarkers to demonstrate how well a patient will respond to certain therapies, Pfizer can improve their understanding of which patients will benefit from their cancer treatments. As for the trial matching program, one which immediately enables nationwide studies for various communities, Pfizer is able to accelerate the data collection process to aid their research and development processes. From one biopharmaceutical company to the next, Tempus is working innovatively and efficiently to thoroughly reform cancer care and treatment by the means of AI-assisted drug discovery.

Conclusion

Without a doubt, cancer is one of the most difficult diseases to cure due to its heterogeneity, as there are numerous types of cancer; complex and various genetic mutations, which vary from patient to patient; and certain biomarkers, which can prevent patients from effectively responding to treatment. All of these factors, for decades, have made treating patients correctly and discovering widespread cancer therapies incredibly difficult, as there is no universal approach to the disease. However, despite these challenges, it is a mid-size, technological, healthcare company, Tempus, that is making impressive headway into reinventing cancer treatment and patient care with one secret ingredient: artificial intelligence. With the strength of AI, Tempus has used their machine learning expertise to create novel platforms and applications, such as Edge and Tempus One. They engage with their vast database, AI healthcare analytics and precision medicine to better aid their patients with a personalized approach. Additionally, they have made pioneering efforts with biopharmaceutical companies, including AstraZeneca and Pfizer, to apply artificial intelligence to cancer drug discovery, while they continue to remain committed to precision medicine. From each rigorous invention or application to the next, Tempus exhibits a persistent attention to detail, demonstrating an unprecedented amount of support for both doctors and patients alike. With their technologies, both parties are able to achieve significant victories during cancer processes, highlighting the incredible influence of their undertakings. Tempus, with their steadfast commitment to intertwining healthcare and artificial intelligence is materializing as a shining symbol of hope for the future of cancer care—all they need is the world to see them as the diamond they are.

Bibliography

About Us. (n.d.). *Tempus*. https://www.tempus.com/about-us/our-team/

AI-Driven HRD Test. (n.d.). *Tempus*. https://www.tempus.com/oncology/algorithmic-tests/

Definition of a Biomarker. (n.d.). *National Cancer Institute*. https://www.cancer.gov/publications/dictionaries/cancer-terms/def/biomarker#

Digital Pathology & AI. (n.d.). *Tempus*. https://www.tempus.com/pathology/

Tempus Announces New Strategic Collaboration with Pfizer to Advance Oncology Therapeutic Development. (2023, February 28). *Tempus*. https://www.tempus.com/news/tempus-announces-new-strategic-collaboration-with-pfizer-to-advance-oncology-therapeutic-development/

Tempus' Edge Platform Leverages Data & AI to Identify Therapeutic Options for Patients Earlier in the Treatment Journey. (2022, March 21). *Tempus*. https://www.tempus.com/news/pr/tempus-edge-platform-leverages-data-ai-to-identify-therapeutic-options-for-patients-earlier-in-the-treatment-journey/

Tempus One. (n.d.). *Tempus*. https://www.tempus.com/oncology/tempus-one/

Tempus Signs Strategic Collaboration Agreement with AstraZeneca to Advance Oncology Therapeutics. (2021, November 19). *Tempus*.

https://www.tempus.com/news/pr/tempus-signs-strategic-collaboration-agreement-with-astrazeneca-to-advance-oncology-therapeutics/

Tempus Announces Broad Launch of Tempus One. (2023, June 1). *Tempus*. https://www.tempus.com/news/tempus-announces-broad-launch-of-tempus-one/

Literary Review

How Artificial Intelligence Can Revolutionize the Healthcare Industry

Rachel Weng, Charlotte Lungren (Advisor)

Abstract

Artificial Intelligence (AI) in healthcare has shown several promising features that can make healthcare tasks easier for providers and guarantee that their patients are satisfied with their treatment. Healthcare providers are more likely to favor using AI because they are less prone to making medical errors compared to humans. Using these machines can also reduce the cost of healthcare spending because not only can they lessen the time health professionals spend on developing drugs, but they are also going to, admittedly, replace some workers. AI can also be included in wearable technology to help patients monitor their health. If algorithms detect that their user has health complications, it can notify them to see a doctor who can give them treatments based on the automatic feedback from the user's AI. All these features within AI can undoubtedly revolutionize the healthcare industry by making tasks easier for healthcare providers and ensuring that their patients receive proper treatment.

Introduction

When first introduced in the 1950s, Artificial Intelligence (AI) lacked the essential components of intelligence: they could only execute commands, not store them. On top of that, these machines were only accessible to prestigious universities and wealthy businesses due to how limited and expensive they were. Over time, AI has advanced and developed the ability to mimic brain power and decision-making processes through algorithms learned from themselves and continued to learn through their own experiences - much like humans (Ross, 2019). As these machines became more prevalent in society, businesses began relying on them more and more to run efficiently and effectively. For example, the healthcare industry's use of AI has undoubtedly revolutionized how hospitals function. Hospital staff has relied heavily on these machines to generate and store information on patients and diagnose and treat them based on any diseases they may have. Several studies have also found that AI can perform healthcare tasks as well as or even better than humans. Even though this belief has raised many questions and challenges regarding privacy and security, several of these problems can be fixed by implementing limitations on how they are designed and used. These machines hold numerous opportunities that can help advance healthcare and ensure that patients in hospitals receive the highest quality care and the most effective in a timely manner. This leads to the question: To what extent does investing in AI-enabled devices help revolutionize hospitals and advance healthcare for patients and medical staff?

Preventing Medical Errors

The term "medical error" encompasses events resulting in an unintended injury caused by medical management. The historical perspective of these errors was often seen as "rare occurrences," but in the past few decades, cases of medical errors have drastically risen in

numbers. A recent study has estimated that medical errors may account for as many as 251,000 deaths annually in the United States, making it the third leading cause of death in this country (Anderson & Abrahamson, n.d.). There are two types of errors: errors of omission, actions not taken, and errors of commission, incorrect action taken. Both types of errors can be preventable if healthcare tasks are done with caution, but making mistakes is an act that is ultimately unavoidable in human nature. Luckily with the advancement of technology, hospitals have begun relying more on AI to perform healthcare tasks because they are less prone to make mistakes than humans. This possible solution to the medical error dilemma can equip healthcare professionals with tools that improve accuracy and function as a safety net. The results of another study stated that improving data discovery, personalized treatment recommendations, and freeing medical staff to focus on their patients can potentially reduce medical errors by 30-40% (SEDGE, 2020). These machines can free up time for medical staff, decreasing fatigue arising from their routine clinical tasks and allowing them to concentrate more on spending quality time with patients (Yu et al., 2018). With the help of AI, medical staff can ensure that a patient care decision is not impacted by critical information that goes unnoticed. AI can demonstrate the ability to regenerate information about patients with 99% accuracy and evaluate and analyze test results at a substantially faster rate than humans. Therefore, the use of AI in healthcare has a tremendous effect on how hospitals function because it can ensure the most accurate test results and treatments and ultimately save the lives of several patients from medical errors.

Reducing Healthcare Costs

As mentioned, AI can analyze vast data sets and identify disease markers and trends faster than humans. This function can be especially helpful in developing a drug for a patient who needs treatment immediately. Drug discovery and development is a time-consuming process that may take several years and cost millions. But with the help of AI, algorithms can extract information on drug interactions and possible side effects to assist healthcare professionals in developing a drug. This assistance can, in turn, help lessen the time spent on creating a drug and reduce the cost of the whole experiment (Manne & Kantheti, 2021).

With the help of AI, healthcare costs can also be reduced through population management. Algorithms can identify chronic risk factors early, which can, in turn, decrease preventable hospital readmissions and control increasing healthcare spending (Olive, 2022). These algorithms can also lead healthcare providers to other non-financial benefits, such as facilitating better patient experiences, closing critical care gaps, making it easier to schedule appointments, and improving patient outcomes through effective population health management. Either way, with the impact AI has on patients, data analytics will continue to reduce costs and allow providers to create more comprehensive treatment plans.

Based on these two examples of ways AI can reduce healthcare costs, hospitals should begin to rely more on these machines because of these potential benefits. It is also estimated that wider adoption of AI can lead to 5 to 10 percent savings in US healthcare spending - roughly

$200 billion to $360 billion annually in 2019 dollars (Sahni et al., 2023). Also, as previously stated, these opportunities can lead to several other non-financial benefits.

Monitoring Personal Health

Over the years, as technology develops, AI has not only become smarter and faster but also smaller in size, so much so that they have become wearable. AI and wearable healthcare technology have greatly impacted patient care, diagnostics, emergency response, and medical research. With these two combined, it is without a doubt that it will revolutionize the healthcare industry. Research shows that the healthcare wearable AI device segment is expected to increase rapidly in use from 2023 to 2030 (Furman & Baryshevskiy, 2023). The primary reason for this growth is customer concerns over their fitness and health. With the help of AI algorithms, wearable technology can help users continuously monitor their health, detect any abnormalities and potential hazards at early stages, and connect them with HCPs for timely intervention. AI can notify its users of these potential problems in their bodies because these devices constantly monitor users' heart rate, blood pressure, ECG/EKG signals, oxygen saturation, blood glucose, sleep patterns, and activity and movement patterns (Furman & Baryshevskiy, 2023). This can be helpful to the user and their doctors as they can now track their progress toward healthy living habits and prescribe the proper treatment based on the automatic feedback received from their AI. Getting this automatic feedback is incredibly important when it comes to someone's health because it can potentially play a part in saving their life (Bocas, 2022). Getting treatment right away when notified by AI instead of waiting months later for doctors to mention it can easily prevent a patient's health complications from worsening. That is why including AI and wearable technology in healthcare can help revolutionize the industry and give patients the proper care they deserve.

Conclusion

Artificial Intelligence first appeared in the 1950s, and since then, it has significantly impacted the healthcare industry. So, to what extent does investing in AI-enabled devices help revolutionize hospitals and advance healthcare for patients and medical staff? After conducting secondary research by analyzing sources, it has been found that several factors have correlated to the importance of using AI in healthcare. Using these machines in hospitals can guarantee that healthcare providers complete their tasks accurately and possibly reduce the number of deaths caused by medical errors. Along with helping providers complete their tasks accurately, they can also help reduce the amount of time and resources spent on developing treatments which can, in turn, reduce healthcare spending. Patients can even benefit from these machines by using wearable technology to keep track of their health. All of these factors help support the fact that hospitals should start implementing AI into their healthcare because it has been proven to aid patients and hospital staff. Overall, it is without a doubt that the future of AI holds several new possibilities that can improve the healthcare industry, leaving both patients and healthcare professionals satisfied.

References

Anderson, J. G., & Abrahamson, K. (n.d.). *Your health care may kill you: Medical errors*. PubMed. Retrieved July 3, 2023, from https://pubmed.ncbi.nlm.nih.gov/28186008/

Bocas, J. (2022, March 7). *Wearables and AI will be the game changer in healthcare*. Digital Salutem. Retrieved July 3, 2023, from https://digitalsalutem.com/wearables-and-ai-in-healthcare/

Furman, O., & Baryshevskiy, A. (2023, June 16). *How AI wearable technology in healthcare helps serve patients better*. Mind Studios. Retrieved July 3, 2023, from https://themindstudios.com/blog/ai-and-wearable-technology-in-healthcare/

Manne, R., & Kantheti, S. C. (2021, April 24). *Application of artificial intelligence in healthcare: Chances and challenges*. OA Library Press. Retrieved July 3, 2023, from http://oalibrarypress.uk/id/eprint/1456/1/3449-Article%20Text-6476-1-10-20220914.pdf

Olive. (2022, March 10). *4 workflows that are key to reducing healthcare costs and improving care with AI*. Olive AI. Retrieved July 3, 2023, from https://oliveai.com/resources/blog/reduce-healthcare-cost-improve-care-ai

Ross, D. (2019, April 26). *Artificial intelligence and healthcare*. The American Health Lawyers Association. Retrieved July 3, 2023, from https://sharepoint.healthlawyers.org/find-a-resource/HealthLawHub/Documents/AI/I_Overview_AI%20and%20Health%20Care.pdf

Sahni, N., Stein, G., Zemmel, R., & Cutler, D. M. (2023, January). *The potential impact of artificial intelligence on healthcare spending*. NBER. Retrieved 3 July 2023, from https://www.nber.org/papers/w30857

SEDGE. (2020, October). *How deploying AI in hospital systems helps reduce medical errors*. SEDGE. Retrieved July 3, 2023, from https://www.sedge.ai/post/how-deploying-ai-in-hospital-systems-helps-reduce-medical-errors

Yu, K.-H., Beam, A. L., & Kohane, I. S. (2018, October). *Artificial intelligence in healthcare*. Nature Biomedical Engineering. Retrieved July 3, 2023, from https://drive.google.com/file/d/10U3KnmNY8lgQk3GXn14sMv7Tp4wsxk-n/view

Literary Review

Sports Performance Anxiety

Adwin Sujin, Charlotte Lungren (advisor), Anika Shah (advisor)
Evergreen Valley High School

Abstract

Extensive research has been conducted on sports psychology, including the role of AI in supporting athletes and coaches. This paper takes a narrower focus and delves into the specific realm of performance anxiety within sports psychology. Its primary aim is to explore the diverse strategies athletes can employ to manage performance anxiety during significant events. Additionally, the report examines the different applications of AI within the sports industry, particularly in the context of sports psychology and addressing performance anxiety.

Introduction

Athletes who engage in competitive sports undergo extensive training for months or even years to prepare for significant games. Despite their proficiency during training, many encounter challenges when it comes to performing at actual events. Extensive research has been conducted on the topic of sports performance anxiety to understand and address this phenomenon.

Sports performance anxiety, also known as competitive anxiety, is a psychological condition characterized by feelings of fear, apprehension, and nervousness experienced by athletes before or during sports competitions or performances. It is often accompanied by physical symptoms such as increased heart rate, sweating, trembling, and difficulty concentrating. Sports performance anxiety can negatively impact an athlete's performance, leading to decreased confidence, impaired focus, and reduced ability to execute skills effectively.

Sports performance anxiety can be caused by various factors that may vary from athlete to athlete. Competing in high-stakes events or important tournaments can increase anxiety levels. The significance of the competition and the desire to perform well can contribute to performance anxiety. The fear of not meeting personal or external expectations or facing negative consequences due to poor performance can also create anxiety in athletes.Low self-confidence in one's abilities, skills, or preparation can lead to heightened anxiety before or during a sporting event.The fear of being judged by coaches, teammates, or spectators can increase anxiety levels. Athletes may feel pressure to perform perfectly or fear criticism from others.Striving for perfection and having excessively high standards can contribute to anxiety, as athletes may feel immense pressure to meet unrealistic expectations.Insufficient mental training, inadequate coping strategies, or a lack of focus and concentration techniques can make athletes more susceptible to performance anxiety.Fatigue, injury concerns, or physical discomfort can heighten anxiety levels, impacting an athlete's confidence and performance.Each athlete may have unique triggers or combinations of factors that contribute to their sports performance anxiety.

This paper examines the various aspects of performance anxiety, aiming to uncover a universally effective coping strategy for athletes to overcome this challenge. If such a solution exists, what might it be?

Alternatively, if no foolproof method is found, could AI intervention present an opportunity to support athletes and coaches in tackling this issue?

Discussion

Literature review and Theoretical Concepts:

The impact of anxiety on performance has garnered significant attention in sport psychology literature. Some of the initial theories that have been explored include the Yerkes-Dodson Law of Arousal and Performance, the Smith and Smoll model,drive theory, reversal theory, and catastrophe theory. The inverted-U hypothesis proposes that there is an optimal relationship between performance and anxiety, represented by an inverted U-shaped curve. As per Yerkes and Dodson, low levels of arousal/anxiety can lead to performance decline, while moderate levels can enhance performance up to an optimal point. However, the model suggests that excessive arousal/anxiety beyond this point can lead to a decline in performance.

The Smith and Smoll model, a conceptual framework for Athletic Performance Anxiety, suggests that anxiety can impact stress responses during competitive situations, which, in turn, can have multidimensional effects on performance—physiologically, behaviorally, and/or mentally/cognitively.

In contrast to the inverted-U hypothesis, drive theory suggests a positive relationship between high performance and high anxiety, implying that increased anxiety levels correspond to improved performance.

In sport psychology, reversal theory adopts the view that an athlete exhibits complex, changeable, and inconsistent behavior that can and does alternate between psychological states from moment to moment, depending upon the meaning and motives felt by that athlete. For example, during a competition, an athlete might perceive the arousal produced by cheering spectators as positive one minute and then reverse the interpretation to negative the next, resulting in a change of metamotivational state that affects performance.

Research, Survey and Analysis:

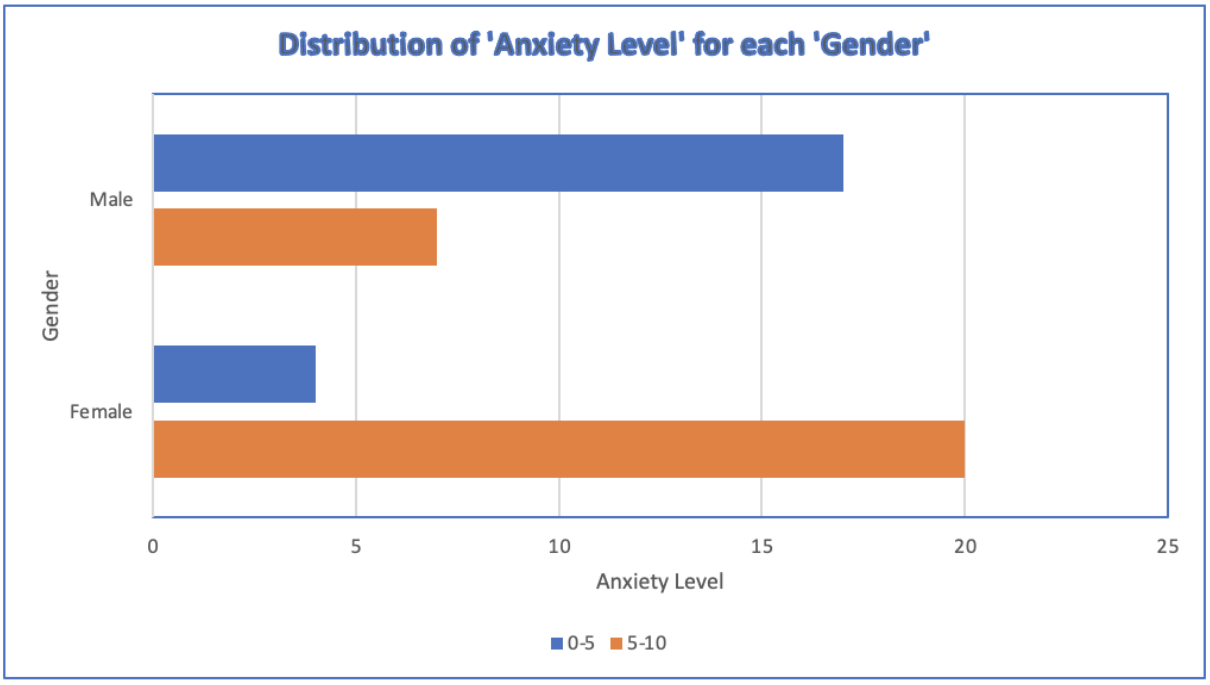
In order to gain insights into the impact of performance anxiety on athletes and identify potential coping strategies, I conducted a survey. The objective of the survey was to collect information on the diverse coping mechanisms employed by athletes, analyze any recurring patterns, and assess the effectiveness of these strategies for managing performance anxiety.

I designed a survey questionnaire that captures key information related to sports performance anxiety and AI interventions.This included questions about athletes' experiences with anxiety, how they tackle it and and their preferences for specific AI-powered tools or techniques to manage performance anxiety. The complete questionnaire is provided in Appendix A. Next I Identified a group of athletes to participate in the survey which included a total of 48 athletes between the ages of 15 and 23, who competed at a state

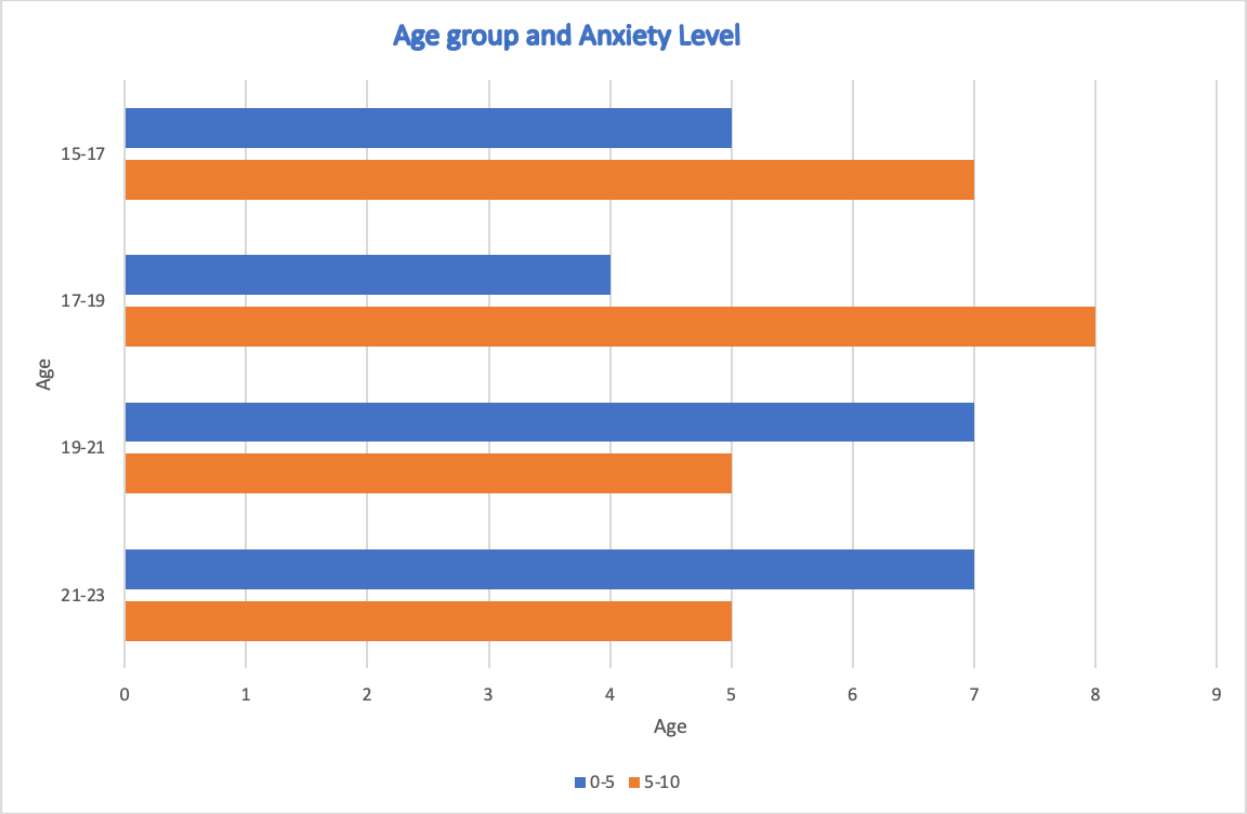
level or higher in their respective sports. All selected athletes had a minimum of three years of experience in their competitive sports and had participated in significant tournaments.Data collection for this study was conducted using an online survey.

According to the survey responses, athletes of all genders and ages experienced some degree of performance anxiety. Notably, it was observed that female participants reported a higher level of anxiety compared to their male counterparts.

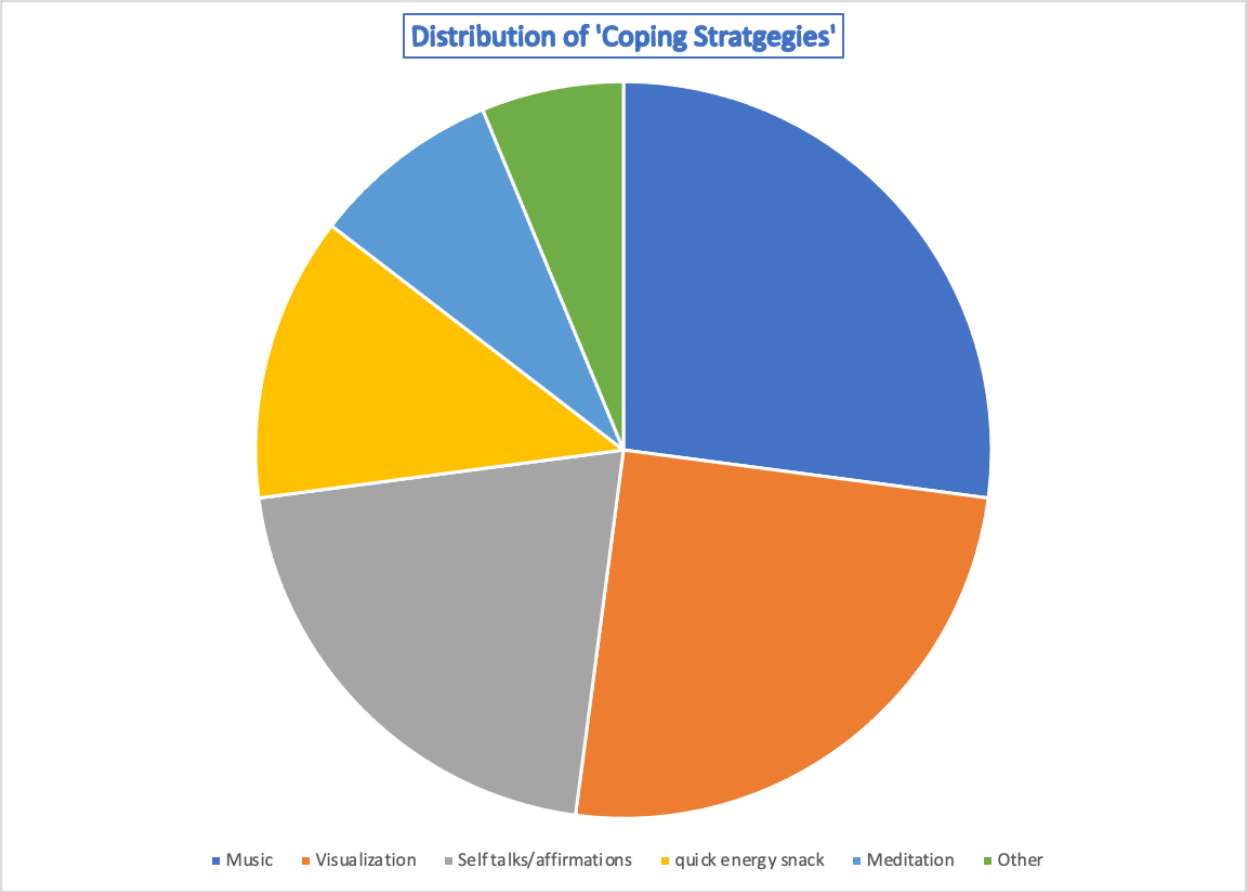
According to the survey responses, athletes of all genders and ages experienced some degree of performance anxiety. Notably, it was observed that female participants reported a higher level of anxiety compared to their male counterparts.



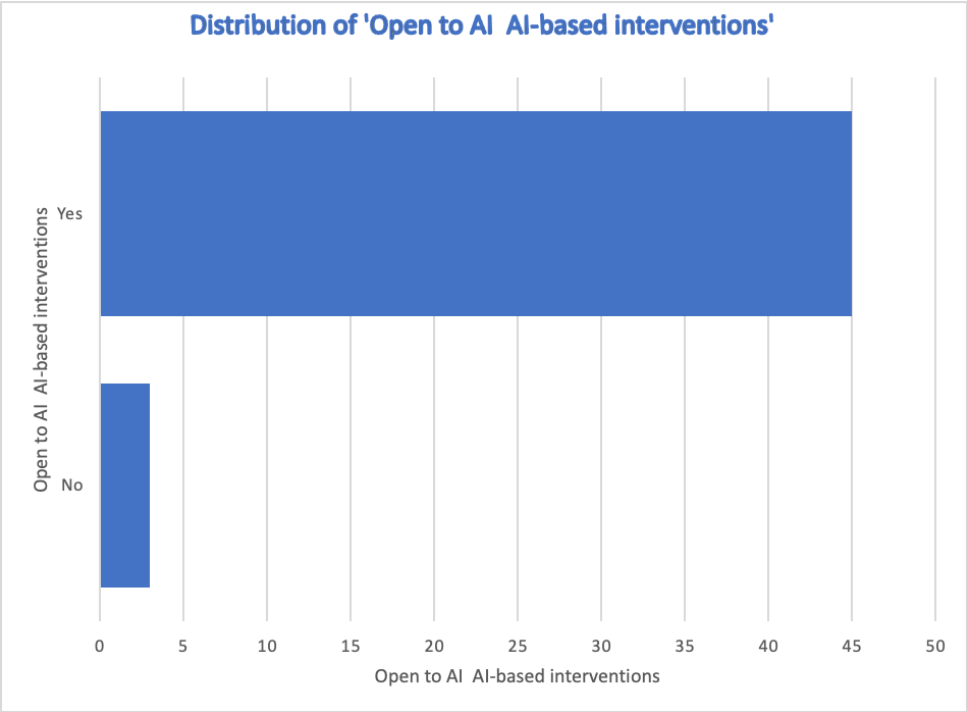
The survey results revealed that athletes in the age group of 17-19 exhibited higher levels of performance anxiety, followed by the 15-17 age group. In contrast, athletes aged 19 and above demonstrated comparatively lower levels of anxiety in relation to the younger age groups.



The analysis examined several coping strategies employed by the athletes. Music emerged as the most prevalent coping mechanism, with approximately 27 percent of participants utilizing it to address performance anxiety. Visualization was used by 25 percent of participants, while 21 percent relied on self-talk/affirmations. Around 13 percent found relief in consuming quick energy snacks, and 8 percent practiced meditation prior to their events to manage stress. Additionally, the survey indicated that some participants employed multiple methods to cope with performance anxiety.



In-depth examination of the survey data uncovered that none of the athletes considered their coping strategies consistently effective. Approximately 60 percent of participants indicated that the strategies they employed were somewhat helpful. Interestingly, none of the participants expressed a likelihood of seeking professional assistance or guidance, such as from a sports psychologist or mental performance coach, to address performance anxiety. However, it is noteworthy that 94 percent of the participants expressed openness to trying AI-based interventions for managing performance anxiety.



Recommendations and future directions

The survey conducted demonstrates the significant potential for personalized performance anxiety management guidance with AI based interventions to greatly benefit athletes. In this examination, I will explore several ways in which AI can contribute to this field, including performance analysis, visual stimulations, mental health monitoring, personalized interventions, virtual support systems, and mindfulness training.

Using AI-powered technologies, performance data of athletes, such as physiological and technical metrics, can be analyzed to detect patterns and areas that need improvement. By offering unbiased insights, these technologies help athletes develop a clearer comprehension of their strengths and weaknesses, ultimately reducing anxiety levels.

AI has the capability to generate virtual environments and simulations that replicate real-game scenarios, providing athletes with a controlled setting for practice and preparation. This aids in diminishing anxiety by acquainting athletes with high-pressure situations and enabling them to devise strategies for effectively managing stress.

Through the analysis of indicators such as stress levels, sleep patterns, and mood fluctuations, AI systems have the capacity to monitor the mental and emotional well-being of athletes. This enables early detection of signs of anxiety or distress, allowing for timely interventions such as offering coping strategies or facilitating connections with mental health professionals.

By utilizing AI algorithms, an athlete's individual performance anxiety triggers and responses can be analyzed, enabling the tailoring of interventions and strategies accordingly. This personalized approach assists athletes in developing effective coping mechanisms and fostering resilience.

Virtual assistants can act as valuable resources for athletes, offering motivational messages, relaxation techniques, and guidance on anxiety management. These virtual coaches are accessible 24/7, ensuring immediate support whenever athletes require it the most.

With the aid of AI-powered devices, athletes can receive real-time biofeedback, enabling them to monitor physiological responses like heart rate variability or breathing patterns and detect signs of anxiety. Furthermore, AI-guided mindfulness and meditation apps can support athletes in practicing relaxation techniques, enhancing their focus, and improving mental clarity.

Conclusion

Based on the aforementioned research, it is evident that a significant number of athletes experience performance anxiety to some degree. Each athlete has developed their own set of strategies, either singularly or in combination, to manage this anxiety. However, it is clear that none of these strategies consistently yield optimal results. Despite this, many athletes hesitate to seek assistance from professional sports psychologists, possibly due to factors like cost, social stigma, privacy concerns, time constraints, and limited availability of professional support.It was also clear that athletes generally appreciate the opportunity to utilize AI-based interventions that offer personalized guidance for managing performance anxiety. In this study, various ways in which AI can contribute to this field have been examined. It is vital to recognize that although AI can offer valuable assistance, it should not substitute human interaction and the expertise of professionals. Optimal outcomes in addressing sports performance anxiety can be achieved through collaborative efforts between AI systems, coaches, sports psychologists, and healthcare professionals.

Sources Cited

Ford, J. L., Ildefonso, K., Jones, M. L., & Arvinen-Barrow, M. (2017, October 27). *Sport-related anxiety: Current insights*. Open access journal of sports medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5667788/#b4-oajsm-8-205

Integration, C. (2022, May 11). *How anxiety can affect sports performance*. UPMC HealthBeat. https://share.upmc.com/2022/05/how-anxiety-affects-sports-performance/

Swaim, E. (2022, March 9). *Why sports anxiety happens and how to Cope*. Healthline. https://www.healthline.com/health/sports-performance-anxiety#who-experiences-it

Li, L., & Li, H. (2022, April 29). *Recognition and analysis of sports on mental health based on Deep Learning*. Frontiers. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.897642/full

Zhang, S., & Shan, F. (2022, June 21). *Feature extraction of athlete's post-match psychological and emotional changes based on Deep Learning*. Computational intelligence and neuroscience. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9239801/

Liu. (n.d.). https://www.ida.liu.se/~769A09/Literature/Stress/Yerkes,%20Dodson_1908.pdf

Reversal theory. Oxford Reference. (n.d.-a). https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100417499

They - british journal of sports medicine. (n.d.-b). https://bjsm.bmj.com/content/bjsports/21/2/29.full.pdf

Appendix A:

Sports Performance Anxiety

Sign in to Google to save your progress. Learn more

* Indicates required question

Age *

- 15-17
- 17-19
- 19-21
- 21-23

Gender *

- Male
- Female

In what type of sporting activity do you engage? *

- ◯ Individual
- ◯ group/team event

How often do you experience performance anxiety before a competitive sports event? *

- ◯ Always
- ◯ Often
- ◯ Never

On a scale of 1 to 10, rate the intensity of your performance anxiety during high-pressure situations. *

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

What are the main symptoms or physical sensations you experience when you feel performance anxiety? *

- [ ] Racing Heart
- [ ] Hyperventilation
- [ ] Tremors/Muscle tension
- [ ] Bathroom troubles
- [ ] None
- [ ] Other: _____

Have you tried any of the below strategies to manage your performance anxiety? *

- [ ] Music
- [ ] Meditation
- [ ] Self talks/affirmations
- [ ] Visualization
- [ ] A quick energy snack
- [ ] None
- [ ] Other

If you answered Other to the above question, please specify the strategy that you use to manage performance anxiety.

Your answer

How effective have the strategies or techniques been in reducing your performance anxiety? *

	1	2	3	4	5	
Never Helps	○	○	○	○	○	Always Helps

How likely are you to seek professional help or guidance, such as from a sports psychologist or mental performance coach, to address performance anxiety? *

	1	2	3	4	5	
Never	○	○	○	○	○	Highly likely

Are you open to using AI-based interventions or support systems to manage performance anxiety? *

- ○ Yes
- ○ No
- ○ Maybe

Literary Review

AI in the ever changing Medical world

Keertana Raghavendra(author), Charlotte Lungren (advisor), Anika Shah (advisor)
Skyline High School

Abstract: AI is a major part of our lives. It is being used in the medical field to perform many tasks. But AI can't be used to diagnose due to the different symptoms of a disease. Yet researchers are developing AI to diagnose diseases with the help of graphs, coding, and algorithms. This article talks about the new founding discoveries and development of AI to diagnose neurological diseases.

INTRODUCTION:

AI is a major part of our lives, dominating our world from cooking to writing essays. As Time passes by, technology keeps advancing. With the fast developing world of technological evolution, AI is also being used in the medical field. Unlike humans, AI are coded to perform activities without any errors like surgeries but there are certain limitations on what AI can do like diagnosing patients. While diagnosing one can't be sure as to what to do as it is an inference based on the patient's condition. Unlike humans, AI can't have feelings or recognise human feelings. So it is unheard of for AI to perform diagnosis, yet despite the limitation AI is being developed to diagnose people.

DISCUSSION:

AI identifying symptoms:

In the recent article published in the Sensors researchers performing a scoping review on the shared relationship between artificial intelligence (AI) and neuroscience to diagnose neurological diseases found that AI systems set up an interface with the brain, extract neurological signals, and generate commands that help AI in devices to identify symptoms. Reinforcement learning (RL) in human and animal models that were used to develop algorithms were used for the artificial systems to function more accurately rather than being precise. Detecting neurological infections like meningitis is tedious due to their wide range of symptoms. To overcome this AI is approaching using various predictor variables such as cerebrospinal fluid (CSF) neutrophils, lymphocytes, and neutrophil-to-lymphocyte ratio (NLR) could predict the type of meningitis with both high accuracy and precision (Mathur).

Diagnosing using Models:

AI is also trying to diagnose with the two primary innovations that improved diagnostic and management efficiency across the spectrum of neurological disorders, the CT and MRI scans. Advanced imaging is playing an increasingly more important role in the

management of patients with neurological diseases. Recently applied in neurosciences, graph-based models opened up new perspectives for the study of brain structural and functional integration through graph-derived metrics. Classification methods, using anatomical information, are widely used for the detection of Alzheimer's Disease (AD) and other cognitive impairments, as well as the characterization of various brain tissues including brain tumors (Fusco). ML detection techniques are performed to identify the areas where the patient's lesions are located as box coordinates and localization of stimulation zones within the brain for DBS treatment used for brain lesions and Parkinson patients (Artificial Intelligence shaping the future of neurology practice.

CONCLUSION:

So AI is being used to classify neurodegenerative diseases based on gait and handwriting. In addition the interpretations of emergency CT scans before stroke thrombolysis, and endovascular thrombectomy are plagued by a lack of available expertise and time delays (Segato). But the time delays to reporting intracranial hemorrhage or early signs of infarct often lead to loss of vital neurons before therapeutic interventions. So AI technologies will have to prove their mettle in prospective randomized control trials in clinical settings that pit AI against humans. That being said, using AI to diagnose has its advantages. Even though AI is being developed to diagnose, researchers are still experimenting and providing data to develop AI even further, to match the pace of the rest of the world with technological evolution. AI is the future of our world so researchers hope that AI can be used to its fullest one day to advance our medical care.

Sources Cited:

Artificial Intelligence shaping the future of neurology practice, Medical Journal Armed Forces India,Volume 77, Issue 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0377123721001490

Fusco, R., Grassi, R., Granata, V., Setola, S. V., Grassi, F., Cozzi, D., Pecori, B., Izzo, F., & Petrillo, A. (2021). Artificial Intelligence and COVID-19 Using Chest CT Scan and Chest X-ray Images: Machine Learning and Deep Learning Approaches for Diagnosis and Treatment. Journal of personalized medicine, 11(10), 993. https://doi.org/10.3390/jpm11100993

Mathur, Neha. (2023, March 15). Combining AI and neuroscience to detect and predict neurological disorders. News-Medical. Retrieved on July 03, 2023 from https://www.news-medical.net/news/20230315/Combining-AI-and-neuroscience-to-detect-and-predic t-neurological-disorders.aspx

Segato, A., Marzullo, A., Calimeri, F., & De Momi, E. (2020). Artificial intelligence for brain diseases: A systematic review. APL bioengineering, 4(4), 041503. https://doi.org/10.1063/5.0011697

Zhang, Z., & Seeram, E. (2020). The use of artificial intelligence in computed tomography image reconstruction - A literature review. Journal of medical imaging and radiation sciences, 51(4), 671–677. https://doi.org/10.1016/j.jmir.2020.09.001

Literary Review

Cutting-edge Technology: Robotic Surgery

Esther Morataya, Charlotte Lungren (advisor), Anika Shah (advisor)
University Prep Value High School

Abstract

In the medical field, there have been many technological innovations constantly propelling our medical capabilities upward. In the surgical field, advancements such as robotic surgery have shed light on a new possibility for surgical excellence. Through an analysis of procedures using robotic surgical systems and an extensive review of the literature, this article aims to cover the history behind robot surgery, modern applications, and benefits and potential challenges to both surgeons and patients.

Introduction

Robotic surgery is a minimally invasive surgery approach that utilizes robotic systems, most commonly a robotic arm, to assist surgeons. Moreover, minimally invasive surgery is desirable because it requires fewer incisions, reduces recovery time and time in the hospital, and minimizes scarring and bleeding as well as the chance of infection. Robotic surgery is done with a mechanical arm and a camera controlled by a surgeon. In addition to that, surgeons who've used robotic systems report that the robot can perform the task quicker, more precisely, and have more range of motion and dexterity. The model for general robotic surgery is typically a mechanical arm to hold the surgical instruments, a 3D camera, and a console in which the surgeon sits and controls the robot arm.

Discussion

Earliest Applications of RoboSurgery

The earliest application of robotic surgery was in the 1970s, being conducted by NASA. They named it "telesurgery." The idea was to connect a surgeon and a patient even from a distance over a wireless network, using a remote-controlled robot made to operate on astronauts. Not long after, in 1985, the Puma 560™ was introduced and designed for stereotaxic surgery. Stereotaxic surgery is a technique used for minimally invasive surgery. Stereotaxic surgery utilizes a three-dimensional coordinate system to find small targets along the body to treat lesions. To direct Puma 560™, the utilization of computed tomography was used with beams of X-rays that can show a body at different angles. Puma 560™ inserts a needle into the brain for the purpose of tissue sampling, also called a biopsy. Later on, in 1988, the PROBOT™ was introduced for prostate surgery. Once the prostate is scanned, the surgeon can set targets on which areas need to be removed, and the techniques for cutting can be manipulated. In 1992, the ROBODOC™ was created in order to replace a man's hip. A cavity in the femur needed to be prepared by an incision to make sure the femur was aligned for surgery, and secured using screws. In PROBOT™, ROBODOC™, and Puma 560™, the purpose of the robot itself was to prevent the risk of hand tremors during surgery. Typically, hand tremors are not fatal and are quite normal unless the surgeon is fatigued. During long surgical procedures, the surgeon might get fatigued. Therefore, these robotic systems can come in handy for long, tedious surgery to avoid mistakes due to tremors. These robots were all reported as having more precision and being able to perform tasks quicker than human surgeons.

Modern Applications; Da Vinci Surgical System

As a result of these past innovations, many new, more modern surgical systems have emerged. For example, the da Vinci™ surgical system is the most commonly used robotic surgical system, manufactured by Intuitive Surgical. This robotic surgical system was approved by the FDA in 2000 for vasectomy, hernia repair, transoral robotic surgery, as well as lung transportation. The da Vinc™ system has 3 main components to it. First, the surgeon's console. This console is where the surgeon controls the robot and oversees the surgical site with both hand and foot controls which translates into actions performed by the robot. Secondly, there is a patient-side cart. The patient side-cart is at the patient's side and consists of four, thin robotic arms. These robotic arms push past human arms' limitations and are much more flexible, dexterous, and allow for more range of motion. The first and second robotic arms will hold all the necessary surgical instruments, such as scissors or scalpels, and the third arm that's in the vision cart will hold a 3D camera for the surgeon to have a clear view of the site. The vision cart also has the computer necessary for processing the surgeon's movements. In the European Journal of Cardio-Thoracic Surgery, an article titled, "First experiences with the da Vinci™ operating robot in thoracic surgery," the authors stated, "We evaluated the role of the robot for several thoracic procedures such as thymectomies, fundoplications, esophageal dissections…Results: A total of 10 thymectomies, 16 fundoplications, 4 esophageal dissections, 5 extirpations of benign mediastinal masses, and 1 right lower lobectomy was performed with the robot." The authors mention that there was no excessive blood loss or complications. However, in one of their patients, a technical issue with the robotic did occur and the surgical procedure being performed had to be continued traditionally. In a different patient, an incomplete lesion was found that the robotic did not treat.

Modern Applications; Ion Endoluminal System

Although the da Vinci™ system is capable of many different surgical procedures, robots are made for specific tasks. Similar to the da Vinci system, the manufacturer Intuitive has created the Ion™ Endoluminal System. This system is designed to operate on the airway of the lungs with minimally invasive surgery. The robot can diagnose and treat both lesions and tremors through bronchoscopic procedures. A bronchoscopic procedure is any surgical procedure involving a bronchoscope, which is a surgical instrument used to examine the airways of the lungs. They're composed of a light source, a camera, and control handles to control the distal end of the scope, which they can rotate. An example of Ion™ being tested has been published by PubMed, National Library of Medicine. The article is titled, "Ion: Technology and Techniques for Shape-sensing Robotic-assisted Bronchoscopy." In the article, the authors state, "Two patients (0.8%) experienced airway bleeding; both cases of bleeding resolved within 5 minutes of tamponade." Tamponade means the closing or blocking of a wound. In their conclusions, the authors wrote, "The Ion Endoluminal System's unique shape-sensing technology can be leveraged to facilitate localization and sampling of PPNs and potentially improve diagnostic accuracy." It is to be noted that I do not have access to the full article, however, these seem to be relevant features of the robot. In another article, titled "State of the Art: Robotic Bronchoscopy" the authors write, "The Intuitive Ion™ robotic bronchoscopy early outcomes have shown that the system is able to navigate through small peripheral airways and show a comparable safety profile. In a single center study, 30 consecutive cases with mean lesions size of 12mm (overall range: 10-30mm), demonstrated that in 96.6% of cases, the target was reached (confirmed by rEBUS) and tissue was obtained. Overall diagnostic yield was 79.3%, of which 88% were malignant." These two studies have shown evidence that Intutive's Ion™ is capable and has the potential to greatly improve bronchoscopy.

Potential Challenges

Although surgical robots can potentially be used to advance minimally invasive surgery, there are defects. As previously mentioned, the robot can have technical and mechanical issues whilst performing surgery and leave a patient untreated. Furthermore, robotic surgery can be quite expensive. The da Vinci™ alone costs $2 million dollars, and that's excluding maintenance which can be up to $180,000. In recent years, this system has been sold for up to 3.3 million dollars. These robot-assisted surgical procedures are used for minimally invasive surgical procedures, which are becoming more and more desirable with benefits such as less scarring and quick recovery times, but the procedures themselves can be incredibly costly to the patient, too. Surgery done by a robot can cost from $3,000 to $6,000, whilst traditional laparoscopic surgery can be $1,000 to $7,000. Robotic surgery can also take longer than traditional surgery. Some laparoscopic surgery can be as short as 30 minutes or up to an hour, meanwhile, robotic surgery can take up to two to three hours. Another disadvantage is what's called “haptic perception.” Haptic perception is a particularly important part of the surgery, as a surgeon can feel for organic tissue hardness, evaluate anatomy, and overall learn to handle the tissue. With a robotic arm carrying out the procedure, this tactile perception is lost and a major challenge with robotic surgery. Additionally, robotic surgery is still a new and niche field and still has a lot of room for improvement. Although the robotic systems that do exist have been researched and cleared by the FDA, they still have a long way to go before it becomes more integrated into clinics.

Conclusion

In conclusion, robotic surgery has the potential to greatly improve and change traditional minimally invasive surgery by going beyond our human capabilities. Robotic surgery has been proven to be safe, quick, and effective in many minimally invasive surgeries and some have even been designed for specific procedures. For patients, this can seem like the most desirable choice because of more dexterity and more range of motion that robotic surgery is accompanied by, as well as minimizing scarring. However, they may be very expensive for the patient and can take longer than traditional surgery. With further development, robotic surgery can overcome these challenges and make it a better experience for both patients and surgeons alike. Is it important to note that robotic surgery has not been around for very long, and it’s still a niche topic that needs to be researched and tested more. Regardlessly, you should always consult your healthcare provider about robotic surgery and if it’s safe and ideal for you. As technology evolves and more hospitals purchase it for use, robotic surgery can potentially become more common in hospitals, more accessible, and potentially used beyond minimally invasive surgery.

Sources Cited

Lanfranco, A. R., Castellanos, A., Desai, J. P., & Meyers, W. H. (2004c). Robotic surgery. Annals of Surgery, 239(1), 14–21. https://doi.org/10.1097/01.sla.0000103020.19595.7d

Bodner, J., Wykypiel, H., Wetscher, G. J., & Schmid, T. (2004c). First experiences with the da Vinci™ operating robot in thoracic surgery☆. European Journal of Cardio-Thoracic Surgery, 25(5), 844–851. https://doi.org/10.1016/j.ejcts.2004.02.001

Lanfranco, A. R., Castellanos, A., Desai, J. P., & Meyers, W. H. (2004d). Robotic surgery. Annals of Surgery, 239(1), 14–21. https://doi.org/10.1097/01.sla.0000103020.19595.7d

Garbarino, G., Costa, G., Frezza, B., Biancafarina, A., Balducci, G., Mercantini, P., De Prizio, M., Laracca, G. G., & Ceccarelli, G. (2020). Robotic versus open oncological gastric surgery in the elderly: a propensity score-matched analysis. Journal of Robotic Surgery, 15(5), 741–749. https://doi.org/10.1007/s11701-020-01168-2

Panch, T., Mattie, H., & Celi, L. A. (2019). The "inconvenient truth" about AI in healthcare. Npj Digital Medicine, 2(1). https://doi.org/10.1038/s41746-019-0155-4

Reisenauer, J. S., Simoff, M., Pritchett, M. A., Ost, D., Majid, A., Keyes, C., Casal, R. F., Parikh, M., Diaz-Mendoza, J., Fernandez-Bussy, S., & Folch, E. (2022). IoN: Technology and techniques for shape-sensing robotic-assisted bronchoscopy. The Annals of Thoracic Surgery, 113(1), 308–315. https://doi.org/10.1016/j.athoracsur.2021.06.086

Kent, A. J., Byrnes, K. A., & Chang, S. E. (2020). State of the art: robotic bronchoscopy. Seminars in Thoracic and Cardiovascular Surgery, 32(4), 1030–1035. https://doi.org/10.1053/j.semtcvs.2020.08.008

Shaheen, M. F. (2021). AI in Healthcare: medical and socio-economic benefits and challenges. ScienceOpen. https://doi.org/10.14293/s2199-1006.1.sor-.pprqni1.v1

Literary Review

AI and its Future in Healthcare

Lauryn Singh, Charlotte Lungren (advisor), Anika Shah (advisor)
Arlington High School

Abstract:

Telemedicine and AI will only continue to have a rising influence on healthcare. According to the NBC article, “The AI revolution in healthcare is coming,” 83% of executives agree that AI should help play a role in the medical field (Curry, 2023). Currently, AI is being used to diagnose, treat, and monitor patients. AI can analyze medical images, develop treatment plans, help physicians focus on treating patients rather than completing tedious administrative tasks, analyze patient history, and monitor patients remotely. However, AI in healthcare doesn’t come without its fair share of controversies. Many fear that AI could cause violations of HIPAA to occur more frequently (Deb, 2023). Ultimately, AI is a new technology, and its use in healthcare could have a positive impact as long as caution is used.

Introduction:

As technology advances, the integration of Artificial Intelligence (AI) in various industries is becoming more common. The Turing test, also known as the imitation game, created in 1950, tested whether computers were capable of human level intelligence, and even to this day no computer has passed. Since the Turing test, there has been almost exponential improvement in AI developments. The first use of AI in healthcare was MYCIN, which was an AI program created in 1970 which was used to identify blood infection treatments (Xsolis, 2021). Despite these promising early advancements, AI did not significantly advance for several decades, particularly in healthcare. It was not until the advancements in computing power and availability of massive amounts of digital healthcare data that AI began to demonstrate significant capabilities broadly, including healthcare. Along with these advancements, the integration of AI in healthcare is becoming increasingly prevalent and it is clear that AI has the potential to greatly improve the accuracy and efficiency of diagnoses and treatments. The current, past and potential role of AI in healthcare, along with the challenges it might pose prompts the question: will AI be able to fully replace doctors in the near future?

Discussion:

Types of Concerns:

One of the primary concerns associated with AI in healthcare is the potential for violations of the Health Insurance Portability and Accountability Act (HIPAA). Protecting patient privacy and confidentiality is of utmost importance in healthcare, and there is a fear that AI may inadvertently lead to breaches of sensitive patient information (Deb, 2023). While AI algorithms have proven to be highly accurate in analyzing data, it is crucial to establish robust security measures and stringent privacy protocols to prevent unauthorized access or misuse of patient data. Striking the right balance between utilizing AI's potential and ensuring patient privacy will be vital to successfully integrating AI into healthcare systems

AI's Benefits:

Telemedicine and AI have the potential to alleviate the burden on healthcare providers by automating certain tasks, allowing them to focus more on direct patient care. For example, AI-powered algorithms can sift through extensive medical literature and data, providing clinicians with relevant information to support their decision-making process (AUGMedix, 2023). This capability can help ensure that physicians are performing effectively at their jobs, and can help avoid burnout among physicians.

Ethics in AI:

While the benefits and concerns of telemedicine and AI in healthcare have been discussed, it is also essential to consider the ethical implications of AI playing a more significant role in healthcare. As these technologies continue to evolve, it becomes crucial to establish ethical guidelines.By addressing the ethical dimensions, the use of AI can be harnessed to improve the lives of patients globally.

Conclusion:

The use of telemedicine and AI in healthcare is still in its early stages, but it has the potential to revolutionize the way that care is delivered. As these technologies continue to develop, it is important to ensure that they are used in a way that protects patient privacy and safety. With careful planning and implementation, telemedicine and AI can help to improve the quality of care for patients around the world.In addition to the benefits and concerns mentioned above, it is also important to consider the ethical implications of using telemedicine and AI in healthcare. Ultimately, By carefully considering the risks and benefits, and by developing ethical guidelines for their use, we can ensure that these technologies are used to improve the lives of patients around the world.

Works Cited:

AUGMedix. (2023, April 27). Using AI for Healthcare Administrative Tasks. Augmedix. https://augmedix.com/resources/blog/ai-in-healthcare-administrative-tasks/

Curry, R. (2023, July 12). The A.I. revolution in health care is coming. CNBC. https://www.cnbc.com/2023/07/12/the-ai-revolution-in-health-care-is-coming.html

Deb, R. (2023, January 9). What are the Challenges of AI in Healthcare? Can They be Resolved? Emeritus. https://emeritus.org/blog/healthcare-challenges-of-ai-in-healthcare/

Literary Review

The Implementation of Artificial Intelligence (AI) in Diagnosing, Predicting, and Treating Cardiovascular Diseases (CVDs)

Queenie Hwang, Charlotte Lungren (advisor), Anika Shah (advisor)
Hsinchu County American School

Abstract:

This paper discusses the use of artificial intelligence in cardiology and how they assist cardiologists to diagnose cardiovascular diseases; predict potential complications, death rates, and survival rates; and treat the disease. Current implementations of AI in cardiology include automatic CVD detection, predictive models, and smart wearable devices. In the future, these existing technologies will hopefully become more developed, safe, and accurate. Additionally, AI will play a larger role in surgery needed to treat CVD. However, despite all of these advancements, there are still issues to address regarding safety, privacy, and cost effectiveness.

Introduction:

Throughout time, technology has always been continuously advancing. This includes the development of artificial intelligence (AI). Generally, AI is the replication of human-like intelligence with the abilities to synthesize, predict, and analyze information. From cybersecurity to personalized shopping assistants, this type of technology has already been implemented in various industries. One particular field in which AI has deemed to be incredibly useful is the medical field. In cardiology, AI technology is currently able to identify genes of those with cardiovascular disease (CVD) and is also being implemented in wearable devices that help monitor patients' conditions after being diagnosed or treated. However, there are still limits to AI's capabilities in regards to diagnosing and treating patients with CVD, ensuring accuracy and efficiency of different AI models, and protecting data on patient conditions collected by the computerized machines.

Discussion:

Diagnosing CVD with AI:

According to the World Health Organization (WHO), cardiovascular diseases are the world's leading cause of death; however, approximately 75% of premature CVD is preventable, which is why it is crucial for patients to be diagnosed and monitored as early as possible. Currently, the role of AI in the diagnosis stage is to guide electrocardiograms (ECGs) to be able to detect abnormalities in a patient's heart rhythm,

which can further help cardiologist diagnose them with CVDs such as coronary heart disease even when symptoms of the disease are not evident. Scientists claim that cardiologists will be able to predict CVD by using AI technology to identify genes that are associated with the occurrence of the disease. Studies done by scientists at Rutgers Institute for Health have analyzed patients with and without cardiovascular disease and used AI and machine learning to find out the genes associated with common manifestations of CVDs. With this data, AI is able to identify those genes in new patients and determine whether or not they carry the disease. It will also be able to predict when the disease may occur as well as further generate appropriate treatment plans to guide doctors and help them to prevent or ease its occurrence. Apart from gene identification, other technologies are also being developed to perform automatic detection of CVD, which is extremely important as CVDs affect one's heart and blood vessels and can leave the patient physically paralyzed or dead. Various different machine learning and deep learning models have been tested such as multilayer perceptron (MLP), support vector machine (SVM), decision tree (DT), random forest (RF), and k-nearest neighbor (KNN), hidden Markov model (HMM), principal component analysis (PCA). Based on the results, KNN and MLP are the most reliable models for automatic detection of CVD. The KNN model had an 82.47% accuracy in detecting CVDs while the MLP model had an accuracy of 86.41%; therefore, MLP models are generally the recommended models for performing CVD detection.

Predicting CVD with AI:

After diagnosis and before treatment, it is good to be able to predict potential abnormal complications that may lead to death as well as the rate of survival for diagnosed patients over the next five years. This information can help cardiologists determine what treatment plan to come up with and how to approach the disease. Recent research suggests that AI machines can predict potential times of death for patients diagnosed with CVD. In the research, AI software recorded cardiac magnetic resonance imaging (MRI) scans and blood tests of 256 affected patients. The software also measured the movement of 30,000 points marked on the heart structures in each heartbeat. By fusing data from the MRI scans and marked points with patients' prior health records, AI was able to predict abnormal conditions that may lead to patient deaths along with their survival rate in the span of five years. The AI software's predictions were 80% accurate, which surpasses the accuracy of clinicians' predictions, which was 60%. Another predictive model established by Motwani M and his colleagues used deep learning algorithms to predict the risk of death for the next five years for 10,030 patients suspected to have coronary heart disease. The results showed that the AI's risk assessment was far more accurate than conventional predictive methods of clinicians. With the two examples of reliable predictive AI models, it is clear that using AI to evaluate the risk of death, survival rate, and potential abnormalities that may lead to major complications is superior compared to the judgment of trained clinicians.

Treating CVD with AI:

Even with several significant developments in diagnosing and treating patients with cardiovascular disease, approximately 50% of affected patients die within five years of their diagnosis due to environmental and genetic factors; therefore, treating CVD within those 5 years is a crucial process. Treating CVDs include prescribing medication, surgery, and lifestyle changes, which are treatments in which AI plays a small role in. Based on prior knowledge collected by AI machines, they are able to generate suggested treatment plans for both patients and doctors that take into consideration the environmental and genetic factors that are currently causing affected patients to die. These plans may contain safe medications to take, specific instructions for lifestyle changes, and recommended appointments times to book for check-ups. The suggestions do not determine what treatment path a patient will take, but rather guide doctors with data that factors in safety, possible reactions to medications, and the prior health records in order to ensure that the patient is receiving optimal care. In regards to surgery, AI plays a small part in helping with surgical decision making by addressing risk factors, patient history, patient values, and anatomy. They help cardiothoracic surgeons analyze the consequences of surgical decisions in order to minimize as many complications as possible in the operating room (OR). Surgery fully done by AI machines is possible with the *da Vinci* surgical system, but only for minimally invasive surgical procedures. Patients with CVD require open heart surgery such as coronary artery bypass grafting (CABG); therefore, treating CVD fully with AI is not currently an option.

Patient Checkups:

A patient's follow up process is a stage that checks that patients are healthy and free of suspicious symptoms that may lead to larger medical complications after being treated for illness or injury. For patients with CVD, routine checkups after treatment include measuring blood pressure, issuing blood tests, and doing an echo test with an echocardiogram. By fusing AI technology with smart wearable devices, patients are able to be monitored all the time. These devices have the ability to analyze large amounts of data regarding a patient's health conditions such as heart rate, blood pressure, and electrical activity in real time. With this data, the devices can predict when CVD complications may occur, alert the user about abnormal activity, and assist doctors in CVD diagnosis. The data can also be recorded for future reference in case cardiologists need to assess recent activity.

Challenges and Limitations:

With any technology, there are always challenges and limitations. When it comes to AI in healthcare, there are several, whether it be ethical or technological. In the field of cardiology, some of these challenges include safety and efficiency, data security and protection, and expensive cost. These are important issues to address because AI technology should be able to generate accurate results to minimize medical errors, such as misdiagnoses, and protect one's privacy. It should also be available and

cost-effective towards low-income countries who need additional medical assistance the most. More research is currently being conducted in order to build softwares with better security systems, so if an AI software has access to patients' electronic health records or is able to record and monitor patient conditions in real time, the data from those actions will be protected.

The Future of AI in Cardiology:

In the future, scientists hope to have developed a device trained through machine learning or deep learning algorithms to work on patient cases without human assistance. This way, cardiologists can make safe and accurate decisions as well as predict patient outcomes. In terms of AI technology, current development aims towards the machines being able to more accurately diagnose CVD, detect potentially dangerous arrhythmia occurrences through smart wearable devices, predict patient outcomes, and become more integrated with robotic surgery.

Conclusion:

AI plays a large role in the medical field. In cardiology, it is used in various ways from diagnosing to treating patients with cardiovascular diseases. By using machine learning and deep learning algorithms, predictive AI models are able to assist cardiologists in diagnosing and treating patients with CVD. However, further development is needed to ensure safety, privacy protection, and widespread availability. Ultimately, AI will be able to guide doctors into making safe and accurate decisions as well as help ease patients between the diagnosis, treatment, and follow-up processes.

Works Cited:

Ai in medical care: A map for clinical practice and patient protection. MedicalEconomics. (n.d.). https://www.medicaleconomics.com/view/ai-in-medical-care-a-map-for-clinical-practice-and-patient-protection?utm_medium=paid&utm_source=google&utm_campaign=audience_development_2023&utm_term=HealthcareTechnology&utm_content=search_

Chiarito, M. (n.d.). *Artificial Intelligence and Cardiovascular Risk Prediction: All that glitters is not gold*. Radcliffe Cardiology. https://www.ecrjournal.com/articles/artificial-intelligence-and-cardiovascular-risk-prediction-all-glitters-not-gold

Dias, R. D., Shah, J. A., & Zenati, M. A. (2020, October). *Artificial Intelligence in cardiothoracic surgery*. Minerva cardioangiologica. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7959017/

Henderson, R. by E. (2023, March 11). *Using AI for early diagnosis of cardiovascular disease*. News. https://www.news-medical.net/news/20230227/Using-AI-for-early-diagnosis-of-cardiovascular-disease.aspx#:~:text=Researchers%20may%20be%20able%20to,to%20a%20new%20Rutgers%20study

Huang, J.-D., Wang, J., Ramsey, E., Leavey, G., Chico, T. J. A., & Condell, J. (2022, October 20). *Applying artificial intelligence to wearable sensor data to diagnose and predict cardiovascular disease: A Review*. MDPI. https://www.mdpi.com/1424-8220/22/20/8002#B133-sensors-22-08002

Karatzia, L., Aung, N., & Aksentijevic, D. (2022, October 13). *Artificial Intelligence in cardiology: Hope for the future and power for the present*. Frontiers in cardiovascular medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9608631/#:~:text=AI%20allows%20accurate%20prediction%20of,outcomes%20for%20heart%20failure%20patients

Mayo Foundation for Medical Education and Research. (2023, January 14). *Cardiovascular medicine*. Mayo Clinic. https://www.mayoclinic.org/departments-centers/ai-cardiology/overview/ovc-20486648#:~:text=AI%20%2Dguided%20ECGs%20are%20also,before%20any%20symptoms%20are%20evident

Meyer, H. V. (1970, January 1). *Genetic and functional insights into the fractal structure of the heart*. AI in Medicine. https://aim-lab.io/publication/nat-2020a/

Pal, M., Parija, S., Panda, G., Dhama, K., & Mohapatra, R. K. (2022, June 17). *Risk prediction of cardiovascular disease using Machine Learning Classifiers*. Open medicine (Warsaw, Poland). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9206502/

ScienceDaily. (2023, February 27). *Researchers use artificial intelligence to predict cardiovascular disease*. ScienceDaily. https://www.sciencedaily.com/releases/2023/02/230227132723.htm#:~:text=Machine%20learning%20can%20be%20used%20to%20help%20clinicians%20with%20early%20diagnosis,-Date%3A%20February%2027&text=Summary%3A,according%20to%20a%20new%20study

Subramani, S., Varshney, N., Anand, M. V., Soudagar, M. E. M., Al-keridis, L. A., Upadhyay, T. K., Alshammari, N., Saeed, M., Subramanian, K., Anbarasu, K., & Rohini, K. (2023, March 9). *Cardiovascular diseases prediction by machine learning incorporation with Deep Learning*. Frontiers. https://www.frontiersin.org/articles/10.3389/fmed.2023.1150933/full

Yan, Y., Zhang, J.-W., Zang, G.-Y., & Pu, J. (2019a, August). *The primary use of artificial intelligence in cardiovascular diseases: What kind of potential role does artificial intelligence play in future medicine?*. Journal of geriatric cardiology : JGC. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6748906/