Journal of Primary Care & Community Health
Volume 15: 1–10

DOI: 10.1177/21501319241245847
journals.sagepub.com/home/jpc
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Exploring the Impact of Artificial Intelligence on Global Health and Enhancing Healthcare in Developing Nations

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Abstract

Background: Artificial intelligence (AI), which combines computer science with extensive datasets, seeks to mimic human-like intelligence. Subsets of AI are being applied in almost all fields of medicine and surgery. **Aim:** This review focuses on the applications of AI in healthcare settings in developing countries, designed to underscore its significance by comprehensively outlining the advancements made thus far, the shortcomings encountered in AI applications, the present status of AI integration, persistent challenges, and innovative strategies to surmount them. **Methodology:** Articles from PubMed, Google Scholar, and Cochrane were searched from 2000 to 2023 with keywords including AI and healthcare, focusing on multiple medical specialties. **Results:** The increasing role of AI in diagnosis, prognosis prediction, and patient management, as well as hospital management and community healthcare, has made the overall healthcare system more efficient, especially in the high patient load setups and resource-limited areas of developing countries where patient care is often compromised. However, challenges, including low adoption rates and the absence of standardized guidelines, high installation and maintenance costs of equipment, poor transportation and connectivvity issues hinder AI's full use in healthcare. **Conclusion:** Despite these challenges, AI holds a promising future in healthcare. Adequate knowledge and expertise of healthcare professionals for the use of AI technology in healthcare is imperative in developing nations.

Keywords

artificial intelligence, developing countries, digital health, healthcare, medicine, surgery, and revolution

Dates received: 19 October 2023; revised: 19 March 2024; accepted: 21 March 2024.

Introduction

Artificial intelligence (AI) is a discipline that merges computer science with extensive datasets to replicate human-like intelligence. In the annals of medical history, a new era is unfolding, characterized by the symbiotic integration of AI with healthcare. This revolutionary combination represents a watershed moment, promising to reshape the medical and patient care landscape. Since the mid-20th century, AI's foray into medicine has evolved from theoretical conjectures to tangible, transformative applications of AI, among which machine learning (ML) and its subset, deep learning (DL), are of utmost importance.[1] ML is an application based on algorithms and techniques that improve a computer program's performance by analyzing and producing valid and consistent conclusions by harvesting regularities from large databases.[2] These algorithms allow computers to continuously learn from stored information unique to a

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problem, enabling them to find hidden insights and complex patterns as automate the task of analytical model building to perform cognitive tasks such as natural language translation or object detection.[2] DL uses layers of neural networks to extract complex patterns, such as data gathering, storage, processing, and analysis.[1] Among the different ML algorithm types, the artificial neural network family is of special importance. Artificial neurons, or mathematical representations of interconnected processing units, constitute artificial neural networks (ANNs).[1] Similar to human brain synapses, every neuron-to-neuron connection emits signals, the intensity of which may be continually modified during the learning process.[3] These artificial neurons are arranged into multi-layered networks, where an output layer generates the final result after receiving the data supplied from an input layer.[3] Furthermore, deep neural networks are created by adding multiple hidden layers arranged in highly nested network designs. They usually contain advanced neurons and techniques in contrast to simple ANNs, enabling them to be used in advanced operations.[4]

These subsets of AI find numerous applications in modern medicine and today, AI is a stalwart ally, empowering healthcare professionals with unparalleled insights, expediting diagnoses, and revolutionizing treatment strategies. However, the application of AI in the healthcare industry has encountered hurdles in fully utilizing its potential in developing countries.[5] Developing countries are those that have not yet achieved a maximum degree of industrialization relative to their populations and, in most cases, have a medium to low standard of living. Most of these countries fall within the Latin America, Asia, and Africa. These countries mostly lack stable economic growth, adequate healthcare systems, modern technologies, and research opportunities. While numerous earlier reviews have explored the use of AI in the field of medicine,[1,5] it is crucial to recognize that AI is a dynamic and ever-evolving domain.[6] Only a few reviews have critically examined how AI can revolutionize healthcare in developing countries.[5,6] This narrative review focuses on the applications of AI in healthcare settings in developing countries, designed to underscore the significance by comprehensively outlining the advancements made thus far, the shortcomings encountered in AI applications, the present status of AI integration, persistent challenges, and innovative strategies to surmount them.

Methodology

To write this review, a literature search on PubMed, Google Scholar, and Cochrane for articles published from the date of inspection until August 1, 2023. Clinical trials, systematic reviews, and cross-sectional studies to write this comprehensive review. The keywords used for the search were artificial intelligence (AI), healthcare, hospitals, medicine, and surgery. Our inclusion criteria strictly focused on studies that examined the applications of AI in radiology, cardiology, oncology, neurology, intensive care, anesthesiology, surgery, and community medicine. We excluded editorial articles, correspondence, case reports, and commentaries.

Subsets of AI Utilized in Healthcare and Hospitals

In 1950, the world was introduced to the transformative potential of AI.[7] However, early AI models faced challenges that initially limited their widespread adoption in the medical field, especially in developing countries.[5,8,9] However, in the 2000s, deep learning (DL) brought about a significant change, allowing AI systems to learn and make decisions independently, similar to the human brain.[3,10,11] This advancement holds promise for improving healthcare overall and in developing nations.[12] Machine learning includes various pre-built algorithms that enable AI to assess the situation, make necessary adjustments, and take appropriate decisions or actions[13] which can play a crucial role in healthcare, especially in developing countries where screening for diseases, risk factor assessment, timely diagnosis, and well-informed decision-making are a challenge.

In Nigeria, the start-up Ubenwa utilizes signal processing and machine learning to predict and enhance the diagnosis of birth asphyxia, particularly in low-resource settings.[14] In developing nations, the effectiveness of diabetic retinopathy (DR) screening is hindered by inadequate eye care infrastructure, particularly in rural regions. A groundbreaking approach utilizing AI for DR screening has surfaced, demonstrating considerable potential in sensitivity and specificity for accurate diagnosis. This innovation alleviates the strain caused by limited facilities and a shortage of ophthalmologists, offering swift and precise assessments. Similarly, Bellemo et al[15] conducted a study in Zambia, demonstrating AI's effectiveness in diagnosing diabetic retinopathy, showcasing promising results compared to human assessments. While AI-powered screening presents a cost-efficient alternative to traditional ophthalmologist-based methods in rural areas of China.[16]

The use of AI in healthcare is especially crucial in these settings due to challenges such as incomplete patient records and high patient loads, which can lead to human errors that have grave consequences. Machine learning models offer a powerful solution for improving record-keeping practices, scheduling, and resource allocation, particularly in high patient load settings in developing countries. For instance, in South Africa, these models have been utilized to analyze administrative data, aiding in the prediction of the length of stay for healthcare workers in underserved communities.[17] Furthermore, AI offers solutions by rapidly processing extensive clinical documentation and identifying disease markers and patterns that might otherwise go unnoticed. Machine learning algorithms play a pivotal role in

recognizing complex patterns within clinical data, facilitating precise predictions.[13,18]

Natural language processing (NLP), a subset of AI, enables computers to understand and generate human language effectively. Its applications include text analysis and speech recognition. In resource-constrained settings, where access to specialized healthcare infrastructure may be limited, NLP holds immense promise. For instance, healthcare professionals can use NLP to easily document verbal patient notes, allowing doctors to focus fully on patient care during consultations.[18-20] This not only improves the quality of patient-provider interactions but also enhances the accuracy and completeness of medical records. Moreover, NLP plays a crucial role in deciphering complex healthcare documents such as physicians' notes and lab reports. In environments with high patient loads, such as rural clinics or busy outpatient rooms, NLP efficiently extracts vital information from scattered patient records. This capability aids healthcare providers in making swift and informed decisions, leading to accelerated treatment processes and reduced errors arising from incomplete or inaccessible data.[20,21] In essence, NLP facilitates streamlined communication, documentation, and data retrieval within healthcare systems in developing countries and rural areas.

NLP's utility extends to diagnostic test results. Automated scanning identifies abnormal values and ensures that critical data is preserved within extensive clinical laboratory reports, particularly in high-volume settings.[2,18] This streamlined approach empowers healthcare professionals to focus on significant findings, especially in busy settings, and enhances patient safety. Modern machine learning models have also demonstrated superior performance in predicting critical care and hospitalization outcomes compared to traditional methods. Implementing these advanced models could lead to improved clinician triage decisions in resource-limited areas, ultimately resulting in enhanced clinical care and a more efficient allocation of resources.[22] Virtual health assistants play a pivotal role in modern healthcare, seamlessly managing many tasks such as handling routine patient inquiries through calls and emails, ensuring the security of patient medical data, coordinating doctor appointments, and facilitating patient follow-ups and reminders.[23,24] These capabilities are made possible by integrating advanced systems that incorporate cognitive computing, augmented reality, and body and speech gestures.[24,25] From an administrative standpoint, incorporating AI in healthcare streamlines tasks such as data entry, claim processing, and appointment scheduling.

In developing countries with constrained healthcare budgets, robotic process automation of these functions offers the potential to significantly reduce overall costs by streamlining administrative tasks, thereby saving on salaries for clerical and administrative positions within healthcare systems and optimizing revenue cycle management.[26,27]

AI in Radiology

Integrating AI into radiology has fundamentally transformed the field, significantly enhancing efficiency, diagnostic accuracy, and overall capabilities. A key AI technology, convolutional neural networks (CNNs), can achieve remarkable image identification accuracy and address various challenges in image processing.[28,29] CNNs can automatically detect intricate patterns and provide quantitative assessments of radiographic characteristics. This technology offers numerous advantages, such as improved radiologist efficiency, prioritization of urgent cases, increased diagnostic confidence, reduced workload, and enhanced guidance for patient prognosis and treatment strategies.[30] Radiology is often overlooked as an essential service in numerous low and middle-income countries (LMICs).[5] A primary obstacle to delivering radiology services is the scarcity of trained radiology personnel and opportunities for skill development. AI presents a solution to this challenge by automating the interpretation of radiological images, expediting the process, and reducing the dependence on experts. This is particularly beneficial in resource-limited areas where skilled radiologists are scarce.[31] A study by van Leeuwen reported that AI can reduce the reading time of chest X-rays by 33%, increase the detection rate of lung nodules by 5%, and improve the diagnostic accuracy of breast cancer by 9.4%.[32] In developing countries, such as India, where healthcare systems face a chronic shortage of medical workers, AI-based diagnostic technology is enabling the decentralization of diagnostic testing, providing a promising avenue to address healthcare challenges.[33,34]

Moreover, AI has significantly impacted 2 vital components of medical diagnosis: computer-aided detection (CAD) and radiomics. CAD systems have greatly improved their ability to automatically detect and highlight abnormalities in medical images, thereby reducing diagnostic errors and enhancing overall accuracy[32,35] and the requirement for specialist doctors for accurate diagnosis. This can be very helpful in developing countries where the shortage of specialist doctors is a common challenge. According to World Bank statistics, South Asia has a specialist surgical workforce of only 6 per 100,000 people, in contrast to 71 per 100,000 in high-income countries. Likewise, the ratio of physicians stands at 0.8 per 1000 in South Asia, whereas high-income nations boast 3.0 physicians per 1000 individuals.[36] Through radiomics, AI automates the extraction and analysis of quantitative data from radiological images, leading to deeper insights into diseases and enabling personalized healthcare based on individual patient data.[37] Moreover,

it aids in prioritizing scans based on case severity and notifying radiologists of urgent issues.[38] Machine learning and signal processing methods have been applied to digital chest radiographs to identify tuberculosis cases, which is a highly prevalent disease in developing countries.[39]

AI in Cardiology

Approximately 80% of cardiovascular disease (CVD) fatalities worldwide are concentrated in low- and middle-income nations, underscoring the need for improving cardiac care in developing countries.[40] AI in cardiology encompasses various aspects of cardiac care, ranging from automated recognition and segmentation of cardiac structures to data analysis and electronic health record mining.[38] AI enhances echocardiography by enabling real-time image analysis, improving the accuracy of cardiac assessments, and assisting in diagnosing conditions such as valvular heart disease[38] and automatically detects coronary artery stenosis from computed tomography (CT) angiography images.[41]AI can also contribute significantly to the prediction of cardiovascular outcomes. Roughly 28% of fatalities in low- and middle-income countries are attributed to CVD.[40] AI can potentially reduce mortality due to CVD by using predictive models and risk scores to forecast strokes, heart failures, and arrhythmias, thereby facilitating timely interventions and informed treatment decisions. Machine learning algorithms have demonstrated the potential to assist in identifying heart failure cases,[42] as heart failure remains a significant financial burden on healthcare systems in developing countries.[43]

AI in Oncology

AI has become integral to cancer imaging, addressing the clinical tasks of detection, characterization, and tumor monitoring.[44] Lung and breast cancers, the leading causes of cancer-related deaths in developing countries, underscore the critical need for early detection. Digital mammography, a standard breast cancer screening method, poses interpretation challenges in developing countries due to a shortage of trained radiologists, including potential errors such as false negatives and false positives. AI-based tools serve as preliminary screens against observational oversights and assist in breast cancer detection by meticulously analyzing mammograms and identifying suspicious lesions warranting further investigation.[32]

Radiotherapy treatment planning involves labor-intensive manual contouring of radiation targets, which is prone to variations and requires expertise. AI automates and enhances contouring precision and aids in classifying brain tumors based on magnetic resonance imaging (MRI) images using DL models trained on annotated datasets, thus making treatment available even in regions where experts for manual contouring are not present.[45] In developing countries, the limited availability of medical resources combined with a high population density poses significant challenges for oncologists while treating cancer patients.[46] AI-assisted medical systems can generate a framework for personalized drug selection for individuals with lung cancer.[46] It considers both the efficacy of targeted drugs and their economic cost as auxiliary decision-making factors. The system predicts the effectiveness-cost ratio of various drugs by utilizing clinical data to identify optimal drug treatment regimens tailored to individual patient conditions.[46] These aids healthcare professionals in making efficient diagnoses and treatment decisions.[46] The reported precision exceeds 90%.[46] A study investigated a cost-effective, point-of-care screening tool for oral cancer, employing cloud-based signal processing. The study revealed high sensitivity and specificity compared to an in-person specialist examination.[47]

AI solutions for primary reconstruction systems and patient positioning enhance the signal-to-noise ratio and promptly alert operators to insufficient imaging, facilitating immediate retakes. Ultimately, this enhances workflow efficiency, which is very essential in busy hospitals with high patient loads. In LMICs, "Watson for Oncology (WFO)" stands out as a significant AI tool in cancer care. It functions as a clinical decision support system (CDSS), employing natural language processing and machine learning to assess patient data and recommend evidence-based treatment options.[48]

AI in Critical Care and Emergency Care

Critical care in low-income countries is not up to standard, encompassing various components such as emergency medicine, hospital infrastructure, quality of care, and the presence of intensive care units (ICU) to address sudden, serious, and reversible conditions.[49] Despite efforts to improve emergency triage and treatment for pediatric admissions, there remains a deficiency in training and awareness of critical care principles. However, the integration of AI holds significant promise for enhancing healthcare delivery in ICU and emergency departments in developing countries.[50] AI algorithms can rapidly assess and prioritize patients based on the severity of the condition, aiding overwhelmed healthcare providers in effective triage and ensuring timely care for those in critical condition. Additionally, AI-powered diagnostic tools facilitate the rapid and accurate interpretation of medical images and lab results, expediting diagnosis and intervention.[51] Predictive analytics enables the anticipation of patient deterioration or complications, allowing for proactive interventions to prevent adverse events. AI-based predictive models optimize resource allocation, including ICU beds and medical supplies, based on anticipated patient volumes and

acuity levels, aiding efficient resource management in resource-constrained settings. It can also predict ICU stay durations, readmission probabilities, and mortality rates.[49-51] Furthermore, AI-powered remote monitoring systems enable continuous monitoring of patients' vital signs outside traditional hospital settings, facilitating early detection of deterioration and timely interventions, particularly where access to healthcare facilities is limited.[49] AI is also instrumental in forecasting the risks associated with medical complications such as sepsis and acute respiratory distress syndrome.[49] Through these applications, AI can address challenges in critical care, improve patient outcomes, and enhance efficiency in low-income countries' healthcare systems. One crucial aspect of AI in ICU care is identifying and categorizing patient-ventilator asynchrony, which measures the alignment between a patient's respiratory efforts and mechanical ventilator support.[50] A Poisson hidden Markov model has been employed to predict the probabilities of different risk levels occurring in the near future. Patients entering high-asynchrony states tend to remain unstable, underscoring the clinical significance. This innovative approach lays the foundation for intelligent, alert systems that notify healthcare professionals of high-risk conditions, enabling timely interventions to enhance patient-ventilator interaction and improve outcomes.[52]

AI in Surgery

Integrating AI into the field of surgery has brought about a paradigm shift, revolutionizing surgical care. Robotic surgery with robots such as the Da Vinci Surgical System safely mimics surgeon hand movements with unparalleled accuracy.[52] Robot-assisted surgery finds utility across various medical disciplines such as urology, general surgery, and surgical oncology. Given the prevalent scarcity of resources and personnel in LMICs, employing robotics in surgical procedures could potentially alleviate physician burnout, mitigate surgical site infections, and shorten hospitalization durations.[53] Robotic surgery has been identified as a practical and effective option within public hospitals in developing nations like Pakistan. Its feasibility was evaluated based on clinical outcomes, specifically examining surgical complications, length of hospital stays, and readmission rates.[54]

Moreover, AI has significantly improved precision, efficiency, and overall surgical outcomes. One of the remarkable applications of AI in surgery lies in optimizing the management of operating rooms. AI systems have demonstrated their ability to accurately predict the duration of surgeries and identify surgeries that are likely to be canceled. This streamlines surgery planning and enhances resource allocation in resource-limited settings.[55] Furthermore, AI-driven systems have substantially enhanced preoperative planning for instance, neural radiance field technology enables 3-dimensional reconstructions from MRI images, which aids medical professionals in visualizing anatomical structures even when data availability is limited.[56]

AI in Public Health and Community Medicine

AI is revolutionizing the field of disease epidemiology by offering innovative solutions. In LMICs, communicable diseases such as malaria and tuberculosis persist as significant contributors to the overall disease burden,[57] drawing considerable attention and funding from donors. Employing AI in community medicine has emerged as a valuable tool for disease epidemiology. For instance, researchers have utilized this approach to forecast outbreaks of dengue fever,[58] as well as to track and predict the spread of influenza.[59] Such initiatives showcase the potential of AI in aiding public health efforts to monitor and manage communicable diseases more effectively in LMICs. Malaria persists as a major public health concern in developing nations, particularly in the WHO African Region. In 2022, this region accounted for approximately 94% of all reported malaria cases and 95% of associated fatalities.[60] Enhanced monitoring of malaria incidences and fatalities assists health ministries in identifying the most affected regions or demographics, facilitating the monitoring of evolving disease trends. Robust malaria surveillance systems further aid countries in devising impactful health interventions and assessing the effectiveness of their malaria control initiatives.[60] AI's capacity to rapidly analyze vast datasets for software-based epidemiological surveillance enables the swift interpretation of data, facilitating the assessment of disease epidemiology, outbreak patterns, and pandemic trends.[61]

Summary of Role of AI in Healthcare

Table 1 shows the role of AI in healthcare. See the table below.

Medical Ethical Considerations

The integration of AI into modern healthcare demands meticulous consideration of medical ethics. Adopting AI-driven technologies necessitates diligent care for patient privacy, data security, algorithmic bias, and accountability issues[2] in developing countries where medical law enforcement tends to be poor.[62] Hong's[63] study delves into the ethical discourse prompted by AI applications within the medical domain, encompassing contentious aspects such as the moral status of AI entities, value judgments, trust dynamics associated with AI technologies, and the importance of safeguarding data accessibility and privacy. Ethical considerations include informed consent, confidentiality,

Table 1. Role of AI in Healthcare

Specialty	Role of AI
Radiology	1. Convolutional neural networks (CNNs) 2. Computer-aided detection (CAD) and radiomics
Cardiology	1. Automatic recognition and segmentation of cardiac structures 2. Prediction of cardiovascular outcomes of cardiac diseases 3. Monitoring of cardiac interventions and side effects of treatments
Oncology	1. Assist in early cancer detection (eg, breast cancer) 2. Automation and enhancement of contour precision 3. Aids in classification of tumors (eg, brain tumors) 4. Detection of tumor-marker variations
ICU	1. Predictions of ICU stay durations 2. Predictions of readmission probabilities and mortality rates 3. Forecasting the risks associated with medical complications 4. Identification and categorization of patient-ventilator asynchrony
Surgery	1. Improve surgical precision, efficiency, and overall surgical outcomes 2. Enhance 3-dimensional reconstructions from MRI images 3. A valuable training tool for novice Surgeons
Public Health and Community Medicine	1. Reduce vaccine development time for unknown microorganisms, especially during epidemics/pandemics 2. Rapid analysis of vast datasets for software-based epidemiological surveillance

and data ownership,[64] which are often overlooked in developing countries. While employing AI, it is imperative to uphold transparency, explicability, and equity and mitigate biases.[65] These multifaceted ethical dimensions mandate rigorous deliberation and the establishment of robust guidelines to ensure AI's responsible and advantageous integration into healthcare.

AI in Improving Healthcare in Rural Areas of Developing Countries

In developing nations, rural populations face significant health disparities due to poverty and limited access to healthcare.[66] The disparity is exacerbated by shortages of skilled healthcare workers in rural areas, particularly across Asia and Africa, where 90% of the global rural population resides.[67] The inequitable distribution of healthcare personnel and facilities between rural and urban areas further compounds these challenges, resulting in reduced healthcare usage and poorer health outcomes.[68] The Early Detection and Prevention System (EDPS), introduced in rural areas of India in 1998, significantly enhanced diagnostics in rural clinics lacking physicians. The EDPS, a computer-based diagnostic tool, demonstrated remarkable consistency with physician diagnoses, as evidenced by a 94% consistency rate across 933 patients in a study in India.[69] Patient responses were favourable, with the system perceived as more accurate than traditional healthcare providers. Village health nurses expressed interest in incorporating the EDPS into their practice, highlighting its potential to empower rural healthcare workers.[70] In China, the deployment of portable diagnostic machine stations in village healthcare facilities has revolutionized diagnostics, enabling the conduction of 11 tests, including blood pressure, electrocardiographs, and routine urine and blood analyses. Supported by the national rural healthcare program, these diagnostic stations automatically upload test results and medical records to an online data analysis system. Moreover, major technology firms in China are investing in AI-driven innovative clinics tailored for rural regions. Notable examples include AI-powered chatbots, which engage with patients, offer medical advice, and provide online training sessions for healthcare workers in rural areas.[71]

In rural regions with limited emergency healthcare accessibility, disease prevention is crucial. AI-based screening for life-threatening conditions shows promise in reducing mortality rates. A recent study introduced the "rural stroke risk score," using a machine learning algorithm to assess stroke risk. Implementing this score could streamline stroke screening and aid in preventing strokes.[71] In underdeveloped regions, cancer diagnosis and treatment delays are problems due to limited resources. A diagnostic system utilizing electronic medical records, which employs breast cancer-enhanced convolutional neural networks with semantic initialization filters, has been proposed for early diagnosis of breast cancer. It extracts pertinent tumor markers from unstructured medical records to aid in breast cancer diagnosis and staging and demonstrates the potential for addressing treatment timing

challenges for people residing in rural areas. Such AI-driven screening systems can potentially lower the cancer burden in developing nations.[72]

Limitations of AI Integration in Healthcare Systems of Developing Countries

Integrating AI into modern healthcare holds immense promise but raises significant challenges, such as data privacy and security. These challenges are well-pronounced in developing nations. While leveraging healthcare data for patient well-being shows potential, it is crucial to carefully manage this data to avoid harm to patients and society.[1] AI often faces the "frame problem," where applications may produce inaccuracies when used beyond their intended context because of specific principal algorithms.[65] Additionally, human biases during AI model implementation can lead to dataset shifts based on gender, socioeconomic conditions, environmental factors, and ethnicity.[71] It is essential to recognize that datasets documented for 1 population may not directly apply to minority populations, especially those in rural areas, potentially causing misdiagnoses and impacting patient care.[72] Moreover, some AI models may lack rigorous clinical validation, meaning their effectiveness and reliability in real-world healthcare settings are not well-established.[73] There is also a lack of standardized protocols and regulations for the development and deployment of AI in healthcare. This can lead to variations in quality and safety across different AI applications and among different populations, with developing nations being at risk of quality breaches the most.

AI systems might inadvertently encourage unnecessary testing or treatment based on algorithmic recommendations, leading to increased healthcare costs and potential harm to patients. This can be detrimental to already overburdened healthcare systems in developing countries. Interpretable AI models are vital for medical decision support, as they can help clinicians and patients understand how and why AI systems make certain recommendations. However, interpretability alone is not enough to ensure the quality and safety of AI in healthcare. AI models also need to be regularly monitored and validated in real-world healthcare settings, where they may encounter various challenges and uncertainties. Studies have identified challenges, including enhancing data quality, contextual AI model training, and establishing robust privacy and ethical policies.[74] Regular monitoring of any performance issues, such as errors, biases, or inconsistencies, and ensuring the ongoing reliability and accuracy of AI systems, is a challenge, especially in rural areas.[1,5]

Clinicians in developing nations must clearly understand how the proposed algorithms enhance patient care in their daily routines. Unfortunately, the majority of clinicians in developing countries lack expertise, hindering the effective use of AI. Moreover, rural clinics often rely on minimally trained nurses and paramedics. However, existing medical AI systems primarily support trained doctors. Thus, there is a crucial need for a user-friendly operating system tailored to rural health workers and training rural health workers to utilize AI effectively.[75]

Even with the proper availability of AI-based healthcare in developing countries, its utilization is hindered by electricity and internet constraints, which are significant challenges in low- to middle-income countries. Moreover, the installation and maintenance costs of AI systems are high, which is why many AI innovations have not yet reached low-income countries due to the lack of financial infrastructure. For example, implementing a new robotic surgical platform possibly costs over 1 million USD, with an additional 3,000–5,000 USD per surgical procedure.[26] Limited healthcare budgets in developing countries often prevent them from affording many AI technologies.[26]

Recommendations

To navigate the growing influence of AI in healthcare and minimize the potential for job redundancy, researchers and clinicians in developing nations must prioritize ongoing education to stay abreast of the latest AI developments. This knowledge would equip healthcare professionals to actively collaborate with AI systems, using technology to improve patient care. Embracing a collaborative model, where AI complements rather than replaces clinicians, is essential.[76] For the efficient implementation of AI in healthcare in developing countries, governments and private organizations in the developing countries should allocate resources to develop robust AI infrastructure in all healthcare institutions, especially secondary and tertiary health centers, and provide comprehensive training on AI to healthcare professionals, enabling them to effectively and safely use AI toward the provision of adequate healthcare services. Governments, in partnership with educational institutions and ministries in developing countries, should advocate for the use of AI in healthcare to be taught in schools, especially among medical, pharmacy, nursing, and other paramedical students. Early knowledge and careers in AI in healthcare among young generations would go a long way to revolutionize AI in healthcare in developing countries. Adequate knowledge and practice of AI in healthcare would also facilitate disability inclusiveness in developing nations.

Furthermore, if researchers and clinicians in developing countries could adapt to the increasing role of AI in healthcare through a multidisciplinary approach, especially working alongside computer scientists and AI experts, etc. Their jobs will not be redundant.[76] These more innovative data annotation methods and the development of more rigorous AI strategies and models would be made easier toward

healthcare delivery in developing countries easier. Additionally, we urge researchers and clinicians in developing countries to create practical, usable, and successfully implemented technology that would be possible for them by ensuring appropriate cooperation between computer professionals and healthcare providers in developing countries. Furthermore, if they could combine current best medical practices for ethical inclusivity, software development, implementation science, and human-computer interactions.[77] The AI community will have the opportunity to revolutionize healthcare in developing countries.[77]

Moreover, international medical associations such as the World Medical Association (WMA), World Federation for Medical Education (WFME), etc. should thoroughly assess the effectiveness of AI in healthcare and create standardized guidelines for its use in developing countries. These guidelines should ensure interoperability and prioritize patient safety. Establishing stringent data governance and privacy regulations is imperative to protect patient information and foster trust in AI applications. International collaborations and partnerships between developed and developing countries are vital for surmounting challenges.[78,79] Efforts involving expertise sharing, knowledge transfer, and technology exchange can expedite the integration of robotic surgery into healthcare systems in developing nations.[78,79] We urge policymakers and health authorities in developing countries to foster more collaborations with developed countries, especially the United States, the United Kingdom, Australia, China, Russia, and Germany, to utilize advanced AI technologies for data protection that can accelerate the transfer of knowledge and capacity building among healthcare providers in developing countries. High-income countries should share resources, establish a national cloud system supported by multiple nations, and provide subsidies to assist hospitals in remote areas with implementation. These measures, along with investments in transportation and logistics, can improve access to remote areas and alleviate strain on healthcare systems in developing countries. AI holds great potential to address healthcare accessibility issues, particularly in developing nations. Thus, the international community should collaborate to expand the reach of AI-powered telemedicine, making healthcare accessible in economically disadvantaged regions.

Conclusion

While challenges exist, AI's future in healthcare is promising. AI's automation and error-reduction capabilities can elevate patient care across various medical disciplines. It assists in both diagnosis and treatment, while also streamlining hospital management for more efficient operations. As we navigate this transformative journey, the synergy between human expertise and AI capabilities will define the future of healthcare, offering a brighter and more patient-centric horizon.

Acknowledgments

None.

Author Contributions

VZ and MOO researched literature and conceived the study. VZ handled the project administration. MOO and VZ participated in protocol development, obtaining ethical approval, patient recruitment, and data analysis. All authors wrote the first draft of the manuscript. MOO supervised, reviewed, and edited the manuscript. All authors approved the final version of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical Approval

Not applicable to this work.

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