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Role of AI in Diagnostics and Treatment in Pakistan's Healthcare System

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ABSTRACT

Artificial Intelligence (AI) has become a revolutionary power in the modern world of healthcare has improved the diagnostic accuracy, allows patients to have a better treatment plan and making healthcare more accessible. In the case of Pakistan, which feels the pressure on the healthcare system over the lack of available medical resources, availability of medical resources among healthcare specialists and healthcare accessibility, AI is playing a vital role to give innovative solutions to the healthcare sector to improve diagnostics and treatment services. This research article focuses on AI utilization in the healthcare system of Pakistan in diagnostics and treatment. The paper includes a theoretical discourse of the available findings as well as applying a new methodology framework and examining the results of AI supported healthcare initiatives. Findings identify that AI has a significant impact on the early detection of the disease, clinical decision making and the management of the patients. However, there are challenges which are infrastructure, data privacy, ethical issues, lack of compliance with regulation, etc. The results of the study conclude that strategic integration of AI can improve the healthcare outcomes in Pakistan provided the support of regulatory frameworks, training and investment.

Keywords: Artificial Intelligence, Diagnostics, Treatment, Healthcare System, Pakistan, Machine Learning, Clinical Decision Support

INTRODUCTION

The accelerated growth of Artificial Intelligence (AI) has transformed a number of industries, one of the most heavily affected being healthcare. AI refers to the study and application of computational systems that are capable of carrying out tasks that normally require human intelligence such as learning, reasoning, recognizing patterns and making decisions. In terms of healthcare, the usage of Artificial Intelligence technologies has increased and is now applied for diagnosis, treatment planning, prediction of diseases, and monitoring patients, as well as transforming the conventional models of healthcare provision (Rajkomar et al., 2019).

The health care system of Pakistan is extremely limited. The country is coping with a high burden of communicable and non-communicable diseases, poor infrastructure of healthcare system, lack of trained medical professionals, and disparity of healthcare facilities between the urban and rural areas (WHO, 2018). These challenges contribute to suboptimal outcome in terms of diagnosis, suboptimal treatment outcome and mortality rates. AI has the ability to help solve many of these systemic weaknesses in making healthcare solutions much faster, more accurate and cheaper.

Globally, it has been showcased that AI-operated diagnose systems have clashed down with great success. Current deep learning algorithms have the ability to accurately detect diseases like cancer, tuberculosis,

cardiovascular diseases and diabetic retinopathy at the same or higher accuracy rates than a human expert (Esteva et al., 2017). However, in the sphere of treatment, AI helps doctors which analyze vast data sets in order to recommend personal treatment measures, as well as predict the response to treatment, as well as reduce the adverse reaction to drugs (Topol, 2019).

In Pakistan the usage of AI in healthcare is still in the early stages but is picking up. AI-powered solutions for radiology tools are being piloted for the screening of tuberculosis and machine learning models are more in use for predicting complications of long-term diseases like diabetes (Khan et al., 2021). Telemedicine platforms in conjunction with AI symptom checkers have led to increased accessibility of healthcare for healthcare in remote areas in particular during times of public health emergencies like Covid-19 (Agha et al., 2019).

Despite all these potentialities, integration of AI in Pakistan is facing with great barriers. Lack of digitization of health records, lack of standardized data, ethical and legal issues and lack of technical expertise precludes widespread implementation. Moreover, there is usually skepticism about reliability of AI in healthcare and fear of professional displacement among the healthcare professionals that requires awareness and training (Hashimoto et al., 2020).

This research investigates the role played by AI in diagnostics and treatment in Pakistan healthcare system by analysing the existing applications, benefits and challenges. The study focuses on evidence-based information to inform policy makers, healthcare administrators and practitioners to the right adoption of AI.

The main theme or aim of this study is to investigate the effect of Artificial Intelligence on the accuracy of diagnosis and effectiveness of treatments in the health system of Pakistan. The research is trying to find out what applications of AI exist at the moment, what the outcomes were, and what are the barriers to implementing AI. Further, the study aims to provide possible ways in which the introduction of AI should be done in clinical practice in an ethical and sustainable way.

The importance of this research is relating for contribution towards the healthcare policy and planning in Pakistan. By providing a detailed evaluation of the diagnostics and treatment facilitated by AI, the study can be beneficial for decision-makers interested in the modernisation of the delivery of healthcare. The findings can help occupy investment towards digital health infrastructure, regulation development and capacity building amongst healthcare professionals. Ultimately, the study highlights the need for the use of AI in order to enhance quality, accessibility and efficiency of healthcare in Pakistan.

LITERATURE REVIEW

Artificial Intelligence has been researched in the healthcare sector since the early 2000s however saw a huge growth with the advancement in machine learning and big data analytics. Early researches were based on expert systems and more recent researches focus on deep learning and neural networks (Shortliffe & Sepulveda, 2018).

In the diagnostics, AI has shown a really great performance in the area of medical imaging. Convolutional neural networks (CNNs) are commonly often in the analysis of radiological images, pathology slides and retinal images, are classified. Esteva et al. 2017 Dermatologist-level accuracy in detecting skin cancer with deep learning. Similar studies have stressed on the efficiency of AI in measuring Lung Cancer, Tuberculosis and Brain Tumors (Litjens et al., 2017).

AI is also playing an important part in predictive diagnostics. Machine learning models are studied on the electronic health records so as to predict disease progression, hospital readmissions as well as mortality risks (Rajkomar et al., 2018). Such prediction capabilities are particularly useful in management of chronic diseases of which there are many in Pakistan.

In the context of treatment plans, AI has been viewed as making a contribution to the idea of personalized medicine, i.e. delimitation of therapies carried out on patients with a patient-specific mode. Studies

illustrates the usage of AI in optimization of chemotherapy regimens, making drugs response prediction and clinical decision making support (Cruz & Wishart, 2007). Reinforcement learning methods enhance adaptive treatment methods further (Yu et al., 2019).

Research concerning developing countries, the potential that AI has in the gap in healthcare. Mobile-based Artificial Intelligence (AI) tools empower community health workers, for the better health of mothers and children (Topol, 2019). In Pakistan, there are a few studies with promising results of artificial intelligence (AI) aided screening of TB and managing diabetes (Khan et al, 2021; Agha et al., 2019).

However, in the literature there are in various ways consistent to challenges such as data quality issues, ethical concerns, lack of regulation and resistance from healthcare professionals. These results have underscored the need for developing context-specific solutions of AI according to the local healthcare realities.

Artificial Intelligence (AI) has slowly evolved to form an integral part of the present healthcare system, particularly in relation to the planning of the diagnosis and treatment process. Since the beginning of the 2000s, more research has been conducted regarding the usefulness of computer intelligence for clinical decision making, reducing human error, and improving a patient's outcome (Shortliffe & Sepulveda, 2018). The convergence of machine learning, big data analytics and more powerful computing has led to an increase in the implementation of AI in healthcare all over the world.

One of the most explored tasks of Artificial Intelligence in healthcare is medical diagnostics. Machine learning and deep learning algorithms, convolutional neural networks (CNNs) in particular, have demonstrated quite high accuracy when reading such type medical images as X-rays, CT scans, MRIs and pathology slides. Esteva et al. (2017) have found dermatologist-level accuracy of deep learning algorithms in the detection of skin cancer using clinical images. Similarly, Litjens et al. (2017) conducted a comprehensive review of artificial intelligence and medical imaging and concluded that artificial intelligence systems exert a major influence on enhanced accuracy of diagnosis at reduced time of interpretation.

Radiology has emerged as one of the beneficiaries of AI technologies. Studies have shown that diseases like tuberculosis, lung cancer, and pneumonia are better detected via supported radiology with the help of artificial intelligence (AI) technology, to a much larger degree in resource limited countries (Rajapurkar et al., 2018). In low-/middle-income countries, the use of AI-powered radiological tools is an especially good idea because of the speaker shortage of skilled radiologists. Research in South Asia emphasizes the use of AI based Chest x-ray interpretation can be successfully used to support mass screening programs and also to reduce the delay of diagnostic procedures (Khan et al., 2021).

Beyond imaging, another manifestation of AI has come in the form of predictive diagnostics based on the use of electronics health records (EHRs) and clinical data. Machine learning models possess the ability to predict spread of the disease, risks of readmission into the hospital and mortality with a high degree of accuracy (Rajkomar et al., 2018). These predictive capabilities are important for the handling of chronic diseases such as diabetes, cardiovascular disorders and cancer. Cruz and Wishart (2007) proved that, artificial intelligence models could be used to predict the prognosis and treatment response of cancer and thus supporting the concept of personalized medicine.

AI is also significant in the field of Treatment planning and clinical decision support systems (CDSS). These systems analyze the individual patient data and recommend the optimal course of action to be followed by the patient, dosage and frequency of follow-up. Topol, 2019 has mentioned that artificial intelligence fueled decision support augments, rather than supplants, physician judgment to result in better precision of treatment and safety for patients. Reinforcement learning methods have been continued these aims of adaptive treatment plans, where AI systems have been able to learn the best ways to treat the patients over time and the response of the patient (Yu et al., 2019).

The concept of using AI in personalized medicine has been depicted widely in the literature. AI algorithms can be applied to integrate genetic information, clinical information and lifestyle information and tailor the treatment practice for specific patients. Studies show better outcomes in treatment and fewer adverse drugs reactions were documented when the AI assisted personalization was implemented (Obermeyer & Emanuel, 2016). Such advancements have a particular relevance for oncology and disease management of chronic disease.

In developing countries such as Pakistan, AI has potential to overcome the disparity in healthcare as it will provide improvement in accessibility of diagnostic and treatment facilities. Mobile apps in combination with integrated AI have been proven to ensure community health workers, plus enable improved descriptive statistics relating to maternal and child health in rural areas of need (WHO, 2020). Literature among low-resource environments/N countries indicates AI's potential as a mitosis for shortage of workforce and absence of infrastructure as long as it is implemented in an appropriate manner (Hashimoto et al., 2020).

Research specific to Pakistan is very limited but is slowly growing. Agha et al. (2019) assessed the application of the machine learning model in the prediction of a complication related to diabetes in a local patient with improved early detection and intervention clinically. Khan et al. (2021) studied artificial intelligence (AI)-assisted tuberculosis (TB) screening based on chest X-rays as practiced in rural Pakistan and have seen remarkable improvements in the case detection rates. These studies suggest that if adapted to local situations, artificial intelligence (AI) tools can bring a positive impact to the delivery of healthcare.

METHODOLOGY

This study permitted the use of the mixed-method research design in the transformative approach to study and examine the role of Artificial Intelligence (AI) in the diagnostics and treatment in the healthcare system in Pakistan. The methodology was deliberately developed to go beyond the traditional methods of description so as to offer context-specific and implementation-focused evidence that is suitable for the development of healthcare systems.

Research Design

A convergent parallel mixed method design was used in a situation where both quantitative and qualitative data were gathered at the same time which were analyzed separately but combined to give comprehensively reliable insights. This design enabled triangulation of findings which led to improved reliability and validity of findings (Creswell & Plano Clark, 2018).

Study Setting

The study was carried out in public and private healthcare institutions from Pakistani tertiary care hospitals, diagnostic centres and telemedicine platforms which works in urban and semi-urban areas. These settings were selected because AI aids in diagnostics and treatment planning in the early stages of the AI technology implementation.

DATA SOURCES AND SAMPLING

Quantitative Component

Purposeful sampling technique was used to evaluate three healthcare systems coupled with AI systems and already under use in Pakistan:

- Screening tuberculosis using AI assisted radiology system
- Machine learning model of predicting Diabetes complications
- AI-powered Telemedicine triage system and decision support system

- Clinical data of 1,200 patient cases (400 for each AI system) was retrospectively extracted for 12 months. Data included the results of diagnosis, treatment decision, the time to diagnosis and follow-up results.

Qualitative Component

Thirty-eight key informants were selected and study using maximum variation sampling:

- Clinicians (n = 18)
- Hospital administrators (n = 8)
- Health informatics specialists (n = 6)
- Health policy experts (n = 6)

Fieldwork was carried out which addressed the functioning of perceptions, ethical concerns, barriers of implementation and training needs relating to adoption of AI. (semi-structured interviews)

DATA COLLECTION PROCEDURES

Quantitative form of data Collection

Clinical performance data was obtained from the hospital information systems and also from artificial intelligence (AI) software dashboards. Standard diagnostic performance indicators were recorded such as sensitivity, specificity and accuracy as well as diagnostic turnaround time. Treatment related outcomes included treatment modification, rate of referrals, and prevention of complications.

Method of Data Collection (Qualitative)

Interviews were carried out in English and Urdu language, and were audio-recorded with consent and transcribed verbatim. An interview guide was used to ensure consistency and flexibility to follow emergent themes.

DATA ANALYSIS

1. Quantitative Analysis

Data were analysed with the help of descriptive and inferential statistics. Confusion matrix analysis was done in order to measure accuracy of diagnosis. Comparative studying was done with the help of AI assisted and conventional way of diagnosis to observe the gain in efficiency.

2. Qualitative Analysis

Thematic analysis was used by following six steps - familiarization, coding, theme development, review, definition and interpretation. NVivo-aided manual aiding coding was being used to ensure rigor and transparency.

3. Integration of Findings

Quantitative and qualitative findings were complemented at interpretation stage. Cohesive results improved conclusions and conflicting outcomes were investigated to see if any contextual influences were present.

4. Ethical Considerations

A permission to conduct the experiment has been received from the institutional review boards. Patient data were anonymized and AI systems were tested in line with the principles of data protection and confidentiality. Participation and informed consent were voluntary.

5. Validity and Reliability

There was methodological rigour in ensuring data triangulation, peer debriefing, audit trails and participant validation. The mixed method approach increased the credibility and transfer of results.

RESULTS AND DISCUSSION

The introduction and testing of AI assisted diagnostic and treatment systems lead to substantial improvements in the delivery of healthcare in the participating institutions.

Table 1: Diagnostic Performance of AI Systems

AI Application	Sensitivity (%)	Specificity (%)	Accuracy (%)
AI Radiology (TB)	92	88	90
Diabetes Prediction Model	85	80	83
AI Triage System	78	82	80

The radiology system with AI assistance has presented the highest diagnostic capability and, in particular, the detection of early signs of tuberculosis. The diabetes prediction model was able to identify high-risk cases and would permit these cases to be provided with on-time intervention. The AI triage system has improved the beginning stages of clinical assessments as well as prioritization of the patients The predictive model developed with machine learning for diabetes complications has shown good results as well. The model was able to accurately identify high-risk patients in overall results of 83%, and then it assists to change treatment approaches and apply preventive measures in the individuals. Given a fact that diabetes is spreading across Pakistan, the use of such predictive tools can be an important element in reducing the long-term complications that are associated with this disease as well as the expenses incurred for healthcare. The results support the current literature to reinforce the importance of the use of AI in the management of chronic diseases in terms of prediction of risk and individualized treatment plans (Cruz & Wishart, 2007).

The results of an AI-powered telemedicine triage system had the effect of improving the flow of patients and the accessibility to healthcare services. The system helped to improve patient waiting time by around 35%, and optimize referrals to specialists by triaging cases based on the severity of the patient. This result demonstrates how AI can be utilized to reinforce telehealth services and provide access to care in underserved and remote areas. Similar findings have been recorded in research in low and middle-income nations where the use of the AI-enabled telemedicine has contributed to the increased reach and efficiency of healthcare (WHO, 2020).

Table 2: Impact on Treatment and Service Delivery

Indicator	Conventional Care	AI-Assisted Care
Average Diagnosis Time	72 hours	43 hours
Specialist Referral Rate	High	Optimized
Patient Waiting Time	Long	Reduced by 35%

DISCUSSION OF RESULTS

The results of this study show that integration of Artificial Intelligence (AI) in diagnostics and treatment is having a positive and measurable effect on the healthcare system in Pakistan. The assessment of artificial intelligence (AI) assisted instruments in certain healthcare institutions found enhancement in diagnostic accuracy, efficiency, and clinical decision-making, against traditional healthcare practices.

The AI assisted radiology was the most performing tool out of the evaluated tools. With sensitivity of 92% and specificity of 88%, the system was able to significantly help detect tuberculosis earlier via chest x-ray analysis. This improvement is especially important for Pakistan where tuberculosis is a major concern for public health and manpower of trained radiologist is limited, especially in rural settings. The

shortening of the diagnostic time by around 40% enabled clinicians to start treatment sooner, and this is crucial to limit transmission of the disease and improve patient outcomes. These results are similar to prior research on the utility of AI-based imaging tools in screening infectious disease (Litjens et al., 2017).

The findings show that the integration of AI has made a significant difference in terms of the efficiency of diagnosis and planning of treatment. Reduced diagnosis time contributed to a better rate of early intervention especially in infectious and chronic diseases. These findings are consistent with the global evidence showing AI's ability to optimize clinical processes and decision-making (Topol, 2019).

Clinicians experience higher confidence when it comes to AI-assisted diagnostics when they are able to interpret the outputs and back it up by clinical data. The perception of AI systems as helpful tools instead of substitutes for medical professionals strengthened human-AI cooperation of decision-making.

However, inconsistency of results between AI systems put the need for data quality and local machine training in the forefront. Systems by training in locally relevant data worked better, stressing the need to adjust them to context.

Qualitative findings included ongoing challenges such as lack of infrastructure, lack of standardized electronic health records, as well as data security. Policymakers stressed the lack of comprehensive regulatory frameworks around the governing of AI in the field of healthcare.

Despite these barriers, overall acceptance of AI was positive, and especially so called younger clinicians and digital health specialists. Stakeholders stressed the importance of structured training programs, national guidelines, and governance mechanisms to ensure the ethical integration of AI.

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DISCUSSION

The results of this research serve as ample proof that Artificial Intelligence (AI) plays a game-changing role in diagnostics and treatment of the healthcare system in Pakistan. The results show that AI-assisted tools have an important impact on the accuracy ofdiagnosis, time to diagnose and on the decision to start any treatment, especially in a resource-constrained environment. These findings are in line with research around the world highlighting the potential of AI to augment clinical capability and overcome healthcare workforce shortages (Rajkomar et al, 2019; Topol, 2019).

One of the best occurrences is that AI-assisted radiology systems are better at detecting tuberculosis. With a high burden of tuberculosis in Pakistan and few radiologists, the use of AI to analyze images to detect the presence of the disease at an early stage and enabling large-scale screening is a viable solution. The high sensitivity and specificity in this study demonstrate results of previously documented literature on the reliability of AI in topping medical imaging diagnostics (Litjens et al., 2017). Early diagnosis not only helps patients, it also promotes the goal of mitigating transmission of the disease, which affects public health efforts.

AI driven predictive models for diabetes complications proved to be meaningful clinically, too. By detecting high-risk patients sooner, these systems allow patients to prevent such circumstances and provide customised treatment. This is in line with prior research showing that risk prediction using machine learning improves the management of chronic diseases and costs to healthcare in the long run (Cruz & Wishart, 2007). In a country with rapidly rising prevalence of diabetes, such predictive tools have a great relevance.

The telemedicine triage system using AI, improved the flow of patients and access to medical care, especially in impoverished regions. Reduced waiting times and optimized referrals would indicate that AI can ensure the efficiency of healthcare without growing infrastructure requirements. This interferes with

previous research highlighting the role of A.I. in increasing access to healthcare in poor and middle-income countries (WHO, 2020).

Despite these advantages, there were a number of problems which emerged. Data quality and availability are also important issues as AI cannot be effectively applied due to fragmented health information systems. Ethical issues concerning data privacy, algorithmic bias, and accountability were also an issue that was highlighted through stakeholders. These concerns reflect what is being discussed internationally about responsible adoption of AI in healthcare (Obermeyer & Emanuel, 2016).

Acceptance of clinicians became a key to successful implementation. While younger professionals were more open to AI, trust and explainability issues continued to be raised by senior clinicians. The literature is clear on the value and explanatory AI, and focused training to achieve acceptance (Shortliffe & Sepulveda, 2018).

Overall, the discussion highlights the point that the success of AI in Pakistan would be based not only on technologies but also on governance, infrastructure, ethical measures, and human capacity building.

CONCLUSION

Artificial Intelligence is a vital opportunity to bolster Pakistan's healthcare system by increasing the diagnostic accuracy level, optimizing the treatment plan, and increasing access to quality healthcare services. This study involved a thorough examination of the role of AI in diagnostics and treatment, incorporating empirical data, stakeholder views, and the material gathered in existing literature to evaluate its effect and feasibility.

The results validate the fact that AI assisted diagnostic tools and especially, radiology and predictive analytics greatly contribute to better clinical outcomes. Faster diagnosis and early disease detection as well as data-based treatment decisions help improve patient care and more efficient use of limited healthcare resources. AI-powered telemedicine systems can also be seen to show even further the potential for expanding healthcare services to remote and underserved populations.

However, the shift from pilot projects to nation-wide implementation means fixing all systemic issues. A lack of digital infrastructure, disjointed health data systems and minimal regulatory oversight are still insurmountable obstacles. Without standardized electronic health records and data governance crusts, AI systems cannot positively interaction or guarantee patient safety.

For example, ethical considerations should be at the heart of integrating AI. Maintaining the trust needed to keep things working together; ensuring data privacy, keeping algorithmic bias to a bare minimum, and creating accountability mechanisms are important for holding the trust of the public. Transparency and explainability for AI systems is also especially important in the clinical environment where decisions have a concrete consequence on the lives of patients.

Human resources development is another important factor. The study emphasises the need for extensive training programmes to give healthcare professionals the skills needed to make good use of AI tools. Integrating AI literacy into medical education and ongoing professional development will foster acceptance and make the greatest efforts to maximize benefits.

Importantly, the focus of this research is on the concept that AI should be seen as an augmentative tool, and not a replacement for doctors. Human expertise, empathy and ethical judgment are still irreplaceable in the health care field. AI's Job Is To Assist Doctors With Perceptive Information, Decrease Cognitive Load & Facilitate Your Ability To Render Decisions Based On Evidence.

From a policy perspective, Pakistan needs to have a strategic approach regarding AI integration. National digital health strategies should have clarity in how AI should be validated, deployed and monitored There needs to be collaboration between various government agencies, academic institutions, healthcare providers and technology developers to drive sustainable and appropriate AI solutions.

In conclusion, it can be said that AI has a huge potential of revolutionizing Pakistan healthcare system if realized in a thoughtfully responsible manner. With the right investments, regulations, and capacity building, AI can help make a significant contribution towards improving the quality, equity, and efficiency of healthcare across the country.

RECOMMENDATIONS

1. WiFi: Develop a National policy framework on Artificial Intelligence in healthcare
2. Establishment regulatory standards for AI validation/safety-
3. Invest in Digital health infrastructure and EHR systems.
4. Data privacy and cybersecurity should be ensured
5. Introduce AI training into education of medicine and nursing.
6. Encourage public-private partnership for AI innovation.
7. Support local solutions to healthcare inequalities through Artificial Intelligence (AI).
8. Implement explainable AI models in order to build trust by clinicians.
9. Form committees of ethical control on the use of AI.
10. Scaling up of successful AI pilot projects at a national level.

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