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# Exploring Explainable Artificial Intelligence (XAI) to Enhance Healthcare Decision Support Systems in Nigeria

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## ABSTRACT

In Nigeria, the healthcare sector faces big challenges. Limited access to quality services and not enough resources are major issues. Using Artificial Intelligence (AI) could help improve healthcare. But understanding AI predictions is hard, especially in healthcare where transparency is crucial. This article looks at Explainable AI (XAI) to help with this problem in Nigeria. It talks about XAI techniques like feature importance examination, model-agnostic methods (e.g., LIME, SHAP), and interactive visualization tools. These tools can make AI models easier to understand and help with decision-making. A literature review was done to see how XAI can help healthcare in Nigeria. The review included scholarly articles, books, and reports on AI in Nigerian healthcare. We looked at methods from past XAI studies to find common approaches and best practices. XAI offers techniques that make AI models easier to understand in healthcare systems. These techniques include feature importance examination, model-agnostic methods, and interactive visualization tools. Case studies from Nigeria show how XAI is used in areas like disease diagnosis, treatment recommendations, and public health interventions. The findings show the importance of XAI in solving interpretability issues in healthcare AI, especially in places with limited resources like Nigeria. By explaining why AI makes certain predictions, XAI helps healthcare workers make better decisions for Nigerian patients. However, more research is needed to improve XAI techniques for Nigeria's healthcare system. Policymakers and healthcare leaders should focus on using XAI-enabled systems to drive innovation and improve healthcare outcomes in Nigeria.

## INTRODUCTION

The Nigerian healthcare landscape presents unique challenges that necessitate innovative solutions to improve patient care and health outcomes. With its current estimated population of 206 million, it is known as Africa's most populous nation (UN World Population Prospects, 2019). The Nigerian healthcare system facing numerous infrastructural and resource constraints, the integration of advanced technologies such as Artificial Intelligence (AI) holds significant promise for transforming healthcare delivery. The potential roles of AI techniques in healthcare delivery and medical research are becoming increasingly evident (Reddy, Fox, & Purohit, 2019). However, the adoption of AI-driven decision support systems in Nigeria is accompanied by challenges related to the transparency and interpretability of AI algorithms.

In recent years, Nigeria has witnessed a growing interest in leveraging AI to address healthcare challenges, ranging from disease diagnosis and treatment optimization to patient management and resource allocation. AI-driven predictive analytics and personalized medicine are reshaping the approach to patient care, leveraging patient data to customize treatment plans and predict disease trajectories with unprecedented precision (Adenubi *et al.*, 2024). Despite these advancements, concerns persist regarding the inscrutable nature of many AI algorithms, which hinder their interpretability and usability in clinical practice due to the rapid proliferation of these AI models (Hassija, Chamola, & Mahapatra, 2024). Healthcare providers in Nigeria, like their counterparts worldwide, require transparency and interpretability in AI predictions to effectively incorporate them into decision-making processes.

Explainable AI (XAI) emerges as a critical tool in bridging the gap between AI predictions and clinical interpretability in the Nigerian healthcare context by explicitly linking the challenges encountered by the Nigerian healthcare sector, such as lack of synergy among government health agencies, the absence of a comprehensive healthcare information system, and insufficient healthcare policies and regulations (Iloh, Ofoedu, Njoku, Odu, & Ifedigbo, 2020). With the role of XAI in addressing these challenges, healthcare providers can overcome the opacity of AI models. XAI delivers interpretable explanations in natural language or other simple-to-understand formats enabling healthcare practitioners to acquire understanding of the underlying factors driving predictions, thereby facilitating informed decision-making (Praveen & Joshi, 2023). Moreover, XAI

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techniques empower healthcare practitioners to validate the reliability of AI predictions and tailor interventions to meet the unique needs of Nigerian patients.

To frame the importance of XAI in the Nigerian healthcare landscape, it is imperative to draw upon relevant literature that underscores the challenges and opportunities facing healthcare delivery in the country. Studies such as (Abubakar *et al.*, 2022) have highlighted the challenges in healthcare access and quality across different regions of Nigeria, emphasizing the need for innovative approaches to address these gaps. Additionally, research (Asan, Bayrak, & Choudhury, 2020) has underscored the importance of transparency and interpretability in AI algorithms for gaining trust among healthcare providers and ensuring the effective integration of AI into clinical workflows.

In light of these considerations, this article seeks to explore the role of Explainable AI in enhancing healthcare decision support systems in Nigeria. By examining the obstacles encountered by the Nigerian healthcare sector and proposing XAI solutions tailored to the local context, this study seeks to further the progress of healthcare delivery and patient outcomes in Nigeria.

## LITERATURE REVIEW

### Explainable Artificial Intelligence in Healthcare

Explainable Artificial Intelligence (XAI) has emerged as a critical tool to address the challenges posed by the lack of transparency in AI systems, particularly in healthcare. Many AI algorithms are complex and difficult to interpret, which can undermine trust among healthcare professionals who rely on clear, interpretable results to make critical decisions (Tiwari, 2023). Studies have demonstrated that XAI techniques, such as Local Interpretable Model-Agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP), effectively enhance the interpretability of AI models by offering localized explanations for predictions (Rodríguez-Pérez & Bajorath, 2020). These techniques have been applied globally in diverse areas of healthcare, including disease diagnosis, predictive analytics, and resource optimization (Han & Liu, 2021). However, most of the existing research focuses on high-resource healthcare systems where the necessary infrastructure supports such advanced models.

### The Challenge of Interpretability in Nigeria's Healthcare AI

In lower-income and resource-constrained settings like Nigeria, the integration of XAI into healthcare decision support systems presents significant opportunities as well as challenges. Nigeria's healthcare system is poorly developed, facing challenges such as inadequate infrastructure, limited access to healthcare services, and a shortage of skilled professionals (Welcome, 2011). The adoption of AI-driven decision support systems holds promise for addressing these issues. However, the lack of interpretability in AI predictions hinders their effective utilization by healthcare practitioners. XAI techniques, therefore, play a crucial role in making AI systems more transparent and aligning AI predictions with clinical insights, allowing healthcare providers to trust and act upon these systems (Tiwari, 2023).

Research conducted in developing countries has shown that XAI can improve healthcare outcomes by making AI-driven tools more accessible to clinicians who may lack specialized knowledge in data science (Asan *et al.*, 2020). The Nigerian healthcare system, with its infrastructure challenges and shortage of trained professionals, could substantially benefit from implementing XAI, particularly in areas like epidemic management, where these techniques can help predict disease outbreaks and guide resource allocation (Olumade *et al.*, 2020). Despite the promise, most existing studies focus on high-income countries, leaving a gap in understanding how XAI can be adapted for environments with fewer resources (Fasanmade & Dagogo-Jack, 2015).

### Existing Research on AI in Nigeria's Healthcare Sector

Although the literature specifically focusing on the application of XAI in Nigeria is limited, there is growing interest in AI-driven healthcare innovations. Studies exploring AI applications in Nigeria's healthcare sector have shown the potential for AI to enhance diagnostic accuracy, improve patient management, and optimize resource allocation (Adenubi *et al.*, 2024). However, many healthcare providers remain hesitant to adopt AI tools due to the opaque nature of AI algorithms, which they cannot fully understand or trust (Iloh *et al.*, 2020). This highlights the importance of XAI in bridging the gap between AI models and clinical usability, offering interpretable insights that healthcare professionals can trust and act upon in a clinical setting.

For instance, AI has been applied to manage infectious disease outbreaks in Nigeria, where models have been used to predict the spread of diseases such as cholera and Lassa fever (Olumade *et al.*, 2020). However, these models often lack interpretability, making it difficult for healthcare authorities to understand the basis of certain predictions. XAI could play a transformative role in enhancing these models, allowing healthcare practitioners to interact with AI-driven insights and make more informed decisions.

## LIMITATIONS

Despite the potential benefits, adopting XAI in Nigeria comes with several challenges. One of the primary obstacles is the lack of access to computational resources needed to implement and maintain complex AI models, including XAI techniques that require additional processing layers to generate interpretable results (Qiu *et al.*, 2023). Moreover, healthcare data in Nigeria is often incomplete or unstructured, which makes it difficult to build reliable AI models. XAI's dependence on high-quality data further complicates its adoption in low-resource settings.

**Complexity and Interpretability**

The complexity of XAI models themselves can pose a barrier. Techniques such as SHAP and LIME often rely on estimating the contribution of individual features to predictions, which can be difficult for healthcare practitioners without a background in data science or machine learning to understand (Rodríguez-Pérez & Bajorath, 2020). This complexity may hinder the adoption and usability of XAI techniques in clinical practice.

**Scalability**

XAI methods can face scalability issues when applied to large datasets or complex AI models. Curating and analyzing large datasets requires domain expertise to identify clinically relevant data, and as healthcare datasets continue to grow, scalability becomes a critical consideration (Qiu *et al.*, 2023).

**Trade-Off Between Explainability and Performance**

Studies have consistently shown that there is a trade-off between the explainability of AI models and their performance. Highly interpretable models may sacrifice predictive accuracy, while more complex models often achieve higher performance but lack transparency (Han & Liu, 2021). This trade-off is particularly problematic in healthcare, where both accuracy and interpretability are crucial for decision-making. Striking a balance between these two factors is essential for the successful use of XAI in Nigeria's healthcare system, where actionable insights must be both accurate and understandable.

**Bias and Fairness**

Another critical concern is the potential for XAI techniques to perpetuate biases present in AI algorithms and datasets (Yelne, Chaudhary, Dod, Sayyad, & Sharma, 2023). If not addressed, these biases could result in unfair or discriminatory outcomes, particularly in sensitive healthcare applications such as disease diagnosis and treatment recommendations. Mitigating bias and promoting equity in XAI systems are challenges that require further research and development.

Finally, the lack of trained professionals capable of interpreting XAI outputs is another significant barrier. Even when AI models are interpretable, healthcare providers without data science expertise may struggle to understand and act on the insights generated (Asan *et al.*, 2020). Training healthcare professionals to use XAI effectively will be an essential step toward successful implementation in Nigeria.

**Gaps in the Literature and Research Direction**

Although substantial progress has been made in developing XAI techniques, there remains a noticeable gap in the literature regarding their application in low-resource settings like Nigeria. Most existing research is conducted in high-income countries with robust infrastructure capable of supporting AI systems. Additionally, little attention has been given to how XAI can be adapted to address the specific challenges faced by Nigeria's healthcare system, such as data incompleteness, the lack of computational resources, and the need for real-time, actionable insights.

Moreover, there has been limited exploration into how healthcare professionals in Nigeria perceive the value of XAI. Understanding how these practitioners engage with XAI tools and identifying the specific challenges they face in interpreting AI insights is crucial for the effective design and implementation of XAI systems. Future research should focus on customizing XAI techniques to meet the unique demands of Nigeria's healthcare infrastructure, exploring the most effective ways to train healthcare providers to interpret AI-driven recommendations, and conducting real-world case studies to validate these approaches.

By addressing these gaps, future research can contribute to the more targeted and effective application of XAI in Nigeria, ultimately improving healthcare delivery and patient outcomes.

## MATERIALS AND METHODS

To explore the role of Explainable AI in enhancing healthcare decision support systems in Nigeria, a comprehensive literature review was conducted. The search encompassed scholarly articles, books, and reports that focus on AI applications in healthcare, both within and outside the Nigerian context. Several databases were queried, including PubMed, Springer, IEEE Xplore, Science Direct, Scopus, and the ACM digital library, using the following terms: "Explainable AI", "Healthcare Decision Support Systems", and "Nigeria." In Table 1 below different combinations of relevant search keywords was used.

Table 1.

**Table 1:** The search queries

| Database | Query | Results |
|---|---|---|
| PubMed | "Explainable (XAI) AI" | 2,000,000 |
| Springer | "Healthcare Decision | 5,000,000 |
| IEEE Xplore | Support Systems" and | 4,000,000 |
| Science Direct | "Nigeria" | 8,000,000 |
| Scopus | | 6,000,000 |
| ACM digital library | | 1,100,000 |

| Abbreviations: |
| --- |
| XAI, Explainable Artificial Intelligence |
| AI, Artificial Intelligence |

For inclusion criteria, studies published in peer-reviewed journals, books, and reports discussing the application of XAI techniques in healthcare decision support systems within and outside Nigeria were considered. Exclusion criteria encompassed studies not related to healthcare or those not relevant to the context of the article. The search queries yielded a total of approximately 26.1 million results. After removing duplicates and screening based on inclusion and exclusion criteria, 157 articles were retained for full-text review. Finally, 42 articles were deemed relevant and included in the final analysis. The selected studies underwent analysis to identify common approaches and best practices in employing XAI techniques.

## RESULTS & DISCUSSION

The literature review revealed a diverse range of XAI techniques that can significantly enhance the interpretability of AI models in healthcare decision support systems. Feature importance analysis emerged as a commonly employed method, allowing healthcare practitioners to understand the key factors driving AI predictions. Model-agnostic interpretability methods, such as LIME and SHAP, provided insights into individual predictions irrespective of the underlying machine learning model. Additionally, interactive visualization tools were identified as effective means of presenting complex AI predictions as shown in the Figure 2 below:

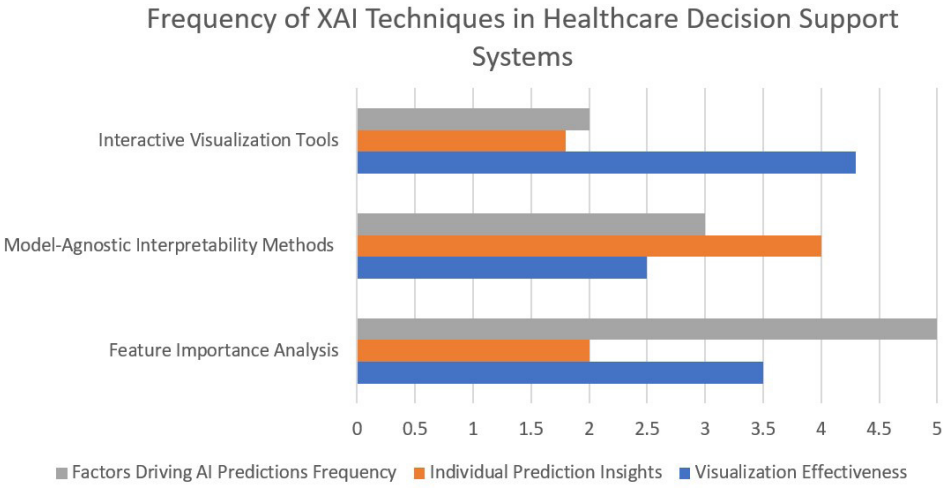


**Figure 1:** Frequency of XAI Techniques in Healthcare Decision Support Systems

Numerous case studies and illustrations from Nigeria showcase the utilization of XAI across various healthcare sectors, encompassing disease diagnosis, treatment recommendation, and public health interventions. For instance, XAI techniques if well utilized to analyze epidemiological data and predict the spread of infectious diseases can enable healthcare authorities to allocate resources effectively and coordinate response efforts.

### Case Studies: Implementation of Explainable AI in Nigerian Healthcare

#### Diabetes Management Case Study

Diabetes poses a significant healthcare challenge in the sub-Saharan region, Nigeria being the most affected (Fasanmade & Dagogo-Jack, 2015), as it has affected a significant portion of the population and straining healthcare resources. To address this challenge, healthcare practitioners are increasingly turning to Artificial Intelligence and Explainable AI for enhanced decision support in diabetes management.

#### Data Sources

The case study utilized a combination of electronic health records (EHRs), patient demographic data, laboratory test results, and clinical notes from healthcare facilities across Nigeria. These data sources provided comprehensive insights into patients' medical history, disease progression, treatment adherence, and outcomes.

#### Methodologies Employed

##### Feature Importance Examination

Assessment of feature significance techniques, such as permutation importance or SHAP (SHapley Additive exPlanations), were utilized to identify the most influential factors driving AI predictions. These factors encompassed biomarkers (e.g., HbA1c levels), medication usage, lifestyle elements (e.g., physical activity), comorbidities, and socioeconomic variables. By quantifying the impact of each factor on the model's predictions, healthcare practitioners gained valuable insights into the relative importance of different factors in diabetes management.

**Model-Agnostic Interpretability Methods**

Model-agnostic methods, such as LIME (Local Interpretable Model-agnostic Explanations) or SHAP values, were utilized to generate local explanations for individual predictions. This allowed clinicians to comprehend the rationale behind a specific prediction made by the AI model for a specific patient, thereby enhancing trust and interpretability. By highlighting the role of each feature to the model's decision-making process for a given instance, model-agnostic interpretability methods provided actionable insights for personalized patient care.

**Interactive Visualization Tools**

Interactive visualization tools, tailored to the needs of healthcare providers, were developed to facilitate the exploration of AI predictions and associated uncertainties. These tools allowed clinicians to interactively explore the relationships between input features and model predictions, enabling them to validate the reliability of predictions and assess potential interventions. Through interactive data visualizations, healthcare practitioners gained a deeper insight into the intricate relationships within the data and made more informed decisions regarding patient care.

AI algorithms, including computational algorithms - machine leaning and advanced analytics techniques - deep learning underwent training using the collected data to predict various aspects of diabetes management, such as glycemic control, medication efficacy, and risk of complications. XAI techniques were then applied to elucidate the process of making decision within these models and provide interpretable insights to healthcare providers.

**Outcomes**

The application of XAI in diabetes management yielded promising outcomes for patient treatment and healthcare provision in Nigeria. By gaining insights into the factors influencing AI predictions, clinicians were able to:

**Personalize Treatment Plans**

Healthcare providers could tailor treatment plans in accordance with specific patient attributes, preferences, and risk profiles. This personalized approach led to improved glycemic control, reduced risk of complications, and enhanced patient satisfaction.

**Enhance Clinical Decision-Making**

XAI empowered clinicians to make more informed and confident decisions regarding medication adjustments, lifestyle interventions, and preventive measures. By understanding the rationale behind AI predictions, healthcare providers could prioritize interventions that were most likely to benefit patients.

**Optimize Resource Allocation**

By identifying high-risk patients and modifiable risk factors, XAI facilitated targeted resource allocation and intervention strategies. This proactive approach enabled healthcare facilities to allocate limited resources more efficiently, thereby maximizing the impact of diabetes management efforts.

**Infectious Disease Management Case Study**

Infectious diseases pose significant challenges to public health in Nigeria, requiring timely and effective interventions to prevent outbreaks and mitigate transmission. Between 2016 and 2018 alone, there were over 20 public health emergencies and infectious disease outbreaks. Amongst the five members of the World Health Organization (WHO) African Region, Nigeria stood out as the only one to report five or more public health events per annum (Olumade *et al.*, 2020). AI-driven decision support systems play a crucial role in predicting disease spread and guiding targeted interventions. For example, with the establishment of a nationwide network of reference laboratories in the public health sector of Nigeria, XAI techniques have been utilized to analyze epidemiological data and predict the spread of infectious diseases such as cholera and Lassa fever (Olumade *et al.*, 2020). By aggregating data from diverse sources, such as population demographics, environmental factors, and disease surveillance reports, the AI model generated dynamic forecasts of disease outbreaks and pinpointed high-risk areas for timely intervention. Healthcare authorities could then use these insights to allocate resources for vaccination campaigns, implement sanitation measures, and coordinate response efforts, ultimately reducing the burden of infectious diseases on public health systems.

**Data Collection**

The study collected epidemiological data from disease surveillance systems, health facilities, and population surveys across southern Nigeria. This included information on disease incidence, demographic characteristics, environmental factors, and healthcare infrastructure.

**Methodologies Employed**

**Algorithm Selection**

Various computational algorithms - machine learning, such as random forests and gradient boosting machines, underwent assessment to gauge their efficacy in predicting disease spread based on the collected data. The choice of algorithms was determined by their performance metrics, which encompassed accuracy, precision, and recall.

**Feature Engineering**

Feature engineering techniques were employed to identify pertinent attributes within the raw data, including population density, climate variables, previous disease incidence, and healthcare access indicators. These features were used as inputs to the computational algorithm models for forecasting disease outbreaks.

**Model Training and Validation**
The selected machine learning models were trained on historical data and validated using cross-validation techniques to assess their generalization performance. Hyperparameter tuning was performed to optimize the models' predictive performance and prevent overfitting.

**XAI Techniques**
Explainable AI methods, like SHAP (SHapley Additive exPlanations) values and partial dependence plots, were employed to analyze the predictions of the computational algorithms models. These techniques helped healthcare authorities understand the factors driving disease spread and prioritize intervention strategies effectively.

**Outcome**
As a result of implementing AI-enhanced decision making support systems, several outcomes were observed:

**Timely Intervention and Resource Allocation**
The real-time forecasts generated by the AI model allowed healthcare authorities to promptly allocate resources for vaccination campaigns, sanitation measures, and other targeted interventions. By identifying high-risk areas, healthcare resources could be strategically deployed to areas most in need, thereby minimizing the burden of infectious diseases on public health systems.

**Effective Disease Prevention Strategies**
By understanding the factors driving disease spread through XAI techniques, healthcare authorities were able to develop and implement more effective disease prevention strategies. These strategies could include targeted vaccination efforts, public health education campaigns, and improvements in sanitation infrastructure, all aimed at reducing the incidence and impact of infectious diseases in Nigeria.

**Improved Response Coordination**
XAI-enabled decision support systems facilitated better coordination of response efforts among healthcare authorities and other stakeholders. Real-time insights into disease outbreaks allowed for more coordinated and efficient response efforts, leading to faster containment of outbreaks and reduced transmission rates.

**Enhanced Public Health Surveillance**
Through the integration of data from various sources and the application of XAI techniques, public health surveillance capabilities were strengthened. Healthcare authorities gained a deeper understanding of disease trends and patterns, enabling them to anticipate future outbreaks and implement proactive measures to mitigate their impact. The utilization of Explainable Artificial Intelligence XAI in infectious disease management in Nigeria resulted in more proactive, efficient, and effective public health interventions. By leveraging XAI to analyze epidemiological data and predict the spread of infectious diseases like cholera and Lassa fever, healthcare authorities were better equipped to address the challenges posed by infectious diseases, ultimately leading to improved health outcomes for the population, gaining valuable insights into disease dynamics and high-risk areas, enabling them to take proactive measures to prevent outbreaks and reduce transmission.

These case studies illustrate the diverse applications of Explainable Artificial Intelligence in addressing healthcare challenges across different domains in Nigeria. From diabetes management to infectious disease management, AI-driven decision support platforms have demonstrated their ability to enrich clinical decision-making, enhance patient outcomes, and optimize resource allocation. By leveraging XAI techniques such as feature importance analysis, model-agnostic interpretability methods, and interactive visualization tools, healthcare providers in Nigeria can gain actionable insights into complex healthcare data, tailor interventions to patient needs, and drive innovation in healthcare delivery. As Nigeria continues to invest in AI-driven healthcare solutions, these case studies serve as valuable examples of how XAI can contribute to achieving universal healthcare coverage and improving health outcomes for all Nigerians.

## RECOMMENDATIONS

**Enhancing Interpretability**
Future researchers are already preserving the interpretability of less complex ML methods while enhancing their performance by boosting and optimizing techniques in their predictive models (Payrovnaziri *et al.*, 2020). They can also focus on developing more intuitive and user-friendly XAI techniques that are easily understandable and interpretable by healthcare practitioners. This may involve the integration of visualizations, natural language explanations, or interactive tools to enhance the transparency of AI predictions.

**Scalable XAI Solutions**
Researchers should explore methods for improving the scalability of XAI techniques to handle large-scale healthcare datasets, and complex AI models effectively and handling exceptional conditions (Sheu & Pardeshi, 2022). This may involve developing distributed computing approaches, parallelization techniques, or model compression methods to enable the efficient deployment of XAI in real-world healthcare systems.

**Addressing Bias and Fairness**
Steps should be taken to recognize and address biases, as well as tackle biases present in healthcare data and AI models to ensure fair and equitable outcomes. This may include developing bias detection algorithms, fairness-aware learning techniques, or incorporating fairness constraints into XAI frameworks to promote fairness and equity in healthcare decision-making, and to optimize the algorithm to reduce bias by overriding the system's decision (Saraswat *et al.*, 2022).

**Clinical Validation and Implementation**

Future investigation should prioritize rigorous clinical validation studies to evaluate the effectiveness of XAI methods on healthcare outcomes, patient safety, and clinical workflow efficiency to foster multidisciplinary collaboration moving forward (Amann, Blasimme, Vayena, Frey, & Madai, 2020). Collaborations between data scientists, clinicians, and healthcare stakeholders are essential to ensure the successful translation of XAI research into clinical practice.

## CONCLUSION

Explainable Artificial Intelligence represents a transformative tool for advancing healthcare decision support systems in Nigeria. By addressing the critical need for transparency and interpretability in AI predictions, XAI empowers healthcare practitioners to make informed decisions and deliver personalized care to patients, thereby improving healthcare delivery and patient outcomes. Moving forward, the integration of XAI into healthcare workflows is essential for realizing the full benefits of AI in Nigeria's healthcare landscape. Future research endeavors should focus on further refining XAI techniques to address the particular requirements and obstacles encountered in the Nigerian healthcare system. Additionally, there is a need for capacity building initiatives to enhance the proficiency of healthcare providers in leveraging XAI technologies effectively. Moreover, policymakers and healthcare stakeholders should prioritize the adoption of XAI-enabled decision support systems and allocate resources for their implementation and ongoing development. By fostering collaboration between academia, industry, and government agencies, Nigeria can position itself at the forefront of AI-driven healthcare innovation, ultimately improving access to quality healthcare services and driving better health outcomes for its population. In essence, the successful integration of XAI into healthcare workflows represents a crucial step towards achieving the overarching goal of universal healthcare coverage and ensuring equitable access to healthcare services for all Nigerians.

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