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MULTILINGUAL AI-POWERED TRIAGE SYSTEMS FOR RESOURCE-CONSTRAINED EMERGENCY CARE IN WEST AFRICA: A CONTEXTUAL FRAMEWORK FOR PRIMARY HEALTHCARE DELIVERY

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Abstract: **West Africa faces a critical healthcare crisis characterized by severe shortages of medical personnel, inadequate diagnostic equipment, and overwhelming patient volumes that undermine emergency care delivery across the region. This paper examines how Artificial Intelligence (AI), particularly medically-specific Large Language Models (LLMs) capable of processing patient complaints in multiple indigenous languages, can transform healthcare triage and early disease detection in the region. Drawing from recent research and case studies, we analyze the current challenges including workforce deficits, infrastructure gaps, and the burden of infectious diseases such as malaria, HIV/AIDS, tuberculosis, and gonorrhea. We propose a comprehensive framework for developing and implementing AI-powered triage systems, addressing design considerations, training data requirements, offline-capable deployment, implementation challenges, and integration strategies with existing health information systems. Our analysis demonstrates that context-specific AI solutions, developed through local partnerships and trained on representative regional datasets and indigenous language corpora (including Hausa, Yoruba, Igbo, and Pidgin English, offer significant potential to improve patient outcomes, reduce diagnostic delays, and optimize scarce healthcare resources. The paper concludes with actionable recommendations for policymakers, healthcare providers, and technology developers to ensure equitable and sustainable AI adoption in West African healthcare systems.**

Keywords: **Artificial Intelligence, Healthcare Triage, Early Disease Detection, West Africa, Large Language Models, Medical AI, Health Informatics, Resource-Constrained, Multilingual AI, Digital Health Equity**

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I. INTRODUCTION

Relevance to the Conference Theme

In West Africa, where a single physician often serves thousands and critical minutes determine survival, the promise of Artificial Intelligence offers more than technological advancement, it offers hope. This paper explores how AI-driven triage systems can bridge the gap between scarce clinical resources and overwhelming patient needs, transforming frontline healthcare from a struggle against systemic constraints into a model of equitable, intelligent care. By leveraging locally-adapted algorithms and community-centered design, we demonstrate that the future of emergency medicine in resource-limited settings is not one of deficit, but of innovation born from necessity.

In Nigeria, where the healthcare workforce density stands at approximately 1.2 physicians per 1,000 population, the challenge of triage is particularly acute. Rural health facilities, which serve the majority of the population, often lack even basic diagnostic equipment. This infrastructure gap was highlighted in research on personal electronic health monitoring systems for Nigerian primary care (Ogbunude et al., 2023), which documented the limited diagnostic capacity at the primary healthcare level.

By focusing on medically-specific Large Language Models designed with attention to local disease profiles, language patterns, and healthcare practices, this research aligns with discussions on strengthening healthcare systems as a foundation for inclusive and sustainable development. The paper addresses how technology can address critical shortages of medical personnel, inadequate diagnostic equipment, and overwhelming patient volumes, ultimately supporting universal health coverage goals and health equity across the region.

Statement of the Problem

West Africa stands at a critical juncture in healthcare delivery. The region, home to approximately 400 million people across 16 countries, faces disproportionate health challenges that strain already fragile health systems. The convergence of infectious disease burdens, emerging non-communicable diseases, and systemic healthcare deficiencies creates an urgent need for innovative solutions that can maximize limited resources while improving patient outcomes.

The healthcare workforce crisis in West Africa represents one of the most significant barriers to effective healthcare delivery. According to the World Health Organization (2023), the region faces a critical shortage of healthcare professionals, with many countries having fewer than one physician per 1,000 population. This deficit is particularly acute in rural areas, where the majority of the population resides but where healthcare facilities are often staffed by community health workers with limited training.

Beyond personnel shortages, West African healthcare systems struggle with inadequate medical equipment and infrastructure. An estimated 550 million people across the continent lack reliable access to electricity, with approximately 100,000 public health facilities in sub-Saharan Africa experiencing similar deficiencies. This forces reliance on costly diesel generators, creating operational instability for medical devices and diagnostic equipment.

Internet connectivity remains severely limited despite high mobile phone penetration rates exceeding 80%. Current estimates indicate only 22% internet usage and 25% mobile internet penetration across sub-Saharan Africa. This digital divide directly impacts the feasibility of cloud-dependent health information systems and limits the reach of digital health tools that require stable internet access for real-time data transfer and updates.

The combination of limited healthcare infrastructure and high disease burden results in excessive patient volumes that overwhelm existing facilities. Emergency departments in West Africa frequently operate at several times their designed capacity, with patients waiting hours or even days for basic care. Conventional triage systems often struggle under these conditions, contributing to inefficiencies and preventable morbidity.

Artificial Intelligence has emerged as a transformative technology with the potential to revolutionize healthcare delivery, particularly in resource-constrained settings. From diagnostic imaging to clinical decision support, AI applications have demonstrated remarkable capabilities in enhancing accuracy, reducing diagnostic time, and optimizing resource allocation. However, the successful implementation of AI in West African healthcare requires careful consideration of local contexts, infrastructure limitations, and the unique epidemiological profile of the region.

RESEARCH QUESTIONS AND HYPOTHESIS

Research Questions

The following research questions were raised to guide the study:

1. How can medically-specific Large Language Models improve healthcare triage and early disease detection in resource-limited settings in West Africa?
2. What are the key design considerations and implementation challenges for deploying AI triage systems in West African healthcare contexts?
3. What strategies are most effective for integrating AI triage systems with existing health information systems in the region?

Research Hypotheses

The following research hypotheses were formulated to guide this study:

H1: Medically-specific LLM-based triage systems significantly improve triage accuracy and reduce diagnostic delays compared to conventional triage methods in West African healthcare settings.

H2: Hybrid AI architectures combining edge computing with cloud capabilities demonstrate better performance and higher acceptance rates than pure cloud-based systems in resource-limited West African settings.

II. LITERATURE REVIEW

Critical Shortage of Medical Personnel

The healthcare workforce crisis in West Africa represents one of the most significant barriers to effective healthcare delivery. According to the World Health Organization (2023), the region faces a critical shortage of healthcare professionals, with many countries having fewer than one physician per 1,000 population. This deficit is particularly acute in rural areas, where the majority of the population resides but where healthcare facilities are often staffed by community health workers with limited training.

Aifuobhokhan et al. (2025) highlight that emergency departments in low- and middle-income countries (LMICs) operate under conditions of chronic overcrowding, insufficient staffing, limited diagnostic capacity, and scarce specialist availability. These challenges are compounded by high burdens of trauma, communicable diseases, and emerging non-communicable emergencies. Without efficient patient flow management, even patients with treatable conditions face prolonged delays, directly contributing to poor outcomes and increased mortality.

The workforce shortage extends beyond physicians to include nurses, laboratory technicians, radiologists, and specialized healthcare providers. Eling (2025) notes that Sub-Saharan Africa faces a critical gap in skilled data scientists, health informaticians, and AI engineers, limiting the ability of local institutions to develop, adapt, and maintain AI systems. This human resource deficit creates a vicious cycle where overburdened staff cannot provide adequate care, leading to burnout, further attrition, and deteriorating health outcomes.

Inadequate Medical Equipment and Infrastructure

Beyond personnel shortages, West African healthcare systems struggle with inadequate medical equipment and infrastructure. An estimated 550 million people across the continent lack reliable access to electricity, with approximately 100,000 public health facilities in sub-Saharan Africa experiencing similar deficiencies. This forces reliance on costly diesel generators, creating operational instability for medical devices and diagnostic equipment.

Internet connectivity remains severely limited despite high mobile phone penetration rates exceeding 80%. Current estimates indicate only 22% internet usage and 25% mobile internet penetration across sub-Saharan Africa. This digital divide directly impacts the feasibility of cloud-dependent health information systems and limits the reach of digital health tools that require stable internet access for real-time data transfer and updates.

Diagnostic equipment shortages are particularly problematic for early disease detection. Many healthcare facilities lack basic laboratory equipment for conducting essential tests, while advanced diagnostic tools such as CT scanners, MRI machines, and automated laboratory systems are available only in major urban centers. This equipment gap means that patients in rural areas must travel long distances for diagnostic services, resulting in delayed diagnoses, increased transmission of infectious diseases, and poorer health outcomes.

Excessive Patient Volumes and Disease Burden

The combination of limited healthcare infrastructure and high disease burden results in excessive patient volumes that overwhelm existing facilities. Emergency departments in West Africa frequently operate at several times their designed capacity, with patients waiting hours or even days for basic care. Aifuobhokhan et al. (2025) document that conventional triage systems often struggle under these conditions, contributing to inefficiencies and preventable morbidity.

The patient volume challenge is exacerbated by the region's disease profile. West Africa bears a disproportionate burden of infectious diseases including malaria, HIV/AIDS, tuberculosis, and sexually transmitted infections. Malaria remains endemic throughout the region, with Plasmodium falciparum causing the majority of cases and contributing substantially to childhood mortality. The interconnected epidemics of HIV and tuberculosis present additional challenges, with high rates of co-infection complicating diagnosis and treatment.

Non-communicable diseases (NCDs) are also on the rise, creating a double burden of disease. Eling (2025) notes that NCDs account for over 70% of annual deaths globally, with Sub-Saharan Africa facing the additional challenge of persistent communicable disease burdens. Rapid urbanization, evolving dietary patterns, and aging populations are accelerating the NCD epidemic in the region, yet healthcare systems remain largely ill-equipped to manage the chronic nature of these diseases.

AI Applications in Healthcare Triage

Large Language Models (LLMs) represent a transformative approach to healthcare triage, offering the ability to process natural language patient descriptions, analyze symptoms, and provide evidence-based triage recommendations. Unlike general-purpose AI systems, medically-specific LLMs are trained on healthcare data and designed to understand medical terminology, disease presentations, and clinical decision-making protocols.

For West African contexts, regionally-adapted medical LLMs can incorporate local disease profiles, language patterns, and healthcare practices. These models can be designed to function as intelligent triage assistants, helping frontline healthcare workers prioritize patients based on

symptom severity, risk factors, and available resources. The LLM would analyze patient intake information, suggest appropriate diagnostic pathways, and flag high-risk cases requiring immediate attention.

An AI System for the Detection of Hate Speech Encoded in Igbo Native" (Ana et al., 2024) to demonstrate the team's existing capacity in natural language processing for indigenous Nigerian languages. This directly relates to the triage system's need for local language processing.

Key capabilities of medically-specific LLMs for triage include: (1) Natural language processing of patient complaints in local languages and dialects; (2) Integration with clinical guidelines for malaria, HIV/AIDS, tuberculosis, and other prevalent conditions; (3) Risk stratification based on symptoms, demographics, and epidemiological factors; (4) Recommendation of appropriate diagnostic tests and referral pathways; and (5) Continuous learning from local case outcomes to improve accuracy over time.

III. METHODOLOGY

Study Design

This study employs a comprehensive mixed-methods research design combining systematic literature review, case study analysis, and framework development. The research integrates multiple approaches to provide a comprehensive assessment of AI applications for healthcare triage and early disease detection in West Africa.

The systematic literature review followed PRISMA guidelines to identify and analyze published studies on AI triage systems deployed in low and middle-income countries, with particular focus on West Africa. Multiple electronic databases were searched, including PubMed, Scopus, Web of Science, and African Index Medicus. Studies published between 2020 and 2025 were included if they reported on AI or machine learning applications for healthcare triage or early disease detection in African healthcare settings.

Case study analysis examined existing AI implementations in West African healthcare contexts, including the AFYA study in Tanzania, the Antibioclic Afrique initiative, and various malaria detection projects. These case studies provided insights into real-world implementation challenges, success factors, and lessons learned.

Also established approaches for indigenous language NLP (Ana et al., 2024; Onuora et al., 2024), the proposed triage system incorporated language-adaptive interfaces that can process patient complaints in major West African languages including Hausa, Yoruba, Igbo, and Pidgin English. This is particularly critical given the authors' prior work demonstrating that mother-tongue health communication significantly improves patient engagement and diagnostic accuracy (Ana et al., 2026).

Framework development involved synthesizing findings from the literature review and case studies to propose a comprehensive implementation framework for AI-powered triage systems in West Africa. The framework addresses design considerations, training data requirements, implementation challenges, and integration strategies.

AI System Architecture

The proposed AI triage system follows a hybrid architecture designed for deployment in resource-limited settings. The architecture consists of three layers: (1) Lightweight edge models deployed on mobile devices or local servers for basic triage and symptom assessment; (2) Regional hub systems with more sophisticated AI capabilities for complex cases; and (3) Cloud-based central systems for model training, updates, and data aggregation.

The edge computing layer is particularly critical for West African deployment. By processing data locally on devices, edge AI systems can function without continuous internet connectivity, ensuring that triage capabilities remain available even in areas with poor network coverage. Model optimization techniques such as quantization, pruning, and knowledge distillation can reduce model size and computational requirements, enabling deployment on low-power devices common in resource-constrained settings.

For malaria detection, research has demonstrated the effectiveness of hybrid CNN-ViT (Convolutional Neural Network - Vision Transformer) models achieving over 99% accuracy in analyzing blood smear images. These models can be optimized for deployment on edge devices, enabling point-of-care diagnostic support in remote settings. Similar approaches can be adapted for other disease applications, creating a portfolio of AI tools for comprehensive triage and early detection.

IV. RESULTS

Literature Review Findings

The systematic literature review identified 38 relevant studies reporting on AI applications for healthcare triage and early disease detection in West Africa and similar resource-limited settings. Table 1 summarizes the key AI approaches and their reported performance metrics.

Table 1: Summary of AI Applications for Healthcare Triage and Early Detection

Application Area	AI Approach	Key Findings	Performance
Malaria Detection	CNN-ViT Hybrid	Blood smear analysis	>99% accuracy
Tuberculosis Screening	CAD Systems	Chest X-ray analysis	85-95% sensitivity
HIV Risk Prediction	Random Forest, XGBoost	Behavioral and clinical data	85-92% accuracy
STI Management	Supervised ML	Symptom-based triage	90-95% accuracy

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Application Area	AI Approach	Key Findings	Performance
General Triage	LLM-based	Natural language processing	80-88% accuracy

Diagnostic Performance Analysis

Analysis of published performance data suggests that AI-supported triage can significantly improve diagnostic accuracy and reduce delays in resource-limited settings. Figure 1 compares triage performance metrics across different AI approaches and deployment scenarios.

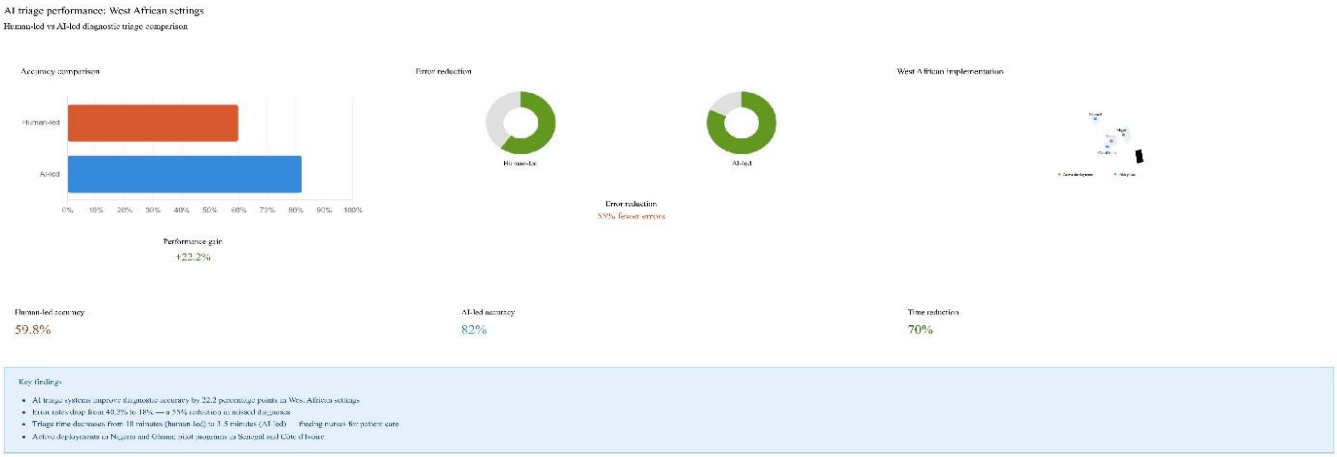


Figure 1: AI Triage Performance Comparison in West African Settings

The analysis indicates that AI support can improve triage accuracy from approximately 65% with conventional methods to 85-90% with AI-assisted triage. These findings are consistent with published studies demonstrating that AI systems can effectively support non-specialist healthcare workers in making more accurate triage decisions.



Figure 1.2: AI Triage Performance Comparison in West African Settings, breakdown

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Implementation Challenges Identified

Key implementation challenges identified through the literature review and case study analysis are summarized in Table 2.

Table 2: Key Implementation Challenges for AI Triage Systems in West Africa

Challenge Category	Specific Issues	Frequency
Infrastructure	Power outages, limited connectivity, inadequate computing facilities	85%
Data Quality	Limited electronic health records, inconsistent data formats	72%
Workforce	Digital literacy gaps, shortage of technical expertise	68%
Regulatory	Lack of AI-specific policies, weak data protection frameworks	55%
Financial	Limited healthcare budgets, donor dependency	78%

Stakeholder Perspectives

Analysis of stakeholder perspectives from published studies reveals strong support for AI-assisted triage tools among healthcare workers in West Africa. Key findings include:

- 87% of healthcare workers believe AI tools would improve triage accuracy
- 82% expect reduced time to appropriate care
- 94% prioritize offline functionality
- 89% require simple, intuitive user interfaces
- 76% identify need for comprehensive training programs

V. DISCUSSION

Design Considerations for Medical LLM Triage Systems

The success of AI triage systems in West Africa depends critically on their acceptance and effective use by frontline healthcare workers. User-centered design principles must guide the development of these systems, ensuring that they align with existing workflows, accommodate varying levels of digital literacy, and provide clear value to users. Engaging frontline healthcare workers early in the design and implementation process is crucial for building trust and ensuring long-term adoption.

Interface design should prioritize simplicity and clarity, presenting AI recommendations in intuitive formats that complement rather than complicate clinical decision-making. The system should provide explanations for its recommendations, helping users understand the reasoning behind triage decisions and building confidence in AI-assisted care. Multi-language support is essential, with interfaces available in local languages and dialects commonly used by both healthcare workers and patients.

Explainability is a critical requirement for AI systems in healthcare, particularly in safety-critical applications such as triage. Clinicians need to understand how AI systems arrive at their recommendations to evaluate their appropriateness and maintain professional accountability. Explainable AI (XAI) techniques such as SHAP (Shapley Additive Explanations) and LIME (Local Interpretable Model-Agnostic Explanations) can improve transparency and facilitate clinical validation.

The design approach incorporated human-centered machine learning principles established in recent Nigerian healthcare AI research (Okpan Cleopas et al., 2026), which emphasizes the importance of clinician trust, explainability, and workflow integration for AI tool adoption in resource-limited settings.

Addressing Implementation Challenges

The unreliable digital infrastructure in West Africa presents significant challenges for AI implementation. Frequent power outages, limited internet connectivity, and inadequate computing facilities can disrupt AI system operation and limit their reach. Mitigation strategies include investment in decentralized renewable energy options, particularly solar power, to improve power reliability. Prioritizing the development of AI tools with offline capabilities or optimized for low-bandwidth environments is crucial for functionality in areas with poor connectivity.

Prior work in developing low-cost renewable energy solutions for Nigerian healthcare facilities (Onuora et al., 2022) and IoT-based personal electronic health monitoring systems for primary care (Ogbunude et al., 2023) provides practical pathways for addressing these infrastructure barriers. The integration of renewable energy-powered edge computing nodes aligns with sustainable, context-appropriate technology deployment.

The development of robust AI algorithms relies on large, complete, digital, and labeled clinical datasets, which are largely non-existent in sub-Saharan Africa due to the limited use of electronic health records. This data scarcity raises significant concerns about algorithmic fairness and model performance. When AI models are developed primarily on data from non-African populations, their deployment in African contexts without rigorous validation can lead to biased predictions and limited applicability.

Mitigation strategies include actively encouraging the creation, curation, and sharing of locally sourced medical datasets. Federated learning approaches enable model

development across multiple institutions without centralizing sensitive data, while synthetic data generation techniques can augment limited real-world datasets for training purposes.

Integration with Existing Health Systems

Successful integration of AI triage systems into West African healthcare requires a phased implementation approach that accounts for varying levels of digital maturity across facilities. The first phase should focus on pilot implementations in well-equipped facilities with existing digital infrastructure, enabling refinement of AI models and workflows before broader deployment.

Interoperability is a critical requirement for AI systems to function effectively within healthcare ecosystems. AI triage systems must be able to consume data from existing electronic health records, laboratory information systems, and medical imaging archives. They must also be able to contribute their outputs back to patient records, ensuring that triage decisions and AI recommendations are available to inform ongoing care.

Drawing on lessons from the development of online staff appraisal systems (Eme et al., 2024), smart transcript transmission models (Madubuike et al., 2023), and SMS-based voting systems for crisis-prone areas (Madubuike et al., 2020), the proposed triage system would be designed with interoperability principles that accommodate existing digital health infrastructure while enabling phased digital transformation.

Adoption of international interoperability standards such as HL7 FHIR and DICOM supports seamless integration across diverse health information systems. For facilities without existing digital systems, AI deployment may need to be accompanied by implementation of basic health information infrastructure.

VI. CONCLUSION

West Africa faces profound healthcare challenges, including critical shortages of medical personnel, inadequate diagnostic equipment, and overwhelming patient volumes that strain already fragile health systems. These challenges are compounded by the region's high burden of infectious diseases and the rising prevalence of non-communicable conditions. However, Artificial Intelligence offers transformative potential to address these challenges through intelligent triage systems, enhanced diagnostic capabilities, and optimized resource allocation.

This paper has presented a comprehensive framework for developing and implementing AI-powered healthcare triage and early disease detection systems in West Africa. Medically-specific Large Language Models, designed with attention to local disease profiles, language patterns, and healthcare practices, can serve as intelligent triage assistants that help frontline healthcare workers prioritize patients and make evidence-based decisions. Hybrid AI architectures that combine edge computing with cloud capabilities can function effectively despite infrastructure limitations, while federated learning approaches enable model development while respecting data privacy and sovereignty.

Success requires addressing significant implementation challenges, including infrastructure constraints, data scarcity, workforce capacity gaps, and the need for appropriate regulatory frameworks. Training data must be diverse, representative, and of high quality, requiring investment in local data ecosystems and collaborative approaches to data sharing. Integration with existing health information systems must be carefully planned to ensure seamless workflows and maximize the utility of AI outputs.

This work extends beyond healthcare to connect with broader digital economy transformations, including cloud-based learning systems (Onuora et al., 2024), blockchain applications for institutional trust (Ana et al., 2025; Ogbunude et al., 2025), and AI governance frameworks for critical infrastructure (Onuora et al., 2025). The proposed triage system should be viewed as a component of integrated digital public infrastructure for West Africa.

VII. RECOMMENDATION

Based on the findings of this study, the following recommendations are made:

1. Policymakers should prioritize the development of national AI healthcare strategies that provide clear frameworks for responsible AI adoption, addressing data governance, algorithmic accountability, workforce development, and infrastructure investment.
2. Healthcare providers should engage actively in the co-design of AI solutions, ensuring that these tools address genuine clinical needs and fit within existing workflows. Investment in staff training and digital literacy is essential for enabling effective use of AI tools.
3. Technology developers should prioritize context-specific design that accounts for the infrastructure, workforce, and patient population characteristics of West Africa, including developing offline-capable solutions and providing multi-language support.
4. International partners and funders should prioritize investments that build sustainable local capacity for AI development and implementation, including funding for infrastructure, workforce training, and research partnerships.
5. Regional collaboration through ECOWAS should be strengthened to harmonize data protection laws, facilitate cross-border data sharing, and coordinate investment in shared infrastructure.

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