

Artificial Intelligence and Machine Learning for Asthma Care in Nigeria and Sub-Saharan Africa: Evidence, Opportunities, and Adoption Barriers

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ABSTRACT

Asthma affects an estimated 363 million people worldwide and caused approximately 442,000 deaths in 2023. The burden of this disease falls disproportionately on low-income and middle-income countries where the disease is mostly underdiagnosed and under-treated. Artificial intelligence (AI) and machine learning (ML) have been presented as tools for earlier diagnosis, personalised treatment, exacerbation prediction, and remote monitoring. However, much of the supporting research originates from high-income settings. Our review evaluates what the supporting evidence offers for asthma care in Nigeria and the African region. We conducted a literature search across PubMed, IEEE Xplore, Google Scholar, and similar databases, with the resulting review library consisting of 170 screened records. 116 records were reviewed in full, while 31 were retained for in-depth review of their techniques, data sources, algorithms, conclusions, and implications. Four themes emerged: an expanding but unevenly equipped African AI ecosystem; AI/ML tools for diagnosis, exacerbation prediction, and digital monitoring developed and validated almost entirely outside Africa; persistent non-technical barriers to asthma care in sub-Saharan Africa, including under-diagnosis, restricted access to medications, and insufficient awareness among carers and educators; and unresolved ethical, legal, and data governance issues. The reviewed studies demonstrate technical feasibility in high-income settings but reveal a lack of African validation. We conclude that AI and ML can enhance asthma care in Nigeria only if models are validated on African data, integrated into existing care frameworks, and governed by explicit regulations. We therefore propose seven recommendations for policymakers, clinicians, and researchers.

Received: 18 Aug. 2026

Accepted: 05 Oct. 2026

Published: 08 Oct 2026

Keywords:

Artificial Intelligence, Machine Learning, Asthma, Exacerbation Prediction, Nigeria, Sub-Saharan Africa

INTRODUCTION

Asthma is a chronic inflammatory disease of the airways and one of the most common non-communicable diseases (NCDs) worldwide. It affected an estimated 363 million people and caused about 442,000 deaths in 2023, and most asthma deaths occur in low-income and middle-income countries, where the disease is often under-diagnosed and under-treated (Global Asthma Network, 2024; World Health Organisation, 2023). It is a leading cause of morbidity among children in these regions, including Nigeria. Under-treated asthma causes disturbed sleep, daytime fatigue and poor concentration; children and adults with the disease miss school and work, with financial consequences for their families and communities; and severe attacks require emergency care and admission and can be fatal (Ozoh et al., 2019). A nationwide survey has confirmed that asthma and allergic rhinitis are common among children, adolescents, and adults in Nigeria (Ozoh et al., 2019). There is no cure for asthma, but it can be controlled with appropriate treatment and regular monitoring of symptoms and lung function (Ogbonnaya et al., 2024; Xiong et al., 2023). Because exacerbations drive disease progression, hospitalisation, and even death, the ability to anticipate them creates an opportunity for prevention (Tong et al., 2022). This is where

artificial intelligence (AI) and machine learning (ML) have attracted most interest.

AI broadly describes systems that replicate cognitive functions associated with humans including learning, communication, and problem-solving (Zuiderwijk et al., 2021; Kaplan & Haenlein, 2019). ML, a subset of AI that identifies patterns from data rather than following explicit rules is well-suited for healthcare because it can process large datasets and analyse complex relationships between variables (Xiong et al., 2023). In respiratory medicine, AI/ML has been applied to the screening, diagnosis, classification and management of chronic airway diseases, including asthma and chronic obstructive pulmonary disease (COPD) (Feng et al., 2021), and to allergy and immunology more widely (MacMath et al., 2023). Most existing AI research in asthma care is developed and validated within high-income health systems. The data infrastructure, clinical workforce, and patient demographics in these settings differ vastly from those in Nigeria and the broader sub-Saharan region. However, although Africa has cultivated a dynamic AI ecosystem over the past decade, the ethical, legal, and socio-cultural dimensions of deploying these technologies on the continent remain underexplored (Adejumo et al., 2023).

To address this gap, this review evaluates the practical relevance of current AI/ML asthma interventions for Nigeria and sub-Saharan Africa, identifying the foundational requirements for their successful implementation. We record the current landscape of AI capacity in the region, synthesise evidence on AI-driven asthma diagnosis and management, and contextualise these technologies against existing systemic barriers to care. This review therefore aims to determine what the current AI/ML evidence for asthma care offers Nigeria and sub-Saharan Africa, and the conditions that must exist for the responsible adoption of these tools.

Literature Search

We conducted a structured narrative review between September 2022 and January 2025, searching peer-reviewed literature across PubMed, IEEE Xplore, Google Scholar, Scimago, ResearchGate, and Academia. Bibliographic databases including PubMed, IEEE Xplore, and Scimago formed the core search, journal websites including IEEE Transactions on Medical Imaging, the Journal of Biomedical Informatics, and Nature Medicine were manually searched, and research sharing platforms such as Google Scholar, ResearchGate, and Academia were used for citation chasing. Search strings combined three conceptual blocks: B1 - intelligence and learning terms (“artificial intelligence”, “machine learning”, AI, ML); B2 - asthma and care-delivery terms (“asthma”, “asthma care”, “exacerbation prediction”, “future trends in asthma care”, “application to healthcare delivery system”); and B3 - region and health-system terms (“Africa”, “Nigeria”, “sub-Saharan Africa”, “healthcare delivery”, “health system”). B1 and B2 retrieved asthma AI/ML studies, B1 and B3 retrieved literature on AI adoption and governance in African healthcare, and B2 and B3 retrieved burden-and-barrier studies. Records retrieved from more than one source were deduplicated using Mendeley’s duplicate-detection tool before a manual title and digital object identifier (DOI) check was conducted to arrive at 170 unique records for screening.

Eligibility Criteria

Eligible studies fell into three broad categories. First, we included work applying AI/ML to asthma diagnosis, exacerbation prediction, or care delivery with a specific emphasis on prevention. Second, we considered literature addressing AI/ML adoption, readiness, or governance within African healthcare systems. Third, we drew on studies documenting the burden of asthma and the barriers to effective care in Nigeria and sub-Saharan Africa, since these realities form the essential context against which any AI/ML tool must be judged. Studies were excluded if they did not address asthma or African health systems, lacked original AI/ML evaluation, or were non-English abstracts. For broader disease-burden and AI-investment context, we supplemented the peer-reviewed literature with policy and institutional sources from the World Health Organisation and the OECD AI Policy Observatory.

Screening and Appraisal

Titles and abstracts were screened by L.U.Y. while A.N.T. independently verified a random 20% sample with P.O. available for adjudication on undecided issues. A total of 170 records were screened on title and abstract with 54 excluded at this stage. The remaining 116 articles underwent full-text review from which 85 were excluded (43 did not meet eligibility criteria, 25 lacked original AI/ML evaluation, and 17 were abstracts or non-English). This left 31 studies retained for critical appraisal (see Figure 1) with L.U.Y. appraising each study while A.N.T. verified the appraisals. We then assessed the methodology, data sources, AI models/algorithms employed, key results, and healthcare delivery implications for each retained study. We also noted methodological strengths and weaknesses alongside any particularly innovative approaches. The findings were synthesised thematically around advances, limitations, and future directions.

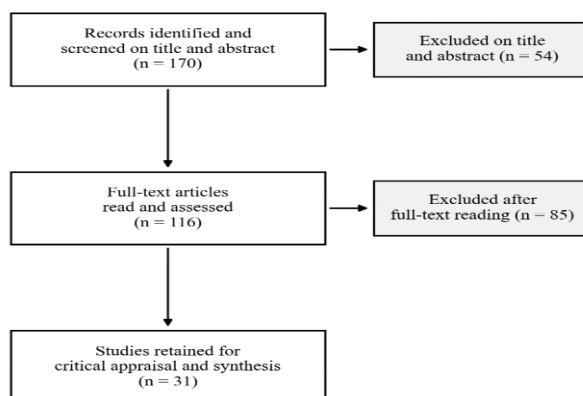


Figure 1: Selection of Studies for the Review

Health-System Readiness and the African AI Ecosystem

Africa’s AI ecosystem combines local technology hubs with centres established by international companies such as Google, Facebook, IBM, Microsoft, Amazon, Huawei, Alibaba Group and Twitter, which have substantially increased the development and deployment of AI systems on the continent (Adejumo et al., 2023). African hubs focus on local problems such as poverty, illiteracy, famine, environmental disasters and health crises (Adejumo et al., 2023), and African workers already contribute to global AI, for example by labelling the data used to train facial-

recognition algorithms (Janah, 2018). IBM Research and Google have established AI laboratories in Nairobi, Johannesburg and Accra that target food production and healthcare, including an IBM machine-learning system to support cancer diagnosis in South Africa, and between 300 and 500 African AI start-ups had attracted over US\$250 million in seed funding by 2019 (Hao, 2019).

This growth is uneven as Nigeria has attracted the largest share of AI seed funding, and South Africa, Nigeria, Kenya, Tunisia, Zimbabwe, Egypt and Ghana host the most active start-up ecosystems; yet Kenya, Tunisia, Mauritius, South

Africa and Ghana score higher than Nigeria on government AI readiness (OECD AI Policy Observatory, 2023). Within Nigeria, finance received the most funding, while healthcare has the largest number of AI start-ups, followed by agriculture and manufacturing (OECD AI Policy Observatory, 2023). AI adoption is also present in Nigerian banking where it has been linked to employee performance (Elegunde and Osagie, 2020). At policy level, the National Centre for Artificial Intelligence and Robotics (NCAIR), established under the National Information Technology Development Agency (NITDA) in November 2020, is mandated to set a national vision for AI, identify AI use cases, support data stewardship and build the AI ecosystem (OECD AI Policy Observatory, 2023). Globally, however, no African country ranked in the top 50 of the 2019 government AI readiness indices, and Asia and North America are projected to capture most of the economic benefits of AI by 2030 (Hao, 2019).

For healthcare specifically, the workforce appears receptive. In a survey of African radiographers, 84.9% (n = 866) expected AI to improve radiography practice and quality assurance, and respondents called for targeted training to prepare the workforce (Botwe et al., 2021). A scoping review of AI for the delivery of essential health services across WHO regions (Okeibunor et al., 2023), commentary on AI in Nigerian medical practice (Adejumo et al., 2023), and analysis of data science for health research in Africa (Adebamowo et al., 2023) all describe real opportunity but also the data, infrastructure, and governance gaps that must be closed first. The implication for asthma is that capacity exists but mostly in finance and technology start-ups rather than in chronic respiratory care.

AI/ML Applications in Asthma Care

The reviewed studies can be grouped into seven application areas (Table 1).

Diagnosis and Classification

For diagnosis and classification, AI has been used to identify asthma among paediatric inpatients (Yu et al., 2020), and ML and deep-learning methods have been applied across the screening, diagnosis and phenotyping of asthma and COPD (Feng et al., 2021).

Exacerbation Prediction

This is the most mature area with ML models trained on electronic health records (EHRs) to predict acute asthma exacerbations (Zein et al., 2021), and a systematic review and meta-analysis has pooled the growing number of such models (Xiong et al., 2023).

Digital Monitoring and Continuity of Care

Digital monitoring extends prediction beyond the clinic. In a 12-week open-label study, an ML model using data from an electronic multi-dose dry-powder inhaler with integrated sensors predicted impending exacerbations (Lugogo et al., 2022), and an electronic peak-flow meter linked to a smartphone app achieved good compliance (Antalfy et al., 2020). Other studies have developed an exacerbation risk model for use through conversational agents by adults in England (Kallis et al., 2023), predicted which patients are likely to maintain continuity of asthma care (Tong et al., 2022), and examined how AI can support personalised asthma treatment (Holgate et al., 2019), and innovation in allergy and immunology (MacMath et al., 2023) (see Figure 2).

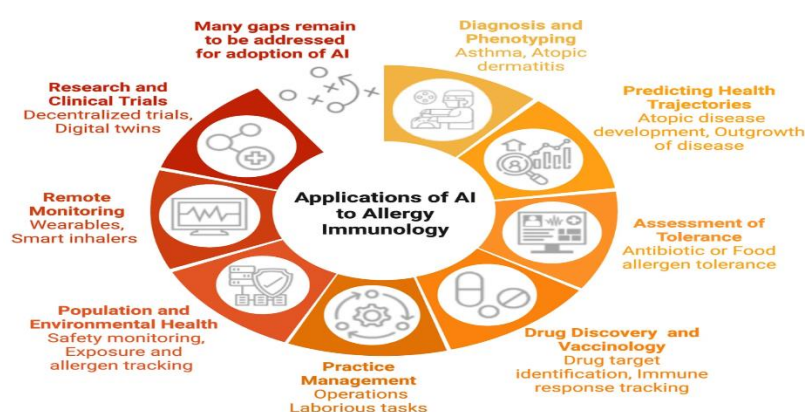


Figure 2: Applications of AI in Allergy and Immunology Studies (MacMath et al., 2023)

From model development to real-world deployment. A critical distinction must be made between model-development performance, external clinical validation, and real-world deployment. The retained studies primarily demonstrate development performance in high-income settings. Because none were externally validated on African patient data, this evidence establishes technical feasibility but does not confirm clinical effectiveness in Nigeria. While predictive accuracy often dominates the literature, integrating AI into routine clinical workflows remains the most significant bottleneck. Research examining both the economic value of these tools in asthma management (Al Meslamani, 2023) and the practical data work required of healthcare providers (Su et al., 2022) suggests that real-world implementation poses a greater challenge than model creation.

Despite these advances, the broader literature suffers from persistent methodological shortcomings. Existing reviews frequently highlight issues such as small sample sizes, reliance on single data sources, and a lack of external validation, cautioning that AI/ML tools should augment rather than replace clinical judgement (Feng et al., 2021; Xiong et al., 2023). More critically for the present review, there is an obvious geographical gap: none of the asthma-specific AI/ML models retained in this analysis was developed or validated using African patient data. Thus, the real-world performance of these algorithms in Nigerian populations remains entirely unknown because environmental exposures, healthcare access, and clinical record-keeping differ significantly in this context.

Table 1: AI/ML Application Areas for Asthma Care Identified in this Review

Application Area	Representative Studies	Data/Approach	Relevance to Nigeria and Africa
Diagnosis and Classification	Yu et al. (2020); Feng et al. (2021)	Paediatric inpatient records; Review of ML and deep learning in asthma and COPD	Offers a diagnostic aid for non-specialist clinicians in settings where respiratory specialists are scarce
Exacerbation Prediction	Zein et al. (2021); Xiong et al. (2023)	EHR-based ML; Systematic review and meta-analysis of ML models	Depends on EHR coverage that is limited in many Nigerian facilities
Digital Monitoring	Lugogo et al. (2022); Antalfy et al. (2020)	Sensor-enabled inhaler; Electronic peak-flow meter paired with a smartphone app	App-based monitoring aligns with mobile-first care delivery, although device cost might constrain adoption
Conversational Risk Assessment	Kallis et al. (2023)	Exacerbation risk model designed for conversational agents	Extends reach to patients living far from clinics, but demands adaptation to local languages and health literacy levels
Continuity of Care	Tong et al. (2022)	ML applied to a retrospective patient cohort	Could identify patients at risk of being lost to follow-up before they disengage from care
Personalised Treatment	Holgate et al. (2019); MacMath et al. (2023)	Phenotyping and precision medicine	A longer-term prospect contingent on improved access to diagnostics and targeted therapies
Deployment and Value	Al Meslamani (2023); Su et al. (2022)	Economic and clinical appraisal; Human-AI data work in asthma care	Shows the distance between developing a model and embedding it in routine practice

Barriers to Asthma Care in Sub-Saharan Africa

The African asthma literature shows that the main bottlenecks occur before the prediction phase. Masekela et al. (2022) document wide gaps between the asthma care sub-Saharan Africa recommends and the care patients receive, while Mortimer et al. (2022) set out priorities and strategies needed to close that gap across the region. A scoping review of three sub-Saharan countries found that asthma in children is frequently missed, and identified community and school-based education, revision of the terms used to diagnose asthma, guideline development and implementation, and health-system strengthening as the main remedies (Magwenzi et al., 2022). Focus group discussions with children and caregivers across several countries identified barriers to asthma care and suggestions for improving the care of adolescents (Naidoo et al., 2023a), and a parallel study found gaps in teachers' knowledge and perceptions of asthma (Naidoo et al., 2023b).

For Nigeria, this evidence reframes what "AI for asthma" should mean in practice. Predicting exacerbations is irrelevant when an individual has never received a diagnosis or when the nearest inhaler is simply out of reach. Therefore, near-term value depends on tools aimed directly at the documented bottlenecks. For instance, decision support could help non-specialist health workers recognise asthma at presentation while low-cost remote monitoring could keep track of patients living far beyond the reach of clinics. Additionally, targeted education for caregivers and schools rounds out these priorities. Remote monitoring also offers a further benefit by supplying real-time data on a patient's condition to allow clinicians to intervene earlier and adjust treatment effectively.

Ethical, Legal and Data-Governance Considerations

Where EHR data quality is degraded by socioeconomic inequity, ML models for predicting childhood asthma exacerbation can perform differently across socioeconomic groups (Nsier, 2023). The risk is likely to be greater where gaps in health records follow poverty and rurality, as they do in much of Africa. Donnelly (2022) sets out guiding principles for a normative framework to regulate AI in health care in South Africa and identifies three key areas for legal reform. More broadly, the ethical, legal and socio-cultural implications of AI in Africa remain under-examined (Adejumo et al., 2023), and data-science research in African health depends on governance frameworks that protect participants while enabling data sharing (Adebamowo et al., 2023). For Nigeria, this means asthma AI tools need clear rules on patient consent, data protection, liability for AI-assisted decisions and reporting of model performance across population groups before they are deployed at scale.

There remains a gap between the development of AI/ML tools for asthma and their deployment in healthcare settings (Al Meslamani, 2023). If that gap is closed, these tools could enable remote asthma management for patients with limited access to clinics, particularly in Africa, and reduce the burden on patients, caregivers, and clinicians. We recommend the following:

Address Structural Inequalities

Policymakers and health stakeholders should prioritise resources, infrastructure, and access in underserved areas. This must be treated as a precondition of global healthcare to limit the widening of existing disparities in AI-enabled asthma care.

Strengthen Data-Privacy and Regulatory Frameworks

Governments, health institutions, and technology developers must collectively establish safeguards that protect patient data without limiting innovation in asthma management.

Validate Models on African Data

Existing diagnostic, classification, and prediction models should be externally validated on Nigerian and other African patient data, with larger samples and multiple data sources that combine demographic, environmental, and clinical history variables.

Integrate Broader Data

Researchers should add genomic, metabolomic, imaging, and other relevant data to better characterise asthma phenotypes and guide targeted therapies such as biological agents where feasible.

Prioritise Research in Developing Countries

Funders and institutions should support AI/ML research on asthma care in settings with weaker health systems. This is important where needs are most urgent such as sub-Saharan Africa.

Prepare for Health Crises

The disruption caused by the COVID-19 pandemic shows the need for AI-supported management systems that keep care for chronic airway diseases running during outbreaks especially in resource-limited settings.

Collaborate Globally

Health communities, researchers, and technology developers should share knowledge, data, and resources to accelerate AI-driven solutions for asthma care.

Limitations of the Review

This is a narrative rather than a systematic review. Therefore, we did not score the included studies with a formal risk-of-bias tool or attempt a meta-analysis. The figures cited on AI investment and readiness also draw on sources that evolve rapidly so they must be read as indicative of the period covered rather than as current estimates.

CONCLUSION

The studies retained in this review demonstrate three concrete capabilities. AI/ML can identify asthma in inpatient records and classify chronic airway disease from clinical data (Yu et al., 2020; Feng et al., 2021), predict exacerbations from EHR cohorts with useful discrimination (Zein et al., 2021; Xiong et al., 2023), and support remote monitoring through sensor-enabled inhalers and smartphone-linked peak-flow diaries (Lugogo et al., 2022; Antalffy et al., 2020). However, they do not demonstrate effectiveness in African health systems, and no retained model was developed or externally validated on African patient data. Furthermore, the distance between development performance and routine deployment remains wide even in high-income settings (Al Meslamani, 2023; Su et al., 2022). The evidence therefore supports a staged approach rather than immediate adoption for Nigeria and the wider African region. Existing models should be validated on Nigerian and African patient data before efforts are concentrated on the documented bottlenecks of under-diagnosis, access, and awareness. Consent, regulation, performance reporting, and data governance rules must also be enacted before scaling any tool. AI/ML realistically offers a pathway to better asthma outcomes for sub-Saharan Africa when pursued on these terms. We therefore offer these findings to policymakers, healthcare providers, and researchers as a basis for capturing those benefits without underestimating associated risks.

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