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Original Research

Cardiologists' insights on AI integration in Nigeria's cardiac healthcare landscape: A qualitative study

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ABSTRACT

Background: Artificial Intelligence (AI) offers transformative potential in cardiology by enhancing diagnostic precision, improving workflow efficiency, and expanding access to care. However, in low- and middle-income countries such as Nigeria, the integration of AI faces unique systemic and contextual challenges. Existing literature is limited in examining healthcare providers' views in these settings, particularly among specialists like cardiologists.

Objectives: This study explored the perspectives of Nigerian cardiologists on AI integration in cardiovascular practice, focusing on their awareness, perceived benefits, concerns, trust, and views on regulatory frameworks.

Methods: A qualitative descriptive exploratory design was employed using semi-structured interviews with 14 purposively sampled cardiologists from diverse healthcare institutions across Nigeria. Data were collected between December 2024 and April 2025. Thematic analysis, guided by Braun and Clarke's framework, was used to identify and interpret key patterns in participant responses. NVivo 12 supported data organisation and analysis.

Results: Five major themes emerged: limited but growing AI awareness; perceived benefits including diagnostic accuracy, efficiency, and remote care delivery; significant implementation barriers such as infrastructure, financial constraints, and data privacy concerns; variable levels of trust shaped by knowledge and training; and the need for clearly defined regulatory frameworks. Despite these challenges, participants showed cautious optimism about AI adoption in cardiology.

Conclusion: Nigerian cardiologists recognise AI's potential to improve cardiovascular care but highlight key contextual barriers. Successful implementation will require coordinated efforts in education, infrastructure, regulation, and culturally adapted technology.

1. Introduction

Artificial intelligence (AI) is rapidly transforming healthcare by enhancing diagnostic accuracy, optimising treatments, and improving patient outcomes across medical specialities¹. In cardiovascular medicine, AI's promise is particularly evident, with applications ranging from

automated electrocardiogram and echocardiographic analysis to predictive modelling for risk assessment and personalised therapies^{2,3}. These advancements include machine learning algorithms that match or exceed cardiologist performance in detecting arrhythmias and acute coronary syndromes, deep learning for precise cardiac function assessment, and superior AI-powered models for identifying at-risk patients

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for targeted prevention ⁴.

Before delving into AI's specific applications in cardiology, it is important to acknowledge its broader impact across various sectors including finance, transportation, and manufacturing, as well as its growing influence across the health sector generally ⁵. AI's evolution from narrow task-specific applications to increasingly sophisticated clinical decision support systems (CDSS) represents a continuum of technological advancement, with CDSS representing AI-enabled tools specifically designed to assist healthcare professionals in making evidence-based clinical decisions ⁶. This distinction is important as CDSS represents the practical manifestation of AI principles in clinical workflows, integrating patient-specific data with medical knowledge bases to generate actionable recommendations.

The potential of AI to address critical cardiovascular care challenges, such as growing disease burden and workforce shortages, is substantial. Cardiovascular diseases (CVDs) kill approximately 17.9 million people globally each year ⁷, with sub-Saharan Africa, including Nigeria, experiencing a rising prevalence that strains already limited healthcare systems. Nigeria faces a complex CVD landscape, where hypertension affects around 28 % of adults and heart failure contributes significantly to morbidity ^{8,9}. This crisis is intensified by a severe shortage of specialists, with fewer than 200 cardiologists serving over 200 million people ¹⁰, highlighting an urgent need for innovative solutions like AI, especially in resource-constrained settings where it can extend expertise via telemedicine, support non-specialists, and enhance clinical decision-making. In Nigeria's context, the current state of digital health infrastructure remains limited, with few pilot initiatives for AI-based tools such as automated ECG interpretation in tertiary hospitals, though widespread deployment has not yet occurred.

Despite AI's promise, its implementation in low- and middle-income countries (LMICs) like Nigeria faces considerable hurdles, including infrastructural deficits (e.g., unreliable electricity, poor internet connectivity), high financial costs for technology and training, and critical data privacy, security, and ethical concerns ^{11,12}. Furthermore, an underdeveloped regulatory landscape for AI in healthcare across many African nations, including Nigeria, creates uncertainty regarding standards, accountability, and liability, posing risks to patient safety and quality assurance ^{13,14}. The success of AI adoption also crucially depends on healthcare providers' perspectives, attitudes, and acceptance. Yet, research in Africa, particularly among specialists like cardiologists, is scarce, with most studies originating from high-income countries and offering limited applicability to these unique contexts.

With its burgeoning tech sector and significant healthcare challenges, Nigeria presents a vital case for understanding AI adoption in cardiology. A significant knowledge gap regarding Nigerian cardiologists' views on AI hinders evidence-based policy and implementation. Previous studies have often overlooked specialist provider acceptance or used quantitative methods that miss nuanced contextual insights. Qualitative methodologies, however, can deeply explore these complex perspectives and socio-cultural influences. Therefore, this study aims to explore Nigerian cardiologists' insights on AI applications in cardiovascular practice. It examines their awareness, perceived benefits, barriers, trust, and regulatory views to inform strategies for optimising AI integration in resource-constrained healthcare settings.

2. Methods

2.1. Study design and framework

We adopted a qualitative descriptive exploratory methodology to examine Nigerian cardiologists' views on artificial intelligence integration in cardiovascular practice. This research utilized thematic analysis as outlined by Braun and Clarke ¹⁵ to systematically examine and interpret emerging patterns from participant narratives. The exploratory nature of this design facilitated comprehensive exploration of participant perspectives while accommodating varying levels of AI familiarity

among cardiovascular specialists.

2.2. Recruitment strategy and participant characteristics

Study participants were recruited using convenience sampling. Cardiologists who were accessible and available to the research team across various Nigerian healthcare facilities were invited to participate. Of approximately 180 practicing cardiologists in Nigeria, 25 cardiologists who were readily accessible through the researchers' professional networks were approached. Fourteen cardiologists accepted the invitation and completed interviews, yielding a participation rate of 56 %. The sample was selected to include representation across different geographic locations, institutes, and subspecialties where possible within the constraints of convenience sampling. This sample size was determined to be adequate based on the principle of information power in qualitative research, which considers the study's aim (narrow and specific), sample specificity (highly relevant participants), theoretical background (established frameworks), quality of dialogue (in-depth semi-structured interviews), and analysis strategy (thematic analysis). Thematic saturation was confirmed when three consecutive interviews yielded no new themes or insights.

Study participants were selected through purposive sampling targeting cardiovascular medicine practitioners across Nigerian healthcare facilities. Inclusion criteria encompassed: active clinical practice in cardiology or cardiac subspecialties, minimum three years post-residency experience, and current employment within Nigerian healthcare institutions. Sampling continued across multiple institutions and subspecialties to achieve diverse representation until thematic saturation was reached.

Fourteen cardiologists constituted our final sample, with eleven males and three females participating. The cohort represented diverse cardiac specialties encompassing general cardiology, interventional procedures, and pediatric cardiac care. Recruitment spanned ten Nigerian healthcare facilities: Afe Babalola University Multisystem Hospital (AMSH), University of Medical Sciences Teaching Hospital (UNIMEDTH), Federal Medical Centre Yenagoa (FMCY), Ekiti State University Teaching Hospital (EKSUTH), Federal Medical Centre Owo (FMCOWO), Lagos State University Teaching Hospital (LASUTH), Aminu Kano Teaching Hospital (AKTH), Chevron Warri Hospital, Federal Teaching Hospital Ido-Ekiti (FETHI), Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), First Cardiology Consultants (FCC), and Babcock University Teaching Hospital (BUTH).

Professional experience varied from three to over fifteen years, with most participants demonstrating 5–15 years of cardiovascular practice. Age distribution concentrated between 35 and 55 years. All participants reported married status, with roughly half having children aged 10–18 years.

2.3. Interview process and data generation

Data collection occurred between December 2024 and April 2025 through individual semi-structured interviews. Given Nigeria's linguistic context where English serves as the medical education and practice language, all conversations proceeded in English without requiring translation services. Virtual platforms facilitated interviews via video or telephone calls, accommodating participants' geographical distribution across multiple states.

Interview duration averaged 30–45 min, following a structured guide developed through literature review and expert consultation in health informatics and cardiovascular medicine. Our questioning framework addressed multiple domains: existing AI knowledge and awareness in cardiology, anticipated advantages and implementation challenges, current AI service exposure, research applications perspectives, ethical considerations surrounding AI adoption, governance and trust concerns, and future integration possibilities.

Digital recording captured all conversations with explicit participant

consent, while concurrent field notes documented contextual observations and non-verbal communications. Data collection proceeded until achieving theoretical saturation, confirmed when three successive interviews failed to generate novel thematic content.

2.4. Research ethics and participant protection

The BOWEN University Teaching Hospital Research Ethics Committee granted ethical clearance (approval reference: BUTH/REC-1134) before study initiation. Verbal consent protocols preceded each interview, with participants receiving comprehensive information regarding study objectives, voluntary participation, and withdrawal rights. Anonymity preservation involved assigning numerical identifiers while removing identifying details from transcriptions. Participants received explicit assurance regarding their autonomy to discontinue participation without penalties.

2.5. Analytical framework and process

Data analysis followed Braun and Clarke's six-stage thematic analysis framework ¹⁵.

Stage 1 - Data Immersion: Research team members conducted multiple transcript readings to achieve comprehensive familiarity, documenting preliminary observations and potential coding directions.

Stage 2 - Code Development: Two independent researchers systematically identified and labeled meaningful data segments, organizing relevant content under emerging codes.

Stage 3 - Theme Construction: Collaborative sessions grouped related codes into preliminary thematic categories, gathering supporting evidence under each potential theme.

Stage 4 - Theme Validation: Extensive review ensured thematic coherence across coded segments and the complete dataset, refining thematic boundaries and relationships.

Stage 5 - Theme Refinement: Final theme definitions emerged through iterative analysis, establishing clear boundaries and comprehensive descriptions for each thematic category.

Stage 6 - Report Generation: Representative quotations were selected to illustrate themes, connecting analytical findings to research objectives and existing literature.

NVivo 12 software supported data management, coding procedures, and analytical organization. Independent coding by two researchers with third-party review of discrepancies established inter-coder reliability through consensus-building discussions.

Multiple validation strategies enhanced analytical trustworthiness:

- **Multi-analyst verification:** Independent coding and interpretation comparison between research team members
- **Participant validation:** Sharing preliminary themes with selected participants for accuracy confirmation
- **Collaborative review:** Regular team discussions challenging interpretations and exploring alternative explanations
- **Researcher reflexivity:** Maintenance of analytical journals documenting potential biases and assumptions

2.6. Quality assurance and trustworthiness

We implemented Lincoln and Guba's trustworthiness framework to ensure methodological integrity:

- **Credibility:** Established through extended data engagement, participant feedback verification, and multiple analyst perspectives
- **Transferability:** Enhanced via detailed contextual descriptions and comprehensive participant characterization
- **Dependability:** Maintained through systematic documentation of analytical decisions and methodological processes

- **Confirmability:** Achieved through reflexive practice and regular team consultation ensuring participant-grounded rather than researcher-imposed interpretations

3. Results

3.1. Sociodemographic information of study participants

Table 1 presents the sociodemographic characteristics of the 14 cardiologists interviewed across various Nigerian hospitals. Participants were predominantly male, with the majority aged between 35 and 55 years. Most respondents were married and approximately half had children aged 10–18 years. The group comprised cardiologists with professional experience ranging from 3 to over 15 years. Christianity was the predominant religion, followed by Islam. This diversity in demographic and professional backgrounds provided rich perspectives on the integration of artificial intelligence in cardiology care and research within the Nigerian healthcare context.

3.2. Influence of demographics on participant perspectives

Analysis of participant responses revealed several patterns related to demographic characteristics. Participants with longer professional experience (>10 years; Participants 1, 7, 8, 10, 11, 12, 13) generally demonstrated greater caution regarding AI implementation and emphasized the importance of maintaining clinical oversight and supervision to prevent potentially risky mistakes. In contrast, early-career cardiologists (3–8 years experience; Participants 2, 3, 5, 9) showed more enthusiasm for AI adoption and focused on efficiency benefits, particularly emphasizing how AI could increase cardiologists' financial capacity through remote reporting of ECGs and echocardiograms without requiring physical presence.

Age appeared to correlate with trust levels, with mid-career participants (35–45 years; n = 8) expressing more variable trust ranging from very low to approximately 80 %, while older participants (45–55 years; n = 4) demonstrated more consistent moderate trust levels. Religious affiliation showed no discernible pattern in AI perspectives. All participants being married with professional responsibilities may have contributed to the consistent emphasis on practical implementation challenges rather than theoretical possibilities. Those with school-age children (n = 7) were more likely to mention time management benefits and work-life balance improvements that AI could facilitate.

3.3. Thematic analysis of nigerian cardiologists' perspectives on AI in healthcare

The thematic analysis of interviews with 14 Nigerian cardiologists revealed five major themes regarding artificial intelligence in cardiology practice. These themes encompassed current knowledge and awareness (generally limited practical experience), perceived benefits (improved efficiency, diagnostic accuracy, patient management), concerns and barriers to implementation (infrastructure limitations, overreliance concerns, contextual adaptation), trust in AI solutions (variable levels influenced by multiple factors), and regulatory frameworks (underdeveloped with suggestions for oversight). Together, these themes provide a comprehensive framework for understanding the factors influencing AI adoption in Nigerian cardiology practice, highlighting both opportunities for improving cardiovascular care and substantial challenges that must be addressed in this resource-constrained setting.

The sections below present each theme with supporting quotations organized in tables for clarity and improved readability. A summary of major themes is also highlighted in Fig. 1.

3.4. Current knowledge and awareness of AI in cardiology

This theme explores cardiologists' familiarity with AI concepts,

Table 1
Sociodemographic Characteristics of Participants.

Participant	Specialty/Department	Years of Experience	Age Range	Religion	Marital Status	Children (10–18 years)
1	Cardiology	14 years medicine, 7 years cardiology	35–45	Islam	Married	Yes
2	Cardiology	8 years (4 as specialist)	35–45	Christian	Married	No
3	Cardiology	8 years (3 as specialist)	35–45	Christian	Married	No
4	Cardiology	15 years (1 as consultant)	35–45	Christian	Married	No
5	Cardiology	3–5 years	35–45	Christian	Married	No
6	Pediatric Cardiology	15 years	35–45	Christian	Married	No
7	Cardiology	> 5 years	45–55	Christian	Married	Yes
8	Cardiology	> 5 years	45–55	Christian	Married	Yes
9	Cardiology	3–5 years	35–45	Christian	Married	No
10	Cardiology	> 10 years	> 45	Islam	Married	Yes
11	Cardiology	15 years	> 45	Christian	Married	Yes
12	Pediatric Cardiology	> 15 years	45–55	Christian	Married	Yes
13	Cardiology	> 10 years	35–45	Christian	Married	No
14	Cardiology	7 years	35–45	Christian	Married	Yes

Table 2
Current Knowledge and Awareness - Key Findings and Representative Quotes.

Sub-theme	Key Finding	Representative Quote	Participant
Limited Knowledge	Most cardiologists have minimal knowledge about AI applications	"About the application of AI in cardiology. I have not seen and I have not been imbibing any."	1
Media-Based Information	Information about AI comes primarily from media rather than professional channels	"Most of what we hear are things that we hear on the internet. So, things you read in the newspapers of AI replacing doctors and stuff that happens. Nothing. I don't think I have any particular information about it."	6
Moderate Knowledge	Some participants demonstrated moderate knowledge of AI applications	"The level of knowledge about AI and its applications in healthcare among the Cardiology team in my area is moderate. The various interactive AI apps like ChatGPT and Gemini can be used to guide humans' thought processes on challenging cases in terms of diagnosis, and management of patients."	13
Specific Applications	Recognition of specific applications in diagnostic tools	"For example, AI related interventions in cardiac arrhythmias. Even in interventional cardiology. Also, I have some knowledge of some AI being applicable in diagnosing some of the interventional cardiology related abnormalities, especially in arrhythmias."	7
Basic Training Experience	Some have received basic training	"My team, they have some basic knowledge on AI applications in healthcare. I personally have done a training last year on digital health and AI applications in cardiology."	3

applications, and implementations within their practice settings. Analysis revealed significant variations in knowledge levels among participants, ranging from very limited awareness to moderate theoretical understanding, though most indicated minimal practical exposure to AI systems.

3.5. Perceived benefits of AI in cardiology practice

Participants identified numerous potential benefits of AI integration in cardiology practice, with particular emphasis on addressing critical healthcare delivery challenges in resource-constrained settings.

3.6. Concerns and barriers to AI implementation

This theme captures the substantial challenges and obstacles that cardiologists identified as potential hindrances to AI implementation in Nigerian cardiology practice.

3.7. Trust in AI solutions

This theme explores cardiologists' current levels of trust in AI systems and the factors that influence trust development.

3.8. Regulatory frameworks and governance

This theme addresses participants' views on current and needed regulatory frameworks for AI in cardiology practice.

3.9. Future outlook and implementation readiness

Despite the challenges identified, many participants expressed cautious optimism about the future of AI in Nigerian cardiology practice

with appropriate adaptation and support.

4. Discussion

This study provides comprehensive insights into Nigerian cardiologists' perspectives on artificial intelligence integration in cardiovascular practice, revealing a complex landscape characterized by limited knowledge, cautious optimism, and substantial implementation barriers. Our findings contribute to the sparse literature on AI adoption in resource-constrained healthcare settings and offer important implications for policy development and implementation strategies across similar contexts in sub-Saharan Africa.

4.1. Knowledge gaps and educational needs

Our findings revealed significant knowledge gaps among Nigerian cardiologists regarding AI applications, with most participants demonstrating limited practical exposure despite theoretical awareness. Participants consistently reported having neither seen nor actively used AI applications in their cardiology practice, reflecting a substantial disconnect between global AI advancement and local practice realities. This pattern aligns with recent studies from other low- and middle-income countries, where healthcare providers similarly demonstrated limited AI familiarity despite growing global interest^{16,17}. The reliance on media sources rather than professional training channels for AI information represents a critical barrier to AI adoption and underscores the urgent need for targeted educational initiatives specifically designed for cardiovascular specialists in resource-limited settings¹⁸.

Notably, participants who had received formal AI training demonstrated greater enthusiasm and specific knowledge about applications, consistent with studies from high-income countries where AI education exposure correlates with increased acceptance and implementation

Table 3
Perceived Benefits - Key Findings and Representative Quotes.

Sub-theme	Key Finding	Representative Quote	Participant
Improved Efficiency	AI could reduce workload and improve workflow	"One of the things I've seen is time management and efficiency. Now since I mentioned that we have a lot of patient load. At least, AI will help with efficiency in time management."	4
Enhanced Diagnostic Accuracy	AI could improve precision in diagnosis	"One of the benefits will be in precision, accurate diagnosis and management. I believe that you actually hit precision in diagnosing and also helping one way or the other in the management of the patients."	9
Remote Patient Management	AI could facilitate care for patients in remote areas	"There are people who are really far away, the roads are bad. There are people who are also separated from by water. So, they come by water transport. So, but with AI, if they have Internet where they are, they're able to pass information to you and then you can actually tell them you know what to do and quickly."	3
Financial Benefits	AI could increase financial capacity of cardiologists	"It also increases the financial capacity of cardiologists. Now you don't have to do physical. One of those things that I have benefited from here is there are some, there are some hospitals where I'm working and I've not been there in a while because I report ECGs, even echoes online."	2
Enhanced Diagnostic Tools	AI improves accuracy of diagnostic tools	"The role of AI in various investigative modalities in cardiology (AI-enabled Echo stethoscope, electrocardiogram, and Echocardiography) can't be overemphasized. It increases the accuracy and precision of diagnosis in the field of Cardiology."	13

readiness ^{19,20}. Those with formal training in digital health and AI applications showed substantially better understanding of AI's potential in cardiology. This finding supports recommendations for incorporating AI literacy into continuing medical education programs and suggests that structured educational interventions could significantly improve adoption rates among Nigerian cardiologists ²¹. The Technology Acceptance Model (TAM) provides a useful framework for understanding these dynamics, as it emphasizes that perceived usefulness and ease of use are primary determinants of technology adoption ²². Our findings suggest that current knowledge gaps impede both perceptions, creating a barrier to acceptance that education could effectively address.

4.2. Perceived benefits and contextual relevance

Despite limited current exposure, participants identified numerous potential benefits of AI integration, particularly emphasizing efficiency improvements and enhanced diagnostic accuracy. Participants highlighted time management and efficiency as major potential benefits, particularly in the context of high patient loads common in Nigerian healthcare settings. These perceptions align with documented benefits

Table 4
Concerns and Barriers - Key Findings and Representative Quotes.

Sub-theme	Key Finding	Representative Quote	Participant
Infrastructure Limitations	Poor infrastructure, particularly electricity and internet connectivity	"Okay, right now our hospital has an issue with power, so we have very poor power supply in the state."	3
Financial Constraints	High costs of implementation and maintenance	"I would guess that it would be finance. The primary concern will be both political will and physical, to finance such AI powered projects."	3
Overreliance on AI	Fear of skill erosion and overdependence	"Risk of near-total or total reliance on AI for patient care in cardiology. It will have a negative impact on the training of cardiologists in terms of reducing the individual brain task-solving capacity (i.e., ability to be fully dependent on your own brain works)"	13
Data Privacy Concerns	Worries about patient confidentiality	"First and foremost is you know most clinical data information is supposed to be called in with utmost secrecy and confidentiality. So, I'm concerned about getting the AI may expose patient secret details which is very confidential, which is part of the medical practice."	1
Contextual Adaptation	Concerns about applicability to local populations	"If you are going to be using it in a particular environment ensure that some of the data you impute into those algorithms are specific to that population and not just transfer of technology from one client to another."	10

in well-resourced healthcare systems, where AI has demonstrated significant improvements in workflow efficiency and diagnostic precision ^{23,24}.

However, the emphasis on remote patient management and telemedicine applications reflects the unique context of Nigerian healthcare, where geographical barriers and specialist shortages create distinct challenges not commonly addressed in AI literature from developed countries ^{25,26}. Participants vividly described geographical challenges including patients separated by water requiring water transport and poor road infrastructure, illustrating how AI-enabled remote consultations could bridge Nigeria's unique geographical and infrastructural divides.

Additionally, the financial dimension emerged as a notable benefit not commonly emphasized in developed-country literature. Participants emphasized how AI could increase cardiologists' financial capacity through remote reporting capabilities, allowing them to work with multiple hospitals without physical presence requirements. This suggests that AI-enabled remote services may create new revenue streams for specialists in resource-constrained settings, potentially incentivizing adoption.

Participants' recognition of AI's potential to address workforce shortages resonates with global discussions about AI's role in

Table 5
Trust in AI Solutions - Key Findings and Representative Quotes.

Sub-theme	Key Finding	Representative Quote	Participant
Variable Trust Levels	Trust levels vary widely among cardiologists	"If I am to rate it, I will be probably like 80 %."	1
		"Intermediate/Moderate level of trust."	13
		"The level of trust actually be below. It will be below average."	9
		"as it is now that is very low. Very very low."	4
Knowledge as Trust Factor	Knowledge and awareness influence trust levels	"What's influencing it is the knowledge level. So if you have a higher knowledge level and you've had intensive training because it cannot be one off training, training and retraining and exposure on these things, I'm sure the level of trust will improve."	3
		"One of the factors could be that artificial intelligence is not 100 %. We want to try as much as possible to get a good percentage to able to implement it. Whatever tool we want to use to be near perfect."	9
Accuracy Concerns	Imperfect accuracy impacts trust	"We are of the opinion that if AIs are deployed, they should be under supervision to make sure we don't make mistakes that are potentially risky."	7
Need for Human Oversight	Emphasis on human supervision		

augmenting healthcare capacity^{27,28}. Interestingly, our findings suggest that Nigerian cardiologists view AI primarily as a tool for extending reach rather than replacing clinical expertise, which differs from some Western contexts where job displacement concerns are more prominent^{29,30}. Participants consistently expressed openness to AI adoption with modifications and emphasized the importance of maintaining supervisory roles, viewing AI as scalable but requiring human oversight. This perspective may reflect the severity of healthcare workforce shortages in Nigeria, where the focus remains on meeting basic care needs rather than concerns about technological displacement³¹.

Table 6
Regulatory Frameworks - Key Findings and Representative Quotes.

Sub-theme	Key Finding	Representative Quote	Participant
Regulatory Responsibility	Various opinions on who should regulate AI	"It should be the cardiologists themselves. They are the trainers. They are the ones who set up the regulations as well as the guidance. The regulations."	1
		"Everything should come under the Medical and Dental Council of Nigeria. But the Nigerian Cardiology society is not a regulatory body. So, there is no law backing such organization to make law to regulate anything."	5
		"1) Medical and Dental Council of Nigeria. 2) Federal Ministry of Health. 3) National Information Technology Development Agency. 4) Nigerian Medical Association and specialist bodies (e.g. Nigerian Cardiac Society)"	13
Current Regulatory Status	Acknowledgment of limited regulations	"Nobody that I know about for now and nobody that I know about."	3
Essential Knowledge Areas	Skills needed for AI engagement	"As far as Nigeria is concerned? For now, there are no such laws in place, but there is room to make them in conjunction with relevant research bodies to provide a good methodology?"	7
		"Well, in terms of building a software, maybe Cardiologists need to work with somebody who is into IT and all of that. Software coding, programming, how to patent discoveries in terms of clinical use." "I think cardiologists need to get better understanding of statistics. Because even when data is churned out by AI, there's a 70 something percent chance that this is the diagnosis or the data is in support of one intervention or the other. The cardiologist needs to be able to scrutinize the quality of the data that is being pushed out by AI."	10 11

4.3. Implementation barriers and infrastructure challenges

The infrastructure limitations identified by participants, particularly electricity and internet connectivity challenges, represent fundamental barriers that distinguish AI implementation in resource-constrained settings from developed countries^{32,33}. Participants described stark realities including hospitals with very poor power supply, identifying foundational obstacles that must be addressed before any AI deployment can succeed. These findings corroborate previous research highlighting infrastructure as a primary barrier to digital health adoption in sub-Saharan Africa^{34,35}.

Financial constraints emphasized by participants extend beyond initial technology costs to include ongoing maintenance and training

Table 7
Future Outlook - Key Findings and Representative Quotes.

Sub-theme	Key Finding	Representative Quote	Participant
Cautious Optimism	General openness to AI adoption with safeguards	"It's something that is highly acceptable if cardiologists are trained, if they are trained for that. So, I perceive that cardiologists where I work are interested in AI."	3
		"In my hospital, it will be a good idea and something that is scalable. However, with some modifications."	4
Complementary Role	Emphasis on AI as complement rather than replacement	"Currently we don't really use AI, but we are aware of it and when and if it becomes generally available, we are open to receiving it and applying it in a way that will be beneficial to our patients with our own supervisory role being of importance."	7
Readiness for Adoption	Willingness to embrace AI when available	"Transition from the traditional ways to the adoption of evolving AI systems may take time. It is capital intensive. Regulating bodies will need to be put in place, getting this done may not be easy."	14
Transition Challenges	Recognition of adaptation period		

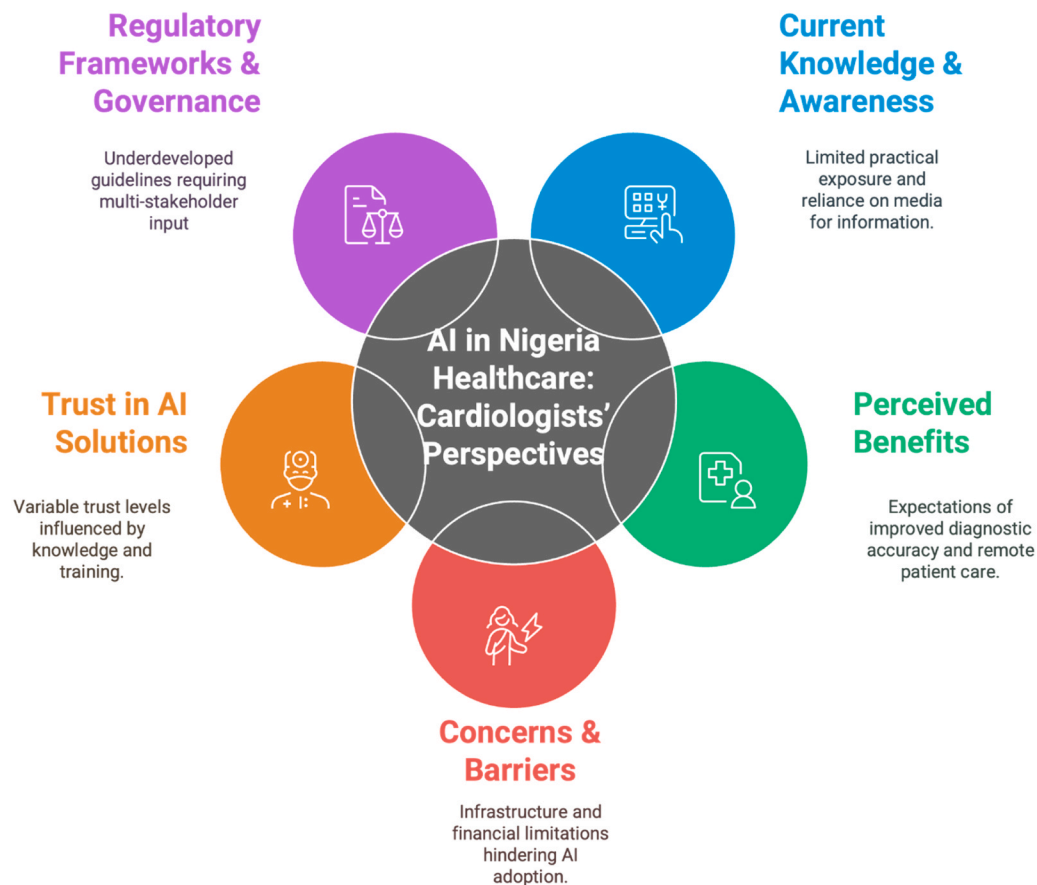


Fig. 1. Major themes examined among Nigerian Cardiologists.

expenses, reflecting broader economic challenges facing African healthcare systems^{36,37}. Participants identified finance as the primary concern, emphasizing the need for both political will and physical resources to finance AI-powered projects, highlighting that sustained political commitment must accompany financial resources.

Concerns about overreliance on AI and potential skill erosion among participants echo debates in global AI literature about maintaining clinical competency in AI-augmented healthcare environments^{38,39}. Participants expressed concerns about near-total reliance on AI negatively impacting cardiologist training by reducing individual problem-solving capacity and ability to depend on one's own clinical reasoning, demonstrating sophisticated understanding of how technology dependency could undermine clinical development.

However, our participants' emphasis on contextual adaptation and population-specific algorithm development represents sophisticated understanding of AI limitations that has received limited attention in implementation studies from other regions^{40,41}. Participants emphasized ensuring that algorithms use data specific to local populations rather than simple technology transfer from one region to another. This awareness suggests that Nigerian cardiologists may be better positioned than previously assumed to engage thoughtfully with AI implementation challenges. This concern aligns with growing global recognition of algorithmic bias and the need for diverse, representative training datasets^{42,43}, particularly given documented racial and ethnic disparities in AI performance across populations.

4.4. Trust, human oversight, and ethical considerations

The variable trust levels observed among participants, ranging from highly optimistic to cautious, reflect patterns documented in international studies of healthcare provider AI acceptance^{44,45}. Trust levels

varied dramatically from approximately 80% to very low, showing substantial polarization in confidence levels. However, the consistent emphasis on human oversight and supervisory roles in our study suggests a more nuanced understanding of AI limitations than reported in some developed country contexts, where providers may have unrealistic expectations about AI capabilities^{46,47}. Participants consistently emphasized the need for AI deployment under supervision to prevent potentially risky mistakes.

The identification of knowledge and training as primary factors influencing trust aligns with established technology acceptance models that emphasize perceived usefulness and ease of use as key determinants of adoption^{48,49}. Participants explicitly connected trust levels to knowledge, noting that higher knowledge and intensive, ongoing training would improve trust levels. This finding supports recommendations for comprehensive training programs as prerequisites for successful AI implementation, particularly in settings where providers have limited prior technology exposure⁵⁰.

Ethical concerns emerged prominently, particularly regarding patient privacy and data protection. Participants voiced concerns about maintaining utmost secrecy and confidentiality of clinical data, fearing that AI implementation might expose confidential patient details. These concerns are particularly salient given that Nigeria's National Data Protection Regulation (NDPR) was only enacted in 2019 and its application to medical AI remains unclear. Public health ethics frameworks emphasize that responsible AI deployment must balance individual privacy rights with collective health benefits⁶, suggesting that Nigeria needs explicit regulatory guidance on how NDPR applies to healthcare AI, particularly regarding data collection, storage, cross-border transfer, and algorithmic decision-making transparency.

Furthermore, the emphasis on cultural acceptability and population specificity reflects lessons from technology diffusion theory²², which

demonstrates that innovation adoption depends heavily on perceived compatibility with existing values and practices. Just as culturally adapted breast cancer screening technologies have shown greater uptake in diverse populations⁵¹, AI tools in Nigerian cardiology will likely require adaptation to local clinical workflows, patient preferences, and healthcare delivery models to achieve meaningful adoption.

4.5. Regulatory frameworks and governance needs

The absence of clear regulatory frameworks for AI in Nigerian healthcare, as identified by participants, reflects broader challenges facing healthcare regulation in many African countries^{52,53}. Participants acknowledged stark regulatory gaps, with many indicating no knowledge of existing AI regulations in Nigerian healthcare.

Participants' suggestions for professional body oversight and multi-stakeholder governance approaches align with emerging recommendations for AI governance in healthcare settings^{54,55}. Regulatory suggestions varied widely, ranging from cardiologist-led self-regulation to comprehensive multi-stakeholder approaches involving the Medical and Dental Council of Nigeria, Federal Ministry of Health, National Information Technology Development Agency, Nigerian Medical Association, and specialist bodies. However, participants also highlighted critical limitations, noting that while the Medical and Dental Council of Nigeria should have oversight, professional societies like the Nigerian Cardiac Society lack legal authority to create regulations, pointing to the need for legal frameworks that empower professional bodies to participate in AI oversight.

Participants also recognized the need for cardiologists to develop new competencies. Some suggested cardiologists need to collaborate with IT professionals and acquire skills in software coding, programming, and intellectual property protection for discoveries. Others emphasized the need for enhanced statistical literacy, noting that cardiologists must be able to scrutinize probabilistic outputs from AI systems to evaluate data quality and diagnostic suggestions. These insights suggest that successful AI integration requires not only technical infrastructure but also human capital development.

The participants' awareness of the need for local population-specific algorithm development demonstrates sophisticated understanding of AI bias and generalizability challenges that have emerged as critical issues in global AI ethics discussions⁵⁶. This positions Nigerian cardiologists as potential leaders in advocating for equitable AI development that addresses LMIC populations, rather than merely being passive recipients of technologies developed elsewhere.

4.6. Implications for AI implementation strategy

Our findings suggest that successful AI implementation in Nigerian cardiology will require a comprehensive approach addressing multiple domains simultaneously. The combination of limited knowledge, infrastructure challenges, and regulatory gaps indicates that technology-focused interventions alone will be insufficient. Instead, implementation strategies must incorporate educational components, infrastructure development, and regulatory framework establishment as interconnected prerequisites for success.

The participants' openness to AI adoption, despite recognizing significant barriers, suggests potential for successful implementation with appropriate support. Participants indicated that AI adoption would be highly acceptable if cardiologists receive adequate training, suggesting strong interest among cardiologists where training is prioritized. This contrasts with studies from some developed countries where provider resistance represents a primary implementation barrier. The emphasis on complementary rather than replacement roles for AI may facilitate smoother integration by addressing concerns about professional autonomy and clinical judgment.

However, participants realistically acknowledged that transitioning from traditional practices to AI-enabled systems will be time-consuming

and capital-intensive, requiring establishment of regulatory bodies. This suggests that stakeholders should adopt long-term perspectives rather than expecting rapid transformation.

4.7. Transferability to other low- and middle-income countries

While this study focused specifically on Nigerian cardiologists, the findings have potential relevance for AI adoption in cardiology and other medical specialties across diverse LMIC contexts. The core challenges identified, infrastructure deficits, financial constraints, knowledge gaps, regulatory vacuums, and concerns about contextual adaptation, are not unique to Nigeria but reflect systemic issues common across resource-constrained healthcare systems globally.

Countries in sub-Saharan Africa sharing similar characteristics with Nigeria, such as Kenya, Ghana, and Uganda, face comparable specialist shortages, infrastructure challenges, and healthcare financing constraints. The emphasis our participants placed on telemedicine applications for reaching geographically dispersed populations would likely resonate in these contexts as well. Similarly, South Asian LMICs such as Bangladesh, Pakistan, and Myanmar confront analogous workforce gaps and infrastructure limitations that make AI's potential for extending specialist expertise particularly relevant.

However, several contextual factors may limit direct transferability. First, Nigeria's relatively advanced technology sector and significant mobile phone penetration may not exist to the same degree in all LMICs, potentially affecting the feasibility of technology-dependent solutions. Second, regulatory environments vary substantially; while Nigeria lacks specific AI healthcare regulations, some countries may have more developed digital health governance frameworks, while others have even less regulatory capacity. Third, cultural factors influencing technology acceptance, professional hierarchies, and patient-provider relationships differ across regions and could affect how AI tools are perceived and adopted.

Fourth, the religious and cultural diversity represented in our sample may not reflect the demographics of other LMICs, potentially affecting generalizability of findings related to cultural acceptability and trust. Fifth, Nigeria's colonial legacy and English as the language of medical education facilitate engagement with predominantly English-language AI literature and tools; this advantage may not exist in Francophone African countries or countries where medical education occurs primarily in local languages.

Despite these contextual differences, several transferable lessons emerge. The finding that knowledge and training directly influence trust and adoption readiness suggests that structured educational interventions should be prioritized across LMICs regardless of specific context. The emphasis on population-specific algorithm development highlights a universal need for diverse, representative training datasets that include LMIC populations. The call for multi-stakeholder governance involving professional bodies, ministries of health, and technology agencies provides a model adaptable to various regulatory contexts.

Future research should examine AI adoption perspectives among cardiologists and other specialists across diverse LMIC settings to identify both universal patterns and context-specific factors. Comparative studies examining how different regulatory frameworks, infrastructure levels, and cultural contexts influence adoption could inform more tailored implementation strategies. Additionally, research should explore how findings from specialist physicians transfer to other healthcare provider cadres (nurses, community health workers) who may play critical roles in AI-enabled care delivery in resource-constrained settings.

5. Limitations of the study

While this study provides valuable insights into Nigerian cardiologists' perspectives on artificial intelligence (AI) integration in cardiovascular practice, several limitations must be acknowledged.

First, the study employed a qualitative design with a relatively small sample size ($n = 14$), which, although sufficient for thematic saturation, limits the generalisability of the findings to the broader population of Nigerian cardiologists or to other medical specialties. The use of convenience sampling, while pragmatic given resource constraints, may have introduced selection bias as participants were recruited from the researchers' accessible professional networks. This approach may have over-represented cardiologists from certain geographic regions or institutional types while underrepresenting others, potentially affecting the breadth of perspectives captured.

Second, all interviews were conducted virtually via video or phone calls. Although this allowed for flexibility and broader geographic reach, it may have limited the depth of interaction and the ability to capture non-verbal cues fully, potentially influencing the richness of the data gathered.

Third, there is the risk of social desirability bias, where participants may have expressed more optimistic or cautious views about AI to align with perceived expectations from the researchers or professional norms, especially given the novelty and prestige often associated with digital innovation in healthcare.

Fourth, the study did not include the perspectives of other key stakeholders such as hospital administrators, IT specialists, patients, or policymakers, whose views are critical for a comprehensive understanding of the feasibility, ethics, and system-level challenges of AI integration in cardiology.

Fifth, while the study highlighted a range of AI applications and concerns, the rapid pace of technological advancement means that findings may become outdated relatively quickly. Additionally, context-specific factors, such as institutional policies and regional infrastructure disparities, may affect the transferability of these results even within Nigeria.

Lastly, although rigorous validation strategies were employed (e.g., multi-analyst coding, participant validation, and reflexivity), researcher interpretation remains inherently subjective in qualitative studies. Despite efforts to maintain neutrality, the framing of questions and interpretation of narratives may have been influenced by the researchers' own academic and cultural orientations.

Future studies may benefit from a mixed-methods approach to quantify acceptance patterns and explore correlations between demographic factors and AI perceptions. Including longitudinal data could also help assess changes in attitudes and adoption behaviours over time as exposure to and infrastructure for AI technologies evolve. Additionally, employing probability-based sampling strategies in future research would enhance the generalizability of findings to the broader population of Nigerian cardiologists.

6. Conclusion

This study explored the perspectives of Nigerian cardiologists on the integration of artificial intelligence (AI) in cardiovascular practice, offering a nuanced understanding of the factors influencing adoption in a resource-constrained context. Despite limited practical exposure, participants expressed a clear awareness of AI's potential to improve diagnostic accuracy, enhance clinical efficiency, and expand access to care, particularly in underserved areas. However, significant barriers were identified, including infrastructural deficiencies, financial constraints, regulatory gaps, and concerns about data privacy, contextual adaptation, and overreliance on technology.

The study underscores the need for a holistic approach to AI implementation that goes beyond technological solutions to include robust clinician training, investment in digital infrastructure, development of clear regulatory frameworks, and the design of contextually relevant AI systems tailored to local healthcare realities. Importantly, the openness of Nigerian cardiologists to engage with AI, if adequately supported, suggests a readiness that can be leveraged to drive innovation in cardiovascular care across similar low- and middle-income settings.

By highlighting both enthusiasm and caution, this research provides a grounded foundation for policymakers, health system planners, and technology developers to design inclusive, sustainable, and ethically sound AI integration strategies. The insights generated here have the potential to inform broader efforts aimed at leveraging AI for improved cardiovascular health outcomes across sub-Saharan Africa and other LMICs facing similar healthcare challenges.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Bowen University Teaching Hospital Research Ethics Committee (Approval No: BUTH/REC-1134). Written informed consent was obtained from all participants prior to enrolment. Participants were fully informed about the study's objectives, procedures, potential risks, and benefits, and were explicitly assured of their right to withdraw from participation at any stage without penalty.

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Declarations

None

Confidentiality and Data Protection

To ensure privacy, no personally identifiable information was collected, and unique identifier codes were assigned to participants. All data were securely stored and accessible only to the research team.

CRedit authorship contribution statement

Oluwakemi Jumoke Bello: Writing – review & editing, Writing – original draft, Methodology, Investigation. **Olawuyi Olabanke:** Writing – review & editing, Writing – original draft, Methodology, Investigation. **Wada Ojima:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation. **Aanuoluwapo Clement David-Olawade:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Oguntola Busayo:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation. **Olawade David Bamidele:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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