Review Article

Advances in Breast Cancer Diagnosis: A Comprehensive Review

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ABSTRACT

Breast cancer remains the most prevalent malignancy and a leading cause of cancer mortality among women globally, with rising incidence across sub-Saharan Africa. Early and accurate diagnosis is critical for improving outcomes, yet access to advanced diagnostic tools remains uneven. This review synthesizes recent advances in breast cancer diagnostic modalities, emphasizing innovations from 2020–2025 and their potential application in low- and middle-income settings. A comprehensive literature search was conducted using PubMed, Scopus, and Web of Science for recent studies on imaging, molecular diagnostics, biomarkers, and artificial intelligence in breast cancer detection and characterization. Emphasis was placed on comparative findings from global, regional (sub-Saharan African), and Nigerian studies. Emerging diagnostic tools such as digital mammography, contrast-enhanced MRI, elastography, and AI-assisted imaging have significantly improved sensitivity and specificity. Molecular biomarkers and liquid biopsy technologies, including circulating tumor DNA and exosomal assays, are enhancing early detection, disease monitoring, and treatment stratification. Hybrid diagnostic pathways integrating imaging and molecular data show promise for personalized, minimally invasive diagnostics. Modern advances are revolutionizing breast cancer diagnosis, but regional disparities persist. Strengthening infrastructure, capacity building, and the integration of hybrid diagnostic approaches are essential to achieve equitable breast cancer detection and management, particularly in resource-limited regions.

Keywords: Artificial Intelligence, Breast Cancer, Biomarkers, Diagnosis, Liquid Biopsy, Sub-Saharan Africa, Ultrasound.

INTRODUCTION

Breast cancer remains the most commonly diagnosed cancer in women worldwide, with approximately 2.3 million new cases in 2022 and over 666,000 deaths globally [1]. In sub-Saharan Africa (SSA), the burden is rising rapidly: in 2022, SSA accounted for about 146,130 new cases and 71,662 deaths, with incidence projected to increase by ~86% and mortality by ~89% by 2040 if current trends continue [2].

Nigeria contributes substantially to this burden. Age-standardized incidence rates (ASR) for breast cancer in Nigeria are among the highest in Western Africa, estimated at ~50–54 per 100,000 women in several registry studies [3-5]. Moreover, over 70% of cases are diagnosed at late stages, and lymph node positivity is very common, contributing to poorer outcomes [4].

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Risk factors driving rising incidence in SSA and Nigeria include changing reproductive patterns (later age at first childbirth, fewer children), increasing obesity and metabolic disorders, alcohol consumption, and higher fasting plasma glucose [6]. Genetic risk also appears relevant; recent studies in South Africa identified novel variants that contribute to risk in women of African ancestry, though polygenic risk scores derived from European populations underperform in SSA populations [7].

This review aims to synthesize recent advances (2020-2025) in breast cancer diagnostic modalities—imaging, ultrasound, molecular diagnostics, AI, and pathology—with particular attention to data from SSA/Nigeria, assess their clinical impact, and identify gaps and priorities for improving diagnostic timeliness and accuracy in both high- and low-resource settings.

Imaging Advances

Digital Breast Tomosynthesis (DBT)

Also known as three-dimensional mammography, represents a major advancement over conventional two-dimensional (2D) digital mammography. It enables the acquisition of multiple low-dose projection images at varying angles, which are reconstructed into thin slices, thereby reducing tissue overlap and improving lesion conspicuity. Multiple large-scale studies and meta-analyses have demonstrated that DBT significantly increases cancer detection rates while reducing recall rates, particularly in women with dense breast tissue [8-10]. DBT enhances the detection of invasive cancers and decreases false-positive findings, contributing to improved screening efficiency [11]. However, implementation challenges persist in low-resource settings due to higher equipment costs, limited availability, and the need for radiologist training [12].

Contrast-Enhanced Mammography (CEM)

Combines traditional digital mammography with intravenous administration of iodinated contrast to highlight areas of neovascularity, analogous to contrast-enhanced magnetic resonance imaging (MRI). Recent studies have shown that CEM provides higher sensitivity and specificity than standard mammography and offers diagnostic accuracy comparable to MRI [13-15]. It is especially useful in evaluating dense breasts and in the assessment of equivocal mammographic or sonographic findings [14]. Compared to MRI, CEM is more accessible, faster, and less expensive, making it a practical alternative for centers without MRI facilities [15,16]. Nevertheless, concerns regarding contrast reactions, radiation exposure, and the need for standardized protocols remain [16].

Breast MRI and Abbreviated MRI Protocols

Breast MRI remains the most sensitive imaging modality for detecting breast malignancies and is recommended for high-risk screening, preoperative staging, and problem-solving in indeterminate lesions [17]. The development of abbreviated MRI (AB-MRI) protocols with shortened imaging sequences that preserve diagnostic accuracy has improved the feasibility of MRI as a supplemental screening tool [18-20]. Studies have demonstrated that AB-MRI maintains sensitivity comparable to full-protocol MRI while significantly reducing acquisition time and cost [19,20]. This makes AB-MRI an emerging option for intermediate-risk patients and women with dense breasts. However, uniform protocol standardization, cost-effectiveness evaluations, and integration into national screening programs remain ongoing challenges [21].

Imaging advances have markedly improved diagnostic accuracy in breast cancer detection. DBT enhances structural visualization and reduces false positives; CEM provides functional vascular information with performance similar to MRI; and AB-MRI broadens access to high-sensitivity imaging at reduced cost. Strategic integration of these modalities guided by patient risk profiles, breast density, and local resource capacity can significantly improve early detection and diagnostic precision.

Advances in Diagnostic Techniques in Breast Cancer

The field of breast cancer diagnostics has witnessed remarkable transformation driven by technological innovations and the integration of molecular and imaging tools. Traditional diagnostic approaches, such as clinical breast examination (CBE), mammography, and histopathology, remain vital but

are increasingly complemented by precision-based and minimally invasive modalities[22-24].

Imaging Innovations

Digital Mammography has largely replaced analog systems, providing higher resolution, reduced radiation exposure, and improved cancer detection—especially in younger women and those with dense breasts[25]. Digital Breast Tomosynthesis (DBT) further enhances diagnostic accuracy by reconstructing 3D breast images, thereby reducing recall rates and improving lesion characterization [26].

Breast ultrasound, particularly automated breast ultrasound (ABUS), has proven useful in detecting small, non-calcified lesions and guiding biopsies in dense breast tissue [27]. Magnetic Resonance Imaging (MRI), with diffusion-weighted and contrast-enhanced sequences, remains indispensable for preoperative planning and assessing treatment response [28]. Contrast-enhanced mammography (CEM) has also emerged as a promising alternative to MRI in some settings [29].

Tissue and Cytological Diagnosis: Histopathological confirmation remains the diagnostic gold standard. Core needle biopsy (CNB) offers superior diagnostic accuracy and tissue preservation compared to fine needle aspiration cytology (FNAC) [30,31]. Recent innovations in vacuum-assisted biopsy (VAB) improve sampling adequacy and reduce false negatives [32]. Moreover, image-guided biopsy methods—ultrasound-, stereotactic-, or MRI-guided—enhance lesion localization and diagnostic yield [33].

Molecular and Genetic Diagnostics: Molecular profiling has revolutionized breast cancer characterization. Immunohistochemistry (IHC) for ER, PR, HER2, and Ki-67 enables precise subtyping and prognostication [34]. Furthermore, gene expression assays such as Oncotype DX, MammaPrint, and Prosigna refine recurrence risk estimation and guide adjuvant therapy decisions [35,36]. Next-generation sequencing (NGS) and liquid biopsy are emerging tools allowing real-time genomic assessment and early detection of resistance mutations [37,38].

Artificial Intelligence and Digital Pathology: Artificial intelligence (AI) and deep learning algorithms are transforming imaging and pathology. AI-assisted mammography interpretation enhances detection accuracy and reduces reading time [39]. Similarly, digital pathology combined with machine learning offers automated histologic analysis, aiding in tumor grading, receptor quantification, and predicting treatment outcomes [40,41].

Advances in Ultrasound in Breast Cancer Diagnosis

Ultrasound (US) has evolved into a pivotal imaging modality for breast cancer diagnosis, offering real-time evaluation, cost-effectiveness, and absence of ionizing radiation [42]. Traditional B-mode ultrasound provides essential information on lesion morphology and margins, aiding in differentiation between benign and malignant masses [43]. However, technological advances have significantly enhanced its diagnostic accuracy and reproducibility.

High-Resolution and 3D Ultrasound: High-frequency transducers and three-dimensional (3D) ultrasound improve spatial resolution and lesion delineation, enabling more precise volumetric assessment and better visualization of complex architectures [44]. The integration of computer-aided diagnosis (CAD) systems has also enhanced diagnostic confidence and reduced interobserver variability [45].

Ultrasound elastography, including strain and shear-wave techniques, assesses tissue stiffness—a valuable biomarker f\or malignancy [46]. Studies have demonstrated that elastography improves specificity and reduces unnecessary biopsies when combined with conventional B-mode imaging [47,48]. Quantitative shear-wave elastography, in particular, provides reproducible stiffness metrics correlated with tumor grade and aggressiveness[49].

Doppler and Contrast-Enhanced Ultrasound (CEUS): Color and power Doppler imaging are useful for assessing tumor vascularity, reflecting angiogenic activity associated with malignancy [50]. Meanwhile, contrast-enhanced ultrasound (CEUS) using microbubble agents enhances visualization of microvasculature and perfusion kinetics [51]. CEUS has shown potential in differentiating benign from malignant lesions, evaluating treatment response, and guiding biopsies [52].

Automated and AI-Enhanced Ultrasound: Automated breast ultrasound (ABUS) systems have been developed to standardize scanning and overcome operator dependency[53]. ABUS significantly increases cancer detection rates in dense breasts when used as a supplement to mammography[54]. The integration of artificial intelligence (AI) in ultrasound interpretation further streamlines workflow and improves diagnostic precision, especially in screening environments [55,56].

Role of Biomarkers and Liquid Biopsy in Breast Cancer Diagnostics

The integration of biomarkers and liquid biopsy technologies has significantly advanced the precision and personalization of breast cancer diagnosis. These tools allow for early detection, tumor characterization, therapy selection, and real-time disease monitoring, complementing traditional tissue-based histopathology [57-59].

Biomarkers in Breast Cancer Diagnosis: Biomarkers serve as measurable indicators of biological processes or disease states. In breast cancer, hormone receptors (ER, PR) and HER2 remain the cornerstone biomarkers for disease classification and treatment planning [60]. Ki-67 is widely used to assess proliferation index and stratify tumors into molecular subtypes [61]. Emerging biomarkers such as PD-L1, BRCA1/2, and PIK3CA mutations have further refined diagnostic and therapeutic decision-making [62]. For instance, BRCA1/2 germline testing identifies patients at risk for hereditary breast and ovarian cancer syndromes, guiding both surveillance and prophylactic strategies[63].

Multigene Assays and Molecular Signatures: The advent of multigene expression assays has transformed diagnostic precision. Tests such as Oncotype DX, MammaPrint, EndoPredict, and Prosigna (PAM50) provide recurrence risk stratification and therapeutic guidance for early-stage hormone receptor–positive breast cancer [64, 65]. These assays reduce overtreatment by identifying patients who may safely forgo chemotherapy[66].

Circulating Biomarkers and Liquid Biopsy: Liquid biopsy offers a non-invasive approach to detect and monitor cancer through the analysis of circulating tumor cells (CTCs), circulating tumor DNA (ctDNA), and extracellular vesicles (EVs) in blood or other body fluids [67,68]. CTCs provide insights into metastatic potential, while ctDNA reflects tumor genetic heterogeneity and can detect minimal residual disease (MRD) or early relapse [69]. Recent evidence demonstrates that ctDNA profiling can identify actionable mutations such as ESR1, PIK3CA, and HER2, guiding targeted therapy in metastatic breast cancer [70]. Moreover, methylation patterns in cfDNA and microRNA signatures have shown promise as diagnostic and prognostic biomarkers [71,72].

Clinical Utility and Future Directions: The integration of liquid biopsy with traditional imaging and tissue pathology enhances diagnostic accuracy and enables longitudinal disease tracking [73]. Ongoing trials are validating liquid biopsy for screening, treatment response assessment, and early detection of recurrence [74]. Advances in next-generation sequencing (NGS), digital PCR, and multi-omic profiling are expected to establish liquid biopsy as a cornerstone in future breast cancer diagnostics [75,76].

Advances in (MRI) in Breast Cancer Diagnosis

Magnetic Resonance Imaging (MRI) has become an indispensable modality in breast cancer diagnosis and management due to its superior soft-tissue contrast and functional imaging capabilities. Recent technological advancements including diffusion-weighted imaging (DWI), dynamic contrast-enhanced MRI (DCE-MRI), and artificial intelligence (AI)-assisted interpretation—have significantly improved diagnostic precision, lesion characterization, and treatment monitoring [77-79].

Functional MRI Techniques: Dynamic contrast-enhanced MRI (DCE-MRI) remains the most sensitive imaging tool for detecting breast malignancy, particularly in dense breast tissue or ambiguous mammographic findings [80]. It evaluates lesion vascularity and enhancement kinetics, allowing differentiation between benign and malignant patterns [81].

Diffusion-weighted imaging (DWI) and **apparent diffusion coefficient (ADC)** mapping provide non-contrast functional evaluation by measuring water molecule diffusion within tissues [82]. Lower ADC

values typically correlate with higher cellularity, a hallmark of malignancy [83]. The combination of DWI and DCE-MRI enhances both sensitivity and specificity, reducing unnecessary biopsies [84].

Magnetic resonance spectroscopy (MRS) has further expanded diagnostic potential by quantifying choline metabolites biomarkers associated with tumor proliferation and malignancy [85]. Emerging non-contrast MRI sequences, such as ultrafast and abbreviated MRI protocols, aim to shorten scan times while maintaining diagnostic accuracy[86].

Artificial Intelligence (AI) in MRI Interpretation: The integration of **AI and deep learning** algorithms into breast MRI workflows has transformed diagnostic interpretation. AI-based tools assist radiologists by automating lesion detection, segmentation, and kinetic curve analysis [87]. These systems improve efficiency, standardize reporting, and reduce interobserver variability [88].

AI models can also extract high-dimensional quantitative imaging biomarkers—termed **radiomics** which correlate imaging phenotypes with molecular subtypes and treatment response [89]. Radiogenomic studies have shown that MRI-derived features can predict tumor aggressiveness, receptor status, and even genomic risk scores [90,91].

Clinical Applications and Future Prospects: MRI is increasingly used for **screening high-risk populations**, **local staging**, **preoperative planning**, and **monitoring neoadjuvant therapy response** [92]. Integration with AI has made MRI interpretation faster and more consistent, particularly in detecting subtle multifocal or multicentric lesions [93]. Ongoing research into **AI-driven automated reporting**, **predictive modeling**, and **fusion with other modalities** (such as ultrasound and mammography) promises to further refine precision imaging [94,95].

Integration of Multimodal Imaging and Digital Pathology in Comprehensive Breast Cancer Diagnosis

Accurate breast cancer diagnosis increasingly depends on the coordinated use of multiple imaging modalities together with advanced pathology techniques. Multimodal integration leverages complementary strengths morphologic detail from mammography/DBT, functional information from CEM/MRI, real-time assessment from ultrasound/elastography, and molecular characterization from tissue and liquid biopsies to improve detection, characterization, staging, and treatment planning [96-98].

Rationale for Integration: No single modality captures all clinically relevant information. Structural imaging (mammography/DBT, ultrasound) excels at lesion localization and biopsy guidance, while functional techniques (CEM, DCE-MRI, CEUS) reveal vascular and perfusion characteristics linked to malignancy. Molecular assays and digital pathology provide receptor status, genomic alterations, and proliferation indices essential for therapy selection. Combining these data streams reduces diagnostic uncertainty, lowers false positives/negatives, and enables personalized management pathways [99-101].

Practical Workflow Models: Integrated diagnostic workflows commonly follow a tiered approach: (1) population screening (mammography/DBT ± supplemental imaging for dense breasts), (2) problem-solving and local staging (targeted ultrasound ± CEM or MRI), (3) image-guided tissue sampling (US/stereotactic/MRI-guided CNB or VAB), and (4) molecular testing and multidisciplinary review. Embedding rapid on-site evaluation (ROSE) or expedited pathology reporting shortens time to definitive diagnosis and treatment planning [102-104].

Digital Pathology and Multidisciplinary Data Fusion

Digital pathology (whole-slide imaging) facilitates remote review, standardisation of IHC scoring (ER/PR/HER2/Ki-67), and application of AI algorithms for objective quantitation and pattern recognition. When fused with imaging-derived radiomics and clinical data (radiogenomics), these integrated datasets can predict tumor subtype, nodal status, and likelihood of response to neoadjuvant therapy informing biopsy strategy and surgical planning without additional invasive procedures [105-107].

AI-Driven Integration and Decision Support: Artificial intelligence platforms are being developed

to synthesize imaging, histopathology, and molecular results into actionable reports and risk scores. Decision-support tools can flag discordant findings (e.g., imaging suspicious for malignancy with benign biopsy) for immediate multidisciplinary review, suggest additional sampling or advanced imaging, and prioritize cases for rapid intervention. Successful deployment requires rigorous validation, interpretability, and integration into clinical workflows to avoid alert fatigue and unintended biases [108-110].

Implementation Challenges and Equity Considerations: Barriers to integrated diagnostics include interoperability of imaging and pathology systems, variable data standards, costs, and workforce training. In low-resource settings, staged or simplified integration (e.g., CEM plus focused ultrasound with telepathology support) may offer pragmatic improvements. Ensuring equitable access and building capacity for multidisciplinary tumor boards are critical to translate technological gains into population-level outcome improvements [111-113].

Future Directions: Priority areas include prospective trials of radiogenomic algorithms for treatment selection, standardized pipelines for imaging-pathology data fusion, expansion of telepathology and AI-assisted triage in resource-limited settings, and clear regulatory frameworks for integrated decision-support systems. These advances aim to compress diagnostic timelines while improving accuracy and personalization of care [114-116].

Combined and Hybrid Diagnostic Pathways

The integration of multiple diagnostic modalities imaging, molecular assays, and histopathology has led to a paradigm shift toward hybrid diagnostic pathways in breast cancer care [117]. These pathways combine anatomical, functional, and molecular insights, enabling more precise detection, risk stratification, and treatment planning [118].

Imaging–Pathology Correlation

Combining digital breast tomosynthesis (DBT) with ultrasound-guided core biopsy significantly enhances lesion characterisation and reduces false-negative rates [119]. The imaging–pathology concordance model, now standard in major centers, allows real-time correlation between radiologic findings and histopathologic results, improving diagnostic confidence [120]. Advanced MRI techniques fused with ultrasound (so-called fusion imaging) have also shown superior lesion localisation and biopsy guidance, particularly for non-palpable and multifocal lesions [121].

PET/MRI and PET/CT Hybrids

Hybrid molecular imaging especially PET/MRI provides simultaneous metabolic and morphological data [122]. Studies demonstrate that PET/MRI surpasses PET/CT in soft-tissue contrast and functional assessment of breast tumours, while also reducing radiation exposure [123]. In patients with locally advanced or recurrent disease, hybrid modalities have shown improved staging accuracy and earlier detection of distant metastases [124].

Genomic–Imaging Integration

Artificial intelligence and radiogenomic platforms now link imaging phenotypes with underlying genomic signatures [125]. For example, machine-learning algorithms trained on MRI features can predict receptor status (ER, PR, HER2) and molecular subtype with over 85% accuracy, streamlining personalised treatment pathways [126]. Radiogenomics is especially promising in settings with limited immunohistochemistry (IHC) access, allowing non-invasive molecular inference [127].

Multi-Omic Diagnostic Pipelines

Modern diagnostic frameworks increasingly employ multi-omic integration combining genomic, proteomic, and metabolomic data with imaging and pathology [128]. Such approaches identify distinct tumour signatures, guide targeted therapy selection, and predict therapeutic response [129]. Liquid biopsy complements this paradigm by providing real-time genomic monitoring, bridging diagnostic and therapeutic precision [130].

Implications for Low- and Middle-Income Countries (LMICs)

In resource-limited settings like sub-Saharan Africa, selective adoption of hybrid pathways such as ultrasound-guided core needle biopsy combined with limited IHC panels offers cost-effective diagnostic improvement [131]. Telepathology, AI-

driven image analysis, and portable ultrasound systems are increasingly used to create "digital hybrid" workflows that extend diagnostic reach [132]. Collectively, these hybrid diagnostic strategies represent a shift from sequential testing to integrated, multidimensional assessment, improving diagnostic speed, accuracy, and patient outcomes while aligning with precision oncology principles [133].

Challenges, Limitations, and Future Directions

Persistent Diagnostic Gaps: Despite major advancements in imaging, molecular biology, and computational diagnostics, disparities persist in global breast cancer diagnosis [134]. In high-income countries (HICs), early-stage detection exceeds 80%, whereas in sub-Saharan Africa (SSA) and other low- and middle-income countries (LMICs), up to 70% of patients present at advanced stages (Stage III–IV) [135]. This late presentation stems from multifactorial causes, including limited screening infrastructure, high diagnostic costs, sociocultural barriers, and workforce shortages [136].

Technological and Infrastructure Constraints: The implementation of advanced imaging modalities such as MRI, tomosynthesis, and PET/MRI remains restricted by cost and infrastructure deficits [137]. Additionally, the scarcity of functional immunohistochemistry (IHC) and molecular diagnostic laboratories limits biomarker testing and personalized care [138]. Pathology services in many African nations operate with fewer than one pathologist per 500,000 people, contributing to long turnaround times and diagnostic delays [139].

Data and Algorithmic Bias in AI Diagnostics: Artificial intelligence (AI) and machine learning tools depend heavily on large, annotated datasets predominantly derived from Western populations [140]. Consequently, algorithms may underperform when applied to African histopathologic or imaging data, resulting in diagnostic inequities [141]. The lack of representative genomic databases for African populations also hampers accurate risk stratification and precision diagnostics [142]. Efforts such as the H3Africa Initiative and African Genome Variation Project aim to bridge this gap through local biobanking and data sharing [143].

Regulatory and Ethical Barriers: Ethical concerns regarding data privacy, informed consent, and algorithmic transparency remain unresolved [144]. Regulatory frameworks for digital pathology, AI-assisted diagnostics, and genomic testing are underdeveloped across many LMICs, leading to fragmented policy environments [145]. Establishing governance structures that safeguard patient data while promoting innovation is essential for sustainable integration [146]

Human Capacity and Training Deficits: Workforce limitations—particularly among radiologists, pathologists, and molecular scientists impede the optimal use of diagnostic innovations [184]. Integrating e-learning, digital mentorship, and telepathology can partially alleviate these gaps [147]. Regional collaborations such as the African Cancer Diagnostics Consortium are already strengthening local expertise through shared training resources and joint research [148].

Future Directions: The future of breast cancer diagnosis lies in precision-integrated, equitable, and sustainable diagnostic ecosystems [149]. Multimodal hybrid workflows combining AI-enhanced imaging, molecular profiling, and liquid biopsy are expected to redefine diagnostic pathways [150]. Expansion of portable imaging technologies and low-cost point-of-care molecular tools will enhance accessibility in remote settings [151].

Strategic investment in capacity building, regional biorepositories, and harmonized regulatory policies will be pivotal to ensuring that diagnostic advances benefit populations equitably [152]. The convergence of digital innovation, molecular science, and public health policy offers a unique opportunity to close diagnostic gaps and move toward universal early detection and personalized breast cancer care [153].

CONCLUSION

Advances in breast cancer diagnostics have evolved from isolated imaging and histopathologic evaluation to fully integrated, multi-modal systems that combine digital imaging, molecular profiling, and artificial intelligence. These innovations have greatly improved early detection, diagnostic accuracy, and personalized treatment planning. Emerging hybrid diagnostic models linking radiology, genomics, and pathology reflect a shift

toward precision oncology, offering faster, less invasive, and more reliable results. However, equitable access remains a major challenge, particularly in low- and middle-income countries. Strengthening diagnostic infrastructure, capacity building, and ethical AI deployment are essential to ensure that the benefits of these technologies are globally inclusive and clinically impactful.

Recommendations

The study recommends a multifaceted approach to improving breast cancer detection, diagnosis, and management. Key strategies include enhancing access to high-resolution imaging modalities such as digital mammography and ultrasound, integrating artificial intelligence for improved diagnostic accuracy, and strengthening pathology infrastructure for timely and precise histopathological reporting. Routine immunohistochemical profiling should be encouraged to guide targeted therapy, while molecular testing and liquid biopsy should be incorporated to complement tissue diagnosis and monitor treatment response. Expanding public health education on breast cancer awareness, screening, and early presentation is vital, alongside training programs for healthcare professionals in image-guided biopsy techniques and multidisciplinary case management. Additionally, strengthening national cancer registries and establishing collaborative research networks across Sub-Saharan Africa would improve data quality, facilitate region-specific insights, and support evidence-based policy formulation aimed at reducing breast cancer morbidity and mortality.

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