AMERICAN JOURNAL OF DIAGNOSTIC IMAGING
2026; 12(2): 37-48
10.5455/ajdi.20260119010543

ORIGINAL ARTICLE

Open Access

Diagnostic accuracy of mammography in detection of breast cancer at Kilimanjaro Christian Medical Centre

Mario Angelo Mbinda[1], Clement Frank Kalambo[1], Sixbert Isoory Mkumbaye[2], Stephen Gondwe[1], Adnan Sadiq[1]

[1]Department of Radiology, KCMC University <AQ1>

[2]Department of Molecular Biology and Immunology, KCMC University

ABSTRACT

Background: Breast cancer is the leading cause of cancer-related mortality among women worldwide. In Tanzania, most patients present at advanced stages due to limited screening programs.

Objectives: To evaluate the diagnostic accuracy of mammography and assess the correlation between mammographic features, BI-RADS categories, and histopathological findings among women suspected of breast cancer at Kilimanjaro Christian Medical Centre (KCMC), Moshi, Tanzania.

Methods: A retrospective analytical study was conducted between January 2019 and December 2024. All mammograms were independently interpreted by two consultant radiologists, with consensus reading applied to resolve discrepancies. BI-RADS 5th edition was used without prior knowledge of biopsy results. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Associations between mammographic features and histopathology were analyzed using logistic regression.

Results: A total of 255 patients were included. Of these, 138 were confirmed malignant on histopathology. Mammography achieved an overall accuracy of 80.3%, with a sensitivity of 83.2%, specificity of 77.8%, PPV of 81.4%, and NPV of 79.8%. BI-RADS 5 lesions were associated with 100% malignancy. Spiculated margins, architectural distortion, and skin thickening were strongly predictive of malignancy, while clinical symptoms such as breast pain and nipple discharge showed limited diagnostic relevance.

Conclusion: Mammography at KCMC demonstrated good diagnostic accuracy and reliable risk stratification using BI-RADS. Spiculated margins, irregular shapes, and architectural distortion were strongly linked to malignancy. These findings support mammography as a cornerstone of early breast cancer detection in Tanzania and underscore the need to expand screening programs.

ARTICLE HISTORY

Received 19 January 2026
Revised 13 April 2026
Accepted 18 April 2026
Published 16 May 2026

KEYWORDS

Mammography; breast cancer; BI-RADS; diagnostic accuracy, Tanzania

Introduction

Breast cancer is the most diagnosed malignancy among women worldwide, accounting for more than 2.3 million new cases annually and representing 11.7% of all cancers. In 2022, it was responsible for over 670,000 deaths, surpassing lung cancer as the leading cause of cancer-related mortality in women. Although predominantly a disease of women, approximately 0.5%–1% of cases occur in men [1].

In Tanzania, breast cancer is the second most common cancer among women, representing 14.4% of new cancers and the second leading cause of cancer-related mortality. Projections indicate an 82% increase in incidence and an 80% increase in mortality by 2030 [2]. Alarmingly, nearly 80% of Tanzanian women present with advanced-stage disease (stage III or IV), largely due to limited screening programs, late presentation, and restricted access to treatment. These factors contribute to poor prognosis and high mortality [3].

Contact Mario Angelo Mbinda ✉ mbindamario@gmail.com Department of Radiology, KCMC University.

© The Author(s) 2025. Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY). http://creativecommons.org/licenses/by/4.0/.

Unlike high-income countries, Tanzania lacks a national population-based breast screening program with defined age intervals. Mammography services are concentrated in a few tertiary and private hospitals. KCMC operates one of the earliest mammography units in northern Tanzania, historically using analog film-screen systems. In Dar es Salaam, Muhimbili National Hospital hosts a dedicated breast unit with digital mammography and multidisciplinary oncology care. Other centers, such as Ocean Road Cancer Institute, Aga Khan Hospital, and Besta Hospital provide diagnostic imaging, though access remains uneven, and mobile screening units are rare [4].

Civil society organizations complement hospital-based efforts. The Tanzania Breast Cancer Foundation provides patient support and advocacy, while the Tanzania Oncology Society and Foundation for Cancer Care in Tanzania promote awareness, training, and service expansion.

Mammography remains the most widely accepted imaging modality for early detection of breast cancer. It has demonstrated population-level sensitivity of 75%–80% and has been shown to reduce mortality by up to 40% in women aged 40–84 years [5]. However, diagnostic accuracy varies with breast density, patient age, and technical quality. The Breast Imaging Reporting and Data System (BI-RADS), developed by the American College of Radiology, provides a standardized framework for mammographic interpretation and risk stratification, with categories ranging from 0 (incomplete) to 6 (biopsy-proven malignancy) [6,7].

Despite global evidence supporting mammography, its adoption in Sub-Saharan Africa remains limited. Preliminary studies in Tanzania suggest promising diagnostic accuracy when BI-RADS guidelines are applied, but comprehensive local data are scarce [8]. Evaluating mammographic performance in Tanzanian clinical settings is essential to guide early detection strategies and improve outcomes.

This study aimed to determine the diagnostic accuracy of mammography in detecting breast cancer at Kilimanjaro Christian Medical Centre (KCMC) and to assess the association between mammographic features, BI-RADS categories, and histopathological findings.

Materials and Methods

Study design and setting

This was a retrospective, record-based analytical study conducted at the Radiology and Pathology Departments of Kilimanjaro Christian Medical Centre (KCMC), Moshi, Tanzania. The study period covered January 2019 to December 2024.

Study population

Patients ≥ 30 years undergoing mammography and biopsy at KCMC; one male patient with a suspicious lesion was included. While BI-RADS 2–3 lesions are usually managed conservatively in screening populations, in our hospital-based cohort, biopsies were performed when patients presented with clinical symptoms (e.g., palpable lump, skin changes), when physician judgment indicated higher risk, or when ultrasound findings raised suspicion. This reflects real-world practice in Tanzania, where limited follow-up capacity encourages histological confirmation even for low-suspicion lesions." Exclusions: incomplete records, prior breast surgery, and known malignancy.

Sample size and sampling technique

A total of 255 patients met the eligibility criteria and were included consecutively.

Imaging protocol, radiation safety and quality assurance

All mammograms were performed using the LORAD MIV analog film-screen system (Hologic Inc., USA, 1999). Technical parameters and quality assurance measures are summarized in Table 1.

Observed exposures were within IAEA and ICRP recommended limits. Personal dosimeter readings and area dosimeter values confirmed compliance with international safety thresholds. References for breast dose estimation include Dance et al. [9,10].

Regarding quality assurance, weekly ACR phantom imaging, daily sensitometry, quarterly maintenance, annual calibration, and radiation safety checks with dosimeters and test software.

Patients' radiological parameters, such as compression thickness, glandularity (%), mean absorbed dose, and menopausal status, were kept into consideration.

Technicians' effective doses via personal dosimeters, protection with lead aprons, Polymethyl

Table 1. Technical characteristics of the LORAD MIV mammography unit.

Parameter	Specification
Mammography unit	LORAD MIV analog film-screen system (Hologic Inc., USA, 1999)
Anode–filter combination	Mo/Mo
Tube voltage (kVp)	25–32
Tube current–time (mAs)	100–200
Focus–image distance	65 cm
Exposure control	Automated Exposure Control (AEC)
Entrance Surface Air Kerma	4–8 mGy

Methacrylate (PMMA) panels, and area dosimeters were all monitored. Observed exposures were within international limits.

Histopathological examination

All patients underwent biopsy (core needle or excisional) following mammographic suspicion. Histological grading was performed by pathologists at KCMC according to standard protocols.

Study variables

Dependent variable in this study is Histopathological diagnosis (benign vs malignant), while independent variables include BI-RADS category, mammographic features (mass shape, margins, calcifications, architectural distortion, skin changes), and clinical features.

Statistical analysis

All analyses were performed using SPSS version 26. Diagnostic accuracy was assessed using histopathology as the reference standard. A positive mammography result was defined as BI-RADS ≥ 4 (categories 4A, 4B, 4C, and 5). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated with corresponding 95% confidence intervals (CIs). The ROC curve was generated using BI-RADS categories as the test variable (positive defined as BI-RADS ≥ 4) and histopathology as the reference standard. For ROC analysis, BI-RADS categories were dichotomized (≤3 vs. ≥4) to reflect the clinical threshold for biopsy recommendation. Sensitivity and specificity were calculated across BI-RADS thresholds, and the AUC was estimated with 95% confidence intervals. This approach follows established diagnostic accuracy methodology[11].

Associations between BI-RADS categories and histopathological outcomes were initially assessed using Chi-square tests. To further quantify the strength of association, ordinal logistic regression was employed, treating BI-RADS categories as ordinal predictor variables and histopathology (benign vs. malignant) as the outcome. This approach allowed estimation of the predictive value of BI-RADS scoring in breast cancer diagnosis. Breast density was qualitatively assessed according to BI-RADS descriptors (fatty, scattered fibroglandular, heterogeneously dense, and extremely dense). Density was included in regression models as a potential confounder.

Finally, associations between mammographic features and malignancy were analyzed using binary logistic regression. Variables with $P < 0.20$ in univariable analysis were entered into the multivariable model. Multicollinearity was assessed using variance inflation factors (VIF < 2). Model fit was evaluated using Hosmer–Lemeshow goodness of fit tests. Adjusted odds ratios (aORs) with 95% CIs were reported. P-value < 0.05 was considered statistically significant.

All mammograms were independently interpreted by two consultant radiologists, with consensus reading applied to resolve discrepancies. Interobserver agreement between the two radiologists was assessed using Cohen's kappa, yielding a value of 0.82, indicating strong concordance. BI-RADS 5th edition was used without prior knowledge of biopsy results at the time of interpretation to minimize bias.

Ethical considerations

Ethical clearance was obtained from the KCMC Institutional Review Board. Patient confidentiality was maintained by anonymizing records.

Results

Sociodemographic characteristics and clinical features

A total of 255 patients with confirmed histopathological diagnoses were included. The majority of these patients were female (99.6%) and only one male patient (0.4%).

The mean age of participants was 52.4 ± 11.6 years (range: 30–78 years). Malignancy was most frequent among women aged ≥60 years (39.9% of malignant cases), while benign lesions predominated in the 40–49 years group (34.2%).

Clinically, a palpable lump was the most common presentation, reported in 95.7% of malignant and 81.2% of benign cases. Skin changes were observed in 38.4% of malignant versus 6.0% of benign cases.

Figure 1 illustrates the STARD flow diagram of patient inclusion and diagnostic pathway. Of 605 patients who underwent mammographic examination during the study period, 350 were excluded due to incomplete records, prior breast surgery, or known malignancy, leaving 255 cases for final analysis". Table 2 summarizes sociodemographic and clinical characteristics of the study population.

Diagnostic accuracy of mammography

Using BI-RADS ≥ 4 as the threshold for test positivity, mammography demonstrated good diagnostic performance compared with histopathology as the gold standard. Mammography demonstrated a diagnostic accuracy of 80.3% in detecting breast cancer when compared with histopathological results as a gold standard for referencing. The tool showed a sensitivity of 83.2% and a specificity of 77.8%,

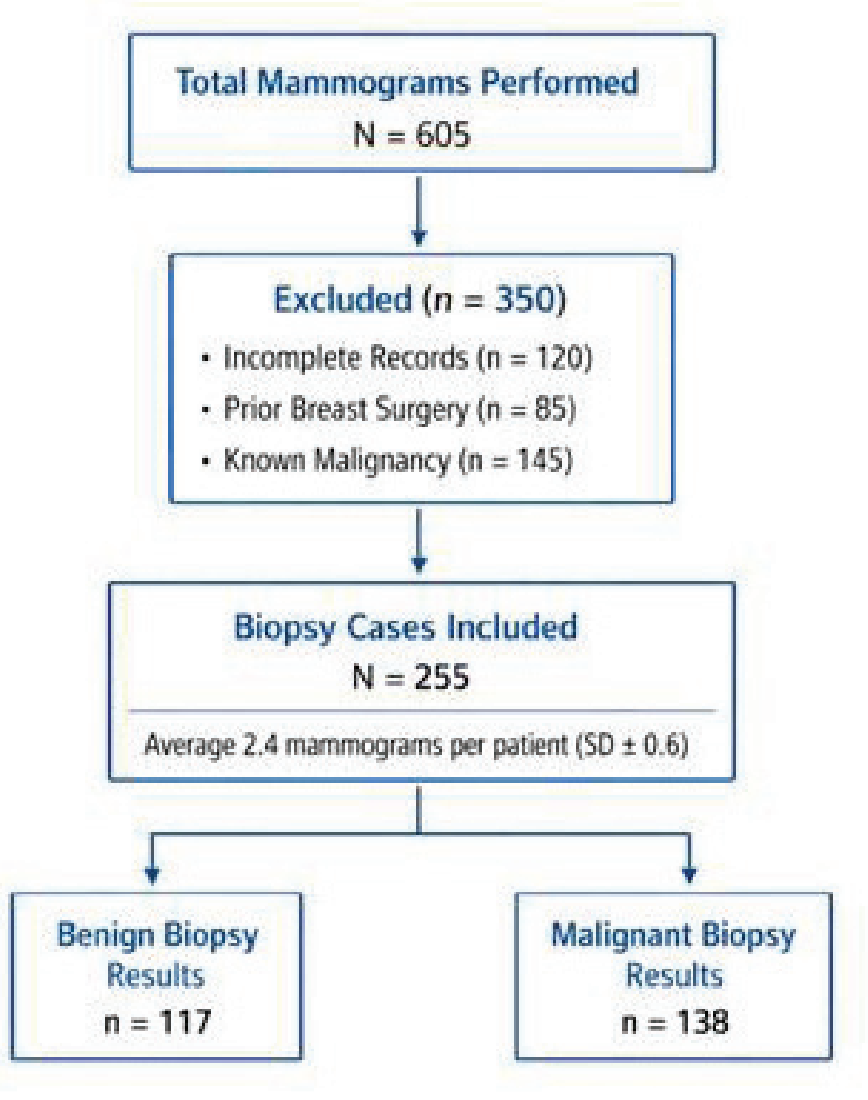


Figure 1. STARD flow diagram of patient inclusion and diagnostic pathway.

Table 2. Sociodemographic and clinical characteristics of participants (*N* = 255).

Characteristic	Total *n* (%)	Benign *n* (%)	Malignant *n* (%)
Age group			
30–39	25 (9.8)	14 (12.0)	11 (8.0)
40–49	71 (27.8)	40 (34.2)	31 (23.0)
50–59	66 (25.9)	25 (21.4)	41 (30.0)
≥60	93 (36.5)	38 (32.5)	55 (40.0)
Sex			
Female	254 (99.6)	116 (99.2)	138 (100)
Male	1 (0.4)	1 (0.9)	0
Clinical presentation			
Lump	227 (89.2)	95 (81.2)	132 (95.7)
Pain	103 (40.4)	46 (39.2)	57 (41.3)
Discharge	44 (17.3)	21 (17.9)	23 (16.7)
Skin changes	60 (23.5)	7 (6.0)	53 (38.4)
Ulceration	10 (3.9)	3 (2.6)	7 (5.1)

Table 3. Diagnostic accuracy of mammography at KCMC using BI-RADS ≥ 4 threshold, with 95% CIs.

Measure	Value	95% CI
Sensitivity	83.2%	76.1–89.0
Specificity	77.8%	69.2–84.7
Positive Predictive Value (PPV)	81.4%	74.0–87.3
Negative Predictive Value (NPV)	79.8%	71.1–86.5
Overall Accuracy	80.3%	74.6–85.1

indicating its reliability in correctly identifying both malignant and benign lesions. The positive predictive value was 81.4%, and the negative predictive value was 79.8%, supporting its clinical utility in breast cancer evaluation and decision-making. Table 3 details diagnostic accuracy metrics.

Furthermore, Receiver Operating Characteristic (ROC) curve analysis yielded an AUC of 0.80 (95% CI: 0.74–0.86, $p < 0.001$), confirming good discriminatory performance in differentiating malignant from benign lesions (Fig. 2 shows the ROC curve of mammography compared with histopathology).

The contingency table (Table 4) compares mammography findings using BI-RADS ≥ 4 as the threshold for test positivity against histopathology results as the gold standard. Of the 138 histologically confirmed malignant cases, 115 were correctly identified as positive on mammography (true positives), while 23 were missed (false negatives). Among the 117 benign cases, 91 were correctly classified as negative (true negatives), whereas 26 were incorrectly categorized as suspicious (false positives).

BI-RADS assessment categories

The likelihood of malignancy increased progressively with higher BI-RADS categories. BI-RADS 2 was predominantly benign (95.6%), while BI-RADS 3 carried a malignancy rate of 30.4%. Subcategories of BI-RADS 4 showed escalating malignancy rates: 66.0% in 4A, 88.0% in 4B, and 88.1% in 4C. BI-RADS 5 was uniformly malignant (100%), underscoring its high predictive value. Figure 3 depicts a representative BI-RADS 4C case, showing an irregular, spiculated mass highly suspicious for malignancy, while Table 5 summarizes BI-RADS categories and biopsy results.

Association between mammographic features and malignancy

Logistic regression analysis identified several mammographic features significantly associated with malignancy. Odds ratios (OR) represent the crude association between a feature and malignancy, while adjusted odds ratios (aOR) account for potential confounders such as age, menopausal status, and breast density. Skin changes remained

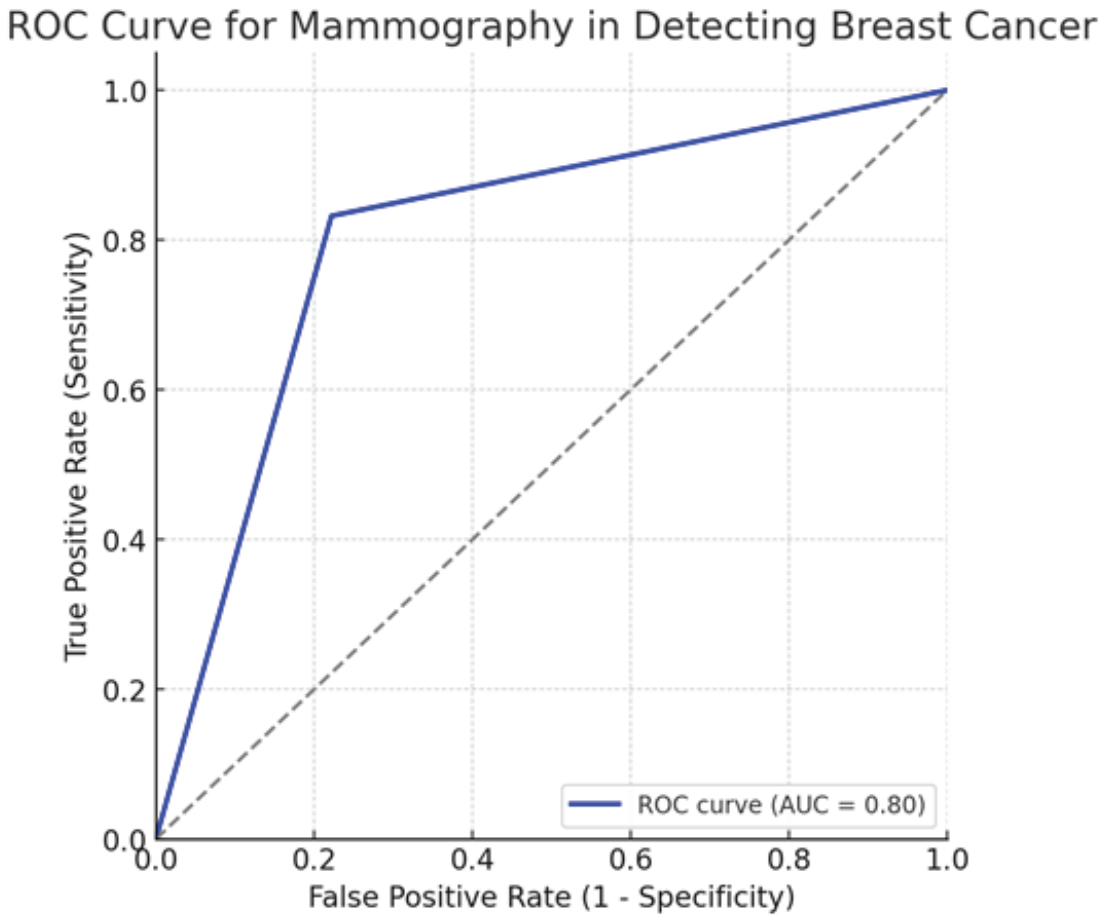


Figure 2. The receiver operator characteristic (ROC) curve of mammography as compared to histopathology. The area under the curve (AUC) was 0.80 (95% CI: 0.74–0.86) with a significance level of $p < 0.001$ at 95% CI. This demonstrates the good diagnostic performance of mammography in differentiating malignant from benign breast lesions when compared to histopathology as the gold standard ($N = 255$).

Table 4. Contingency table showing mammography test positivity (BI-RADS ≥ 4) versus histopathology findings.

	Malignant ($n = 138$)	Benign ($n = 117$)	Total
Positive (BI-RADS ≥ 4)	115 (true positive)	26 (false positive)	141
Negative (BI-RADS ≤ 3)	23 (false negative)	91 (true negative)	114
Total	138	117	255

a strong independent predictor (aOR = 4.51, 95% CI: 1.99–21.28). Mass margins: spiculated (aOR = 2.05) and micro-lobulated (aOR = 3.76) margins were significantly associated, while indistinct and masked margins lost significance after adjustment. Mass shape: irregular (aOR = 2.41) and round (aOR = 2.16) shapes were predictive compared to oval. Other features: skin thickening (aOR = 2.79), architectural distortion (aOR = 2.07), and intramammary lymph nodes (aOR = 2.64) were independently associated with malignancy. Microcalcifications showed a crude association (OR = 1.85) but were not significant after adjustment (aOR = 0.46). Table 6 presents logistic regression results for mammographic features.

Association between mammographic features and malignancy across BI-RADS categories

Chi-square analysis demonstrated strong associations between specific mammographic descriptors and malignancy. Mass margins: spiculated margins had the highest predictive value (PPV = 89.5%, $p < 0.001$), while circumscribed margins were least predictive (PPV = 23.8%). Mass shape: irregular masses showed a PPV of 74.8% ($p = 0.004$), compared to oval (10.6%, $p = 0.013$) and round (32.7%,

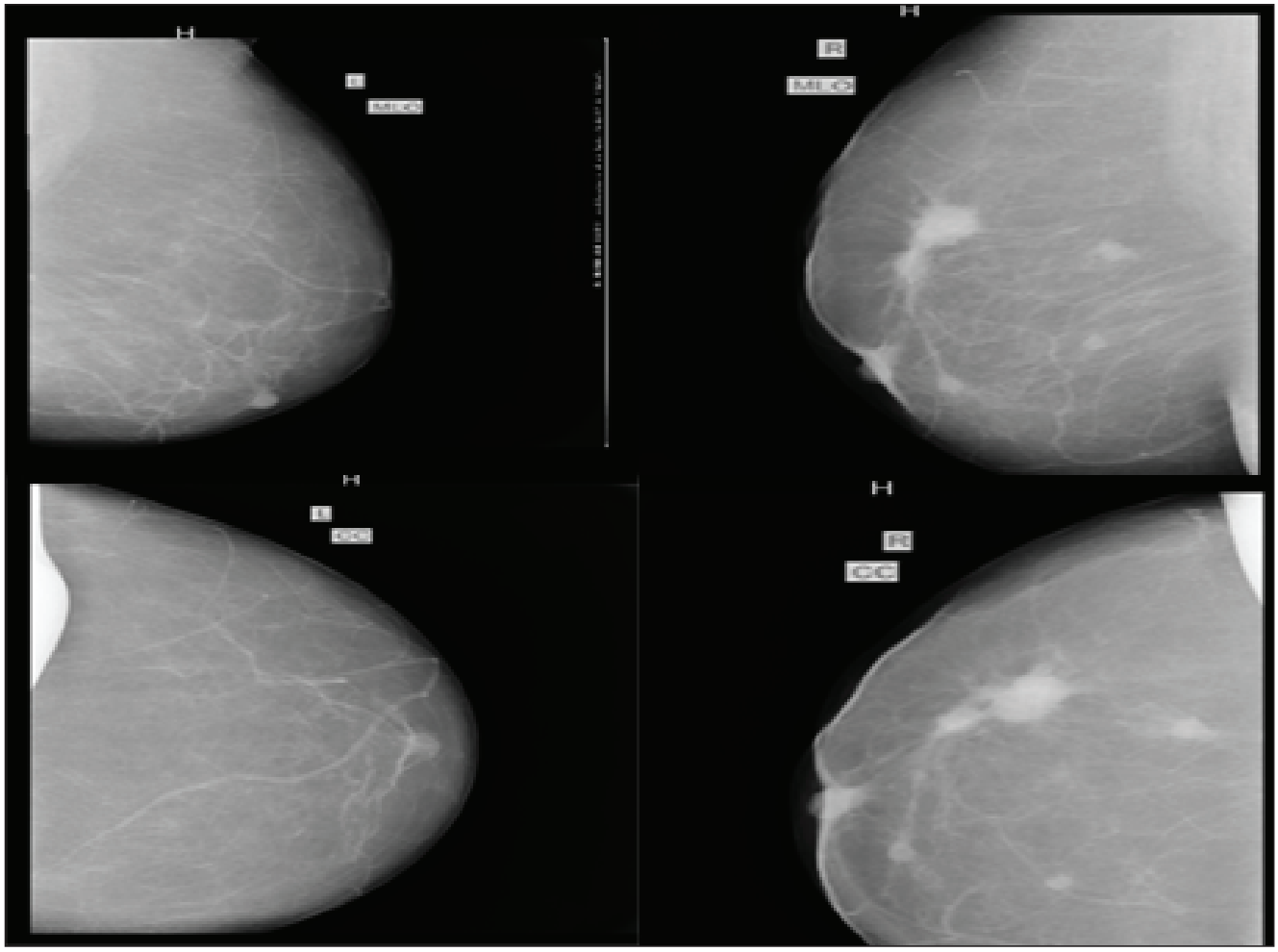


Figure 3. Representative BI-RADS 4C mammographic case (MLO and CC views). The image demonstrates an irregular, spiculated mass in the upper outer quadrant of the left breast in a 62-year-old female patient. These features are highly suspicious for malignancy, warranting histopathological confirmation through biopsy.

Table 5. BI-RADS assessment categories and biopsy results (N = 255).

BI-RADS Category	Total *n* (%)	Malignant *n* (%)	Benign *n* (%)
2	45 (17.7)	2 (4.4)	43 (95.6)
3	69 (27.2)	21 (30.4)	48 (69.6)
4A	53 (20.9)	35 (66.0)	18 (34.0)
4B	25 (9.8)	22 (88.0)	3 (12.0)
4C	42 (16.5)	37 (88.1)	5 (11.9)
5	20 (7.9)	20 (100)	0

**Percentages calculated using total cases in each BI-RADS subgroup as denominators.*

p = 0.001). Associated findings: architectural distortion (PPV = 92.7%, $p < 0.001$), skin thickening (PPV = 68.8%, $p < 0.001$), and intramammary lymph nodes (PPV = 77.6%, $p < 0.001$) were strongly predictive. Microcalcifications had a moderate PPV (67.3%) but did not reach statistical significance (p = 0.06). Table 7 summarizes associations of mammographic descriptors with malignancy across BI-RADS categories.

In summary, the study population was predominantly female, with malignancy more common in older age groups. Mammography demonstrated good diagnostic performance with an AUC of 0.80. BI-RADS categories showed a strong correlation with histopathological outcomes, with malignancy

Table 6. Association between mammographic features and malignancy among women suspected of breast cancer at KCMC.

Characteristics	OR with 95% CI	*p* value	aOR with 95% CI	*p* value
Lump				
No	1.0		1.0	
Yes	5.09 (1.98-13.05)	0.001	3.09 (0.91-10.54)	0.072
Skin changes				
No	1.0		1.0	
Yes	6.79 (2.24-42.64)	<0.001	4.51 (1.99-21.28)	0.002
Mass margin				
Circumscribed	1.0		1.0	
Spiculated	5.15 (2.27-31.71)	<0.001	2.05 (1.38-10.97)	0.007
Micro lobulated	4.98 (1.87-13.22)	0.001	3.76 (1.34-10.53)	0.0012
Masked	2.96 (1.16-7.50)	0.023	2.54 (0.92-6.97)	0.071
Indistinct	2.29 (0.99-5.24)	0.051	1.29 (0.48-3.48)	0.605
Mass shape				
Oval	1.0		1.0	
Irregular	4.36 (1.90-25.85)	<0.001	2.41 (1.26-17.37)	0.004
Round	4.08 (1.37-12.18)	0.012	2.16 (1.03-9.28)	0.017
Microcalcifications				
Absent	1.0		1.0	
Present	1.85 (0.97-3.53)	0.062	0.46 (0.15-1.39)	0.168
Skin thickening				
Absent	1.0		1.0	
Present	6.83 (3.36-17.88)	<0.001	2.79 (1.93-11.95)	0.048
Architectural distortion				
Absent	1.0		1.0	
Present	3.39 (1.96-24.09)	<0.001	2.07 (1.03-13.27)	0.026
Intramammary lymph nodes				
Absent	1.0		1.0	
Present	4.39 (2.37-8.13)	<0.001	2.64 (1.41-5.22)	0.047

rates increasing across higher categories. Several mammographic features including spiculated margins, irregular shape, skin thickening, and architectural distortion were significantly associated with malignancy, reinforcing their diagnostic value in breast cancer evaluation. Cohen's kappa for independent radiologist readings was 0.82, indicating strong agreement. Breast density did not significantly affect diagnostic accuracy in multivariable models ($p > 0.05$).

Discussion

Our findings highlight the diagnostic accuracy achieved by radiologists at KCMC and the strong association of specific mammographic features with malignancy, underscoring the importance of radiologist expertise in resource-limited settings. This study demonstrated that mammography at KCMC achieved an overall diagnostic accuracy of 80.3%, with sensitivity of 83.2% and specificity of 77.8%. These values are consistent with international reports, where sensitivity typically ranges from 75%–87% and specificity from 77%–88% [5]. The findings confirm mammography's utility as a reliable diagnostic tool in Sub-Saharan Africa, even in resource-limited settings.

The BI-RADS system proved effective in stratifying malignancy risk. BI-RADS 5 lesions were associated with 100% malignancy, aligning with studies from the United States and Nigeria that reported malignancy rates exceeding 90% for BI-RADS 5 [12,13]. BI-RADS 4 lesions showed intermediate

Table 7. Association of mammographic descriptors with malignancy across BI-RADS categories (Chi-square test).

Features	BI-RADS2 (*n* = 45)	BI-RADS3 (*n* = 69)	BI-RADS4a (*n* = 53)	BI-RADS4b (*n* = 25)	BI-RADS4c (*n* = 42)	BI-RADS5 (*n* = 20)	Malignant/ total (PPV)	*p*-value
Mass margin Circumscribed	38 (45.2)	35 (41.7)	8 (9.5)	1 (1.2)	2 (2.4)		20/84 (23.8)	<0.001
Spiculated		2 (2.3)	21 (24.4)	18 (20.9)	32 (37.2)	13 (15.1)	77/86 (89.5)	<0.001
Micro lobulated	1 (4.4)	6 (26.1)	7 (30.4)	4 (17.4)	5 (21.7)		14/23 (60.9)	0.496
Masked	4 (16.0)	9 (36.0)	11(44.0)		1 (4.0)		12/25 (48.0)	0.518
Indistinct	2 (5.6)	17 (47.2)	6 (16.7)	2 (5.6)	2 (5.6)	7 (18.4)	36/36 (100)	0.106
Mass shape								
Irregular	3 (1.9)	28 (18.1)	42 (27.1)	24 (15.5)	38 (24.5)	20 (12.9)	116/155(75)	0.004
Oval	21 (44.7)	21 (44.7)	3 (6.4)	1 (2.1)	1 (2.2)		5/47 (10.6)	0.013
Round	21 (40.4)	20 (38.5)	8 (15.4)		3 (5.8)		17/52 (32.7)	0.001
Microcalcification	4 (8.2)	9 (18.4)	12 (24.5)	7 (14.3)	7 (14.3)	10 (20.4)	33/49 (67.3)	0.06
Skin thickening	2 (2.6)	7 (9.1)	12 (15.6)	12 (15.6)	31 (40.3)	13 (16.9)	53/77 (68.8)	<0.001
Architectural distortion	0	5 (4.6)	30 (27.3)	19 (17.3)	37 (33.6)	19 (17.3)	102/110 (93.0)	<0.001
Intramammary lymph node	5 (6.6)	10 (13.2)	10 (13.2)	16 (21.1)	25 (32.9)	10 (13.2)	59/76 (77.6)	<0.001

risk, underscoring the importance of biopsy confirmation. These results validate the application of BI-RADS in Tanzanian practice, supporting its role in guiding clinical decision-making.

The inclusion of BI-RADS 2–3 cases in the biopsy cohort may introduce verification bias, since these categories are usually managed conservatively in other settings. However, this approach reflects real-world practice in Tanzania, where limited screening programs, restricted follow-up capacity, and high rates of advanced disease presentation encourage clinicians to obtain histological confirmation even for lesions with low radiological suspicion. While this strategy increases diagnostic certainty, it may also inflate sensitivity and specificity estimates compared to populations where BI-RADS 2–3 lesions are not routinely biopsied. Future prospective studies with standardized biopsy criteria are needed to minimize this bias and better align with international protocols.

In our cohort, malignancy rates for BI-RADS 4A (66%), 4B (88%), and 4C (88.1%) were substantially higher than standard BI-RADS guideline estimates. This discrepancy likely reflects the symptomatic nature of our hospital-based population, where patients are referred with clinically suspicious features and biopsy is routinely performed for BI-RADS 4 lesions. Such selection bias enriches the sample with higher-risk cases. Similar trends have been reported in symptomatic cohorts from South Africa and India. Alexander et al. in a South African referral unit found elevated predictive values for BI-RADS 4 lesions due to referral bias and clinical suspicion [14].

Likewise, Vardhan et al. [15] in a tertiary cancer center in India reported malignancy rates in BI-RADS 4 subcategories are higher than ACR-recommended ranges but consistent with other Indian studies. These findings support our interpretation and underscore the importance of contextualizing BI-RADS performance within symptomatic, hospital-based populations rather than general screening settings.

Spiculated margins, architectural distortion, and skin thickening were strongly predictive of malignancy, consistent with findings from South Africa and Europe [16,17]. Conversely, benign-appearing features such as round or oval masses with well-defined margins were less frequently malignant. These correlations emphasize the diagnostic value of detailed feature analysis and reinforce the importance of structured BI-RADS reporting in improving accuracy. Some adjusted odds ratios yielded wide confidence intervals, reflecting small subgroup sizes and variability. This should be interpreted cautiously.

The use of an analog mammography system may have reduced sensitivity for subtle findings such as microcalcifications compared with modern digital systems. Although breast density was not

statistically significant in our cohort, the observed trend toward reduced sensitivity in dense breasts highlights the limitations of analog mammography systems. Future studies with digital mammography are warranted to better quantify this effect.

The inclusion of interobserver agreement statistics (kappa = 0.82) confirms the reliability of radiologist interpretations and enhances methodological rigor.

Strengths and limitations

This study has several notable strengths. It included a relatively large sample size of 255 patients, all of whom had histopathological confirmation, thereby ensuring robust diagnostic comparisons. The systematic application of BI-RADS 5th edition descriptors, interpreted by two experienced radiologists with consensus reads, enhanced consistency and minimized inter-observer variability. Blinded interpretation further reduced bias, while the integration of both categorical variables (BI-RADS categories and mammographic features) and continuous variables such as age provided a comprehensive evaluation of diagnostic performance. In addition, the use of ROC curve analysis and logistic regression strengthened the statistical rigor of the study.

Nonetheless, several limitations should be acknowledged. The retrospective design limited control over data completeness and potential confounders. The inclusion of BI-RADS 2–3 cases in the biopsy cohort introduced verification bias, which may have inflated sensitivity and specificity estimates compared to populations where these categories are managed conservatively. The higher malignancy rates observed in BI-RADS 4A and 4B categories likely reflect selection bias inherent to a hospital-based, symptomatic population rather than a screening cohort. Breast density was assessed qualitatively rather than quantitatively, reducing precision in evaluating its impact on diagnostic accuracy. Furthermore, the use of an older analog mammography system (LORAD M-IV, manufactured in 1999) may have limited sensitivity for subtle findings such as microcalcifications. Finally, some subgroup analyses yielded wide confidence intervals, reflecting reduced precision due to small sample sizes.

Clinical implications

The findings of this study highlight the important role of mammography in improving early breast cancer detection in Tanzania. Despite reliance on an older analog system, diagnostic accuracy was consistent with international benchmarks, underscoring the value of mammography even in resource-limited environments. The strong predictive value of BI-RADS categories, particularly BI-RADS 4 and 5, supports their routine use in guiding biopsy decisions and standardizing reporting across institutions. Incorporating BI-RADS into everyday practice can enhance diagnostic consistency, reduce unnecessary procedures, and improve patient triage.

The associations observed between specific mammographic features—such as spiculated margins, irregular shape, architectural distortion, and skin thickening—and malignancy emphasize the need for radiologists to carefully evaluate these descriptors during interpretation. Training programs should prioritize recognition of these high-risk features to strengthen diagnostic confidence.

At a systems level, the study underscores the importance of expanding access to mammography services beyond tertiary centers. Establishing mobile screening units, upgrading to digital mammography, and integrating breast density assessment could further improve diagnostic performance. In addition, prospective studies with standardized biopsy protocols are needed to reduce verification bias and align local practice with international guidelines. Ultimately, strengthening mammography services and BI-RADS adoption can contribute to earlier detection, more timely treatment, and reduced breast cancer mortality in Tanzania and similar settings.

Conclusion

Mammography at Kilimanjaro Christian Medical Centre achieved an overall accuracy of 80.3%, with BI-RADS 4 and 5 lesions showing high predictive value for malignancy. Key mammographic features such as spiculated margins, irregular shape, architectural distortion, and skin thickening were significantly associated with malignancy. Despite reliance on analog technology, diagnostic metrics aligned with international standards, underscoring the utility of mammography in resource-limited settings. These findings support the expansion of screening programs and the routine use of BI-RADS to improve breast cancer detection and triage in Tanzania. services, upgrading to digital systems, and adopting standardized biopsy protocols will be

critical steps toward strengthening breast cancer diagnosis and care in Sub-Saharan Africa.

Recommendations

Based on the findings of this study, the routine use of the BI-RADS system should be encouraged across institutions to standardize reporting, improve diagnostic consistency, and guide biopsy decisions more effectively. Training programs for radiologists and technologists should emphasize recognition of high-risk features such as spiculated margins, irregular shape, architectural distortion, and skin thickening, which were strongly predictive of malignancy in this cohort.

Second, efforts should be made to expand access to mammography services beyond tertiary centers.

Establishing mobile screening units and upgrading equipment to digital mammography would improve sensitivity, particularly for subtle findings such as microcalcifications, and enhance early detection. Incorporating quantitative breast density assessment into routine practice would further refine risk stratification.

Third, prospective studies with standardized biopsy protocols are needed to reduce verification bias and align local practice with international guidelines. This would ensure more accurate estimates of diagnostic performance and facilitate comparison with global benchmarks.

Finally, policymakers should prioritize investment in breast cancer screening infrastructure, workforce training, and public awareness campaigns. Strengthening mammography services and integrating BI-RADS into routine practice can contribute to earlier detection, timely treatment, and ultimately reduced breast cancer mortality in Tanzania and across Sub-Saharan Africa.

References

1. WHO. WHO applauds new Lancet Report on Cancer in sub-Saharan Africa. 2022.
2. Sood R, Masalu N, Connolly RM, Chao CA, Faustine L, Mbulwa C, et al. Invasive breast cancer treatment in Tanzania: landscape assessment to prepare for implementation of standardized treatment guidelines. BMC Cancer 2021; 21(1): 527; doi:10.1186/s12885-021-08252-2
3. MoH. National Guidelines for Early Diagnosis of Breast Cancer and Referral for Treatment. 2018;1–28.
4. Jingu JAK. Tanzania Health Facility Atlas 2023 The United Republic of Tanzania Ministry of Health. 2024.
5. Porter GJR, Evans AJ, Burrell HC, Lee AHS, Chakrabarti J. NHSBSP type 1 interval cancers: a scientifically valid grouping?. Clin Radiol 2007; 62(3):262–7; doi:10.1016/J.CRAD.2006.10.002
6. De Jesus C, Moseley TW, Diaz V, Vishwanath V, Jean S, Elhatw A, et al. The Benefits of Screening Mammography. Curr Breast Cancer Rep 2023; 15(2):103–7; doi:10.1007/s12609-023-00479-1
7. ACR Breast Imaging Reporting & Data System (BI-RADS®) [Internet]. [cited 2026 Feb 17]. Available from: https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Reporting-and-Data-Systems/BI-RADS
8. Burson AM, Soliman AS, Ngoma TA, Mwaiselage J, Ogweyo P, Eissa MS, et al. Clinical and epidemiologic profile of breast cancer in Tanzania. Breast Dis 2010; 31(1):33–41; doi:10.3233/BD-2009-0296
9. Dance DR. Monte Carlo calculation of conversion factors for the estimation of mean glandular breast dose. Phys Med Biol 1990; 35(9):1211–9; doi:10.1088/0031-9155/35/9/002
10. Dance DR, Skinner CL, Young KC, Beckett JR, Kotre CJ. Additional factors for the estimation of mean glandular breast dose using the UK mammography dosimetry protocol. Phys Med Biol 2000; 45(11):3225–40; doi:10.1088/0031-9155/45/11/308
11. Zhou JJ, Wang YJ, Gao SN, Zhang Y, He LH, Wang F, et al. Application of Gail model for assessment on breast cancer risk [Internet]. Shanghai J Prev Med 2014; 26(5): 236–239. Available via https://pesquisa.bvsalud.org/portal/resource/pt/wpr-789276
12. Lee CH, Dershaw DD, Kopans D, Evans P, Monsees B, Monticciolo D, et al. Breast cancer screening with imaging: recommendations From the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. J Am Coll Radiol 2010; 7(1): 18–27; doi:10.1016/j.jacr.2009.09.022
13. Umeh E, Ebubedike U, Nwammuo B. Suspicious and malignant features on mammogram among women in a group of communities within south east Nigeria. Int J Med Health Develop 2019; 24(1):23; doi:10.4103/ijmh.ijmh_10_19
14. Alexander N, Viljoen I, Lucas S. Stereotactic breast biopsies: radiological-pathological concordance in a South African referral unit. SA J Radiol 2022; 26(1):1–9; doi:10.4102/sajr.v26i1.2463

15. H.R V, C A S. A Retrospective Study of Breast Imaging Reporting and Data System and Histopathological Correlation in Breast Lumps: a Single-Center Experience at R.L. Jalappa Hospital, Kolar, India. Cureus 2026; 18(3): e105247; doi:10.7759/cureus.105247

16. Weigel S, Heindel W, Heidrich J, Heidinger O, Hense H. Reduction of Advanced Breast Cancer Stages at Subsequent Participation in Mammography Screening. RoFo Fortschritte Auf Dem Gebiet Der Rontgenstrahlen Und Der Bildgebenden Verfahren 2016; 188(1):33–7; doi:10.1055/s-0041-107835

17. Botha MH, Rajaram S, Karunaratne K. Cancer in pregnancy. Int J Gynecology Obstetrics 2018; 143:137–42; doi:10.1002/ijgo.12621

Author Query

<AQ1> Please provide city and country name for the affiliations “1 and 2”.