

Breast Density Patterns and Their Association with BI-RADS Categories among a Large Cohort of Ghanaian Women

Caroline Kachana PWAMANG ^{1,2,6,ABCDE*}, Edem SOSU ^{1,3,ABEF}, Francis HASFORD ^{1,3,ABE}, Mary BOADU^{1,3,AEF},
Klenam DZEFI-TETTEY ^{4,5,BEF}, Renata LONGO ^{6,CEF}

¹University of Ghana, School of Nuclear and Allied Sciences, Medical Physics Department, Accra, Ghana

²Radiological and Non-Ionizing Installations Directorate, Nuclear Regulatory Authority, Accra, Ghana

³Radiological and Medical Sciences Research Institute, Ghana Atomic Energy Commission, Accra, Ghana

⁴Radiology Department, Korle Bu Teaching Hospital, Accra, Ghana

⁵Department of Radiology, University of Health and Allied Sciences, Ho, Ghana

⁶University of Trieste, Department of Physics, Trieste, Italy

*Corresponding author: Caroline Kachana Pwamang; pwamangc@yahoo.com

(received 21 August 2025; revised 24 November 2025; accepted 22 January 2026)

Abstract

Introduction: Breast cancer remains a major global health challenge, with Africa and other developing countries experiencing its greatest impact. Knowledge of breast density (an independent risk factor) is essential for early breast cancer diagnosis. However, such data is scarce across Africa and absent in Ghana. The aim of this work was to investigate the association between mammographic breast density patterns and BI-RADS assessment categories among women in Ghana.

Material and methods: A retrospective cross-sectional study was conducted on 2,108 women who underwent mammography between October 2011 and December 2022. Breast density was visually assessed by radiologists using the American College of Radiology (ACR) Breast Imaging Reporting and Data System (BI-RADS). Associations between breast density, age, and BI-RADS assessment categories were analysed using Fisher's Exact Test.

Results: Breast density category B (scattered fibroglandular tissue) was most common (44%, $n = 935$), followed by category A (almost entirely fatty; 39%, $n = 821$), category C (heterogeneously dense; 16%, $n = 397$), and category D (extremely dense; 1%, $n = 23$). More than 50% of all categories received benign diagnoses (BI-RADS 2), while less than 10% recorded negative diagnoses (BI-RADS 1). Higher-density categories demonstrated a greater proportion of suspicious and malignant findings: in category D, 17% were BI-RADS 3, 17% BI-RADS 4, and 13% BI-RADS 5, compared to lower proportions in categories A and B. Confirmed malignancies (BI-RADS 6) were observed across categories A–C (1% each). A significant association was found between breast density and cancer diagnoses ($p < 0.05$), as well as between age and breast density ($p < 0.05$).

Conclusion: There is a significant association between breast density and BI-RADS assessment categories, with lower breast density observed in older women, a finding consistent with published literature. These results highlight the need for tailored breast cancer screening strategies in Ghana.

Keywords: Breast cancer; breast density; mammography; BI-RADS

Introduction

Breast cancer is a major global health concern. In 2020, it was the most frequently diagnosed cancer, with 2.26 million cases and 685,000 deaths among females¹. Moreover, its associated annual economic burden could be as high as US\$20 billion, even with conservative estimates²⁻⁵. The disease was previously more common in developed countries, but its epidemiology has evolved, with developing countries now accounting for

over half of global breast cancer cases and deaths¹. In less developed regions, the burden of the disease is highest among those below 50 years of age, whereas in developed countries, those above the age of 70 shoulder the highest burden⁶. This glaring disparity has been attributed to the predominance of younger persons and the decade-shorter life expectancy of populations in developing countries⁶. Besides, the five-year survival rate for breast cancer exceeds 80% in developed countries, compared to less than 50% in developing nations¹. The

poorer outcome in developing countries is due to multiple interacting factors, such as poor awareness and knowledge about cancer, delayed presentation, late detection, and limited access to affordable and effective treatments⁷⁻⁹.

In Africa, one of the less developed regions in the world, breast cancer is the leading female malignancy, recording 186,598 new cases and 85,787 deaths in 2020 (age-standardised incidence rate [ASIR] = 132.1%; age-standardised mortality rate [ASMR] = 88.8%)¹. West Africa has the second highest number of cases in the region – 49,339 (ASIR = 41.5%, cumulative risk = 4.5%) – while recording the highest number of breast cancer deaths (25,626; ASMR = 22.3%, cumulative risk = 2.5%)¹⁰.

In 2018, Ghana, one of the highest-ranked West African countries in terms of cancer cases, recorded close to 5,000 cases of breast cancer, the predominant cause of cancer deaths in the country^{11,12}. The high burden of breast cancer in Africa necessitates its prioritisation as a public health issue, especially as its high cost of management could further cripple the struggling economies of these regions^{1-5,13}. One epidemiological strategy is to target breast density, which has been identified as an independent predictor of breast cancer occurrence and prognosis^{14,15}. Breast density is a measure of the ratio of fibroglandular tissue and fatty tissue in breasts, as seen on a mammogram¹⁶. High breast density means there is more fibroglandular tissue and less fat. Nonetheless, most of what is known about breast density and its relationship with breast cancer comes from outside Africa¹⁴⁻²⁸. Thus, the epidemiology of breast density patterns and breast cancer in Ghanaian and other West African female populations remains obscure, hindering the design of tailored interventions. To improve insights on the subject area, this study evaluated mammographic breast density patterns and their relationship with breast cancer incidence among a large cohort of Ghanaian women seen at the biggest tertiary hospital in Ghana.

Methodology

Study design and site

This was a retrospective cross-sectional study conducted at the Mammography Unit of the Radiology Department of the Korle Bu Teaching Hospital (KBTH), Accra, Ghana. KBTH is the largest tertiary healthcare facility in Ghana and serves as a major referral centre for the country and the West African sub-region. The hospital is affiliated with the University of Ghana Medical School and provides advanced clinical training and specialised diagnostic services. The Radiology Department performs over 37,000 imaging procedures annually, including approximately 1,200 mammography examinations,²⁹ making it a key facility for breast imaging and diagnoses in the region.

Study population and Data collection

The study included women aged 30 to 99 years who underwent screening or diagnostic mammography between October 2011 to December 2022. The study was done as a census in-

volving 2,108 patients. Their information was extracted from anonymised mammography reports taken from the hospital's patient records. In Ghana, mammography is usually done for patients aged 40 years and above. However, younger patients with significant risk factors may also undergo screening if the potential benefits outweigh the risks associated with radiation exposure. From the extracted data, the ages of the women were between 30 and 99 years old. The breast density patterns for all the patients were scored by five experienced radiologists using the ACR-BI-RADS categories as follows: almost entirely fatty (Category A), scattered fibroglandular tissue (Category B), heterogeneously dense breast (Category C) and extremely dense breasts (Category D). Categories A and B were classified as low-density breasts, while Categories C and D were classified as high-density breasts³⁰. BI-RADS 0 - BI-RADS 6 is also used in reporting breast imaging, where BI-RADS 0 is an incomplete assessment, additional imaging or evaluation is needed to conclude the report, BI-RADS 1 is negative, BI-RADS 2: Benign, BI-RADS 3: Probably benign, BI-RADS 4: Suspicious of malignancy, BI-RADS 5: Highly suggestive of malignancy, and BI-RADS 6: Biopsy-proven malignancy³¹.

Data analysis

Data was analysed using Microsoft Excel and the R programming language. The breast types were categorised based on density and assigned labels. The categories “Almost Entirely Fatty,” “Scattered Fibroglandular tissues,” “Heterogeneously Dense Breast,” and “Extremely Dense” were labelled A, B, C, and D, respectively. These labels indicate an increasing trend in breast density, where $A < B < C < D$. Diagnoses, initially ranging from BI-RADS 1 to BI-RADS 6 in ascending order of severity, were grouped into two categories: BI-RADS 1 to BI-RADS 3 representing “non-severe” and BI-RADS 4 to BI-RADS 6 representing “severe” diagnoses. Participants were grouped into 10-year age intervals: 30-39, 40-49, up to 90-99 years. The frequency of participants within each age class was recorded, and a contingency table was created to assess the relationships between age, breast density, and BI-RADS scores. **Table 1** shows the age distribution with breast density categories.

Table 1. Age distribution with Breast density categories.

Age group	Breast density categories				Total
	A	B	C	D	
30-39	0	17	13	0	30
40-49	149	331	159	17	656
50-59	354	366	105	5	830
60-69	232	165	34	1	432
70-79	72	44	16	0	132
80-89	11	11	1	0	23
90-99	3	1	1	0	5
Total	821	935	329	23	2108

Table 2. Breast density patterns with BI-RADS Score.

Breast Density	BI-RADS 1 (Negative diagnosis)	BI-RADS 2 (Benign diagnosis)	BI-RADS 3 (Probably Benign diagnosis)	BI-RADS 4 (Suspicious of malignancy)	BI-RADS 5 (Highly Suggestive of malignancy)	BI-RADS 6 (Confirmed Cancer)	Total
A (Almost entirely fatty breast)	47	625	48	49	46	6	821
B (Scattered fibroglandular tissues)	69	633	88	61	72	12	935
C (Heterogeneously dense breast)	28	198	35	32	33	3	329
D (Extremely Dense)	2	10	4	4	3	0	23
Total	146	1466	175	146	154	21	2108

A second contingency table was developed to explore the relationship between breast density pattern and BI-RADS assessment categories, detailing the number of participants exhibiting a particular breast density category with a specific BI-RADS score. **Table 2** shows the breast density patterns with the BI-RADS Score.

Statistical analyses

In both contingency tables, some cells contained zero counts, violating the assumptions for a chi-square test. Therefore, Fisher's Exact Test was used for statistical analysis. The analysis was undertaken using the *R* programming language.

This process of data analyses provides a structured approach to analysing the relationship between participants' age, breast density, and BI-RADS score of examinations while addressing missing data and statistical limitations.

All inferential statistics were performed at an *alpha level* of 0.05, and hence, differences whose *p-values* were below 0.05 were considered statistically significant.

Ethical considerations

Approval for the study was obtained from the Institutional Review Board of the institution (protocol identification number: KBTH-IRB 00091/2022) and the University of Ghana Ethics Committee for Basic and Applied Sciences (protocol identification number: ECBAS 050/21-22).

Results

Background information on the study participants

The total number of participants for this study was 2,108, and the mean age was 55 years. Those between the ages of 50 and 59 years were in the majority (39.37%). Details of the age distribution of the participants are provided in **Figure 1**.

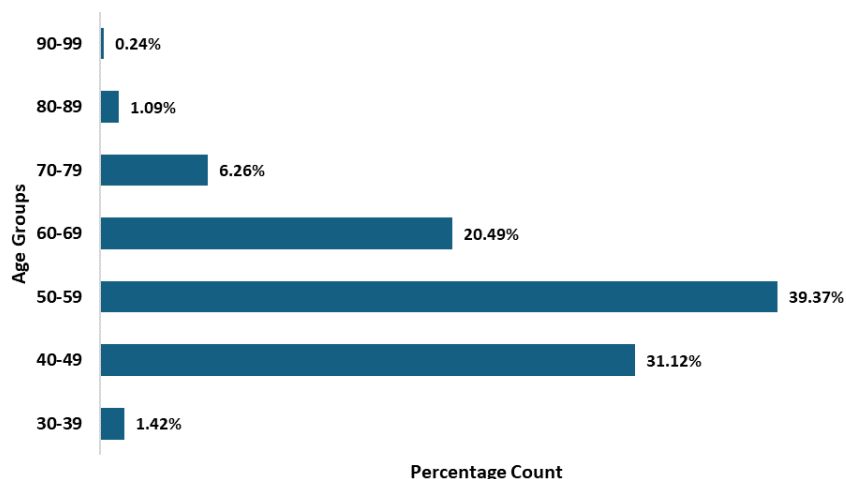


Figure 1. Age group distribution of participants. This figure illustrates the distribution of study participants across different age groups, showing how the population is spread among younger, middle-aged, and older women, highlighting the predominant age ranges represented in the study cohort.

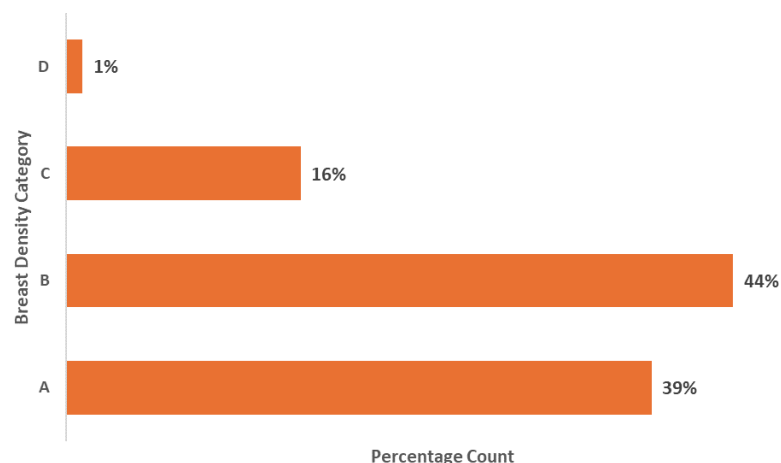


Figure 2. Breast density distribution of participants. This figure presents the distribution of participants according to their breast density categories (A-D) as defined by the BI-RADS classification system. It illustrates the relative proportions of each category within the study population, providing insight into the overall breast density profile of the participants.

Mammographic breast density patterns among the study participants

Breast density patterns, category A (almost entirely fatty) and B (scattered fibroglandular tissues) were the most prevalent: 39%, $n = 821$ and 44%, $n = 935$, respectively. Category C (heterogeneously dense breasts) recorded 16%, $n = 329$, while category D (extremely dense breast) was the least encountered among the study participants: 1%, $n = 23$. This is presented in **Figure 2**.

Relationship between breast density patterns and age distribution

A greater percentage of all the age groups had breast density category A, except the 30-39 age group, which had only breast density categories B and C, 57% and 43%, respectively. Only age groups 40-49 and 50-59 had participants with breast density category D, 3% and 1%, respectively. Further details are presented in Figure 3.

Relationship between breast density patterns with BI-RADS score

It is important to note that even though the BI-RADS score for breast cancer reporting is from BI-RADS 0 - BI-RADS 6, this study included only BI-RADS scores 1-6 from the patients' mammogram reports. This implies that patients who had BI-RADS 0 had further imaging before reports were written. Across all breast density categories, over 50% of participants had benign findings (BI-RADS 2), while fewer than 10% had negative findings (BI-RADS 1). The proportions of suspicious or malignant findings increased with breast density. Specifically, BI-RADS 3-5 scores rose progressively from categories A to D: in category A, 6% each had BI-RADS 3, 4, or 5; in category B, 9%, 7%, and 8%; in category C, 11%, 10%, and 10%; and in category D, 17%, 17%, and 13%, respectively. Biopsy-proven malignancy (BI-RADS 6) occurred in only 1% of categories A-C. These findings indicate a trend of increasing BI-RADS 3, BI-RADS 4, and BI-RADS 5 scores with higher breast density, suggesting that individuals with denser breasts may have a higher likelihood of suspicious or malignant diagnoses. Figure 4 shows more details.

Relationship between breast density patterns and breast cancer

Null Hypothesis (H_0): There is no significant relationship between Breast Density pattern and BI-RADS score.

Alternate Hypothesis (H_1): There **EXISTS** a relationship between Breast Density patterns and BI-RADS score.

Decision

Since $p - \text{Value} < \alpha$, the null hypothesis is **REJECTED**. Hence, there is a significant relationship between Breast Density patterns and Breast Cancer. This is shown in Table 3. Research has shown that women who have high breast density are more likely to be diagnosed with breast cancer than those with less dense breasts^{32,33}.

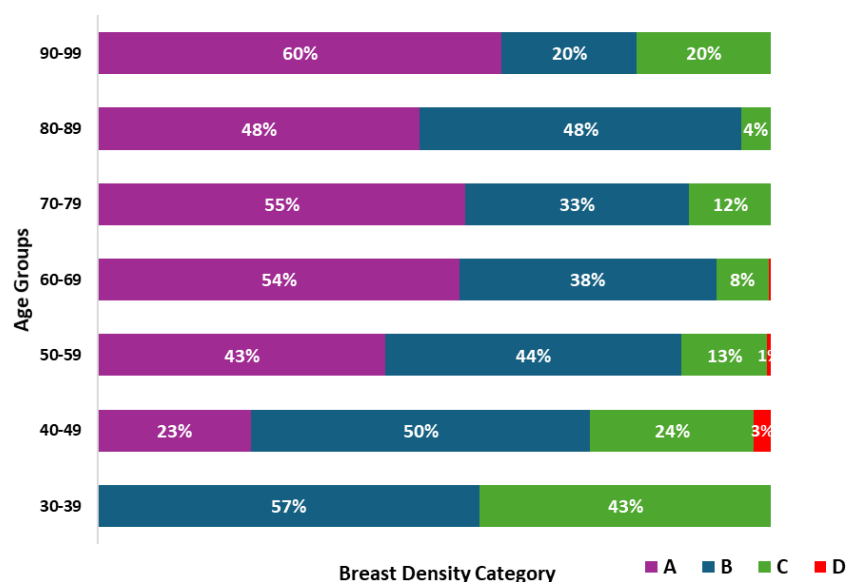


Figure 3. Age distribution with breast density. This figure illustrates the relationship between participants' age groups and their corresponding breast density categories (A-D) based on the BI-RADS classification. The distribution highlights the general trend of decreasing breast density with increasing age, reflecting the physiological replacement of glandular tissue with fatty tissue over time.

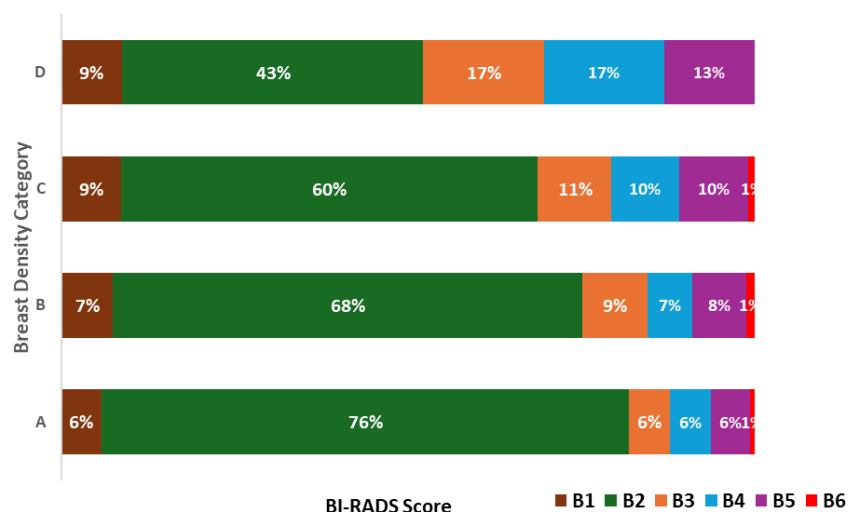


Figure 4. Breast density category distribution with BI-RADS score. This figure shows the distribution of BI-RADS scores (1-6) across the different breast density categories (A-D). It illustrates how the likelihood of higher BI-RADS scores, indicative of suspicious or malignant findings, tends to increase with increasing breast density.

Table 3. Results of Fisher's Exact Test 1.

Test	Alpha Level (α)	Degree of Freedom	p-Value	No. of replications
Chi-Square	0.05	15	7.211×10^{-5}	
Fisher's Exact Test	0.05		4×10^{-5}	100,000

Effect of age groups on breast density patterns

Null Hypothesis (H_0): There is no significant relationship between Age Groups and Breast Density patterns.

Alternate Hypothesis (H_1): There **EXISTS** a relationship between Age Groups and Breast Density patterns.

Decision

Since $p - \text{Value} < \alpha$, the null hypothesis is **REJECTED**. Hence, there is a significant relationship between age groups and breast density patterns. This can be seen in **Table 4**. Studies have established that breast density decreases with increasing age^{23,34}.

Table 4. Results of Fisher's Exact Test 2.

Test	Alpha Level (α)	Degree of Freedom	p-Value	No. of replications
Chi-Square	0.05	18	2.2×10^{-16}	
Fisher's Exact Test	0.05		1×10^{-5}	100,000

Discussion

This study found that a majority (83%) of Ghanaian women had low breast density (Categories A and B), with the remaining 17% having high breast density (categories C and D). Most age groups were dominated by breast density type A, except for the 30-39 age group, which only had categories B and C. Breast density category D was observed in the 40-49 and 50-59 age groups, at 3% and 1%, respectively. These findings are consistent with studies in Nigeria, in which the majority - 69.8% of the participants had low-density breasts (35.2% for category A and 34.6% for category B), while just a few had high-density breasts (30.2% - 21.1% for category C and 9.1% for category D)¹⁸. Similarly, more low-density breasts were observed among participants of the studies of Gathara *et al.*,¹⁷ in Uganda (61%), Singh *et al.*,³⁵ in India (84%), Kang *et al.*,²³ in the UAE (76.4%), and Alshakarh *et al.*²⁶ in Saudi Arabia (62%). These similarities may be attributed to the methods used and the similar selection criteria for study participants, despite variations in sample sizes and geographical locations across the studies. In contrast, predominantly dense breasts were observed among participants of the studies of Al-Mousa *et al.*,²⁵ in Jordan (69.4%), Ali & Fateh,²⁴ in Iraq (54.3%), Ahmadinejad *et al.*,¹⁹ in Iran (51.9%), Salem *et al.*,²⁰ in Lebanon (52.9%), Sung *et al.*,²¹ in China (52.8%), and Checka *et al.*,¹⁶ in the United States (55.4%). In these studies, histopathology reports, body mass index (BMI), reproductive factors, family history of breast cancer (FHBC), oral contraceptive consumption (OCP), and hormone replacement therapy (HRT) of participants were recorded. The significant differences in breast density grades between the current study and those reporting contrasting findings may be linked to the additional information of participants that was recorded and used in the data analyses. In this study, the absence of BMI, reproductive history, and hormone therapy data limited the robustness of statistical analyses.

The data also showed that over 50% of participants in all breast density categories had BI-RADS 2 (benign diagnoses), while less than 10% in each category had BI-RADS 1 (negative diagnoses). For breast density category A, 6% had BI-RADS 3 (probably benign diagnoses), 6% had BI-RADS 4 (suspicious

of malignancy), and 6% had BI-RADS 5 (highly suggestive of malignancy). Among category B breasts, 9% had probably benign diagnoses, 7% were suspicious of malignancy, and 8% were highly suggestive of malignancy. For category C breast density, 11% had probably benign diagnoses, 10% were suspicious of malignancy, and 10% were highly suggestive of malignancy. 17% of participants with breast density category D had probably benign diagnoses, 17% of them were suspicious of malignancy, while 13% were highly suggestive of malignancy. Additionally, 1% of participants with breast density categories A, B, and C had biopsy-proven malignancy. This shows a trend of increasing BI-RADS 3, 4, and 5 scores with higher breast density, indicating that individuals with denser breasts may have a higher likelihood of suspicious or malignant diagnoses. From Fisher's Exact Test, $p < 0.05$, there is a significant association between breast density type and breast cancer. Additionally, a significant relationship exists between age and breast density pattern, $p < 0.05$. However, there wasn't any strong evidence to prove this relationship. No follow-up was conducted to confirm or refute the benign or probably benign (BI-RADS 2 and 3) diagnoses. BI-RADS 4 and 5 were also not confirmed. According to a study by Nelson *et al.* (2016), women with low breast density (categories A and B) had lower false-negative mammogram result rates than those with high breast density (categories C and D), particularly among women aged 40-69 years. Women within all the age groups, excluding the 60-69 years group and having category D breast density, had the highest false-negative rates³⁶. From a report by the American Cancer Society on Limitations of Mammograms, 1 in 8 breast cancers are missed during screening mammograms.³⁷ Similarly, a study in Norway by Hovda *et al.*, (2021) found that 24% of interval breast cancer cases were missed cancers, with 69% of women diagnosed with occult cancer having category C and D breast densities³⁸.

This study has clinical and epidemiological significance. It provides baseline information on breast density patterns and their relationship with breast cancer in Ghana. It fills a knowledge gap on breast cancer epidemiology in Ghana and sub-Saharan Africa, where such studies are scarce.

This aligns with findings from the Fisher's Exact Test, which shows a correlation between breast density category and breast cancer diagnosis, though without enough evidence. Future studies that use prospective sampling in their design could provide enough evidence and further clarification on the relationship between breast density patterns and breast cancer risk and incidence in Ghana.

Limitations

It is important to identify missed cancers in a screening program to reduce the breast cancer mortality rate among the screening population and to increase trust in mammography screening programs. Nonetheless, this study did not identify any missed cancers. This could be attributed to the non-availability and use of additional information in the data analyses,

as already stated. These factors have been shown to influence breast density patterns³⁹⁻⁴¹. Also, there was no follow-up on patients with negative, benign, and probably benign diagnoses, and histopathology reports of patients with BI-RADS 4 and 5 scores, which could have led to identifying possible missed cancers and confirming the breast cancer incidence among the study population. Finally, the qualitative method of breast density estimation was used by the radiologists in the breast density categorisation. This is a subjective method and observer-dependent, so it can introduce intra- and inter-reader variability in the breast density estimation.

Conclusion and recommendation

In this study, Ghanaian women predominantly had low-density breasts. The analyses of the data show a significant association between breast density and BI-RADS assessment categories, with lower breast density observed among older women, a finding consistent with published studies. These findings, however, need to be interpreted in the context of the limitations of the current study: Lack of data on BMI, reproductive factors, family history of breast cancer (FHBC), oral contraceptive consumption (OCP), and hormone replacement therapy (HRT) for more robust statistical analyses. Secondly, no follow-up was done on patients that could have led to the

detection of any possible missed cancers. Also, the qualitative method of breast density estimation, which was used by the radiologists in the breast density categorisation, is subjective and observer-dependent and can introduce intra- and inter-reader variability. It is therefore recommended that a prospective study be conducted, where more patient data is recorded, and follow-up of patients is included for a more robust statistical analysis and conclusive results.

Acknowledgements

The authors acknowledge the staff of the Radiology and Information Technology Departments of Korle-Bu Teaching Hospital, Accra, for their support during data collection. Support from the International Atomic Energy Agency (IAEA) and the Abdus Salam International Centre for Theoretical Physics (ICTP) through the STEP fellowship programme, which funded Caroline's travel to ICTP in Trieste, Italy, for part of this research, is gratefully acknowledged. The Department of Medical Physics, School of Nuclear and Allied Sciences, University of Ghana, and the Department of Physics, University of Trieste, Italy, are acknowledged for co-hosting this research. The authors also acknowledge the Nuclear Regulatory Authority of Ghana for granting Caroline permission to undertake this work.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA A Cancer J Clinicians*. 2021;71(3):209-249. doi:10.3322/caac.21660
2. Sun L, Legood R, dos-Santos-Silva I, Gaiha SM, Sadique Z. Global treatment costs of breast cancer by stage: A systematic review. Diaby V, ed. *PLoS ONE*. 2018;13(11):e0207993. doi:10.1371/journal.pone.0207993
3. Greenup RA, Rushing C, Fish L, et al. Financial Costs and Burden Related to Decisions for Breast Cancer Surgery. *JOP*. 2019;15(8):e666-e676. doi:10.1200/jop.18.00796
4. Kim YA, Oh IH, Yoon SJ, et al. The Economic Burden of Breast Cancer in Korea from 2007-2010. *Cancer Res Treat*. 2015;47(4):583-590. doi:10.4143/crt.2014.143
5. Luengo-Fernandez R, Leal J, Gray A, Sullivan R. Economic burden of cancer across the European Union: a population-based cost analysis. *The Lancet Oncology*. 2013;14(12):1165-1174. doi:10.1016/s1470-2045(13)70442-x
6. Heer E, Harper A, Escandor N, Sung H, McCormack V, Fidler-Benaoudia MM. Global burden and trends in premenopausal and postmenopausal breast cancer: a population-based study. *The Lancet Global Health*. 2020;8(8):e1027-e1037. doi:10.1016/s2214-109x(20)30215-1
7. Beral V, Peto R. UK cancer survival statistics. *BMJ*. 2010;341(aug11 1):c4112-c4112. doi:10.1136/bmj.c4112
8. Brand NR, Qu LG, Chao A, Ilbawi AM. Delays and Barriers to Cancer Care in Low- and Middle-Income Countries: A Systematic Review. *The Oncologist*. 2019;24(12):e1371-e1380. doi:10.1634/theoncologist.2019-0057
9. Denny L, de Sanjose S, Mutebi M, et al. Interventions to close the divide for women with breast and cervical cancer between low-income and middle-income countries and high-income countries. *The Lancet*. 2017;389(10071):861-870. doi:10.1016/s0140-6736(16)31795-0
10. Arnold M, Morgan E, Rumgay H, et al. Current and future burden of breast cancer: Global statistics for 2020 and 2040. *The Breast*. 2022;66:15-23. doi:10.1016/j.breast.2022.08.010
11. Ghana cancer statistics. International Agency for Research on Cancer, 2020.
12. Sharma R, Aashima, Nanda M, et al. Mapping Cancer in Africa: A Comprehensive and Comparable Characterization of 34 Cancer Types Using Estimates From GLOBOCAN 2020. *Front Public Health*. 2022;10. doi:10.3389/fpubh.2022.839835
13. Cancer Research UK. Breast Cancer Statistics. 2021. Available from: <https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer> [Accessed Aug 25, 2023].
14. Chen JH, Chang YC, Chang D, et al. Reduction of breast density following tamoxifen treatment evaluated by 3-D MRI: preliminary study. *Magnetic Resonance Imaging*. 2011;29(1):91-98. doi:10.1016/j.mri.2010.07.009
15. Lokate M, Peeters PH, Peelen LM, Haars G, Veldhuis WB, van Gils CH. Mammographic density and breast cancer risk: the role of the fat surrounding the fibroglandular tissue. *Breast Cancer Res*. 2011;13(5). doi:10.1186/bcr3044
16. Checka CM, Chun JE, Schnabel FR, Lee J, Toth H. The Relationship of Mammographic Density and Age: Implications for Breast Cancer Screening. *American Journal of Roentgenology*. 2012;198(3):W292-W295. doi:10.2214/ajr.10.6049

17. Gathara J, Galukande M, Kiguli-Malwadde E. Breast density as a risk factor for breast cancer amongst a cohort of women in Uganda. *East Cent Afr J Surg.* 2012;17:98-103.
18. Obajimi MO, Adeniji-Sofoluwe ATS, Oluwasola AO, et al. Mammographic breast pattern in Nigerian women in Ibadan, Nigeria. *BD.* 2011;33(1):9-15. doi:10.3233/bd-2010-0313
19. Ahmadinejad N, Movahedinia S, Movahedinia S, Holakouie Naieni K, Nejat S. Distribution of Breast Density in Iranian Women and its Association with Breast Cancer Risk Factors. *Iran Red Cres Med J.* 2013;15(12). doi:10.5812/ircmj.16615
20. Salem C, Atallah D, Safi J, et al. Breast Density and Breast Cancer Incidence in the Lebanese Population: Results from a Retrospective Multicenter Study. *BioMed Research International.* 2017;2017:1-9. doi:10.1155/2017/7594953
21. Sung H, Ren J, Li J, et al. Breast cancer risk factors and mammographic density among high-risk women in urban China. *npj Breast Cancer.* 2018;4(1). doi:10.1038/s41523-018-0055-9
22. Wengert GJ, Helbich TH, Kapetas P, Baltzer PA, Pinker K. Density and tailored breast cancer screening: practice and prediction – an overview. *Acta Radiologica Open.* 2018;7(9):205846011879121. doi:10.1177/2058460118791212
23. Kang YJ, Ahn SK, Kim SJ, Oh H, Han J, Ko E. Relationship between Mammographic Density and Age in the United Arab Emirates Population. *Journal of Oncology.* 2019;2019:1-6. doi:10.1155/2019/7351350
24. Ali KAS, Fateh SM. Mammographic breast density status in women aged more than 40 years in Sulaimaniyah, Iraq: a cross-sectional study. *J Int Med Res.* 2022;50(12). doi:10.1177/03000605221139712
25. Al-Mousa DS, Alakhras M, Spuur KM, et al. Mammographic Breast Density Profile of Jordanian Women With Normal and Breast Cancer Findings. *Breast Cancer (Auckl).* 2020;14. doi:10.1177/1178223420921381
26. Alshakarh F, Aldahash S, Algaali K, Abd-Ellatif EE. Relationship of breast cancer types with tissue density and patient age, Riyadh, Saudi Arabia, 2012-2020. *World Cancer Research Journal.* 2022;9(December 2022). doi:10.32113/wcrj_202212_2451
27. Bodewes FTH, van Asselt AA, Dorrius MD, Greuter MJW, de Bock GH. Mammographic breast density and the risk of breast cancer: A systematic review and meta-analysis. *The Breast.* 2022;66:62-68. doi:10.1016/j.breast.2022.09.007
28. Kocer B. The Relationship between Mammographic Density and Factors Affecting Breast Cancer Risk. *Sisli Etfal.* Published online 2021. doi:10.14744/semb.2021.30771
29. Korle Bu Teaching Hospital 2016 Annual Report. http://kbth.gov.gh/assets/downloads/pdf/2016_Annual_Report.pdf
30. American College of Radiology (2003) Breast imaging reporting and data system atlas (BI-RADS Atlas). American College of Radiology, Reston.
31. Magny SJ, Shikhman R, Keppke AL. Breast Imaging Reporting and Data System. In: *StatPearls.* StatPearls Publishing, Treasure Island (FL); 2022.
32. Lange JM, Gard CC, O'Meara ES, Miglioretti DL, Etzioni R. Breast density and risk of breast cancer: masking and detection bias. *American Journal of Epidemiology.* 2024;194(2):441-448. doi:10.1093/aje/kwae245
33. Mann RM, Athanasiou A, Baltzer PAT, et al. Breast cancer screening in women with extremely dense breasts recommendations of the European Society of Breast Imaging (EUSOBI). *Eur Radiol.* 2022;32(6):4036-4045. doi:10.1007/s00330-022-08617-6
34. Perera D, Pirikahu S, Walter J, et al. The distribution of breast density in women aged 18 years and older. *Breast Cancer Res Treat.* 2024;205(3):521-531. doi:10.1007/s10549-024-07269-y
35. Singh T, Khandelwal N, Singla V, et al. Breast density in screening mammography in Indian population - Is it different from western population? *Breast J.* 2017;24(3):365-368. doi:10.1111/tbj.12949
36. Nelson HD, O'Meara ES, Kerlikowske K, Balch S, Miglioretti D. Factors Associated With Rates of False-Positive and False-Negative Results From Digital Mammography Screening: An Analysis of Registry Data. *Ann Intern Med.* 2016;164(4):226-235. doi:10.7326/m15-0971
37. American Cancer Society (2022). Breast Cancer Early Detection and Diagnosis. Available from: <https://www.cancer.org/cancer/types/breast-cancer/screening-tests-and-early-detection.html>
38. Hovda T, Hoff SR, Larsen M, Romundstad L, Sahlberg KK, Hofvind S. True and Missed Interval Cancer in Organized Mammographic Screening: A Retrospective Review Study of Diagnostic and Prior Screening Mammograms. *Academic Radiology.* 2022;29:S180-S191. doi:10.1016/j.acra.2021.03.022
39. Ciatto S, Visioli C, Paci E, Zappa M. Breast density as a determinant of interval cancer at mammographic screening. *Br J Cancer.* 2004;90(2):393-396. doi:10.1038/sj.bjc.6601548
40. Duffy SW, Jakes RW, Ng FC, Gao F. Interaction of dense breast patterns with other breast cancer risk factors in a case-control study. *Br J Cancer.* 2004;91(2):233-236. doi:10.1038/sj.bjc.6601911
41. McCormack VA, dos Santos Silva I. Breast Density and Parenchymal Patterns as Markers of Breast Cancer Risk: A Meta-analysis. *Cancer Epidemiology, Biomarkers & Prevention.* 2006;15(6):1159-1169. doi:10.1158/1055-9965.epi-06-0034