

Analysis of Mammography BI-RADS Distribution and Follow-up Ultrasound Assessment: A Single-Center Study

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Purpose: Our study has three main aims: 1) to assess the distribution of Breast Imaging Reporting and Data System (BI-RADS) classifications in a cohort of Turkish women undergoing screening mammography, 2) to analyze the frequency and non-completion rates of recommended follow-up ultrasound (US) examinations, and 3) to examine the outcomes of completed follow-up US examinations. Our goal was to evaluate potential gaps in the current breast cancer screening process by analyzing BI-RADS classifications, follow-up completion rates, and outcomes of completed ultrasound examinations.

Patients and Methods: This retrospective study analyzed 1761 Turkish women who underwent screening mammography from 2020–2022 at the Istanbul Aydin University General Surgery Clinic, Istanbul, Turkey. We assessed the distribution of BI-RADS classifications, analyzed the frequency and non-completion rates of recommended follow-up US, and examined the outcomes of completed follow-up US examinations. Chi-square tests of independence and Spearman's rank correlation test were used to analyze the data.

Results: Our study revealed three key findings: 1) Over half of mammograms (55.9%) were classified as BI-RADS 0, requiring further imaging. 2) Nearly one-third of patients who recommended US examinations (31.91%) did not complete recommended follow-up ultrasound appointments. 3) Among those who completed follow-up ultrasonography, almost one-third (29.7%) were reclassified as BI-RADS 3 or higher. Notably, 2.3% (n=18) were classified as BI-RADS 4 or 5, suggesting findings suspicious for malignancy.

Conclusion: Our findings highlight the crucial role of follow-up US in breast cancer screening. The high rate of initial BI-RADS 0 classifications using mammography, coupled with the significant non-completion rate for follow-up US examinations, particularly among older age groups, highlights potential gaps in the current screening process.

Keywords: breast ultrasonography, mammography, breast cancer, early diagnosis, BI-RADS classification

Introduction

According to the World Health Organization's (WHO) "Global Cancer Incidence, Prevalence, and Mortality Measurement (GLOBOCAN) 2020" report, breast cancer is the most frequent cancer type in the world and the leading cause of cancer-related mortality among women worldwide, including in Turkey.^{1,2} In the American Cancer Society breast cancer screening guideline, early detection and treatment of breast cancer utilizing screening methods has been identified as one of the most effective approaches for minimizing morbidity and mortality from breast cancer.³ Therefore, enhancing breast cancer detection through robust screening practices is fundamental to improve overall women health outcome.

Given the importance of early detection, it's crucial to understand the strengths and limitations of current screening methods. Mammography is an internationally approved screening technology that has been shown to minimize breast cancer-related mortalities.^{4–8} However, the accuracy and precision of mammography screening techniques are not optimal, and consequently, several sensitivity and precision thresholds for detecting breast cancer have been published.^{9–11} While screening mammography can identify up to 98% of tumors in fatty breasts, sensitivity drastically

decreases to 30–48% in highly dense breasts. To address the limitations of mammography in this patient population, additional imaging procedures such as ultrasonography have been recommended to enhance the odds of diagnosing the tumors before they become symptomatic, as delayed diagnosis is associated with shorter survival.^{7,12} When mammography reveals heterogeneous density or hyperdense areas, it is recommended that women undergo further imaging examinations, particularly ultrasonography, to obtain the final categorization using BI-RADS.¹³

Despite these recommendations, our study highlights two critical gaps in the current breast cancer screening approach. Firstly, we observed a high rate of BI-RADS 0 classifications, indicating that over half of the women undergoing screening mammography required additional imaging for definitive diagnosis. Secondly, nearly one-third of patients who were recommended follow-up ultrasound examinations did not complete them, potentially leading to missed or delayed diagnoses.

Our study has three main aims: 1) to assess the distribution of Breast Imaging Reporting and Data System (BI-RADS) classifications in a cohort of Turkish women undergoing screening mammography, 2) to analyze the frequency and non-completion rates of recommended follow-up ultrasound (US) examinations, and 3) to examine the outcomes of completed follow-up US examinations. Our goal was to evaluate potential gaps in the current breast cancer screening process through analysis of these parameters.

Materials and Methods

Ethics Approval

The study protocol was approved by the Istanbul Aydin University Ethics Committee (approval number: 43/2024). The requirement for individual informed consent was waived by the ethics committee due to the retrospective nature of the study. This waiver was granted because the study involved analysis of existing data with no additional interventions or patient contact, and all patient data were anonymized prior to analysis. The study was conducted in accordance with the Declaration of Helsinki and its later amendments.

Study Design and Participants

We conducted a retrospective analysis of 1761 Turkish women aged over 40 years (mean age 53.08 ± 9.30 years) who underwent screening mammography between January 2020 and December 2022 at the Istanbul Aydin University General Surgery Clinic, Istanbul, Turkey.

Mammography and Ultrasonography

All participants underwent standard two-view digital mammography (craniocaudal and mediolateral oblique). Images were interpreted by board-certified radiologists in breast imaging, using the Breast Imaging Reporting and Data System (BI-RADS) classification.

Patients with BI-RADS 0 classification were recommended for follow-up ultrasonography. Ultrasound examinations were performed with a high-frequency linear transducer. The entire breast and axillary regions were examined following standard protocols.

Data Collection and Analysis

Demographic data, mammography results, and follow-up ultrasonography findings were extracted from medical records. Patients were categorized into four age groups: 40–49, 50–59, 60–69, and ≥ 70 years. BI-RADS classifications were recorded for both initial mammography and follow-up ultrasonography when necessary.

Statistical analysis was performed using Python (version 3.12.4) with pandas (version 2.2.3), numpy (version 1.26.4), and scipy (version 1.13.1) libraries. Descriptive statistics were calculated for age and BI-RADS classifications. The chi-square test of independence was used to assess the association between age groups and BI-RADS classifications. Spearman's rank correlation was employed to evaluate the relationship between age and BI-RADS scores. A p -value < 0.05 was considered statistically significant.

Table 1 Descriptive Statistics of All Patients

Variable	Unit	Values
Total patients	Number	1761
Mean age $\pm$ SD	Years	53.08 $\pm$ 9.30
Minimum age group	Years	40
Median age	Years	54.5

The frequency and proportion of patients requiring follow-up ultrasonography (BI-RADS 0) were calculated, along with the completion rates of recommended follow-up examinations. Subsequent BI-RADS classifications after ultrasonography were analyzed for those who completed the follow-up.

Data Visualization

Graphical representations were created using matplotlib (version 3.9.2) and seaborn (version 0.13.2) libraries in Python. Figures depicting the distribution of patients by age group, BI-RADS classifications, and BI-RADS 0 cases by age group were generated. All figures were prepared at 300 dpi resolution using Arial font, adhering to standard publication requirements.

Sample Size Calculation

Sample size calculations were performed for each BI-RADS classification category using a precision-based approach, implemented through Python programming language (version 3.12.4) with statistical libraries (NumPy 1.26.4, SciPy 1.11.4). For the primary outcome (BI-RADS 0), with a 5% margin of error and 95% confidence level, the minimum required sample size was 379 patients. Calculations for other BI-RADS categories (1–5) yielded required sample sizes ranging from 13 to 301 patients. Our final sample size of 1761 patients substantially exceeded these requirements across all categories, ensuring adequate statistical power for both primary analyses and subgroup comparisons.

Results

A total of 1761 Turkish women underwent screening mammography between 2020 and 2022 at the Istanbul Aydin University General Surgery Clinic, Istanbul, Turkey. The mean age of the participants was 53.08 years (SD = 9.30) (Table 1).

In Figure 1, the distribution of patients by age group was as follows: 780 (44.3%) in the 40–49 age group, 570 (32.4%) in the 50–59 age group, 297 (16.9%) in the 60–69 age group, and 114 (6.5%) in the 70+ age group.

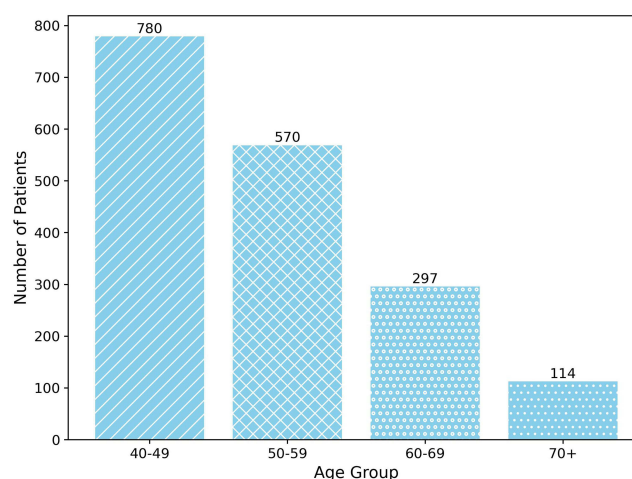


Figure 1 Bar graph represents the age distribution of 1761 Turkish women who underwent screening mammography between 2020–2022.

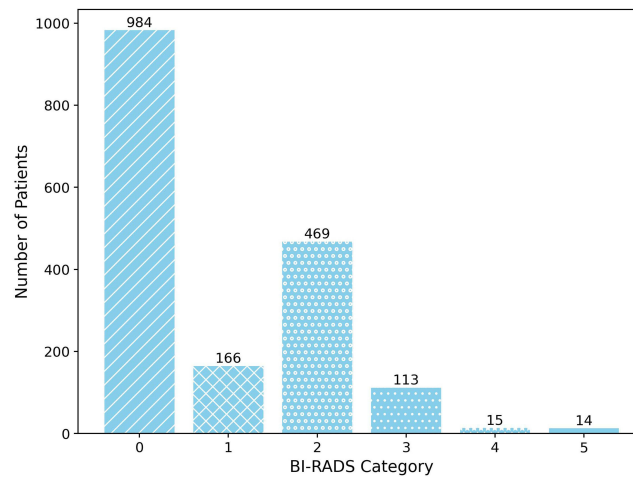


Figure 2 Bar graph illustrates the distribution of Breast Imaging-Reporting and Data System (BI-RADS) classifications among the 1761 women who underwent screening mammography.

In [Figure 2](#), the distribution of BI-RADS classifications of all patients (n=1761) using mammography revealed that the majority of cases (n=984, 55.9%) were classified as BI-RADS 0, indicating a need for additional imaging. The remaining classifications were: BI-RADS 1 (n=166, 9.4%), BI-RADS 2 (n=469, 26.6%), BI-RADS 3 (n=113, 6.4%), BI-RADS 4 (n=15, 0.9%), and BI-RADS 5 (n=14, 0.8%).

[Figure 3](#) illustrates the age distribution of the 984 patients classified as BI-RADS 0 using mammography, who required additional imaging for BI-RADS classification using ultrasonography (US). The distribution across age groups was as follows: 480 patients (48.8%) in the 40–49 age group, 320 patients (32.5%) in the 50–59 age group, 134 patients (13.6%) in the 60–69 age group, and 50 patients (5.1%) in the 70+ age group. This distribution shows a clear trend of decreasing BI-RADS 0 classifications with increasing age, with the majority of cases concentrated in the younger age groups.

In [Table 2](#), we observed that 31.91% of patients did not complete recommended follow-up US examinations. Notably, this non-completion rate varied across age groups, with a clear trend of increasing non-completion as age increased. The youngest age group (40–49 years) demonstrated the lowest non-completion rate at 25.83%, while the oldest group (70 years and older) showed the highest at 46.00%.

[Table 3](#) presents the outcomes for patients who completed the recommended ultrasonography. Of the 984 patients initially classified as BI-RADS 0 using mammography, 670 completed the recommended ultrasonography. In [Table 3](#) and

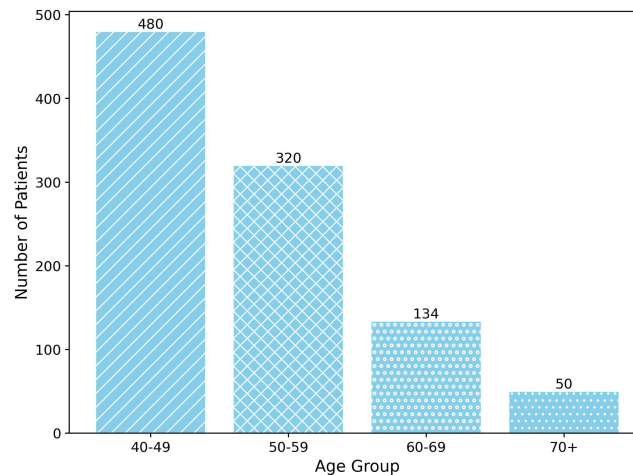


Figure 3 Bar graph represents the age distribution of 984 patients classified as BI-RADS 0 using mammography, which indicates a need for additional imaging for correct BI-RADS classification.

Table 2 Age Distribution of Patients Who Did Not Complete Follow-up US Appointments (N=314)

Age Group	Non-completion Rate of US Appointments
40–49	25.83%
50–59	35.00%
60–69	41.04%
70 and older	46.00%
Overall Ratio	31.91%

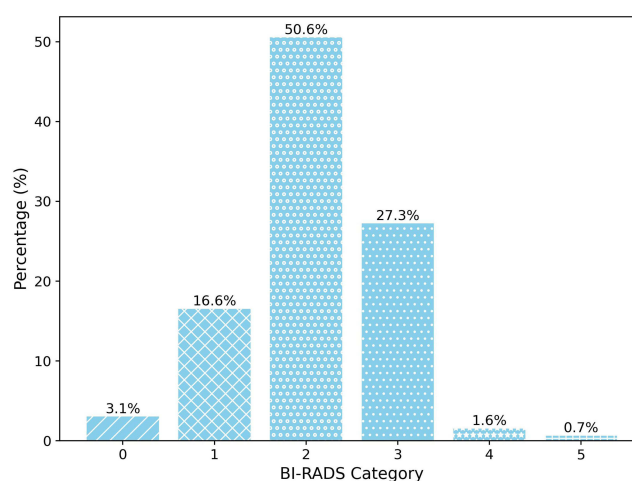
Table 3 Distribution of BI-RADS Classifications After Ultrasonography Across Age Groups (N=670)

	BI-RADS 0	BI-RADS 1	BI-RADS 2	BI-RADS 3	BI-RADS 4	BI-RADS 5
40–49	10	44	170	122	9	1
50–59	5	41	112	49	0	1
60–69	5	19	45	7	2	1
>70	1	7	12	5	0	2
Total	21	111	339	183	11	6

Abbreviations: BI-RADS, Breast Imaging Reporting and Data System; US, Ultrasonography; WHO, World Health Organization; J-START, Japan Strategic Anti-Cancer Randomized Trial; NBCRD, National Breast Cancer Registry Data.

Figure 4, the subsequent BI-RADS classifications using ultrasonography for these patients (n=670) were as follows: BI-RADS 0 (n=21, 3.1%), BI-RADS 1 (n=111, 16.6%), BI-RADS 2 (n=339, 50.6%), BI-RADS 3 (n=183, 27.3%), BI-RADS 4 (n=11, 1.6%), and BI-RADS 5 (n=5, 0.7%).

The association between age groups and BI-RADS classifications was assessed using a chi-square test of independence and Spearman's rank correlation. Both analyses demonstrated a strong positive correlation between age and BI-RADS classification (chi-square statistic: $p < 0.001$; Spearman's rank correlation: $p < 0.001$). These results indicate that BI-RADS scores tend to increase significantly with age.

**Figure 4** Bar graph illustrates the distribution of Breast Imaging-Reporting and Data System (BI-RADS) classifications after ultrasonography.

Discussion

This retrospective analysis assessed BI-RADS classifications and ultrasonography follow-up patterns among Turkish women undergoing screening mammography. Analysis focused on primary aspects: the distribution of initial BI-RADS classifications, completion rates of recommended ultrasonography, and outcomes of completed follow-up examinations.

Previous studies have demonstrated the limitations of mammography as a standalone tool for breast cancer diagnosis, particularly in younger women and those with dense breast tissue.^{1–3} Harada-Shoji et al found that mammography sensitivity did not exceed 80% across all breast densities, even in the younger age group of 40–49 years.⁹ This is particularly relevant as breast cancer incidence rates in Japan peak among women aged 45 to 49 years.⁹ While the study observed slightly higher sensitivity in women with dense breasts compared to those with nondense breasts (70.6% vs 60.9%), it suggested that even nondense tissue might obscure cancers in this age group.⁹ Notably, the study demonstrated that adjunctive ultrasonography alongside mammography significantly improved sensitivity in both dense and nondense breasts, leading the authors to recommend considering supplemental ultrasonography for breast cancer screening in women aged 40 to 49 years, regardless of breast density.⁹ Our study found that over half (55.9%) of the screening mammograms were initially classified as BI-RADS 0, indicating a need for additional imaging. These findings, in conjunction with prior studies, highlight the crucial role of ultrasonography in the breast cancer screening process.

Several studies have highlighted the importance of age-specific considerations in breast cancer screening protocols and the potential need for supplementary imaging techniques in younger populations.^{13,14} In our study, the higher proportion of BI-RADS 0 classifications observed in younger women may be attributed to the increased breast density typically observed in this demographic, which can make mammographic interpretation more challenging and necessitate additional imaging.

Prior studies have reported significant non-completion rates for follow-up recommendations after abnormal mammograms, with rates ranging from 10–40%.^{4–6} In our study, we observed that nearly one-third (31.92%) of patients did not complete recommended follow-up US examinations. Notably, this non-completion rate varied across age groups, with a clear trend of increasing non-completion as age increased. The youngest age group (40–49 years) demonstrated the lowest non-completion rate at 25.83%, while the oldest group (70 years and older) showed the highest at 46.00%. These findings add to the existing literature and highlight the need for strategies to improve patients' completion rates for follow-up US recommendations, particularly among older age groups.

These age-dependent patterns in follow-up completion suggest the need for targeted communication and counseling strategies. While younger patients showed better adherence to follow-up recommendations, the increasing non-completion rates with age indicate that older patients may benefit from enhanced counseling approaches. This could include clear communication about the importance of follow-up imaging, scheduling assistance, reminder systems, and addressing age-specific barriers to completion such as transportation or mobility concerns. Educational materials and counseling sessions could be tailored to different age groups, considering factors such as health literacy, technological comfort, and specific concerns about breast cancer screening. While our study did not directly assess communication methods, the significant proportion of patients not completing recommended follow-up ultrasound examinations (31.91% overall) indicates a potential gap in the current follow-up process. Future prospective studies could evaluate specific communication interventions and their impact on follow-up completion rates. This is particularly important given our finding that 29.7% of patients who completed follow-up ultrasonography were reclassified as BI-RADS 3 or higher, highlighting the clinical significance of successful follow-up completion.

The BI-RADS classification system stratifies the risk of malignancy, with BI-RADS 3 indicating probably benign findings (<2% likelihood of malignancy), BI-RADS 4 suggesting suspicious abnormalities (2–95% likelihood of malignancy), and BI-RADS 5 being highly suggestive of malignancy (>95% likelihood of malignancy).^{3,15} Previous studies have demonstrated the ability of adjunctive ultrasonography to detect mammographically-occult cancers, particularly in women with dense breasts.^{7–9} In our study, we found that among patients who completed the recommended follow-up ultrasonography after an initial BI-RADS 0 classification on mammography, 29.7% were subsequently classified as BI-RADS 3 or higher. This indicates a significant proportion of cases with potential abnormalities that were not apparent on initial mammography. Notably, 1.6% of patients were classified as BI-RADS 4 and 0.7% as BI-

RADS 5, suggesting findings suspicious for malignancy. These reclassification rates emphasize the importance of follow-up ultrasonography in identifying potential breast abnormalities and malignancies that may be missed by mammography alone. Our findings highlight the potential consequences of missed follow-up examinations and the value of timely follow-up imaging in the breast cancer screening process.

Prior single-center studies have demonstrated the feasibility and potential benefits of same-day ultrasonography, including reduced time to diagnosis and improved patient satisfaction.^{10–12} Our findings suggest that implementing ultrasonography in conjunction with mammography could potentially improve the screening process by providing follow-up imaging for BI-RADS 0 cases. This approach may help reduce non-completion rates and allow for more diagnostic resolution. However, to provide a foundation for this potential recommendation, further research is needed to evaluate the feasibility, cost-effectiveness, and patient outcomes of suggested approach in multicenter studies as well as needed to evaluate the impact of same-day ultrasonography on cancer detection rates, patient outcomes, and cost-effectiveness in larger, multi-center studies. Prospective trials comparing same-day ultrasonography with standard screening protocols would provide more evidence to support the implementation of this approach in clinical practice.

It is important to acknowledge the limitations of our study. Our data reflects only follow-up examinations completed at our institution, as we did not have the capability to track patients who may have completed their follow-up imaging at other facilities. Future prospective studies with more comprehensive patient tracking across multiple institutions could provide a more accurate assessment of follow-up completion rates and the impact of missed follow-up examinations on patient outcomes.

Conclusion

Our study reveals significant gaps in the current breast cancer screening process in our Turkish cohort, particularly concerning follow-up completion rates and the clinical importance of completed ultrasound examinations. We found that a substantial proportion of patients did not complete recommended follow-up ultrasonography, with non-completion rates increasing with age. Among those who did complete follow-up imaging, nearly one-third were reclassified as BI-RADS 3 or higher, emphasizing the value of timely follow-up in identifying potentially suspicious findings missed by mammography alone. These findings suggest that implementing same-day ultrasonography in conjunction with mammography could potentially facilitate earlier detection of breast abnormalities and malignancies. However, further research is needed to evaluate the feasibility, cost-effectiveness, and patient outcomes of this approach. Our study highlights the need for targeted strategies to improve follow-up completion rates and optimize breast cancer screening practices, particularly for older patients. By addressing these gaps, we can work towards enhancing early detection and ultimately improving outcomes for women with breast cancer.

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Disclosure

The authors report no conflicts of interest in this work.

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