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# The association between mammography reports and women's age using retrospective data form a medical system

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**Objective:** We explored the association of age, obesity and marital status with Breast Imaging Reporting and Data System (BI-RADS) category distribution in women, using retrospective mammography data from a medical system, as only a few studies have investigated this association.

**Materials and methods:** This retrospective study collected the first left-lateral and right-lateral mammography data of 4,165 and 4,213 women from 2,011 to 2020 in a medical system, respectively, to be analyzed. We examined the association of age, body mass index (BMI), and marital status with BI-RADS categories using the Chi-square test and multinomial logistic regression.

**Results:** The proportion of BI-RADS category 0 decreased with age, but the proportion of BI-RADS categories 4 and 5 increased with age. Women aged >69 years had a higher proportion of BI-RADS categories 4 and 5 [adjusted odds ratio (aOR) = 1.34 for left-lateral mammography and aOR = 1.29 for right-lateral mammography data] than women aged 45–69 years. Overweight was associated with the rate of the proportion of BI-RADS categories 4 and 5 of the left-lateral breast (aOR = 1.26,  $p < 0.05$ ) but not with the right-lateral breast.

**Conclusions:** Age >69 years, being overweight, and being separated/divorced/widowed were the factors associated with BI-RADS categories 4 and 5 of women who underwent mammography.

## KEYWORDS

mammography, BI-RADS, female, breast cancer, age, BMI, marital status

## 1 Introduction

It is believed that early diagnosis of breast cancer can reduce the mortality rate by approximately 20%–40% (1, 2). Mammography is commonly used to detect breast cancer in its early stages (3, 4). Mammography data interpretation and classification are based on the Breast Imaging Reporting and Data System (BI-RADS) (5). According to the BI-RADS 5th version, BI-RADS category of 0 is recommended combining ultrasound or other examination to clarify the current status; categories of 1, 2, and 3 needing regular follow-up; and categories of 4 and 5 needing tissue diagnosis, that is, biopsy (5).

However, the sensitivity of mammography was associated with breast density (6, 7). Carney et al. analyzed seven population-based mammography registry data in the

United States (6). They found that mammography sensitivity increased from 62.9% in women with high breast density to 87.0% in women with low breast density (6). A previous study found that more than a quarter of women with dense breasts were misdiagnosed during mammography because of the masking of lesions (6).

Women's breast density was found to be inversely associated with age (8, 9). It was reported that almost 75% of women aged 40–49 years had dense breasts, and the percentage decreased to 57% when women's age was over 50 years old. Heller et al. found a negative trend between breast density and age when women were younger than 56 years (9).

In addition, obesity is an identified risk factor for breast cancer (10–12) in postmenopausal women. A 13-year follow-up study of postmenopausal women in the US found that the risk of invasive breast cancer increased with increasing Body Mass Index (BMI) (10). A case-control study in Egypt reported that the risk of breast cancer was 2.28 times in overweight/obese postmenopausal women compared with underweight/normal-weight postmenopausal women (12).

Marital status was mentioned associated with the willing to undergo mammography and with breast cancer (13–15). Jolidon et al. found married women were more willing to undergo mammography compared with women without a partner or those living alone (13). Widowed women were associated with breast cancer (14) and had higher probability of being diagnosed with breast cancer at a later stage (15). Therefore, in the present study, we aimed to investigate the association of the BI-RADS category distribution with age, obesity and marital status among women in Taiwan using retrospective 10-year mammography data from a medical system to survey the BI-RADS category distribution.

## 2 Materials and methods

### 2.1 Sampled mammography data

The retrospective study was used in this study. The mammography data from 2011 to 2020 were collected from a medical system in southern Taiwan because the government provides the same mammography screening program during this period. Considering that each person had a different number of mammography data, only data of women's first mammogram in this medical system were included to be analyzed. The mammography data without the BI-RADS categorized were excluded in this study.

We also collected data on age, height, weight, and marital status from the participant's medical records at the time of the first mammogram in this medical system. The data of height and weight were measured and recorded and marital status was self-reported. The overall left and right lateral mammography data of 4,165 and 4,213 women, respectively, were included and analyzed.

### 2.2 Data analysis

According to the BI-RADS 5th version, different BI-RADS categories have different corresponding recommendation (5).

Therefore, we categorized the results of mammography as BI-RADS “0,” “1,2,3,” and “4,5”. Body mass index (BMI) was calculated as weight (kg) divided by height squared ( $m^2$ ) and classified into underweight (BMI < 18.5), normal weight ( $18.5 \leq \text{BMI} < 24$ ), overweight/ obese ( $24 \leq \text{BMI}$ ), according to the recommendation of the Taiwan Health Promotion Administration (16). In this study, we categorized age into the following groups: <45 years, 45–69 years, and >69 years as the government provides a free biennial mammography screening program for women aged 45–69 years and for women aged 40–44 years whose relatives (grandmother, mother, or sister) have had breast cancer (17); marital status was categorized as married, unmarried, and separated/divorced/widowed.

We first examined the distribution of age, BMI, marital status, and BI-RADS of mammography data. Then, the association of BI-RADS categories distribution with age, BMI, and marital status was examined using a chi-square test. The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using univariate- and multivariate-multinomial logistic regression analysis with a main effect model to examine the association of BI-RADS categories with age, BMI classification, and marital status. In this multinomial logistic regression analysis, BIRADS “1,2,3,” age 45–69 years, normal BMI, and married were used as references. Left- and right-lateral mammography data were examined separately. We set the  $\alpha$  value at 0.05, and data analyses were performed using SPSS software version 18 (IBM Corp., Armonk, NY, USA).

### 2.3 Ethical approval

This study was approved by the Research Ethics Committee of E-Da Hospital (EMRP-111-009). Informed consent was not required because retrospective data was used in this study.

## 3 Results

### 3.1 Age distribution, BMI, and marital status of study objects

About 75.8% of women between the ages of 45–69 underwent left-lateral mammography, over 49% were overweight/obese, 78.4% were married, 12.0% were classified into BI-RADS category 0, and 10.2% were classified as BI-RADS categories 4 and 5. About 75.7% of women aged 45–69 years underwent right-lateral mammography, overweight/obese were 49.2%, 77.9% were married, 11.7% were classified into BI-RADS category of 0, and 9.9% were classified of BI-RADS categories 4 and 5 (Table 1).

### 3.2 Description of the Bi-RADS categories associated with age, BMI, and marital status

The association of BI-RADS categories with age, BMI classification, and marital status in women who underwent mammography are presented in Table 2. The proportion of

women with a BI-RADS category 0 decreased with increasing age in the bilateral mammography data; on the contrary, as the age increased, the proportion of those with BI-RADS categories 4 and 5 increased and showed statistically significant differences ( $p < 0.05$ ). Marital status also showed a statistically significant association with the BI-RADS categories ( $p < 0.05$ ). The

proportion of those with BI-RADS categories 4 and 5 was the highest among women with other marital status (separated/divorced/widowed) than married and unmarried women. In bilateral mammography, data showed that the proportion of BI-RADS categories 4 and 5 of overweight/obese women were higher than underweight and normal-weight women. However, BMI was not associated with the BI-RADS categories.

The results of univariate- and multivariate- multinomial logistic regression analysis of the association of age, BMI, and marital status with BI-RADS categories are shown in Table 3. Women aged <45 years who underwent mammography were associated with the BI-RADS category 0, the adjusted OR (aOR) was 1.47 [95% confidence interval (CI) = 1.06–2.04] in left-lateral mammography and aOR in right-lateral mammography was 1.46 (95% CI = 1.05–2.03).

In the analysis of left-lateral mammography data, age >69 years (aOR = 1.34, 95% CI = 1.04–1.73), being overweight/obese (aOR = 1.26, 95% CI = 1.02–1.55), and being other marital status (aOR = 1.45, 95% CI = 1.10–1.91) were the factors associated with BI-RADS categories 4 and 5. However, only other marital status (aOR = 1.37, 95% CI = 1.04–1.80) were associated with BI-RADS categories 4 and 5 in right-lateral mammography data.

## 4 Discussion

In our study, the proportion of those with a BI-RADS category 0 was over 10%, and it decreased with age. The mammography of women classified into the BI-RADS category 0 was recommended to combine ultrasound or other examinations to clarify the current status of the breast. More than a quarter of women with dense breasts were misdiagnosed during mammography owing to the masking of lesions (7). The breast density decreased with increasing age (8, 9). Young women, particularly Chinese

TABLE 1 Distribution of age, BMI, marital status, and BI-RADS categories of women who underwent mammography.

Variables	Left-lateral mammography ( <i>n</i> = 4,165)	Right-lateral mammography ( <i>n</i> = 4,213)
	<i>n</i> (%)	<i>n</i> (%)
<b>Age, years</b>		
<45	320 (7.7)	322 (7.6)
45–69	3,155 (75.8)	3,189 (75.7)
>69	690 (16.6)	702 (16.7)
<b>BMI classification</b>		
Underweight	153 (3.7)	163 (3.9)
Normal	1,990 (47.8)	1,978 (46.9)
Overweight/obese	2,022 (49.3)	2,072 (49.2)
<b>Marital status</b>		
Married	3,267 (78.4)	3,284 (77.9)
Unmarried	338 (8.1)	342 (8.1)
Others <sup>a</sup>	560 (13.5)	587 (14.0)
<b>BI-RADS category</b>		
0	498 (12.0)	492 (11.7)
1,2,3	3,242 (77.8)	3,305 (78.4)
4,5	425 (10.2)	416 (9.9)

<sup>a</sup>Including being widowed, separated and devided.

TABLE 2 BI-RADS categories associated with age, BMI, and marital status in women who underwent mammography.

Variables	Left-lateral BI-RADS ( <i>n</i> = 4,165)			Right-lateral BI-RADS ( <i>n</i> = 4,213)		
	0	1,2,3	4,5	0	1,2,3	4,5
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
<b>Age, years</b>						
<45	53 (16.6)	249 (77.8)	18 (5.6)	54 (16.8)	245 (76.1)	23 (7.1)
45–69	365 (11.6)	2,476 (78.5)	314 (10.0)	365 (11.4)	2,519 (79.0)	305 (9.6)
>69	80 (11.6)	517 (74.9)	93 (13.5)	73 (10.4)	541 (77.1)	88 (12.5)
<i>p</i> -value*	<0.001			0.002		
<b>BMI classification</b>						
Underweight	15 (9.8)	124 (81.0)	14 (9.2)	17 (10.4)	129 (79.1)	17 (10.4)
Normal	239 (12.0)	1,572 (79.0)	179 (9.0)	236 (11.9)	1,563 (79.0)	179 (9.0)
Overweight/obese	244 (12.1)	1,546 (76.5)	232 (11.5)	239 (11.5)	1,613 (77.8)	220 (10.6)
<i>p</i> -value*	0.096			0.537		
<b>Marital status</b>						
Married	379 (11.6)	2,575 (78.8)	313 (9.6)	378 (11.5)	2,603 (79.3)	303 (9.2)
Unmarried	43 (12.7)	260 (76.9)	35 (10.4)	49 (14.3)	255 (74.6)	38 (11.1)
Others <sup>a</sup>	76 (13.6)	407 (72.7)	77 (13.8)	65 (11.1)	447 (76.1)	75 (12.8)
<i>p</i> -value*	0.016			0.032		

<sup>a</sup>including being widowed, separated and devided.

\*Chi-square test.

TABLE 3 Multinomial logistic regression analysis of age, BMI, and marital status associated with BI-RADS categories.

Variables	BI-RADS			BI-RADS		
	0	1,2,3	4,5	0	1,2,3	4,5
	Odds ratios (95% CI)			Adjusted odds ratios (95% CI) <sup>a</sup>		
Left-lateral mammography (n = 4,165)						
Age, years						
<45	1.44 (1.05–1.98)	Ref	0.57 (0.35–0.93)	1.47 (1.06–2.04)	Ref	0.55 (0.33–0.92)
45–69	Ref	Ref	Ref	Ref	Ref	Ref
>69	1.05 (0.81–1.36)	Ref	1.42 (1.11–1.82)	1.01 (0.78–1.32)	Ref	1.34 (1.04–1.73)
BMI classification						
Underweight	0.80 (0.46–1.38)	Ref	0.99 (0.56–1.76)	0.78 (0.45–1.36)	Ref	0.99 (0.56–1.76)
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Overweight/obese	1.04 (0.86–1.26)	Ref	1.32 (1.07–1.62)	1.05 (0.86–1.27)	Ref	1.26 (1.02–1.55)
Marital status						
Married	Ref	Ref	Ref	Ref	Ref	Ref
Unmarried	1.12 (0.80–1.58)	Ref	1.11 (0.76–1.61)	1.03 (0.72–1.46)	Ref	1.35 (0.92–1.98)
Others <sup>b</sup>	1.27 (0.97–1.66)	Ref	1.56 (1.19–2.04)	1.27 (0.97–1.66)	Ref	1.45 (1.10–1.91)
Right-lateral mammography (n = 4,213)						
Age, years						
<45	1.52 (1.11–2.08)	Ref	0.78 (0.50–1.21)	1.46 (1.05–2.03)	Ref	0.72 (0.46–1.14)
45–69	Ref	Ref	Ref	Ref	Ref	Ref
>69	0.93 (0.71–1.22)	Ref	1.34 (1.04–1.73)	0.94 (0.71–1.23)	Ref	1.29 (0.99–1.67)
BMI classification						
Underweight	0.87 (0.51–1.47)	Ref	1.15 (0.68–1.95)	0.85 (0.50–1.44)	Ref	1.15 (0.68–1.95)
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Overweight/obese	0.98 (0.81–1.19)	Ref	1.19 (0.97–1.47)	1.01 (0.83–1.23)	Ref	1.15 (0.93–1.43)
Marital status						
Married	Ref	Ref	Ref	Ref	Ref	Ref
Unmarried	1.32 (0.96–1.83)	Ref	1.28 (0.89–1.84)	1.19 (0.85–1.67)	Ref	1.44 (0.99–2.10)
Others <sup>b</sup>	1.00 (0.76–1.33)	Ref	1.44 (1.10–1.89)	1.01 (0.76–1.35)	Ref	1.37 (1.04–1.80)

<sup>a</sup>Model included age, BMI classification, and material status.

<sup>b</sup>Including being widowed, separated and devoiced.

women, have dense breasts, which may lead to misclassifications in mammography (9). As people age, breast density decreases, and breast abnormalities become easier to detect through mammography. Carney et al. found the sensitivity of mammography from 68.6% in women aged 40–44 years increased to 83.3% in women aged 80–89 years (6).

Age was positively associated with the proportion of BI-RADS categories 4 and 5. This result was similar to a five-year community-based breast cancer screening results in Turkey (18). The mammography of women classified into the BI-RADS category 4 and 5 were advised to undergo tissue diagnosis, that is, biopsy. Compared with women aged 45 to 69 years, the ORs of breast biopsy among women aged >69 years were 1.42 and 1.34 for left- and right-lateral breasts, respectively. Noonpradej et al. found that positive predictive rate of breast cancer increased with age of women with BI-RADS category 4 (19).

Checka et al. found that more than 35% of women aged over 70 years still had dense breasts (8). Women aged 70–84 years had a higher risk (OR = 1.31) of diagnosis of breast cancer at a later stage than women in screening ages (50–69 years) in Swiss (15). Women older than 69 years, no longer eligible for free mammography programs provided by the government may experience delays in seeking medical services. Besides, according

to the Nutrition and Health Survey in Taiwan from 2017 to 2020, the overweight and obesity rate was approximately 42.8% in women aged over 18 years and the rate increased with age in Taiwan (20). Obesity was mentioned as a risk factor for postmenopausal breast cancer (10–12). This implied that women aged >69 years may have a higher likelihood of receiving mammography results in BI-RADS categories 4 and 5.

In the current study, being overweight/obese was associated with BI-RADS categories 4 and 5 in the left-lateral mammography data analysis. In the right-lateral mammography data analyzed, the ORs of overweight/obese women showed little higher values than that of the normal-weight women, however, without statistical significance. The asymmetry of bilateral breast may cause this result. Abdou et al. (2022) found compared with right-lateral breast, several cell proliferation gene sets more enriched on the left-lateral breast (21). Women who underwent mammography and were classified as BI-RADS categories 4 and 5 were recommended further biopsy to have tissue diagnosis.

Obesity was reported to be associated with breast cancer (10–12, 22). A US follow-up study of postmenopausal women found that the risk of invasive breast cancer increased with increasing Body Mass Index (BMI) (10). A Singapore study found that the attributable risk proportion of breast cancer associated

with BMI was 16.2%; women with a breast density <12% and maintaining a BMI <25 kg/m<sup>2</sup> could decrease the breast cancer rate by 45.9% (22). Overweight and obese women who underwent mammography and were classified into BI-RADS categories 4 and 5 should follow the doctor's recommendation for further biopsy or combining other examinations to determine whether they have breast cancer and receive treatment as soon as possible.

Being separated/divorced/widowed was associated with the BI-RADS categories 4 and 5 in our study. Compared with married women, widows and separated or divorced women might have less financial and emotional support, which may result in them neglecting their physical health. In a previous study, married women were more willing to undergo mammography than women without a partner or those living alone (13). A Swiss population-based study showed that single/widowed/divorced women had a higher probability of being diagnosed with breast cancer at a later stage than married women (15). Duijts et al. found that the death of a spouse was associated with breast cancer. In addition, widows and separated or divorced women might experience more life stress than married women (14). Such stress may affect their immune system and, subsequently, breast health. Lawrence et al. (2023) found that life stress was associated with estrogen receptor-negative breast cancer (23).

To the best of our knowledge, few studies have investigated the factors associated with the BI-RADS categories in women through mammography data analysis. Our study provides valuable information that may help women aged >69 years, who are separated/divorced/widowed, or who are overweight and obese to be concerned about their breast health.

## 5 Conclusions

This study highlighted that women aged >69 years, and being overweight/ obese, being widowed/ separated/ divorced were the factors associated with the BI-RADS categories 4 and 5 (needing further tissue diagnosis, that is, biopsy) through mammography. Nowadays, with the life expectancy increasing, even women over 69 should be concerned about their breast health and have regular mammography for early detection and early treatment.

## 6 Limitations

This study had few limitations. Retrospective mammography data and medical records were used in this study; limited by the data, only a few confirmed variables could be analyzed. Otherwise, the mammography data were interpreted. Although hospital radiologists receive regular professional training, there is still a possibility of misclassification.

## Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: We use de-identified mammography data in

this paper; however, the data belongs to E-Da medical system and application is required. Requests to access these datasets should be directed to kimi@isu.edu.tw.

## Ethics statement

The studies involving humans were approved by the Research Ethics Committee of E-Da Hospital (EMRP-111-009). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

## Author contributions

W-MC: Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing. Y-CC: Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing. I-CL: Formal analysis, Methodology, Resources, Writing – original draft. J-LC: Conceptualization, Methodology, Writing – original draft. H-YC: Methodology, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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