HEALTH PROMOTION

Predictive factors of breast cancer mammography screening among Iranian women

SAHAR MOHAMMADNABIZADEH[1], EHSAN MOSA FARKHANI[2], NASRIN TALKHI[3]
[1] Social Determinants of Health Research Center, Mashhad University of Medical Sciences, Mashhad, Iran;
[2] Department of Epidemiology and Biostatistics, School of Health, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran; [3] Department of Biostatistics, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran

Keywords

Breast cancer • Mammography • Lifestyle • Predictors

Summary

Introduction. *Understanding the factors that influence women's cancer screening behavior is crucial in reducing cancer mortality through early detection. Therefore, the objective of this study was to examine the status of mammography and related factors among women who presented to the health centers of Khorasan Razavi province, Iran.*

Methods. *For this study, a sample of 251,011 women who visited healthcare centers affiliated with Mashhad University of Medical Sciences was selected. The study examined several variables, including sociodemographic information, current smoking, nutrition status, and physical exercise. All analyses were performed using Python programming language and SPSS software. Furthermore, to handle imbalanced data, we used SMOTE balancing method that is an oversampling method and produce synthetic samples from the minority class.*

Results. *The factors of age, education, being employed, having children, family history of cancer, physical activity, smoking status, and diet were all predictors of mammography screening. Moreover, findings showed that age and family history of breast cancer were most important variables to predict mammography status, respectively.*

Conclusions. *By examining various variables such as dietary habits, exercise, smoking, and demographic properties, it sheds light on the relationships between these factors and mammography screening. This provides valuable insights into the associations between breast cancer screening behavior and preventive lifestyle behaviors. By targeting both preventive lifestyle choices and breast cancer screening behaviors, interventions can effectively promote positive changes in behavior and ultimately reduce the incidence and impact of breast cancer.*

Introduction

Breast cancer is a significant health concern globally, ranking as the second leading cause of death after cardiovascular disease [1]. In Iran, the incidence of breast cancer has shown an upward trend according to national cancer registry reports from 2003 to 2017, affecting both women and men. The age-specific incidence rates of breast cancer among women were 15.96 per 100,000 in 2003 and increased to 40.72 per 100,000 in 2017 [2]. Unfortunately, the findings also indicate that Iranian women have low awareness of breast cancer preventive behaviors. Additionally, the utilization of screening methods such as self-examination, clinical examination, and mammography is also low [3].

Early detection plays a crucial role in reducing both the mortality and morbidity associated with cancer. Cancer screening techniques, such as mammography, have proven to be effective in identifying breast cancer at an early stage. Without early diagnosis, the costs of treatment tend to increase, resources may not be utilized efficiently, and the need for supportive services may rise [3]. Study conducted by Uhachi et al. have specifically examined the rate of early detection of breast cancer using screening accompanied by mammography. Their findings indicated that with screening accompanied by mammography, a higher number of breast cancers can be identified and detected compared to screening without mammography [4]. These results highlight the importance of incorporating mammography into breast cancer screening programs to enhance the effectiveness of early detection efforts.

Previous studies have highlighted that screening behavior for breast cancer is influenced by various factors within social environments. These factors include age, income, marital status, education, screening service delivery, perception of disease risk, cultural barriers, and physician's recommendation [5, 6]. Furthermore, there is substantial evidence indicating that lifestyle and health behaviors, such as cigarette smoking, diet, exercise, and mental well-being, play a significant role in the development of breast cancer and the likelihood of undergoing screening tests. Women who maintain a healthy lifestyle throughout their lives are more likely to regularly participate in screening tests [7]. Therefore, it is crucial to enhance our understanding of the factors associated with consistent mammography screening, particularly those related to lifestyle and health promotion. In this regard, in addition to examining sociodemographic factors, we assessed certain lifestyle factors, including smoking status, physical activity, and attention to diet, which may impact participation in mammography screening.

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Increasing public awareness about the risk factors associated with breast cancer is indeed crucial, considering the low awareness among women. It is important to educate women about these risk factors to empower them to take proactive measures for early detection and prevention [8]. Studies conducted in Iran have shown that women often delay seeking medical attention for breast cancer diagnosis, leading to a decreased chance of survival. This emphasizes the need for timely detection and intervention to improve outcomes [9]. Therefore, the objective of this study was to examine the status of mammography and related factors among women who presented to the health centers of Khorasan Razavi province, Iran. By understanding the current situation and associated factors of mammography utilization, appropriate interventions can be developed to improve screening rates and ultimately enhance breast cancer outcomes in the region.

Methods

This cross-sectional descriptive study, conducted in 2023, focused on women who sought healthcare services in the health centers of Razavi Khorasan province of Iran. The data for this study was obtained from the Sina electronic health record system database, which is supervised by Mashhad University of Medical Sciences. Since 2015, the Sina system has been utilized in Razavi Khorasan Province to electronically register health records of clients in the province's health centers. The system contains various information, including demographic data, individual health records, reports from doctors and healthcare providers, as well as screening and care forms for different age groups.

For this study, a sample of 251,011 women who visited healthcare centers affiliated with Mashhad University of Medical Sciences was selected. The study examined several variables, including sociodemographic information such as age, educational level, marital status, employment status, family history of cancer, and whether they had children. Furthermore, to assess lifestyle behaviors, several factors were taken into account, including current smoking (yes or no), nutrition status (desirable or undesirable), and physical exercise (desirable or undesirable). Leisure-time physical activity was measured using the International Physical Activity Questionnaire [10]. Participants who reported engaging in at least 150 minutes of walking or moderate physical activity per week, or at least 60 minutes of strenuous physical activity per week, were classified as physically active (desirable). On the other hand, those who reported less than 150 minutes of walking or moderate physical activity per week, or less than 60 minutes of strenuous physical activity per week, were considered physically inactive (undesirable). Regarding nutrition status, the study examined the desirable and undesirable rankings of three food groups: dairy products, vegetables and fruits, and fast food. The desirable consumption of each food group, including dairy products, fruits, and vegetables, was defined as consuming 3-2 units per day. On the other hand, the undesirable definition of nutrition was consuming less than 3-2 units of dairy products, fruits, and vegetables daily. As for fast food, consuming it rarely or never was considered desirable, while consuming it more than twice a month was considered undesirable.

The dependent variable was whether or not individuals had undergone a mammography test within the last three years. This variable was used to assess the frequency of mammography screenings among the study participants.

Data analysis

All analyses in this study were performed using Python programming language version 3.0 and SPSS software version 25. To check the normality assumption of age, the Kolmogorov–Smirnov test was used. Initial association between independent variables and outcome was studied using Chi-square statistical test. Before model building, data were preprocessed and a comprehensive review of the data was done. After removing inaccurate, irrelevant, missing, and incomplete data, a complete dataset with 9 variables and 251,011 instances remained. Furthermore, to handle imbalanced data, we used SMOTE (Synthetic Minority Over-sampling Technique) balancing method that is an oversampling method and produce synthetic samples from the minority class [11].

Modeling

To model data, two machine learning techniques including binary logistic regression and binary decision tree were used as classifier to perform the classification task. Logistic regression is a widely statistical method in the medical researches. The popularity of the LR model compared to other methods among medical researchers is that the exponentiated slope coefficient in the LR model can be interpreted as an odds ratio (OR) [12, 13]. Decision tree algorithm are non-parametric and non-linear methods. On the other hand, these used in the most fields, especially medical sciences which applies to classification problems (binary or multiple outcomes) as well as the regression problems [14-16]. To predict the outcome, predictors in each nodes are split into hierarchical nodes based on the entropy or Gini impurity indices [17]. One of the reasons for the popularity of the decision tree among doctors and decision makers is the simple interpretability of it [14].

Parameter estimation techniques

The K-fold cross-validation (CV) procedure was used to estimate the optimal hyper parameters with respect to that this procedure provides almost unbiased estimates. The K-fold CV approaches were combined with grid search method to set the best model hyper-parameters and evaluate the performance of model on training and test dataset as well.

There are some hyper parameters in decision tree that must be tuned. The max_depth that refers to the maximum depth of the tree, Gini index/entropy/ information gain as a criterion for measuring impurity of

Tab. I. Description of demographics and clinical characteristics

Attribute	Level	Mammography-	Mammography+	Effect size/Phi coefficient (p value)
Age	-	45.0 (14.0)*	52.0 (11.0)*	0.065 (< 0.001)
Having a child	No	14,009(5.6)	375 (0.1)	0.023 (< 0.001)
	Yes	225,686 (89.9)	10,941 (4.4)	
Family history of breast cancer	No	231,682 (92.3)	9,832 (3.9)	0.106 (< 0.001)
	Yes	8,013 (3.2)	1,484 (0.6)	
Smoking	No	220,150 (87.7)	10,468 (4.2)	-0.005 (0.012)
	Yes	19,545 (7.8)	848 (0.3)	
Dietary	Desirable	221,397 (88.5)	10,650 (4.3)	-0.015 (< 0.001)
	Undesirable	17,637 (7.0)	623 (0.2)	
Physical Activity	Desirable	124,665 (49.7)	5,470 (2.2)	0.015 (0.023)
	Undesirable	115,030 (45.8)	5,846 (2.3)	
Marriage	Single	1,350 (0.5)	32 (0.0)	0.008 (0.001)
	Married	214,883 (85.6)	10,151 (4.0)	
	Widow	15,023 (6.0)	710 (0.3)	
	Divorced	8,439 (3.4)	423 (0.2)	
Occupation	Unemployed	220,345 (87.8)	9,644 (3.8)	0.050 (< 0.001)
	Employed	19,350 (7.7)	1,672 (0.7)	
Education	Not having a university education	209,543 (83.5)	9,019 (3.6)	0.048 (< 0.001)
	Having a university education	30,152 (12.0)	2,297 (0.9)	

Data were reported as N (%) and * referred to median (Interquartile range).
Mann-Whitney U test and Chi-square test were used. Phi coefficient was computed for Chi-square tests.

a node, min_samples_split, and min_samples_leaf refers to the minimum number of samples required to split an internal node and the minimum number of samples required to be at a leaf node, respectively.

Model evaluation

To assess the classifiers' performance, some evaluation criteria are essential, such as sensitivity, specificity, and accuracy with the following formulas:

Sensitivity = $\frac{TP}{TP + FN}$	Specificity = $\frac{TN}{TN + FP}$	Accuracy = $\frac{TP + TN}{TP + TN + FP + FN}$

TP, FN, FP, and TN are True Positive, False Negative, False Positive, and True Negative, respectively [18-20]. In addition, another important criterion is the Area Under the Curve (AUC) of the Receiver Characteristic Operator (ROC) that measures the ability of a classifier to classify between classes [21].

Results

A total of 251,011 records were analyzed. In this sample, 239,695 (95.5%) of the subjects do not get mammography done and 11,316 (4.5%) get mammography done. We denote visiting and not visiting for mammography with mammographyì+ and mammography-, respectively. The average age ± standard deviation in mammography groups was 51.47 ± 7.44 years and 46.25 ± 8.98 years in mammography- group. Further information regarding the research variables has been detailed in Table I. The Kolmogorov–Smirnov test was showed that the age variable was not distributed as normal in both Mammography+ and - groups. To assess the initial association of mammography status with independent variables, Mann-Whitney U and Chi-square test showed a statistically significant association. Furthermore, we reported the effect size for Mann-Whitney U and Phi coefficient for Chi-square test to show intensity of associations.

The logistic regression was fitted using backward elimination approach and the associated factors were showed in Table II. According Table II, individuals with family history of breast cancer had the highest effect in classifying the mammography status with an OR equal to 4.454 [CI: 4.189, 4.736]. After that having a university education had high OR equal to 2.338 [2.201, 2.484] and placed in the second rank in terms of effectiveness. Other factors such as age, having at least one child, occupation had a similar OR (almost the same effect) between OR minimum value = 1.082 and OR maximum value = 1.441. Furthermore, others had a protective effect with an OR less than one according to Table II. The only factor of marriage did not have a significant effect in predicting mammography status. The crude OR was showed in Table II, too. The crude OR refers to the presence of the desired variable alone in the model.

In the second step, we trained the decision tree and logistic regression models. To found the optimum value of hyper parameters and evaluate the model's performance 5-fold CV method was applied. During the optimization process, we found the entropy impurity

Tab. II. The associated factors with mammography status using Backward logistic regression.

Variable	Crude model	Full model		
	OR (95% CI)	p value	OR (95% CI)	p value
Age	1.065 (1.063,1.068)	< 0.001	1.082 (1.079, 1.085)	< 0.001
Family history of breast cancer				
No	Ref.		Ref.	< 0.001
Yes	4.364 (4.11, 4.62)	< 0.001	4.454 (4.189, 4.736)	
Smoking				
No	Ref.		Ref.	0.042
Yes	0.912 (0.85, 0.98)	0.012	0.927 (0.861, 0.997)	
Dietary				
Favorable	Ref.		Ref.	< 0.001
Unfavorable	0.734 (0.676, 0.797)	< 0.001	0.794 (0.730, 0.864)	
Physical Activity				
Unfavorable	Ref.		Ref.	< 0.001
Favorable	0.863 (0.831, 0.897)	< 0.001	0.882 (0.848, 0.916)	
Having a child				
No	Ref.		Ref.	< 0.001
Yes	1.811 (1.63, 2.01)	< 0.001	1.403 (1.258, 1.565)	
Marriage				
Single	Ref.		Ref.	
Married	0.502 (0.353, 0.713)	< 0.001	0.833 (0.572, 1.214)	0.342
Widow	1.00 (0.926, 1.081)	0.991	1.431 (0.978, 2.093)	0.065
Divorced	1.061 (0.960, 1.172)	0.244	1.353 (0.935, 1.956)	0.108
Occupation				
Unemployed	Ref.		Ref.	
Employed	1.974 (1.87, 2.084)	< 0.001	1.441 (1.350, 1.539)	< 0.001
Education				
Under university	Ref.		Ref.	
University	1.770 (1.688, 1.856)	< 0.001	2.338 (2.201, 2.484)	< 0.001

criterion, max_depth = 4, min_samples_split = 60, and min_samples_leaf = 30 as the optimal hyper parameters and decision tree was optimized.

The results of model's performance have been reported in Table III. Performance metrics were showed the decision tree outperformed compared to logistic regression in both train and test phases. The accuracy values on training and testing data for decision tree (logistic regression) were 76.95% and 76.80% (75.95% and 71.15%), respectively. The sensitivity, specificity, and AUC were 70.50, 73.50, and 71.12 for decision tree on the unseen data or test dataset, respectively. On the other hand, logistic regression had sensitivity = 65.45%, Specificity = 71.42%, and AUC = 69.40% on the test dataset. Therefore, decision tree classifier compared to logistic regression can predicts mammography status accurately.

The trained decision tree was led to 16 rules. Extracted rules are expressed as if-then rules for predicting the positive class (mammography+) and negative class (mammography-) according to Table IV. As well, we have shown the feature importance bar plot (blue horizontal bars) in the construction of the tree in the background of Table IV. This plot is showed that age, family history of breast cancer, education, and dietary status were most important variables to predict mammography status, respectively.

Rule 9 are showed that you might observe that patients who are older than 44.5 and also have university education and age more than 48.5 years, and having favorable life style are more likely to refer for doing mammography test (percent of probe = 86.84%).

In another subgroup, we can see, if the age is older than 44.5 and individuals have under university education,

Tab. III. The model's performance evaluation using 5-fold CV

Index	Decision tree		Logistic regression	
	Train	Test	Train	Test
Accuracy	76.95 ± 0.042	76.80 ± 0.061	75.95 ± 0.052	71.15 ± 0.067
Sensitivity	76.31 ± 0.046	70.50 ± 0.057	75.85 ± 0.050	65.45 ± 0.058
Specificity	77.59 ± 0.052	73.50 ± 0.068	76.05 ± 0.044	71.42 ± 0.063
AUC	82.10 ± 0.048	71.12 ± 0.059	80.20 ± 0.049	69.40 ± 0.069

Indices was reported as mean ± standard deviation.

Tab. IV. The 16 rules extracted from the trained decision tree model.

Rule	If (A sequence of attributes)	Then class is:	Probe (%)
1	if (age > 44.5) and (Education = under university) and (family history of breast cancer = no) and (age > 49.5)	+	58.51
2	if (age > 44.5) and (education = under university) and (family history of breast cancer = no) and (age ≤ 49.5)	-	51.32
3	if (age ≤ 44.5) and (age <= 39.5) and (family history of breast cancer = no) and (age > 34.5)	-	80.36
4	if (age ≤ 44.5) and (age > 39.5) and (family history of breast cancer = no) and (education = under university)	-	69.63
5	if (age > 44.5) and (education = university) and (age > 48.5) and (dietary = favorable)	+	86.84
6	if (age > 44.5) and (education = under university) and (family history of breast cancer = yes) and (Marriage = widow)	+	85.65
7	if (age ≤ 44.5) and (age ≤ 39.5) and (family history of breast cancer = no) and (age ≤ 34.5)	-	89.78
8	if (age ≤ 44.5) and (age > 39.5) and (family history of breast cancer = no) and (education = university)	-	51.60
9	if (age > 44.5) and (education = university) and (age <= 48.5) and (dietary = favorable)	+	73.36
10	if (age ≤ 44.5) and (age > 39.5) and (family history of breast cancer = yes) and (dietary = favorable)	+	74.26
11	if (age ≤ 44.5) and (age ≤ 39.5) and (family history of breast cancer = yes) and (age > 36.5)	+	52.38
12	if (age ≤ 44.5) and (age ≤ 39.5) and (family history of breast cancer = yes) and (age ≤ 36.5)	-	69.06
13	if (age > 44.5) and (education = under university) and (family history of breast cancer = yes) and (marriage = single or married or widow)	+	64.24
14	if (age > 44.5) and (education = university) and (age > 48.5) and (dietary = unfavorable)	+	57.51
15	if (age ≤ 44.5) and (age > 39.5) and (family history of breast cancer = no) and (dietary = unfavorable)	-	67.27
16	if (age > 44.5) and (education = university) and (age ≤ 48.5) and (dietary = unfavorable)	-	71.64

and have a positive family history of breast cancer and also being widow then chance of reference for doing mammography is 85.65%. Other rules are detailed in Table IV.

Discussion

Understanding the factors that influence women's cancer screening behavior is crucial in reducing cancer mortality through early detection. By gaining a comprehensive understanding of these factors, we can develop more effective interventions that encourage women to choose to undergo cancer screening. The objective of this study was to examine the current status of mammography screening and identify the factors that are associated with it among women.

In the current study, we found a positive significant relationship between age and having mammography. The risk of developing breast cancer increases with age. As women get older, their chances of developing breast cancer also increase, which makes regular mammograms more important for early detection and treatment; and the findings obtained in this study can be due to the above. Moreover, with advancing age, individuals tend to become more conscious of their health and take proactive measures to prevent diseases. Older women may prioritize their health and recognize the significance of mammograms as a preventive measure. Also, menopause and hormonal changes at older ages, which can increase the risk of breast cancer, may be another reason that makes older women more eager and sensitive to mammography. Studies dealing with woman's cancer screening behaviors have demonstrated that screening behavior is affected by age [22]. In the study of Ricardo-Rodrigues et al., age was found to be a strong predictor of breast cancer screening uptake. In this study, regarding mammography, uptake was found to increase with age up to 69 years [23]. In the study of Sun et al., age was positively associated with screening attendance, too [6]. Despite the variability in findings regarding age and breast cancer screening, it is important to recognize that women aged 65 or older are still at risk of developing breast cancer, as incidence and mortality rates increase with age. Breast cancer incidence rates begin to rise after the age of 40 and are highest in women over the age of 70 [24]. Therefore, it is crucial to encourage cancer screening in high-risk groups, and specifically, to promote breast cancer screening among elderly women.

The findings of the current study indicated no significant association between marital status and the mammography for breast cancer screening. While there is limited evidence on the impact of marital status on cancer screening [6, 23], previous studies have shown similar trends. For example, no association was observed between marital status and the mammography screening for Hispanics women in the study done by Borrayo et al. [25]. Another study also did not find any link between marital status and attendance for mammography [26]. It should also be noted that emotional support, which is often present in marital relationships, has been identified as a factor that promotes healthy behaviors and may increases adherence to cancer screening [27]. On the other hand, it is concerning to note that non-married women are at a greater risk of breast cancer, as highlighted by a recent systematic review [28]. Since Iranian women did not perform mammography regularly, so results of studies are not comparable. To gain a comprehensive understanding of the impact of marital status on breast cancer screening, future studies should prioritize longitudinal analyses, focus on high-risk groups, and explore how this factor may shape healthcare utilization and screening practices.

The current study suggested that higher levels of education were associated with a greater likelihood of compliance with mammography screening. Women with higher education levels may have easier access to opportunistic cancer screening programs like mammography. This could be due to their increased awareness of their health conditions and the importance of preventive measures [29]. In a study by Ricardo-Rodrigues et al., it was found that women with higher education levels, particularly those who had completed university, were more likely to undergo mammography [23]. A systematic review conducted by Islam et al., identified education level as one of the variables that facilitated breast cancer screening uptake in women [30]. However, it is worth noting that some studies, such as Sun et al. [6] and Charkhchi's research [31], reported no significant relationship between education level and screening uptake. Further research is needed to better understand the mechanisms through which education level influences screening uptake.

The results of the current study indicated that being employed was a statistically significant positive predictor of adherence to mammography screening. A study conducted by Sun et al. focusing on breast cancer screening adherence among Chinese women found that employed women were more likely to participate in screening compared to those who were unemployed or out of work [6]. Similarly, Charkhchi's study revealed that being employed significantly increased breast screening adherence [31]. Financial independence in employed women can be a reason for doing more mammography in this group. Furthermore, this may be attributed to the fact that women with employment have greater access to information and knowledge about screening through interactions with colleagues and more opportunities for physical examinations organized by their workplace. Women in professional occupations are often more aware of their health conditions and the importance of preventive measures [8].

The current study suggested that having children was associated with a higher likelihood of compliance with mammography. Studies conducted by Sun et al. [6] and Leinonen [32] found that having children was significantly linked to screening attendance. The presence of childcare responsibilities among women with children may contribute to their heightened health awareness and engagement in preventive health behaviors [6]. Therefore, it is crucial to strengthen advocacy and education efforts regarding breast cancer screening for women without children. However, it is worth noting that a few studies, such as the one conducted by Farshbaf et al. [33], have reported contrasting results. This suggests that the relationship between breast cancer screening and the number of children may be influenced by various factors that require further investigation in the future.

The findings of this study indicated that women with a family history of cancer were more likely to undergo mammography screening tests. This aligns with the observations made in Oran et al.'s study, where academicians who reported a family history of cancer were more inclined to have mammography tests done [34]. In Bahrami et al.'s study, which surveyed the prevalence of breast cancer screening behavior and related factors, it was found that the family history of cancer was among the significant factors affecting screening tests [35]. These findings highlight the importance of family history in influencing women's awareness and participation in breast cancer screening. Having a family history of cancer can serve as a motivating factor for women to prioritize and engage in regular screening tests.

The findings of the study indicated that there were high rates of mammography screening among women with insufficient physical activity. This finding contrasts with previous research that has shown a positive relationship between physical activity and mammography screening [36, 37]. Limited evidence suggests that women who engage in less physical activity are more likely to have undergone mammograms. For instance, a study by Ng'ang'a found high screening rates among individuals with insufficient physical activity [38]. Another study by Spongier and Konen found a negative correlation between exercise and screening mammography [39]. The inverse relationship between exercise and screening mammography is puzzling and could be attributed to various factors such as differences in sample size, the population under study, and the measurement method used. It is also possible that women who exercise regularly may be healthier overall, have fewer encounters with the healthcare system, and therefore may be less likely to be referred for annual screening mammography. Another factor that may have influenced these results is the method used to collect information on physical activity, which relied on self-report questionnaires. It is important to note that self-report measures of physical activity have been found to vary in accuracy, leading to both under- and over-estimation of physical activity levels. A recent meta-analysis highlighted the differences in accuracy among self-report measures [40]. Moreover, high screening rates have been observed among women who engage in little physical activity, suggesting that primary prevention programs should target all populations, including those with healthy habits, rather than solely focusing on individuals with unhealthier lifestyles. Therefore, it is crucial to address this factor in health promotion programs and interventions, particularly in the context of breast cancer prevention among women.

The current study indicated that being a smoker was associated with lower odds of undergoing mammography screening. This aligns with the findings of several other studies, which have consistently reported lower rates of mammography screening among cigarette smokers compared to non-smokers [41, 42]. For example, study conducted by Byrne et al. found a significant association between smoking status and both the likelihood of ever having received a specific screening test and compliance with national screening guidelines for breast cancer [43]. These findings suggest that smokers, in general, may

be less compliant with preventive care measures, more inclined to take risks, and more likely to underestimate the health risks associated with smoking, such as cancer. It is important to note that these observations are based on the available research and may not apply to every individual.

In this study, it appeared that there were high rates of mammography screening among women who have a desirable diet. While there have been limited studies on the relationship between diet and mammography screening. For example, in a study conducted by Richard et al., it was observed that individuals who did not pay attention to their diet participated significantly less in screening [44]. Generally, women with unhealthy behaviors, such as an improper diet, may have lower health consciousness compared to individuals with healthier habits. As a result, they may be less likely to adhere to regular cancer screening [45]. These mentioned findings indicate that encouraging women to prioritize regular mammography screening may be influenced by promoting healthy behaviors, such as maintaining a proper diet.

It is important to acknowledge the limitations of this study to ensure a comprehensive understanding of the findings. The cross-sectional design of the study prevents us from establishing causality between the identified associations. Additionally, the use of secondary data restricts the analysis to variables available in the datasets, potentially missing important factors such as women's knowledge and attitude towards preventive services, which could have provided a more detailed understanding of the associations. It is worth noting that factors such as lack of knowledge, low motivation, cultural or cognitive beliefs, attitudes, self-efficacy, and fear of tests are known to influence cancer screening behaviors in women [46]. Therefore, examining these factors alongside other variables would have provided a more comprehensive analysis. Furthermore, caution should be exercised when comparing uptake data from different sources and countries, as variations in screening programs and target populations can affect the results. To improve breast cancer screening behaviors among women, it may be necessary to consider interpersonal and community factors in addition to individual factors. This broader approach can help identify additional correlates of prevention behaviors and contribute to more effective strategies for promoting breast cancer prevention.

Indeed, this study has its strengths, particularly in its population-based sample size of 251,011 women. By examining various variables such as dietary habits, exercise, smoking, and demographic properties, it sheds light on the relationships between these factors and mammography screening. This provides valuable insights into the associations between breast cancer screening behavior and preventive lifestyle behaviors. By targeting both preventive lifestyle choices and breast cancer screening behaviors, interventions can effectively promote positive changes in behavior and ultimately reduce the incidence and impact of breast cancer.

Conclusions

Understanding the factors that influence women's cancer screening behavior is crucial in reducing cancer mortality through early detection. In the current study, the factors of age, higher education, being employed, having children, family history of cancer, physical activity, smoking status, and diet were all predictors of mammography screening. By examining various variables such as dietary habits, exercise, smoking, and demographic properties, it sheds light on the relationships between these factors and mammography screening. This provides valuable insights into the associations between breast cancer screening behavior and preventive lifestyle behaviors. By targeting both preventive lifestyle choices and breast cancer screening behaviors, interventions can effectively promote positive changes in behavior and ultimately reduce the incidence and impact of breast cancer.

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Conflict of interest statement

The authors declare that they have no conflicts of interest.

Authors' contributions

SM participated in the writing and design of the study, performed the statistical analysis and drafted the manuscript. EMF participated in the design of the study, and read the paper critically for theoretical content. NT participated in design of the study and statistical analysis.

References

[1] GBD 2015 Mortality and Causes of Death Collaborators. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016;388:1459-544. https://doi.org/10.1016/S0140-6736(16)31012-1

[2] Bener A, Barışık CC, Acar A, Özdenkaya Y. Assessment of the gail model in estimating the risk of breast cancer: effect of cancer worry and risk in healthy women. Asian Pac J Cancer Prev 2019;20:1765-71. https://doi.org/10.31557/APJCP.2019.20.6.1765

[3] Tahmasebi R, Noroozi A. Factors influencing breast cancer screening behavior among Iranian women. Asian Pac J Cancer Prev 2011;12:1239-44.

[4] Uchida K, Ohashi H, Kinoshita S, Nogi H, Kato K, Toriumi Y, Yamashita A, Kamio M, Mimoto R, Takeyama H. Breast cancer screening and the changing population pyramid of Japan.

Breast Cancer 2015;22:172-6. https://doi.org/10.1007/s12282-013-0470-6

[5] Cui Z, Kawasaki H, Tsunematsu M, Cui Y, Kakehashi M. Factors affecting the cervical cancer screening behaviors of Japanese women in their 20s and 30s using a health belief model: a cross-sectional study. Curr Oncol 2022;29:6287-302. https://doi.org/10.3390/curroncol29090494

[6] Sun Y, Ma Y, Cao M, Hu Z, Lin W, Chen M, He Y. Breast and cervical cancer screening adherence in Jiangsu, China: an ecological perspective. Front Public Health 2022;10:967495. https://doi.org/10.3389/fpubh.2022.967495

[7] Sarkeala T, Heinävaara S, Fredman J, Männistö S, Luoto R, Jäntti M, Malila N. Design and respondent selection of a population-based study on associations between breast cancer screening, lifestyle and quality of life. BMC Public Health 2015;15:1256. https://doi.org/10.1186/s12889-015-2603-7

[8] Bahmani F, Vakilian K, Faramarzi M. Effects of motivational interview on awareness, attitude, and practice of breast self-examination in high-risk women: a clinical trial study. Curr Womens Health Rev 2019;15:301-7. https://doi.org/10.2174/1573404815666190327171814

[9] Keshavarzi A, Asadi S, Asadollahi A, Mohammadkhah F, Khani Jeihooni A. Tendency to breast cancer screening among rural women in Southern Iran: a Structural Equation Modeling (SEM) analysis of theory of planned behavior. Breast Cancer (Auckl) 2022;16:11782234221121001. https://doi.org/10.1177/11782234221121001

[10] Hagströmer M, Oja P, Sjöström M. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. Public Health Nutr 2006;9:755-62. https://doi.org/10.1079/phn2005898

[11] Maldonado S, López J, Vairetti C. An alternative SMOTE oversampling strategy for high-dimensional datasets. Appl Soft Comput 2019;76:380-9. https://doi.org/10.1016/j.asoc.2018.12.024

[12] Schober P, Vetter TR. Logistic regression in medical research. Anesth Analg 2021;132:365. https://doi.org/10.1213/ANE.0000000000005247

[13] Bagley SC, White H, Golomb BA. Logistic regression in the medical literature: standards for use and reporting, with particular attention to one medical domain. J Clin Epidemiol 2001;54:979-85. https://doi.org/10.1016/s0895-4356(01)00372-9

[14] Yang L, Liu S, Tsoka S, Papageorgiou LG. A regression tree approach using mathematical programming. Expert Syst Appl 2017;78:347-57. https://doi.org/10.1016/j.eswa.2017.02.013

[15] Brownlee J. Classification And Regression Trees for Machine Learning Machine Learning Mastery. Available at: https://machinelearningmastery.com/classification-and-regression-trees-for-machine-learning/ (Accessed on: 10/09/2023).

[16] Tavakolian A, Farhanji M, Shapouran F, Zal A, Taheri Z, Ghobadi T, et al. Investigating the association of acute kidney injury (AKI) with COVID-19 mortality using data-mining scheme. Diagn Microbiol Infect Dis 2023;107:116026. https://doi.org/10.1016/j.diagmicrobio.2023.116026

[17] Saheb-Honar M, Dehaki MG, Kazemi-Galougahi MH, Soleiman-Meigooni S. A Comparison of three research methods: logistic regression, decision tree, and random forest to reveal association of type 2 diabetes with risk factors and classify subjects in a military population. J Arch Mil Med 2022;10:e118525. https://doi.org/10.5812/jamm-118525

[18] Nellore SB. Various performance measures in Binary classification - An overview of ROC study. Int J Innov Sci Eng Technol 2015;2:596-605.

[19] Tong Z, Liu Y, Ma H, Zhang J, Lin B, Bao X, et al. Development, validation and comparison of artificial neural network models and logistic regression models predicting survival of unresectable pancreatic cancer. Front Bioeng Biotechnol 2020;8:196. https://doi.org/10.3389/fbioe.2020.00196

[20] Fawcett T. An introduction to ROC analysis. Pattern Recognit Lett 2006;27:861-74. https://doi.org/10.1016/j.patrec.2005.10.010

[21] Bhandari A. AUC-ROC Curve in Machine Learning Clearly Explained Analytics Vidhya 2022. Available at: https://www.analyticsvidhya.com/blog/2020/06/auc-roc-curve-machine-learning/ (Accessed on: 10/09/2023).

[22] Ho V, Yamal JM, Atkinson EN, Basen-Engquist K, Tortolero-Luna G, Follen M. Predictors of breast and cervical screening in Vietnamese women in Harris County, Houston, Texas. Cancer Nurs 2005;28:119-29. https://doi.org/10.1097/00002820-200503000-00005

[23] Ricardo-Rodrigues I, Jiménez-García R, Hernández-Barrera V, Carrasco-Garrido P, Jiménez-Trujillo I, López de Andrés A. Social disparities in access to breast and cervical cancer screening by women living in Spain. Public Health 2015;129:881-8. https://doi.org/10.1016/j.puhe.2015.02.021

[24] Lee SY, Lee E, Natipagon-Shah B, Toyama J. Factors associated with breast cancer screening among Korean American women in California: results from the California Health Interview Survey 2015-2016. Asian Pac J Cancer Prev 2018;19:3271-7. https://doi.org/10.31557/APJCP.2018.19.11.3271

[25] Borrayo EA, Hines L, Byers T, Risendal B, Slattery ML, Sweeney C, Baumgartner KB, Giuliano A. Characteristics associated with mammography screening among both Hispanic and non-Hispanic white women. J Womens Health (Larchmt) 2009;18:1585-94. https://doi.org/10.1089/jwh.2008.1009

[26] Simon MS, Gimotty PA, Coombs J, McBride S, Moncrease A, Burack RC. Factors affecting participation in a mammography screening program among members of an Urban Detroit Health Maintenance Organization. Cancer Detect Prev 1998;22:30-8. https://doi.org/10.1046/j.1525-1500.1998.00009.x

[27] Blom J, Yin L, Lidén A, Dolk A, Jeppsson B, Påhlman L, et al. Toward understanding nonparticipation in sigmoidoscopy screening for colorectal cancer. Int J Cancer 2008;122:1618-23. https://doi.org/10.1002/ijc.23208

[28] M, Han M, Chen Z, Tang Y, Ma J, Zhang Z, Liu Z, Zhang N, Xi C, Liu J, Tian D, Wang X, Huang X, Chen J, Wang W, Zhai S. Does marital status correlate with the female breast cancer risk? A systematic review and meta-analysis of observational studies. PLoS One 2020;15:e0229899. https://doi.org/10.1371/journal.pone.0229899

[29] Ascunce N, Salas D, Zubizarreta R, Almazán R, Ibáñez J, Ederra M. Cancer screening in Spain. Ann Oncol 2010;21(Suppl 3):iii43-51. https://doi.org/10.1093/annonc/mdq085

[30] Islam RM, Billah B, Hossain MN, Oldroyd J. Barriers to cervical cancer and breast cancer screening uptake in low-income and middle-income countries: a systematic review. Asian Pac J Cancer Prev 2017;18:1751-63. https://doi.org/10.22034/APJCP.2017.18.7.1751

[31] Charkhchi P, Schabath MB, Carlos RC. Breast, cervical, and colorectal cancer screening adherence: effect of low body mass index in women. J Womens Health (Larchmt) 2020;29:996-1006. https://doi.org/10.1089/jwh.2019.7739

[32] Leinonen MK, Campbell S, Klungsøyr O, Lönnberg S, Hansen BT, Nygård M. Personal and provider level factors influence participation to cervical cancer screening: a retrospective register-based study of 1.3 million women in Norway. Prev Med 2017;94:31-9. https://doi.org/10.1016/j.ypmed.2016.11.018

[33] Performance conditions of breast cancer screening methods and its efficient factors among women referring to Health Centers of Tabriz. Iran J Nurs Midwifery Res 2009;4:27-38.

[34] Oran N, Can H, Senuzun Aykar F, Aylaz R. Health promotion lifestyle and cancer screening behaviors: a survey among academician women. Asian Pac J Cancer Prev 2008;9:515-8.

[35] Bahrami M, Taymoori P, Bahrami A, Farazi E, Farhadifar F. The prevalence of breast and cervical cancer screening and related factors in woman who refereeing to Health Center of Sanandaj city in 2014. Zanko J Med Sci 2015;16:1-12.

[36] Patrão AL, de Almeida MDCC, Matos SMA, Menezes G, Gabrielli L, Goes EF, Aquino EM. Healthy lifestyle behaviors and the periodicity of mammography screening in Brazilian women. Womens Health (Lond) 2021;17:17455065211063294. https://doi.org/10.1177/17455065211063294

[37] Lagerlund M, Drake I, Wirfält E, Sontrop JM, Zackrisson S. Health-related lifestyle factors and mammography screening attendance in a Swedish cohort study. Eur J Cancer 2015;24:44-50. https://doi.org/10.1097/CEJ.0000000000000025

[38] Ng'ang'a A, Nyangasi M, Nkonge NG, Gathitu E, Kibachio J, Gichangi P, Wamai RG, Kyobutungi C. Predictors of cervical cancer screening among Kenyan women: results of a nested case-control study in a nationally representative survey. BMC Public Health 2018;18(Suppl 3):1221. https://doi.org/10.1186/s12889-018-6054-9

[39] Spongier JG, Konen JC. Annual screening mammography, among diabetic women: demographics, psychological stress, and family functioning. Fam Community Health 1996;18:1-8.

[40] Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int J Behav Nutr Phys Act 2008;5:56. https://doi.org/10.1186/1479-5868-5-56

[41] Rakowski W, Clark MA, Truchil R, Schneider K, Meersman S. Smoking status and mammography among women aged 50–75 in the 2002 behavioral risk factor surveillance system. Women Health 2005;41:1-21. https://doi.org/10.1300/J013v41n04_01

[42] Lian M, Jeffe DB, Schootman M. Racial and geographic differences in mammography screening in St. Louis City: a multilevel study. J Urban Health 2008;85:677-92. https://doi.org/10.1007/s11524-008-9301-z

[43] Byrne MM, Davila EP, Zhao W, Parker D, Hooper MW, Caban-Martinez A, Dietz N, Huang Y, Messiah A, Lee DJ. Cancer screening behaviors among smokers and non-smokers. Cancer Epidemiol 2010;34:611-7. https://doi.org/10.1016/j.canep.2010.06.017

[44] Richard A, Rohrmann S, Schmid SM, Tirri BF, Huang DJ, Güth U, Eichholzer M. Lifestyle and health-related predictors of cervical cancer screening attendance in a Swiss population-based study. Cancer Epidemiol 2015;39:870-6. https://doi.org/10.1016/j.canep.2015.09.009

[45] Muus KJ, Baker-Demaray TB, Bogart TA, Duncan GE, Jacobsen C, Buchwald DS, Henderson JA. Physical activity and cervical cancer testing among American Indian women. J Rural Health 2012;28:320-6. https://doi.org/10.1111/j.1748-0361.2011.00394.x

[46] McFarland DM. Cervical cancer and Pap smear screening in Botswana: knowledge and perceptions. Int Nurs Rev 2003;50:167-75. https://doi.org/10.1046/j.1466-7657.2003.00195.x

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Correspondence: Sahar Mohammadnabizadeh, Social Determinants of Health Research Centre, Mashhad University of Medical Sciences, Mashhad, Iran. Tel.: +98 9151054260. Fax: +98 38522775 - E-mail: Mohammadnabizadehs@mums.ac.ir

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