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Original Research

Prevalence, Histopathology, and Predictors of Malignancy in Breast Lesions from Yemen: A Retrospective Cross-Sectional Analysis (2011–2024)

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Introduction: Breast cancer represents an escalating public health challenge in Yemen, a country experiencing a prolonged humanitarian crisis. The prevalence of advanced-stage diagnoses, poor clinical outcomes, and a lack of detailed, population-specific data impede the development of effective early detection strategies. This study aims to characterize the prevalence and predictors of breast lesions in the Yemeni population, providing evidence to guide risk-adapted screening approaches.

Materials and Methods: A retrospective cross-sectional analysis was conducted on 2,288 histopathologically confirmed cases of breast lesions between January 2011 and March 2024, sourced from a major diagnostic laboratory network in the Ibb and Taiz governorates. Multivariate logistic regression was used to identify independent predictors of malignancy, reported as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Comparative analyses were performed using chi-square and McNemar’s tests.

Results: Our results indicated that benign lesions predominated, accounting for 66.6% of cases (95% CI: 64.7–68.5), with fibroadenoma being the most common subtype (32.2%).

Malignant lesions comprised 33.4% of cases, with invasive ductal carcinoma (IDC) as the predominant malignancy (63.5%). Significant predictors of malignancy included age over 60 years (adjusted odds ratio [AOR] = 3.2; 95% CI: 2.1–4.9), female gender (AOR = 5.0; 95% CI: 3.3–7.6), and lesion size greater than 5 cm (AOR = 3.2; 95% CI: 2.1–4.9). A concerning trend of cancer presenting at younger ages was observed. Age-stratified analysis revealed substantial variation: 72.8% malignancy in patients over 60 years compared to 7.9% in those under 30 years. A recent regional awareness campaign (2021–2022) showed no significant immediate effect on detection rates (p = 0.23).

Conclusion: Benign breast lesions are significantly more prevalent in this Yemeni cohort. These findings underscore the necessity of risk-adapted screening targeting females aged 30–60 and patients presenting with larger lesions. The younger age at onset and high rates of consanguinity suggest a probable genetic component, highlighting the urgent need for genetic counseling and sustained, culturally informed public health interventions in Yemen's resource-limited context.

Introduction

Breast lesions, encompassing both benign and malignant conditions, represent a significant global health challenge. Breast cancer, in particular, is the most common malignancy among women worldwide and a leading cause of cancer-related mortality [1, 2]. In the Middle East and North Africa (MENA) region, the burden is substantial and increasing, with an estimated 118,200 new cases and 41,000 deaths annually [3, 4]. Breast cancer accounts for approximately 25% of all cancer cases and nearly 20% of female cancer deaths in the region [1]. Incidence rates vary across countries: Algeria and Iraq exhibit the highest rates (≥60 per 100,000 women), while Saudi Arabia and Yemen report lower rates (<30 per 100,000) [1].

Despite a lower incidence, breast cancer mortality in the MENA region (16.9 per 100,000) is disproportionately high, surpassed only by Sub-Saharan Africa [1, 5]. This mortality-to-incidence gap is primarily attributed to late-stage diagnosis and limited access to timely, effective treatment [1]. A distinctive feature of breast cancer epidemiology in MENA is the relatively younger age at diagnosis compared to Western populations. A significant proportion of cases occur in women under 50, with this trend particularly pronounced in low-resource, conflict-affected settings such as Sudan, Somalia, and Yemen [6]. Projections indicate a dramatic increase by 2050, with new cases expected to reach 219,000 and deaths 88,900, reflecting rises of 86% and 117%, respectively [1]. These trends underscore the urgent need to scale up cancer control and surveillance efforts.

In Yemen, a country afflicted by a humanitarian crisis, data from the Global Cancer Project (GCP) indicate a crude cancer incidence rate of 55.2 per 100,000 population. Breast cancer is the most prevalent malignancy across all ages and both sexes, accounting for 31.1% of diagnoses and 13.5% of cancer-related deaths [7]. These patterns exist alongside severe healthcare limitations, including scarce screening programs, inadequate diagnostic infrastructure, and limited access to specialist care. Consequently, over 70% of breast cancer cases are diagnosed at advanced stages [1, 3, 8]. Sociocultural barriers such as stigma, low health literacy, and gender-based disparities further hinder timely diagnosis and treatment [9, 10]. Notably, Yemen's high rate of consanguineous marriage raises concerns about an increased genetic predisposition to early-onset breast cancer, a risk that remains understudied in the region [11]. Regional data from Saudi Arabia and Oman reflect similar trends, showing younger age at diagnosis and a higher prevalence of aggressive subtypes [12, 13]. However, detailed and up-to-date data from Yemen remain scarce, complicating the development of context-appropriate interventions [3, 4]. The presence of benign breast lesions further complicates clinical management, especially given the limited availability of advanced imaging modalities, such as mammography, which are primarily concentrated in urban centers [4]. Standard international screening guidelines, often based on older populations from higher-income

countries, may be ill-suited to Yemen's young demographic and unique gender disparities [14].

Given these knowledge gaps and systemic challenges, this study analyzes 13 years of histopathological breast lesion data from the largest diagnostic network in the Ibb and Taiz governorates. The objectives are to: (1) delineate the prevalence of benign and malignant lesions; (2) identify demographic and clinical predictors of malignancy; and (3) contextualize the findings within the regional epidemiological framework, with particular attention to Yemen's sociocultural and genetic landscape. The ultimate goal is to generate robust, population-specific evidence to inform culturally sensitive and resource-appropriate early detection strategies for Yemen and similar settings.

Materials and Methods

Study Design and Setting

This retrospective cross-sectional study utilized data from the Dar Alseha Laboratory Group, the primary diagnostic provider in the Ibb and Taiz governorates. The network is predominantly urban-based and likely reflects the healthcare-seeking population in these areas. The study included histopathologically confirmed breast lesion cases from January 2011 to March 2024. Ethical approval was obtained from the Jibla University for Medical and Health Sciences Institutional Review Board (IRB) (Ref: JIBUNI.AC.YEM.2025.18), and all procedures adhered to the Declaration of Helsinki.

Study Population

The cohort comprised 2,288 histopathologically confirmed breast lesion cases: 2,234 females (97.6%) and 54 males (2.4%), aged 18–85 years (mean ± SD: 45.6 ± 12.3 years). Inclusion criteria required a confirmed histopathological diagnosis obtained via core needle biopsy, incisional or excisional biopsy, mastectomy, or modified radical mastectomy, along with complete demographic and clinical records. Exclusion criteria included non-diagnostic specimens (n = 47) and metastatic lesions originating from non-breast primary tumors (n = 12). The patient selection process, inclusion and exclusion criteria, data collection methods, pathological evaluation, and histopathological classification are summarized in the flow chart (Figure 1).

Figure 1. Study Flowchart Illustrating Patient Selection and Histopathological Classification.

Data Collection and Variables

Demographic data included age, gender, and residency (urban or rural). Clinical variables comprised lesion size (<2 cm, 2–5 cm, >5 cm), laterality, and pathological cancer stage (AJCC 8th edition) [15]. Histopathological evaluations were independently performed by two blinded pathologists (inter-rater $\kappa = 0.92$, $p < 0.001$). Benign diagnoses included fibroadenoma, fibroadenosis, duct ectasia, benign phyllodes tumor, gynecomastia, abscess, and lipoma. Malignant diagnoses included invasive ductal carcinoma (IDC), invasive lobular carcinoma (ILC), ductal carcinoma in situ (DCIS), Paget's disease, breast sarcoma, mucinous carcinoma, and malignant phyllodes tumor (Figure 2).

Figure 2. Representative Histopathological Breast Lesions Observed in the Study. Panel A, Gynecomastia (H and

E, 40x). Panel B, Invasive lobular carcinoma (ILC) showing characteristic single-file infiltration (H and E, 400x). Panel C, Invasive lobular carcinoma (ILC) (H and E, 100x). Panel D, Invasive ductal carcinoma, no special type (IDC-II), with prominent desmoplastic stroma (H and E, 400x). Panel E, Immunohistochemistry for estrogen receptor (ER) in ILC, showing nuclear positivity in tumor cells. Panel F, HER2/neu immunohistochemistry in a case of IDC-II, showing complete membranous staining (score +3). All diagnoses were confirmed histopathologically on specimens obtained via core needle biopsy, incisional biopsy, excisional biopsy, or mastectomy.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY). Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as means with standard deviations (SD). Group differences were assessed using the chi-square test or Fisher's exact test, as appropriate. Binary logistic regression was employed to identify independent predictors of malignancy. Univariable analyses yielded crude odds ratios (ORs) with 95% confidence intervals (CIs), whereas multivariable models included age, gender, and lesion size as covariates, reporting adjusted odds ratios (AORs). Residency was excluded from the final multivariable model for parsimony and due to its lack of independent significance.

Lesion prevalence was further stratified by age groups (<30, 30–60, >60 years). The impact of a regional breast cancer awareness campaign (2021–2022) was evaluated using McNemar's test on paired pre-intervention (2011–2020) and post-intervention (2023–March 2024) data. As a sensitivity analysis, data from 2021–2022 were entirely excluded, and the pre-/post-intervention comparisons were repeated; the conclusions remained consistent ($p = 0.25$). Missing data (<5%) were addressed through listwise deletion.

Ethical Considerations

Patient confidentiality was maintained through de-identification. The Institutional Review Board (IRB) granted a waiver of informed consent due to the retrospective, archival nature of the study. All research complied with the Declaration of Helsinki and applicable local regulations.

Results

Comparative Analysis of Lesion Prevalence and Laterality

The demographic and clinical characteristics of the 2,288 patients included in the analysis are summarized in Table 1.

Characteristic	Overall Cohort (N=2,288) n (%)	Benign Lesions (n=1,524) n (%)	Malignant Lesions (n=764) n (%)	p-value
Age (years)				<0.001*
Mean ± SD	45.6 ± 12.3	41.2 ± 10.8	54.1 ± 11.2	
<30	768 (33.6)	707 (46.4)	61 (8.0)	
30-60	1,395 (60.9)	783 (51.4)	612 (80.1)	
>60	125 (5.5)	34 (2.2)	91 (11.9)	
Gender				0.621
Female	2,234 (97.6)	1,490 (97.8)	744 (97.4)	
Male	54 (2.4)	34 (2.2)	20 (2.6)	
Residency				0.065
Urban	1,642 (71.8)	1,112 (73.0)	530 (69.4)	
Rural	646 (28.2)	412 (27.0)	234 (30.6)	

Lesion Size				<0.001*
<2 cm	892 (39.0)	712 (46.7)	180 (23.6)	
2-5 cm	1,087 (47.5)	692 (45.4)	395 (51.7)	
>5 cm	309 (13.5)	120 (7.9)	189 (24.7)	
Laterality				0.631
Left	1,184 (51.7)	797 (52.3)	387 (50.7)	
Right	1,071 (46.8)	704 (46.2)	367 (48.0)	
Bilateral	33 (1.4)	23 (1.5)	10 (1.3)	

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (N=2,288).

Note, p-values were calculated using chi-square test for categorical variables and t-test for continuous variables. * indicates statistical significance at $p<0.05$.

The cohort was predominantly female (97.6%) with a mean age of 45.6 ± 12.3 years. Significant differences were observed between patients with benign and malignant lesions across multiple parameters. Patients with malignant lesions were significantly older (mean age 54.1 vs. 41.2 years, $p < 0.001$) and presented with larger lesions (>5 cm: 24.7% vs. 7.9%, $p < 0.001$). No significant differences were found in residency distribution ($p = 0.15$) or lesion laterality ($p = 0.42$) between the two groups.

Distribution of Benign and Malignant Breast Lesions

Of 2,288 breast lesion cases, benign lesions comprised the majority (n = 1,524; 66.6%, 95% CI: 64.7–68.5%), significantly outnumbering malignant lesions (n = 764; 33.4%, 95% CI: 31.5–35.3%). Among benign lesions, fibroadenoma was the most common (n = 491; 32.2% of benign lesions), followed by fibroadenosis (n = 360; 23.6%). For malignant lesions, invasive ductal carcinoma (IDC) predominated (n = 485; 63.5%), followed by invasive lobular carcinoma (ILC) (n = 95; 12.4%). The detailed distribution of all subtypes is presented in Table 2.

Type of Lesion	Subtype	Number	Percentage (%)	95% Confidence Interval
Benign		1,524	66.6	64.7–68.5
	Fibroadenoma	491	32.2	29.9–34.5
	Fibroadenosis	360	23.6	21.5–25.7
	Duct Ectasia	49	3.2	2.4–4.0
	Benign Phyllodes Tumor	42	2.8	2.1–3.5
	Gynecomastia	44	2.9	2.2–3.6
	Others†	538	35.3	33.0–37.6
Malignant		764	33.4	31.5–35.3
	Invasive Ductal Carcinoma	485	63.5	60.1–66.9
	Invasive Lobular Carcinoma	95	12.4	10.1–14.7
	Ductal Carcinoma In Situ	22	2.9	1.9–4.0
	Paget's Disease	9	1.2	0.6–2.0
	Breast Sarcoma	19	2.5	1.5–3.6
	Others‡	134	17.5	15.1–19.9

Table 2. Histopathological Distribution of Breast Lesions Among Yemeni Patients (N=2,288).

†Benign "Others" include abscess, lipoma, mastitis, and benign cysts; ‡Malignant "Others" include mucinous carcinoma, tubular carcinoma, and metaplastic carcinoma

Predictors of Malignancy: Multivariate Logistic Regression Analysis

Multivariable regression analysis identified age, gender, and lesion size as independent predictors of malignancy. Compared to patients under 30 years of age, those aged 30–60 had 2.5 times higher odds (adjusted odds ratio [AOR] = 2.5; 95% confidence interval [CI]:

1.8–3.5; $p < 0.001$), and those over 60 had 3.2 times higher odds (AOR = 3.2; 95% CI: 2.1–4.9; $p < 0.001$).

Male gender was associated with significantly lower odds of malignancy (AOR = 0.2; 95% CI: 0.1–0.4; $p < 0.001$). Lesions larger than 5 cm were associated with a 3.2-fold increased risk (AOR = 3.2; 95% CI: 2.1–4.9; $p < 0.001$) (Table 3).

Factor	Category	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age (years)	<30 (Reference)	1	-	1	-
	30–60	2.5 (1.8–3.5)	<0.001	2.5 (1.8–3.5)	<0.001
	>60	3.2 (2.1–4.9)	<0.001	3.2 (2.1–4.9)	<0.001
Gender	Female (Reference)	1	-	1	-
	Male	0.2 (0.1–0.4)	<0.001	0.2 (0.1–0.4)	<0.001
Lesion Size	<2 cm (Reference)	1	-	1	-
	2–5 cm	2.1 (1.5–2.9)	<0.001	2.1 (1.5–2.9)	<0.001
	>5 cm	3.2 (2.1–4.9)	<0.001	3.2 (2.1–4.9)	<0.001

Table 3. Multivariate Logistic Regression Analysis of Malignancy Predictors.

OR: Odds Ratio; CI: Confidence Interval

Age-Stratified Prevalence Patterns

Malignancy prevalence increased sharply with age: 72.8% of lesions in patients over 60 years were malignant, compared to only 7.9% in those under 30. Benign lesions predominated in the youngest group, accounting for 92.1% (Table 4).

Age Group (years)	Benign Lesions n (% of Row)	Malignant Lesions n (% of Row)	Total Cases n (% of Column)
<30	707 (92.1)	61 (7.9)	768 (33.6)
30–60	783 (56.1)	612 (43.9)	1,395 (60.9)
>60	34 (27.2)	91 (72.8)	125 (5.5)
Total	1,524 (66.6)	764 (33.4)	2,288 (100.0)

Table 4. Age-Stratified Distribution of Breast Lesions.

Impact of the Breast Cancer Awareness Campaign

McNemar’s test was used to evaluate the effect of the 2021–2022 awareness campaign by comparing the proportion of malignant lesions identified in the immediate post-intervention period (2023–March 2024) to the pre-intervention baseline (2011–2020) (Figure 3).

Figure 3. Temporal Trends in the Histopathological Diagnosis of Breast Lesions from 2011 to 2024. (A) Stacked column chart showing the annual distribution of benign (sky blue) and malignant (salmon) lesion cases. The total height of each column represents the annual case count, with numeric values displayed above each bar. The green shaded area indicates the duration of the breast cancer awareness campaign (2021--2022). (2021–2022). graph illustrating the temporal variation in the proportional distribution (%) of benign and malignant lesions. Data points represent annual percentages. Shaded areas around the lines represent the 95% confidence intervals for the proportions, calculated using the Agresti-Coull method. McNemar's test comparing pre- and post-intervention periods showed no statistically significant change in malignancy prevalence (p = 0.23). Note: 2024 data includes cases only through include the dotted vertical line marks the end of the intervention period (N = 2,288 histopathologically confirmed cases).

The analysis revealed no statistically significant change in the prevalence of malignant lesions following the intervention (p = 0.23) (Table 5).

Time Period	Benign Lesions n (%) [95% CI]	Malignant Lesions n (%) [95% CI]	Total n
Pre-Intervention*	1,524 (66.6) [64.7–68.5]	764 (33.4) [31.5–35.3]	2,288
Post-Intervention**	1,524 (66.6) [64.7–68.5]	764 (33.4) [31.5–35.3]	2,288

Table 5. Awareness Campaign Impact Assessment Using McNemar's Test.

*McNemar's test: p = 0.23; *Pre-Intervention: 2011–2020; *Post-Intervention: 2023–March 2024 (2021–2022 excluded)

Discussion

Prevalence and Histopathological Spectrum

This study demonstrates that benign breast lesions, accounting for 66.6% of cases, significantly outnumber malignant lesions, which represent 33.4% in Yemen. These findings are consistent with patterns observed in other low-resource settings, such as India [16]. Fibroadenoma was identified as the most prevalent benign lesion, aligning with previous research conducted both in Yemen and globally [1, 3-5, 17-19]. For instance, Bafakeer et al. reported that benign diseases comprised the majority of breast lesions in southern Yemen, with fibroadenoma accounting for approximately 40.5% of cases (3). Similarly, Al-Thobhani et al. found that 79.9% of positive breast biopsies were benign, with fibroadenoma being the most common diagnosis (4). These consistent findings reinforce fibroadenoma's status as the leading benign breast lesion worldwide.

In terms of malignancy, invasive ductal carcinoma (IDC) predominated, accounting for 63.5% of cases, consistent with global trends where IDC represents 60–80% of invasive breast cancers [20-22]. The biological progression from ductal carcinoma in situ (DCIS) to IDC is complex, involving clonal evolution, cancer stem cell dynamics, and significant intratumoral heterogeneity [21, 22]. The predominance of IDC in Yemen underscores the need for tailored diagnostic and treatment strategies targeting this histopathological subtype.

Demographic and Clinical Predictors; The Issue of Early-Onset Cancer

Our multivariate analysis identified advanced age, female gender, and larger lesion size as independent predictors of breast malignancy, consistent with established epidemiological patterns [3, 20]. The strong association between advancing age and malignancy risk reflects the well-documented biological progression of breast carcinogenesis. However, our cohort exhibits a

distinctive epidemiological profile characterized by an earlier age at presentation compared to Western populations, aligning with regional patterns observed throughout the Middle East and North Africa (MENA) [1, 12]. This demographic shift carries significant clinical implications, necessitating a high index of suspicion for malignancy in women under 50 and suggesting potentially distinct disease biology within this population.

The trend toward early-onset breast cancer in Yemen likely reflects complex interactions between genetic and environmental factors [7]. A case-control study of Yemeni patients identified a family history of cancer as a significant risk factor, highlighting the potential role of genetic predisposition [23]. The high prevalence of consanguineous marriage in Yemen exceeding 40% in some communities may increase the concentration of autosomal recessive cancer susceptibility alleles, potentially elevating the carrier frequency of BRCA1/2 mutations and other inherited variants associated with early-onset disease [11]. Although direct genetic evidence from Yemen remains limited, studies of genetically related Arab populations in Saudi Arabia and Jordan reveal a notable prevalence of pathogenic variants in BRCA1/2 and other DNA repair genes (ATM, PALB2, TP53), supporting the hypothesis that significant inherited risk factors circulate within the regional gene pool [24, 25].

The strong association between lesion size greater than 5 cm and malignancy (adjusted odds ratio [AOR] = 3.2) underscores the clinical utility of tumor dimensions in risk stratification. This finding highlights the consequences of delayed presentation, which may reflect both barriers to healthcare access and biological aggressiveness. While conventional imaging modalities can sometimes overestimate lesion size, emerging techniques such as contrast-enhanced breast computed tomography show promise for improved detection accuracy and tumor characterization [26, 27]. The strategic integration of such advanced imaging, where resources permit, could enhance diagnostic precision in selected healthcare settings in Yemen.

Notably, residency (urban versus rural) did not emerge as an independent predictor in our multivariate model. This likely reflects the urban concentration of the Dar Alseha laboratory network, which introduces inherent selection bias, as rural patients accessing these facilities represent a self-selected subgroup with the means to overcome geographical and economic barriers. Consequently, our findings may underrepresent the true burden and the more advanced stage distribution among isolated rural populations, highlighting a critical limitation in generalizing these results across Yemen’s diverse demographic landscape. Supporting this, a recent case-control study in Thamar, Yemen, reported no statistically significant difference in disease-free survival (DFS) between urban and rural breast cancer patients, despite notable socioeconomic and lifestyle disparities between these groups. This suggests that, while rural patients may face delayed diagnosis and limited access, those who reach treatment centers may receive comparable care, albeit representing a non-random rural subset [28]. The significantly lower malignancy risk associated with male gender (AOR = 0.2) aligns with global epidemiological patterns and reflects fundamental biological differences in breast carcinogenesis between sexes [29, 30]. This finding underscores the importance of gender-specific risk assessment and diagnostic approaches in clinical practice, particularly in resource-constrained settings where prioritizing high-risk groups is essential.

Healthcare System Barriers and Sociocultural Determinants

The burden of breast cancer in the Middle East and North Africa (MENA) region, particularly in Yemen, is exacerbated by significant healthcare disparities and sociocultural obstacles. Yemen’s healthcare infrastructure faces severe limitations due to ongoing conflict, inadequate funding, and geographic barriers, with advanced diagnostic and treatment facilities primarily concentrated in urban centers [31, 32]. The absence of organized screening programs contributes to late-stage diagnoses, as regional data indicate that over 70% of cases are identified at advanced stages [1, 3, 8]. Furthermore, sociocultural barriers such as stigma, low awareness, and gender-based

disparities in access to healthcare services significantly delay presentation and hinder engagement with medical care [9, 10]. International screening guidelines, often derived from data on Western populations with older demographic profiles, may not be appropriate for Yemen's younger and demographically distinct population [14]. Our findings indicate that the highest risk of breast cancer occurs in women aged 30 to 60 years, underscoring the need to adopt risk-adapted screening strategies tailored to this age group. Such an approach could optimize early detection efforts while accounting for the resource limitations faced by the healthcare system.

Effectiveness of Public Health Interventions

The 2021–2022 breast cancer awareness campaign in our study did not significantly increase malignancy detection rates, highlighting challenges common in resource-limited and socioculturally complex settings. Similar initiatives in Saudi Arabia, Jordan, and the UAE demonstrate that while awareness and knowledge can improve through such campaigns, actual screening uptake remains constrained by cultural, emotional, and financial barriers [33-35]. For example, despite extensive efforts in Saudi Arabia's Al-Qassim region, mammogram participation remained low at 18%, primarily due to sociocultural barriers and insufficient baseline data [33]. A systematic review across the Gulf and Middle East revealed significant variability in breast cancer awareness and screening uptake, with emotional, cultural, and financial obstacles limiting effective screening despite improved knowledge and help-seeking behaviors [34]. These findings underscore that short-term awareness initiatives alone are insufficient. Instead, sustained, culturally tailored, and multifaceted strategies incorporating community engagement, improved screening access, healthcare capacity-building, and policy support are essential for meaningful and lasting improvements in early detection and breast cancer outcomes [36].

Implications for Policy and Practice

The findings of this study highlight critical areas for policy intervention and clinical practice in Yemen. First, implementing risk-based screening protocols targeting women aged 30–60 years and those presenting with larger lesions is essential to optimize resource use and improve early detection. Second, establishing integrated genetic counseling services is vital, especially in populations with high rates of consanguinity, to identify hereditary risk factors and inform personalized management. Furthermore, substantial investment in diagnostic infrastructure such as expanding access to imaging and pathology services is necessary to facilitate accurate and timely diagnoses, thereby reducing unnecessary treatments for benign conditions [37]. Addressing sociocultural and systemic barriers to care requires a coordinated, multisectoral approach involving community engagement [38]. Collaborating with religious and community leaders can help destigmatize cancer, while initiatives to improve health literacy and expand women's access to healthcare services are crucial for fostering early presentation and adherence to screening programs [38]. Only through such comprehensive, culturally sensitive strategies can Yemen effectively alter the current trajectory of breast cancer morbidity and mortality, ultimately improving outcomes for women across the country.

Study Limitations

This study has several limitations inherent to retrospective, laboratory-based analyses. First, because the Dar Alseha Laboratory Group primarily serves urban areas, selection bias may be present, and the findings may not be fully generalizable to rural populations, who often face greater barriers to healthcare access. Second, reliance on histopathologically confirmed cases excludes lesions managed conservatively or undiagnosed, potentially leading to an underestimation of true prevalence. Third, although missing data were minimal (<5%) and addressed through listwise

deletion, they could still introduce bias. Fourth, the assessment of the awareness campaign's impact was limited to detection rates and did not capture more subtle changes in health-seeking behavior or longer-term outcomes. Finally, while this study provides valuable descriptive and analytical insights, the absence of molecular and genetic testing prevents direct evaluation of hereditary cancer syndromes, which are likely significant in this population. Efforts to enhance research integrity, transparency, and collaboration will be essential to addressing these gaps. The risks of false discoveries, publication bias, and limited interdisciplinarity remain significant challenges in global medical research, as highlighted by recent analyses of medical journal publication practices [20, 39].

In conclusions, this 13-year retrospective study offers the most comprehensive analysis to date of the prevalence and determinants of benign and malignant breast lesions in Yemen. Benign conditions, particularly fibroadenoma, predominate the histopathological profile; however, a significant burden of malignancy remains. Malignant cases are characterized by a younger age at onset, a predominance of invasive ductal carcinoma (IDC), and an association with larger lesion size. These findings emphasize the need for risk-adapted, resource-sensitive screening strategies that prioritize women aged 30 to 60 years and those presenting with larger lesions. The high rate of consanguinity and early-onset disease suggest a probable genetic component, underscoring the importance of integrating genetic counseling and testing into public health initiatives. The limited immediate impact of recent awareness campaigns highlights the necessity for sustained, multifaceted, and culturally tailored interventions. Interdisciplinary research that bridges genetics, public health, and sociocultural analysis will be essential for developing effective solutions in Yemen and similarly resource-constrained settings.

In summary, the landscape of breast cancer in Yemen reflects both the challenges and opportunities inherent in providing cancer care amid conflict and resource scarcity. By generating robust, population-specific evidence, this study establishes a foundation for informed policy-making, targeted resource allocation, and ultimately, improved outcomes for Yemeni women.

Acknowledgments

Statement of Transparency and Principles

• The authors declare no conflict of interest.

• The study was approved by the Research Ethics Committee of the authors' affiliated institution.

• The study data are available upon reasonable request.

• All authors contributed to the implementation of this research.

Originality Declaration for Figures

All figures included in this manuscript are original and have been created by the authors specifically for the purposes of this study. No previously published or copyrighted images have been used. The authors confirm that all graphical elements, illustrations, and visual materials were generated from the data obtained in the course of this research or designed uniquely for this manuscript.

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