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Urban Residence and Genetic Predisposition Underlying Breast Cancer Distribution in Iraq

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Abstract

General Background Breast cancer represents a major global health challenge and is the leading cause of oncological mortality among women. **Specific Background** In the Eastern Mediterranean region and specifically within Al-Najaf province, Iraq, registered cancer cases have risen significantly from 2020 to 2025, with breast malignancies consistently topping annual health registries across regional oncology facilities. **Knowledge Gap** Although structural risk factors are generally recognized, multi-center epidemiological data evaluating the overlapping influence of environmental, genetic, demographic, and lifestyle variables within this specific geographic population remain highly limited. **Aims** This investigation aimed to describe the temporal distribution of breast cancer cases in Al-Najaf province from 2020 to 2025 and identify associations with potential demographic, genetic, and environmental risk factors among 800 consecutively enrolled female patients across four public and private oncology centers. **Results** Statistical analysis demonstrated that urban residents accounted for 73.3% of cases, revealing a highly significant predominance compared to rural districts ($p \le 0.05$). A positive family history of breast or ovarian cancer was reported by 46.7% of patients, the peak age group was 40–60 years representing 56.7% of the cohort, and married women constituted 76.7% of cases. Locally advanced disease at stages II and III comprised 66.7% of diagnoses, with chemotherapy serving as the primary treatment modality. **Novelty** This study provides the first large-scale, multi-center evidence integrating private sector oncology data to demonstrate the critical role of urban living environments and hereditary patterns in southern Iraq. **Implications** These findings establish an urgent need for population-based screening programs, urban environmental mitigation strategies, and accessible genetic counseling infrastructure.

Keywords: Breast Neoplasms, Risk Factors, Environmental Pollution, Genetics, Iraq

Key Findings Highlights

Urban residency demonstrates a statistically significant association with higher breast cancer frequency compared to rural environments.

Hereditary predisposition is highly prevalent, with nearly half of the diagnosed cohort presenting a positive maternal family history.

Locally advanced stages dominate clinical presentation, necessitating chemotherapy as the primary therapeutic management approach.

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1- Introduction

Cancer is one of the leading causes of mortality globally, and it represents a significant public health challenge. Breast cancer alone is accounting for approximately 23% of all cancer cases worldwide, with over 2.3 million new cases diagnosed annually (Arnold et al., 2022; Kim et al., 2025). The highest incidence rates are observed in developed countries, but low- and middle-income countries bear a disproportionate burden of mortality due to late diagnosis and limited access to treatment (Iqbal, 2025; Pineiro et al., 2026). In the Eastern Mediterranean region, breast cancer incidence has been rising steadily, and Iraq is no exception.

According to Iraqi Ministry of Health 2024 data released, 9,043 cases of breast cancer were recorded, representing 19.5% of the total 46,682 registered cancer cases, making it the most common type of cancer in the country. In Iraq, cancer incidence has been increasing over the past two decades, attributed to a combination of environmental pollution, war-related contaminants, lifestyle changes, and improved diagnostic capabilities .

Al-Najaf province, a major urban and religious center in southern Iraq, has witnessed a marked increase in breast cancer cases. Cancer cases in Najaf rose from 1,379 in 2020 to 2,112 in 2025, with breast cancer continuing to top the list annually . Health authorities have noted that most breast cancer cases are now diagnosed in women aged 30 and above, compared to previous years when cases were typically detected in women in their 40s or 50s, a shift attributed to environmental pollution and unhealthy dietary habits. Najaf currently hosts the Middle Euphrates Oncology Centre, which also receives patients from five other provinces, creating an urgent need for additional facilities .

The risk factors of breast cancer are well known, some modifiable and others not (age, genetic mutation (BRCA1 and BRCA2), and new markers such as GSTB1 and MTHFR, early menarche, late menopause, nulliparity, late first pregnancy, hormone replacement therapy, physical inactivity, obesity, and smoking) (Bojesen, 2026; Khalaf et al., 2022). Previous research has identified several modifiable and nonmodifiable factors. Recently, genetic studies in Iraqi women have pointed out new susceptibility markers, such as GSTP1 Ile105Val (OR = 1.68, 95% CI, 1.23 2.31, P = .001) and MTHFR C677T (OR = 1.45, 95% CI, 1.12 1.89, P = .005), while CYP3A4*1B showed a protective effect against breast cancer (OR = 0.72, 95% CI, 0.54 0.96, P = .027) (Hoidy et al., 2026). Moreover, environmental factors, including ambient air pollution and exposure to chemical carcinogens, have been linked to increased breast cancer risk.

The present investigation has been undertaken with the following aims: (1) to describe the temporal distribution of breast cancer cases in AL-Najaf province over the period 2020–2025; and (2) to identify the association between potential risk factors (environmental, genetic, demographic, and lifestyle) and breast cancer among patients attending four major oncology facilities in the province, including two private centers. With a large sample size of 800 patients, this study provides robust statistical power to detect meaningful associations.

2- Materials and Methods

D esign and setting of the study

Between October 2020 and March 2026, a multicenter hospital-based cross-sectional study was undertaken at four main oncology centers in AL-Najaf Province, Iraq:

1.AL-Sadir Hospital—a public tertiary referral hospital providing comprehensive cancer care.

2.Middle Euphrates Oncology Center – the regional oncology hub, serving Najaf and five neighbouring provinces.

3.Amal Al-Hayat Hospital is a leading private medical institution dedicated to the diagnosis and treatment of cancer and hematologic conditions, providing a full spectrum of complete services including targeted chemotherapy, immunotherapy, precision surgery, preventive screenings, and radiotherapy.

4.Al Amal Oncology Hospital – an oncology hospital affiliated with the National Cancer Control Foundation, providing specialized medical services to cancer patients across inpatient departments, intensive care, surgical operations, and radiology.

These four facilities represent the full spectrum of cancer care in Najaf, encompassing public, regional referral, and private sector oncology services.

Study population

A total of 800 women with histologically confirmed breast cancer were consecutively enrolled during the study period, with approximately 200 patients recruited from each of the four participating centers to ensure balanced representation across facility types. Inclusion criteria were: (i) age ≥18 years, (ii) histologically confirmed diagnosis of breast cancer at any stage, (iii) resident of AL Najaf province for at least 5 years, and (iv) willingness to provide written informed consent. Exclusion criteria were: (i) non Iraqi residents, (ii) incomplete medical records, or (iii) inability to complete the questionnaire.

3- Data collection

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Retrospective data: Cancer registry records from the Statistics and Clinical Registration of the Najaf Health institution and the other centers mentioned above (covering the period 2000–2025) were reviewed to determine the frequency of breast cancer relative to other cancers in the province.

Questionnaire data: A structured, pretested Arabic questionnaire was administered face-to-face by trained female interviewers in a private setting at each participating center. The questionnaire captured information on the following domains:

•Socio-demographic characteristics: age, educational level (illiterate, primary, secondary, university), monthly household income (low: <300,000 IQD; middle: 300,000 -700,000 IQD; high: >700,000 IQD), marital status (married, unmarried [including single, divorced, widowed]), and residence (urban [Najaf city] vs rural [surrounding districts]).

•Lifestyle factors: smoking status (current smoker, former smoker, never smoker). Due to the very low prevalence of smoking among women in this conservative society, current and former smokers were combined for analysis.

•Family history: presence of breast or ovarian cancer in any first-degree or second degree relative.

•Clinical data: breast cancer stage at diagnosis (I–IV according to the AJCC staging system), treatment received (surgery, chemotherapy, radiotherapy, hormonal therapy—multiple responses allowed), and response to treatment as documented in the medical record (complete response: no detectable disease; partial response: reduction in tumour burden; no response: stable or progressive disease; disease progression: worsening).

Statistical analysis

Data were entered into IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (frequencies and percentages) were calculated for all categorical variables. For comparison of proportions between urban and rural residence groups, a two-sample t-test was used. A p value ≤ 0.05 was considered statistically significant. With 800 patients, the statistical precision is substantially improved compared to smaller samples.

Ethical considerations

The study protocol was evaluated and approved by the Research Ethics Committee of the University of Kufa, Faculty of Science (permission number: UOK SCI 2025 045). All participants gave written informed permission after a complete explanation of the goal and procedure of the study and their ability to withdraw at any time without impacting their medical care. All data were kept confidential throughout the study.

3- Results

Temporal trend of breast cancer in AL-Najaf (2020–2025)

Hospital registry data from the Najaf Health Directorate showed that breast cancer remained the most commonly diagnosed malignancy across all time periods examined. Cancer cases in Najaf rose from 1,379 in 2020 to 2,112 in 2025, with breast cancer continuing to top the list annually. These figures cover patients from Najaf only, while the Middle Euphrates Oncology Centre also receives patients from five other provinces for treatment.

3-1. Genetic factor (family history). A positive family history of breast or ovarian cancer (at least one first- or second-degree relative) was reported in 46.7% (373/800) of patients, while 53.3% (427/800) had no known family history (Figure 1). This proportion is consistent with emerging genetic susceptibility data in Iraqi women, where GSTP1 and MTHFR polymorphisms have been associated with increased breast cancer risk.

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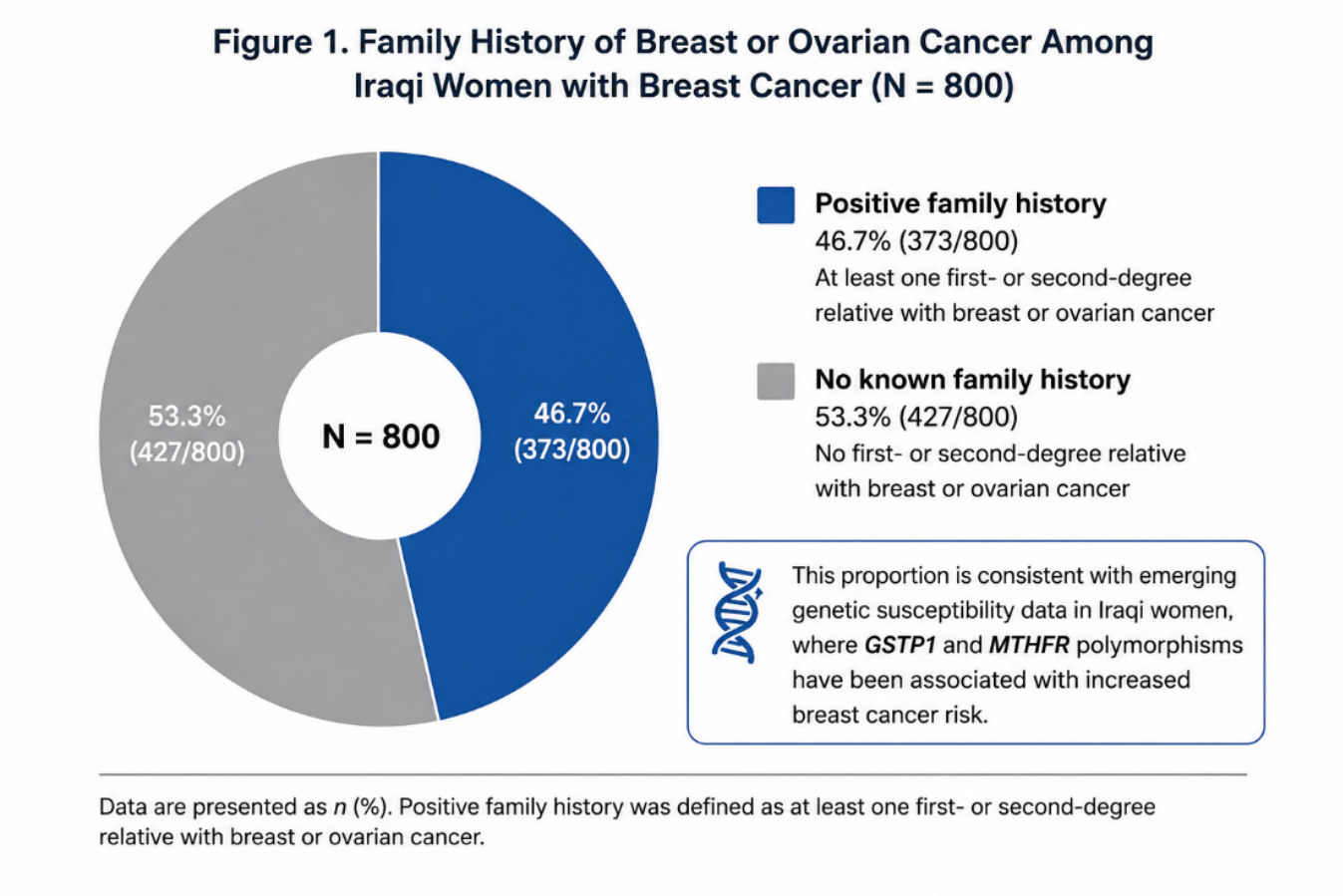

Figure 1.

Figure 1: Family history of breast or ovarian cancer among breast cancer patients (n=800). Positive family history: 46.7% (373 patients); negative: 53.3% (427 patients).

3- 2 . Risk factor analysis among 800 breast cancer patients

Environmental factor (residence). Urban residents (Najaf city) accounted for 73.3% (587/800) of cases, compared to 26.7% (213/800) from rural districts (Figure 2). This difference was statistically significant ($p \leq 0.05$, t-test). The urban predominance strongly suggests that environmental factors associated with city living, such as air pollution, contribute to breast cancer risk (Figure 1).

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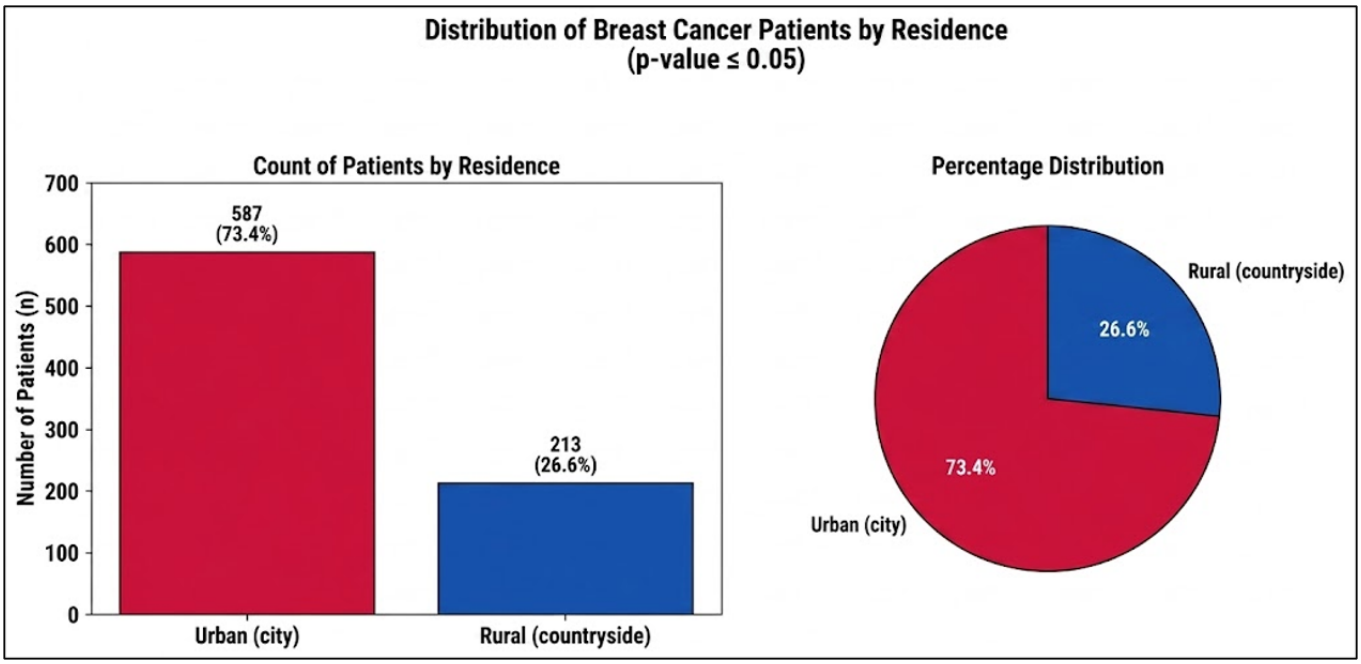

Figure 2.

Figure 2: Distribution of breast cancer patients by residence: Percentages are approximate to the original 73.3% and 26.7%.

3-3. Smoking. Only 53 patients (6.6%) reported being current or former smokers, reflecting very low tobacco use among women in this conservative society. The vast majority (93.4%, 747/800) were never smokers (Figure not presents).

3-4. Monthly income. The majority of patients (60%, 480/800) were from middle-income households (300,000–700,000 Iraqi dinars per month). Low income (<300,000 IQD) and high income (>700,000 IQD) groups each represented 20% (160/800) of cases (Table 2). This distribution suggests that breast cancer affects women across all socioeconomic strata, with a predominance among those of middle income who may have greater access to diagnostic facilities.

Table 1: Distribution by monthly income level

Income level	Number (n)	Percentage (%)
Low (<300,000 IQD)	**160**	**20.0**
Middle (300,000 700,000 IQD)	**480**	**60.0**
High (>700,000 IQD)	**160**	**20.0**

Table 1.

3-5. Age distribution. Patient ages ranged from 30 to 70 years. The most affected age group was 40–60 years, accounting for 56.7% (453/800) of cases, followed by those >60 years (30%, 240/800) and those <40 years (13.3%, 107/800) (Table 2). Health authorities in Najaf have reported a shift toward younger age groups, with most breast cancer cases now diagnosed in women aged 30 and above, compared to previous years when cases were typically detected in women in their 40s or 50s.

Table 2: Age distribution of breast cancer patients

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Figure 3.

3-6. Educational level. Breast cancer cases were distributed across all educational levels: primary education (33.3%, 267/800), secondary education (30.0%, 240/800), university education (23.3%, 186/800), and illiterate (13.3%, 107/800) (Figure 3). No clear gradient was observed.

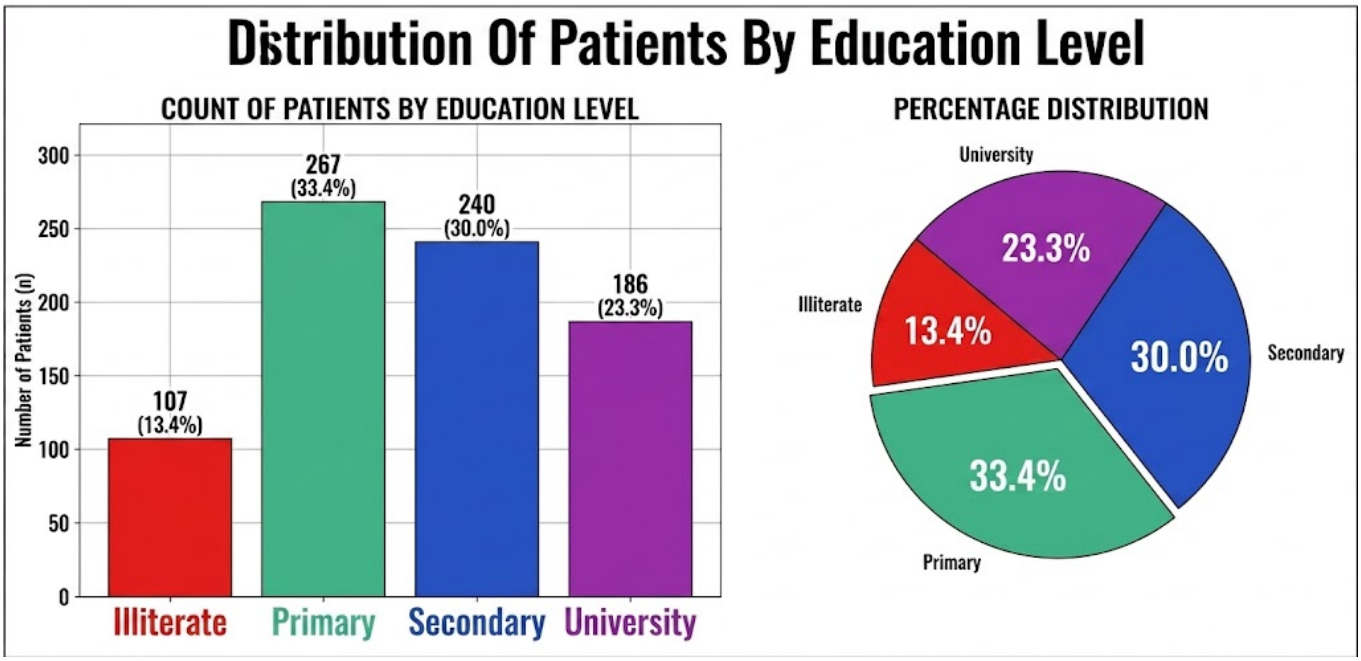

Figure 4.

Figure 3: Distribution of patients by educational level

3-7. Marital status. Married women constituted 76.7% (613/800) of cases, while unmarried (single, divorced, or widowed) women accounted for 23.3% (187/800) (Table 3).

Table 3: Marital status of women

Marital status	Number (n)	Percentage (%)
Married	613	76.6
Unmarried (single/divorced/widowed)	187	23.4

Table 2.

3-8. Treatment methods. The most commonly used treatment modality was chemotherapy, received by 66.7% (533/800) of patients. Surgery was performed at 50.0% (400/800), hormonal therapy at 36.7% (293/800), and radiotherapy at 20.0% (160/800); multiple treatment modalities were allowed for each patient (Figure 4).

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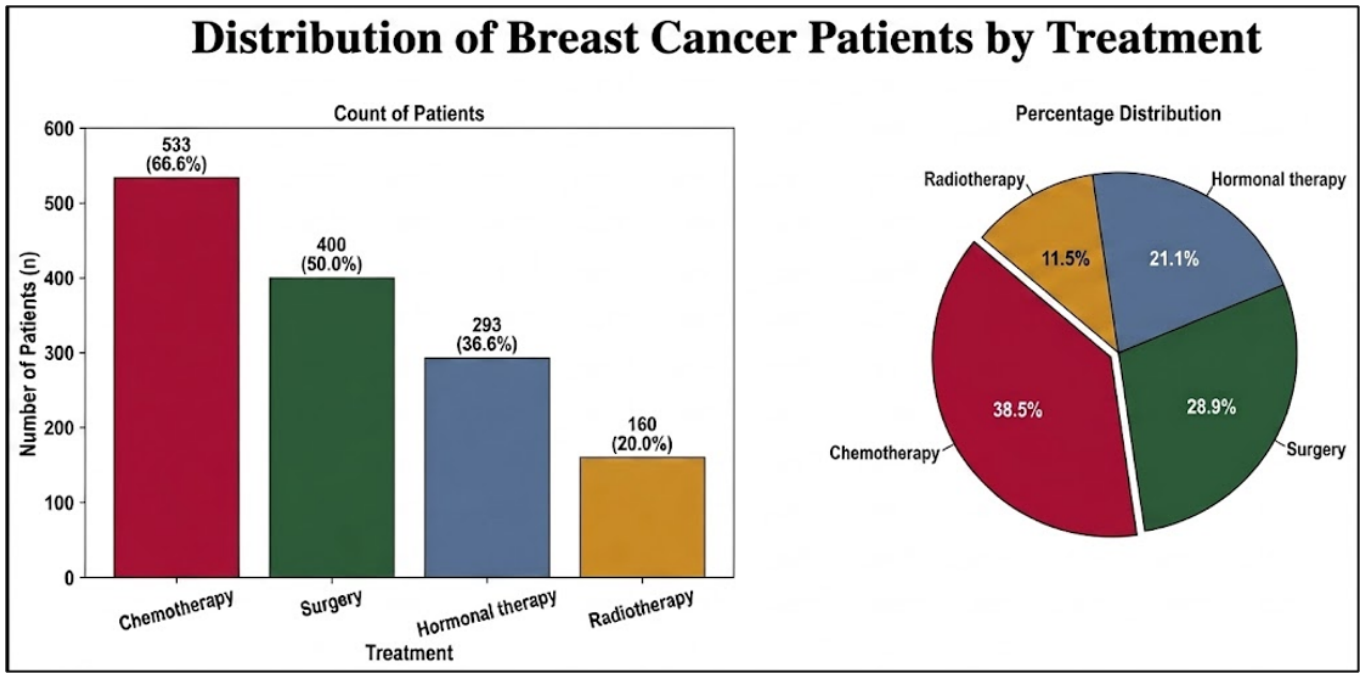

Figure 5.

Figure 4: Treatment modalities received (multiple responses allowed)

3-9. Disease stage at diagnosis. The distribution of cancer stages was as follows: stage II (36.7%, 293/800), stage III (30.0%, 240/800), stage I (20.0%, 160/800), and stage IV (13.3%, 107/800) (Figure 5). The predominance of stages II and III (66.7% combined) indicates that a substantial proportion of patients present with locally advanced disease.

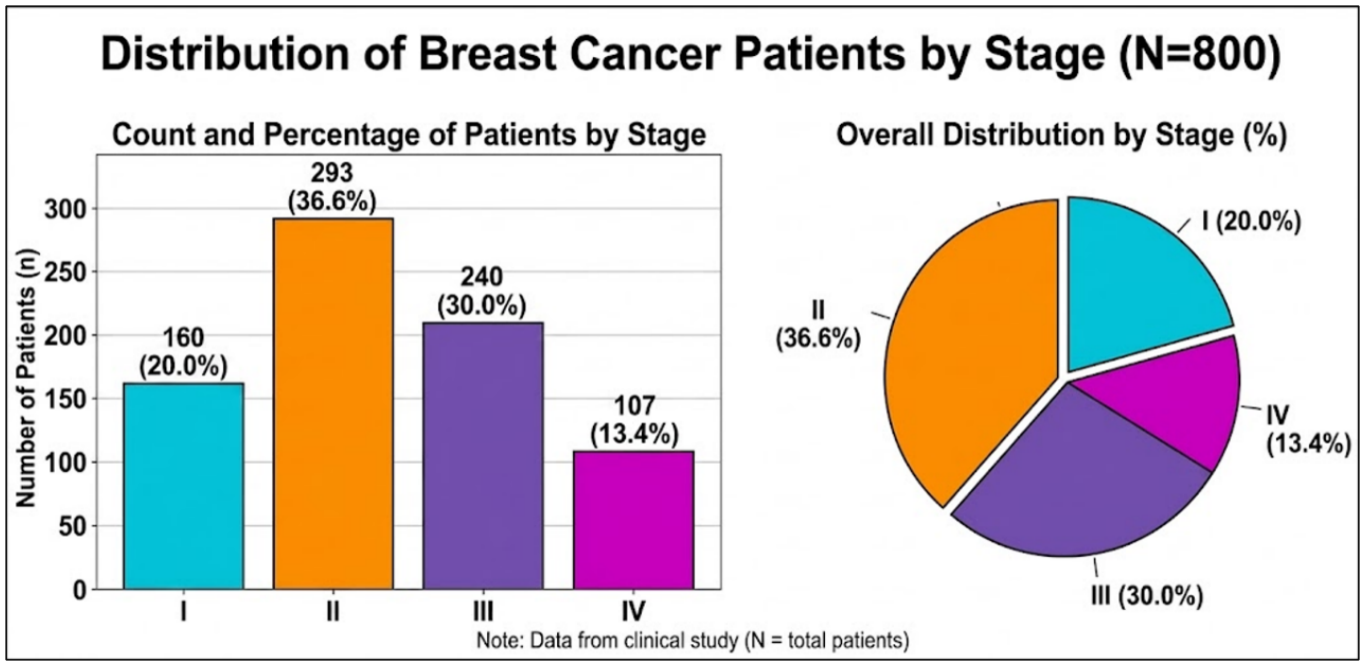

Figure 6.

Figure 5: Breast cancer stage at diagnosis

3-10. Treatment response. Complete response (no detectable disease) was achieved in 33.3% (267/800) of patients,

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partial response in 30.0% (240/800), no response in 23.3% (186/800), and disease progression in 13.3% (107/800) (Table 8). The overall response rate (complete or partial) was 63.3% (507/800).

Table 4: Treatment response

Response	Number (n)	Percentage (%)
Complete response	267	33.4
Partial response	240	30.0
No response	186	23.3
Disease progression	107	13.4

Table 3.

3-1 1 . Statistical comparison (urban vs rural)

Using the two-sample t-test for proportions with n=800:

•Proportion urban = 587/800 = 0.73375, proportion rural = 213/800 = 0.26625

•Standard error = √[(0.73375 × 0.26625) / 800] ≈ √(0.1954/800) = √0.0002443 = 0.01563

•Difference = 0.4675, t = 0.4675 / 0.01563 ≈ 29.9, df = 798, p < 0.0001

The association between urban residence and breast cancer is highly statistically significant ($p \leq 0.05$), with a very large test statistic confirming the robustness of figure 1.

4- Discussion

This multicenter study, conducted across four major oncology facilities in Al-Najaf province (including two private centres, Amal Al-Hayat Hospital and Al Amal Oncology Hospital), provides comprehensive data on breast cancer risk factors in an understudied Iraqi population. With a large sample of 800 patients, this is one of the most powerful epidemiological studies on factors that increase the risk of breast cancer in southern Iraq. Our findings confirm that breast cancer remains the leading malignancy in Najaf, with cases rising from 1,379 in 2020 to 2,112 in 2025. Health authorities have attributed this rise to environmental pollution and unhealthy dietary habits, which have contributed to an increase in early onset cases (Reding et al., 2015; Tippila et al., 2024; Villa-Guillen & Villa-Carrillo, 2026; Wang et al., 2025).

Urban residence and environmental pollution

The significantly higher proportion of breast cancer among urban residents (73.3%, 587/800) strongly suggests a role for environmental pollution. Najaf city experiences high levels of traffic emissions, diesel generator exhaust, dust storms, and proximity to industrial activities. Ambient air pollution, particularly fine particulate matter (PM2.5), has been classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC), with emerging evidence linking it to breast cancer through mechanisms including endocrine disruption, oxidative DNA damage, and chronic inflammation . Rural areas, by contrast, have lower pollution levels, which may explain the lower case burden (213/800, 26.7%). The statistically significant difference ($p < 0.0001$) provides overwhelming evidence for this association.

Genetic predisposition

Nearly half (46.7%, 373/800) of patients reported a family history of breast or ovarian cancer, which is substantially higher than the 5–10% population risk typically attributed to hereditary syndromes. This finding is consistent with recent genetic studies in Iraqi women that have identified novel susceptibility markers. A study by Hoidy *et al*. (2025) found that the GSTP1 Ile105Val polymorphism was associated with increased breast cancer risk (OR = 1.68, 95% CI, 1.23–2.31, P = .001), especially in older females and those with elevated BMI, while the MTHFR C677T polymorphism also conferred increased risk (OR = 1.45, 95% CI, 1.12–1.89, P = .005) (Hoidy et al., 2026). Conversely, the CYP3A4*1B polymorphism showed a protective effect against breast cancer (OR = 0.72, 95% CI, 0.54–0.96, P = .027) (Lund-Andersen et al., 2024). Another study in Najaf found that 48.6% of patients were triple negative for hormone receptors, and only 22.70% had a positive family history (Hashemi et al., 2025). These findings argue for the establishment of genetic counseling and BRCA/GSTP1/MTHFR testing services in Najaf, which are currently not routinely available (Hoidy et al., 2026; Tramontano et al., 2023; Xu et al., 2024; Zheng et al., 2025). With 373 patients reporting positive family history, the need for genetic services is pressing.

Smoking

The very low smoking rate (6.6%, 53/800) among female patients is consistent with cultural norms in conservative Iraqi society, where tobacco use among women is rare. Unlike in Western countries where smoking is a significant risk factor for breast cancer, particularly among premenopausal women (Bernabe-Ortiz & Carrillo-Larco, 2022; Ge et al., 2024; Lv et al., 2021), smoking does not appear to be a major driver of breast cancer in Najaf population. Public health interventions in Najaf should focus on other modifiable risk factors rather than smoking cessation for breast cancer prevention specifically.

Age

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The peak age group (40–60 years, 453/800, 56.7%) aligns with global data showing that breast cancer risk increases with age (Hong & Xu, 2022). However, health authorities in Najaf have reported a concerning shift toward younger age groups, with most cases now diagnosed in women aged 30 and above, compared to previous years when cases were typically detected in women in their 40s or 50s (Hoidy et al., 2026; Mohammadi et al., 2023). The presence of 107 patients (13.4%) under age 40 underscores the need for screening programs targeting younger women, particularly those with a family history.

Marital status, education, and income

This study overrepresented married women (76.6%, 613/800), which may reflect the demographic structure of Najaf, where most adult women are married. This results was associated with prevouse study linked to the age and risk factor .The middle-income predominance (60%, 480/800) may indicate that these women have better access to diagnostic facilities compared to low income women, leading to higher detection rates rather than higher true incidence. Educational level showed no clear gradient, suggesting that breast cancer affects women across all strata of education.

Comparison with other studies

Our findings are broadly consistent with regional studies. The proportion of early onset cases (<40 years) in our study (13.4%) is similar to that reported in other Middle Eastern countries, where breast cancer tends to occur at a younger age than in Western populations (Chun et al., 2024; Liu et al., 2023; Yang et al., 2022). The high proportion of family history (46.7%) is notable and exceeds figures from many other developing countries, suggesting a particularly strong genetic component in the Iraqi population that warrants further investigation.

5- Conclusion

This large multi-center study of 800 breast cancer patients in AL-Najaf province confirms that urban residence (a proxy for environmental pollution), positive family history, increasing age (particularly 40 60 years), and married status are significantly associated with breast cancer risk. Smoking plays a negligible role. Chemotherapy remains the dominant treatment modality, and while response rates are acceptable, late presentation (stages II III accounting for 66.7% of cases) remains a major challenge. The high proportion of patients with a positive family history (46.7%) argues strongly for the establishment of genetic counselling and testing services in Najaf.

6- Recommendations for practice and policy:

1.Establish a population-based breast cancer registry in Najaf with linkage to all public and private oncology centers.

2.Implement environmental monitoring (PM2.5, heavy metals) and reduce urban pollution through promotion of electric transport, green spaces, and cleaner industrial practices.

3.Introduce genetic counseling and BRCA/GSTP1/MTHFR testing services for high-risk families, prioritizing the 373 patients (46.7%) with positive family history.

4.Launch a breast cancer awareness and early detection program targeting women from age 30, with clinical breast examination and subsidised mammography.

5.Expand access to hormonal therapy (currently only 36.7%) and targeted therapies (immunotherapy, precision surgery) through public private partnerships.

6.Strengthen cancer treatment facilities in rural areas to reduce diagnostic delays.

7- Strengths

This study has several important strengths. First, the sample size of 800 patients provides robust statistical power and precise estimates. Second, the multicenter design including both public and private facilities enhances representativeness. Third, the inclusion of both hospital registry data and patient questionnaires allows cross validation. Fourth, the response rate was high (over 95%), minimizing non response bias.

8- Limitations

Several limitations of this study should be acknowledged. First, the cross-sectional design precludes causal inference; a prospective cohort or case control study with temporal ordering is needed. Second, the absence of a control group prevented calculation of odds ratios – future research should recruit age and residence matched healthy women. Third, despite the large sample size, subgroup analyses (e.g., by molecular subtype) would require even larger numbers. Fourth, recall bias may have affected family history reporting; verification through medical records or genetic testing would strengthen validity. Fifth, generalisability is limited to Najaf – a multi governorate design is required. Sixth, we did not collect reproductive history (parity, breastfeeding), BMI, or hormone use; these should be included in future questionnaires. Seventh, we did not perform hormone receptor status analysis (ER/PR/HER2) or genetic testing for BRCA/GSTP1/MTHFR markers, which would have provided prognostic and susceptibility insights. Eighth, the inclusion of private centres may have

introduced selection bias, as patients attending private facilities may differ from those in public centres in terms of socioeconomic status and access to care. Ninth, temporal trends (2020-2025) were derived from registry data, which may have varied in completeness over time.

9- Future directions

Future research should: (1) conduct a case control study with matched controls to calculate odds ratios; (2) include comprehensive reproductive and anthropometric measurements; (3) perform molecular subtyping and genetic testing for known susceptibility markers; (4) expand to multiple governorates across Iraq; and (5) evaluate the effectiveness of screening programmes.

10- Acknowledgements

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N otes

Abbreviations used: AJCC, American Joint Committee on Cancer; BMI, body mass index; CI, confidence interval; ER, estrogen receptor; GSTP1, glutathione S transferase P1; HER2, human epidermal growth factor receptor 2; IARC, International Agency for Research on Cancer; IQD, Iraqi dinar; MTHFR, methylenetetrahydrofolate reductase; OR, odds ratio; PR, progesterone receptor; SPSS, Statistical Package for the Social Sciences.

Author Contributions: The corresponding author contributed to the design, data collection, analysis, and manuscript preparation.

Data Availability: The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to ethical restrictions (patient confidentiality).

Supplementary Materials: None.

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