

RESEARCH ARTICLE

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Survival Outcomes and Mortality Predictors in Breast Cancer: An Ambidirectional Cohort Study from Central Vietnam

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Abstract

Background: Breast cancer (BC) is one of the most common cancers worldwide; however, there is a lack of comprehensive data on survival outcomes and prognostic factors in Central Vietnam. This study aimed to estimate overall survival (OS) rates and identify key prognostic factors associated with mortality among BC patients in this region. **Methods:** This ambidirectional cohort study included 1,213 patients newly diagnosed with BC at Danang Oncology Hospital between January 2019 and December 2023. OS rates at 1, 3, and 5 years were estimated using the Kaplan-Meier method, and survival differences across molecular subtypes and TNM stages were evaluated using the log-rank test. Prognostic factors for mortality were assessed using a multivariable Cox proportional hazards model. **Results:** The 1-, 3-, and 5-year OS rates were 97.4%, 91.0%, and 86.0%, respectively. The Luminal A subtype had the highest 5-year OS rate (91.5%), while the triple-negative subtype had the lowest (76.9%). Patients with stage IV disease had a 5-year OS rate of 29.5%. Significant predictors of higher mortality included unemployment [adjusted hazard ratio (aHR) 1.59], liver diseases (aHR 3.06), progesterone receptor-negative status (aHR 2.20), Ki-67 index $\geq 30\%$ (aHR 2.13), and TNM stage III–IV (aHR 10.27). Surgical intervention was associated with a reduced risk of mortality (aHR 0.40). **Conclusions:** The study found relatively high OS rates in this cohort. However, advanced stage, unfavorable tumor characteristics, comorbidities, and socioeconomic disadvantage were associated with worse outcomes. Collaborative multicenter research using standardized data collection is necessary to validate and expand these findings across diverse settings, ultimately supporting efforts to improve survival outcomes in BC patients.

Keywords: Breast cancer- overall survival rate- mortality- prognostic factors

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Introduction

Cancer is a non-communicable disease that has a major impact on population health, the economy, and society globally [1]. Approximately 20% of the global population is expected to develop cancer during their lifetime, with mortality rates of 11% in men and 8.3% in women. According to GLOBOCAN 2022, based on data from 185 countries, there were an estimated 20 million new cancer cases and 9.7 million cancer-related deaths [2]. Breast cancer (BC) is one of the most common cancers worldwide, particularly among women, accounting for 11.6% of all female cancer cases and contributing to 17.4 million disability-adjusted life years (DALYs) globally [2, 3]. In Southeast Asia, BC ranks first among all cancers, with 168,536 new cases, accounting for 14.7% of total cases in both sexes and 28.0% in women [4]. Similarly, BC is also the most commonly diagnosed cancer in Vietnam, with 24,563 new cases in 2022, accounting for 13.6% of all cancer cases in both sexes and 28.9% in women [5].

Although BC mortality is relatively low, making up just 6.9% of all cancer deaths in women [6], investigating prognostic factors associated with mortality is crucial for enhancing treatment outcomes and reducing the risk of death.

Globally, a multitude of studies have published data on overall survival (OS) rates among BC patients, with a particular focus on a 5-year period. Despite this, the quality of these data varies due to differences in follow-up periods, selection criteria, and the scope of the studies. A systematic review of 126 original studies reported OS rates of 92% at 1 year, 75% at 3 years, and 73% at 5 years [7]. The survival outcomes of BC patients were influenced by several related factors. Key among these were the stage at diagnosis, with survival rates of 100.0% for localized stages, 87.2% for regional spread, and 32.6% for distant metastasis [8]. Prognostic factors for mortality identified in a cohort study included high tumor grade, large tumor size, involvement of axillary lymph nodes, and negative estrogen and progesterone receptor status [9].

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A study conducted in Vietnam and published in 2013 reported 1-year, 3-year, and 5-year OS rates of 94%, 83%, and 74%, respectively, for BC patients [10]. These figures represent a significant improvement over an earlier study published in 2007, which reported 1-year, 3-year, and 5-year OS rates of 52.2%, 30.4%, and 8.7%, respectively [11]. Mortality among the patients was significantly influenced by factors including marital status, educational attainment, cancer stage at diagnosis, and the use of hormone therapy [10]. However, these data may be outdated due to recent changes in BC incidence and mortality in Vietnam, where it is now the most commonly diagnosed cancer.

Although numerous studies have been conducted on BC globally and in Vietnam, information on OS rate or predictors of mortality in Central Vietnam remains limited. This region has unique geographical, socio-economic, and healthcare characteristics, requiring context-specific research. Distinctive environmental and lifestyle factors in this region play a direct role in the development of BC [12]. Furthermore, variations in cancer incidence trends have also been observed across different geographic areas, as reported in previous studies [13]. Therefore, this study was carried out to estimate 1-year, 3-year, and 5-year OS rates and identify prognostic factors for mortality among BC patients in Central Vietnam. The findings are expected to provide a scientific basis for optimizing BC treatment and management, thereby helping to reduce mortality and improve public healthcare in the region.

Materials and Methods

Study Design and Settings

This study was conducted at Danang Oncology Hospital, a Class I medical facility specializing in cancer care, located in Danang City, Vietnam. With 960 beds and a staff of 601, including 127 physicians, the hospital provides comprehensive oncology services, including surgical interventions, chemotherapy, radiotherapy, palliative care, and nuclear medicine [14]. This ambidirectional cohort study focused on BC patients residing in 19 provinces and municipalities across Central Vietnam. Data were obtained from digital health records (DHR) at the hospital, covering the period from January 2019 to December 2023, and were supplemented by telephone-based survival follow-ups at least one year from the initial diagnosis, concluding in December 2024.

Study Participants and Data Collection Procedures

Participants included BC patients who were first diagnosed with BC at Danang Oncology Hospital between January 2019 and December 2023, and who resided in Central Vietnam. Exclusion criteria included patients who were male; missing essential information such as clinical or paraclinical characteristics and treatment procedures; unknown dates of initial diagnosis or death; prior treatment for BC at other medical facilities; suspected but unconfirmed BC cases or benign conditions under observation; patients with multiple primary cancers; and those who were lost to follow-up, defined as less than one year from the initial diagnosis to the end of the follow-up

period.

At the beginning, data were extracted from the DHR system, managed through the hospital information system using FPT.eHospital software [15], to identify BC patients who were admitted and received initial treatment at Danang Oncology Hospital. Patients were selected based on the ICD-10 code C50 (Malignant neoplasm of breast) over a five-year period, resulting in an initial sample of 2,327 cases. Subsequently, 772 cases were excluded for meeting at least one of the predefined exclusion criteria. The remaining 1,555 eligible cases proceeded to the follow-up phase for monitoring survival status or metastasis due to disease progression. To obtain follow-up information, hospital medical staff contacted patients or their relatives using phone numbers recorded in the hospital information system. These calls aimed to verify survival status, defined as death from any cause (whether related or unrelated to breast cancer), confirm the occurrence of metastasis, and record the date of the event when applicable. During the follow-up period, which started at the time of initial BC diagnosis for each patient and ended in December 2024, 330 cases were excluded due to unsuccessful contact after three attempts. Additionally, 12 cases were removed because, although relatives confirmed the patient's death, they declined to provide the date of death. Ultimately, a total of 1,213 cases were included in the final analysis, representing 16 out of 19 provinces and municipalities in Central Vietnam. The data collection procedures were described in Figure 1.

Study Variables

The survey collected baseline information at the time of initial diagnosis, including participant characteristics such as age, place of residence, employment status, and health insurance coverage. Clinical data included factors such as a family history of BC, existing comorbidities, and body mass index (BMI). Paraclinical data encompassed immunohistochemical markers, molecular subtypes, the presence of distant metastasis at diagnosis (*de novo*), metastatic location, and Tumor–Node–Metastasis (TNM) stage. Additionally, information on the types of BC treatment administered during the initial hospital admission was recorded.

BMI was calculated using the standard formula: $\text{BMI (kg/m}^2\text{)} = \text{weight (kg)} / \text{height}^2 \text{ (m}^2\text{)}$. For Vietnamese participants in this study, BMI classification followed the WHO's 2000 guidelines for the Asia-Pacific population, categorizing individuals into three groups: underweight ($\text{BMI} < 18.5$), normal range ($\text{BMI } 18.5\text{--}22.9$), and overweight ($\text{BMI} \geq 23$) [16].

The immunohistochemical markers analyzed in this study included estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor 2 (*HER2*), and *Ki-67* (%). BC molecular subtypes were classified according to the St. Gallen 2015 guidelines, five subtypes were identified: Luminal A ($\text{ER+}/\text{PR+}$, *HER2*-, $\text{Ki-67} < 30\%$), Luminal B/*HER2*-negative ($\text{ER+}/\text{PR+}$, *HER2*-, $\text{Ki-67} \geq 30\%$), Luminal B/*HER2*-positive ($\text{ER+}/\text{PR+}$, *HER2*+, any *Ki-67*), *HER2*-enriched (*ER*-, *PR*-, *HER2*+), and triple-negative (*ER*-, *PR*-, *HER2*-) [17, 18].

Histologic tumor grade was categorized into three

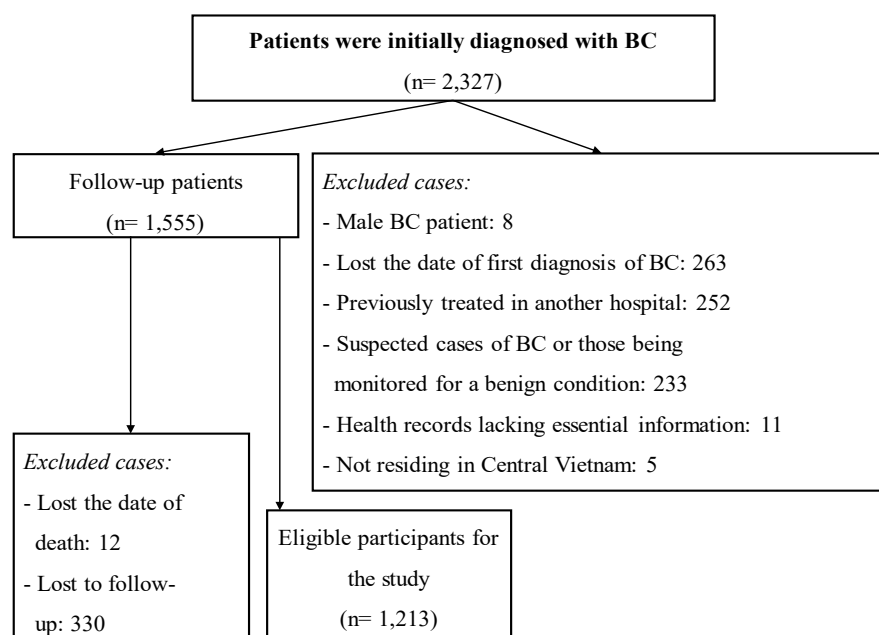


Figure 1. Eligible Participants for This Cohort Study (2019 – 2024)

levels: grade I, II, and III by the Nottingham–Bloom–Richardson system, which was based on three features: the extent of tubular formation, the severity of nuclear pleomorphism, and the level of mitotic activity [19].

The TNM staging at diagnosis was determined according to the 8th edition of the American Joint Committee on Cancer (AJCC) staging manual, which classifies cancer based on anatomical criteria, including tumor size (T), lymph node involvement (N), and the presence of distant metastasis (M). The TNM staging system categorizes BC into five stages, ranging from stage 0 to stage IV [20]. For the purpose of the multivariable Cox proportional hazards (PH) analysis, TNM stages were grouped into two categories: stages 0 to II were defined as early-stage disease, while stages III and IV were classified as late-stage disease [21].

Follow-up information: death from any cause was considered the event of interest in the survival analysis. Follow-up duration, calculated in months, was defined from the date of initial BC diagnosis to the date of death, last follow-up contact, or loss to follow-up. Individuals who were either lost to follow-up or remained alive at the end of the follow-up period were treated as censored cases. Additionally, the occurrence of distant metastasis as a result of disease progression was also recorded during follow-up.

Data Analysis

The collected data were coded, cleaned, and analyzed using Stata version 17.0. Categorical variables were summarized as frequencies (n) and percentages (%), while continuous variables were presented as mean, standard deviation (SD), minimum (Min), and maximum (Max) values. In the survival analysis, the 1-year, 3-year, and 5-year OS rates along with their 95% confidence intervals (CI) were estimated using the Kaplan–Meier method (Figure 2). Differences in OS rate across molecular subtypes and TNM stage at diagnosis were compared using

the log-rank test. Expected survival (ES) was estimated using Ederer’s second method [22]. Relative survival (RS) was then calculated as the ratio of the observed OS in BC patients to the ES derived from a Vietnamese population life table, matched by age and year of breast cancer diagnosis [23]. Additionally, prognostic factors associated with mortality in BC patients were identified using univariable and multivariable Cox PH models, with crude hazard ratios (cHRs) and adjusted hazard ratios (aHRs) reported to assess changes after controlling for other variables. Candidate variables were selected based on a literature review of previous studies and stepwise elimination, retaining only those with p-values less than 0.05 in the final multivariable model [24]. Finally, the PH assumption was assessed, and Harrell’s C-index was calculated to evaluate the model’s discriminatory ability.

Results

Baseline Characteristics

Among the 1,213 eligible participants, a mean age of the study population was 51.18 years (SD 11.02); 57.8% resided in urban areas and 70.1% were employed. Clinically, a family history of BC was rare (0.8%); hypertension was the most common comorbidity (7.6%). BMI data showed that 7.8% were underweight, and 41.0% were overweight. Paraclinical assessments revealed ER- in 35.4%, PR- in 47.8%, and HER2- in 53.7%, with 75.6% exhibiting a high Ki-67 index ($\geq 30\%$). The most common molecular subtypes were Luminal B, comprising 25.1% HER2- and 25.0% HER2+ cases, while grade 2 tumors predominated (89.5%). De novo metastasis was observed in 8.3% of cases, primarily involving bone (38.5%) and distant lymph nodes (44.6%). TNM staging showed that 55.7% were at stage II and 8.9% at stage IV. The majority received surgery as the initial treatment (81.1%), followed by chemotherapy (22.6%). Details of characteristics of BC patients were presented in Table 1.

Table 1. Characteristics of BC patients

Characteristics		n	%
Age at initial diagnosis (year)	Mean (SD)	51.18 (11.02)	
	Min - Max	20 – 92	
Age group	< 40	179	14.8
	40 – 49	368	30.3
	50 – 59	405	33.4
	≥ 60	261	21.5
Residence	Urban	701	57.8
	Rural	512	42.2
Employment status at diagnosis	Employed	850	70.1
	Non-employed	264	21.8
	Retired	99	8.2
Health insurance coverage		1178	97.1
Family history of BC		10	0.8
Comorbidities	Hypertension	92	7.6
	Diabetes	48	4.0
	Cardiovascular	33	2.7
	Bone and joint diseases	22	1.8
	Liver diseases	21	1.7
	Others	81	6.7
Number of comorbidities per patient	0	990	81.6
	1	168	13.8
	≥ 2	55	4.5
BMI classification (a)	Underweight	73	7.8
	Normal range	482	51.3
	Overweight	385	41
Immunohistochemical markers	ER- (b)	408	35.4
	PR- (b)	550	47.8
	HER2- (c)	613	53.7
	Ki-67 ≥ 30% (d)	869	75.6
Molecular subtypes (e)	Luminal A	178	15.6
	Luminal B/HER2-	286	25.1
	Luminal B/HER2+	285	25
	HER2-enriched	244	21.4
	Triple-negative	148	13.0
Tumor grade (f)	Grade 1	16	3.9
	Grade 2	368	89.5
	Grade 3	27	6.6
Distant metastasis	De novo	101	8.3
	Due to disease progression	29	2.4
	No	1083	89.3
Metastatic location (g)	Liver	39	30
	Lung	44	33.8
	Bone	50	38.5
	Brain	6	4.6
	Distant lymph node	58	44.6
	Other locations	16	12.3
TNM stage at diagnosis (h)	Stage 0	10	0.9
	Stage I	131	11.6
	Stage II	631	55.7
	Stage III	260	22.9
	Stage IV	101	8.9

Table 1. Continued

Characteristics		n	%
Type of BC treatment at first admission	Surgery	984	81.1
	Chemotherapy	274	22.6
	Targeted therapy	47	3.9
	Hormone therapy	21	1.7
	Radiotherapy	11	0.9
	Palliative care	7	0.6

SD, standard deviation; BC, breast cancer; BMI, body mass index; ER, estrogen; PR, progesterone; *HER2*, human epidermal growth factor receptor 2; +, positive; -, negative; TNM, Tumor–Node–Metastasis; Analysis conducted on (a) 940, (b) 1151, (c) 1142, (d) 1150, (e) 1141, (f) 411, (g) 130, and (h) 1133 available records.

Overall Survival Rate of Breast Cancer Patients

Table 2 presents the OS rates stratified by molecular subtypes and TNM stage at initial BC diagnosis. The overall cohort demonstrated OS rates of 97.4% at 1 year, 91.0% at 3 years, and 86.0% at 5 years, with corresponding RS rates of 98.2%, 93.0%, and 89.9%, respectively. Among molecular subtypes, patients with Luminal A tumors exhibited the highest OS rates of 98.9%, 96.4%, and 91.5% at 1, 3, and 5 years, respectively, whereas those with triple-negative BC had the lowest OS rates, at 93.9%, 84.6%, and 76.9% ($p < 0.001$). Survival outcomes also varied significantly by TNM stage ($p < 0.001$), with stages 0 and I showing near-complete survival at 1 year and stage I maintaining a 5-year OS of 99.2%. In contrast, patients diagnosed at stage IV had markedly lower OS rates of 75.3%, 54.6%, and 29.5% at 1, 3, and 5 years, respectively.

Prognostic Factors for Mortality among Breast Cancer Patients

Table 3 summarizes the results of univariable and multivariable Cox PH regression analyses evaluating factors independently associated with mortality among BC patients. Six variables were significantly associated with an increased risk of mortality in the multivariable model, including unemployment (adjusted hazard ratio [aHR] 1.59; 95% CI: 1.03–2.46), presence of liver diseases (aHR 3.06; 95% CI: 1.08–8.60), PR- (aHR 2.20; 95% CI: 1.43–3.40), *Ki-67* index ≥30% (aHR 2.13; 95% CI: 1.07–4.24), and late-stage disease (TNM stage III–IV) (aHR 10.27; 95% CI: 5.95–17.74). In contrast, surgical treatment was significantly associated with a reduced risk of mortality (aHR 0.40; 95% CI: 0.26–0.61). The model demonstrated good discriminatory performance, with a Harrell's C-index of 0.847, and met the PH assumption ($p = 0.984$).

Discussion

This cohort study evaluated OS rates and patterns among BC patients in Central Vietnam. The findings revealed 1-, 3-, and 5-year OS rates of 97.4%, 91.0%, and 86.0%, respectively. These rates are considerably higher than those reported in a previous Vietnamese study, which indicated a 5-year OS rate of only 74% [10], and closely align with global survival estimates for BC [7]. In particular, the high RS rate, especially in the first year

Table 2. OS Rate According to Molecular Subtypes and TNM Stage of BC Patients

Variables	OS rates (%), (95% CI)			p-value
	1-year	3-year	5-year	
Number of death	32	59	22	N/A
OS rate	97.4 (96.3 – 98.1)	91.0 (89.0 – 92.6)	86.0 (83.0 – 88.5)	N/A
RS rate	98.2 (97.2 – 98.9)	93.0 (90.9 – 94.7)	89.9 (87.1 – 92.3)	N/A
Molecular subtypes (a)				
Luminal A	98.9 (95.6 – 99.7)	96.4 (91.3 – 98.5)	91.5 (80.4 – 96.4)	<0.001*
Luminal B/HER2-	99.0 (96.8 – 99.7)	93.1 (89.0 – 95.7)	88.2 (81.6 – 92.6)	
Luminal B/HER2+	97.9 (95.4 – 99.1)	93.0 (88.7 – 95.7)	89.9 (83.4 – 93.9)	
HER2-enriched	98.4 (95.7 – 99.4)	88.6 (83.2 – 92.3)	82.9 (75.6 – 88.2)	
Triple-negative	93.9 (88.6 – 96.8)	84.6 (77.2 – 89.7)	76.9 (66.0 – 84.7)	
TNM stage(b)				
Stage 0	100	N/A	N/A	<0.001*
Stage I	100	99.2 (94.5 – 99.9)	99.2 (94.5 – 99.9)	
Stage II	99.5 (98.5 – 99.9)	97.6 (95.8 – 98.7)	96.1 (93.2 – 97.8)	
Stage III	98.9 (96.5 – 99.6)	83.5 (77.6 – 87.9)	74.9 (66.2 – 81.7)	
Stage IV	75.3 (65.6 – 82.5)	54.6 (43.3 – 64.5)	29.5 (16.4 – 43.9)	

OS, overall survival; RS, relative survival; CI, confidence interval; N/A, not applicable; HER2, human epidermal growth factor receptor 2; +, positive; -, negative; TNM, Tumor – Nodes – Metastasis; Analysis conducted on (a) 1141, (b) 1133 available records; *log-rank test.

after diagnosis (98.2%), suggests that the survival of BC patients in this cohort is comparable to that of the general population, suggesting notable improvements in disease management, early detection, and treatment accessibility in recent years. Analysis by molecular subtype revealed that patients with Luminal A tumors experienced the most favorable outcomes, consistent with the subtype's typically indolent nature and responsiveness to hormone therapy. In contrast, patients with triple-negative BC exhibited the lowest OS rates, reflecting the aggressive biology and limited targeted treatment options associated with this subtype [25]. Furthermore, TNM staging demonstrated a strong prognostic influence, with patients diagnosed at stage IV showing a markedly reduced 5-year

OS of 29.5%, nearly identical to the 32.6 percent reported in the SEER Program [8]. The predominance of stage II diagnoses (55.7%) within the cohort may help explain the overall favorable survival outcomes, highlighting the critical role of earlier detection and timely intervention in improving prognosis among BC patients in this region.

Key patient-related factors associated with increased mortality among BC patients included unemployment and the presence of liver diseases. Unemployment at diagnosis increased the risk of mortality by 59%. This finding aligns with existing research highlighting the impact of socioeconomic status (SES) on cancer outcomes. For instance, a cohort study in Pakistan among women with BC found that lower SES was associated with poorer

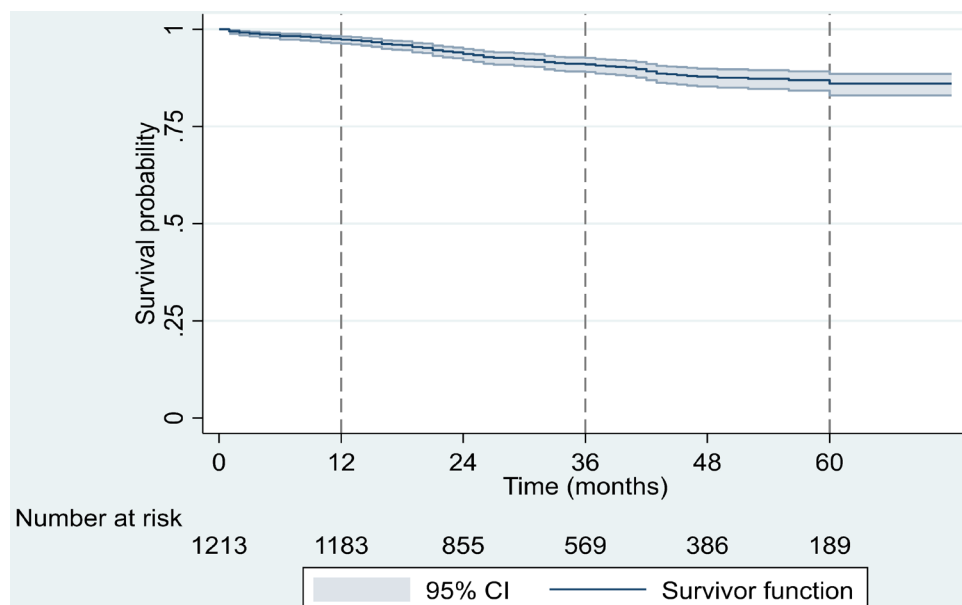


Figure 2. Kaplan-Meier Survival Estimate of BC Patients. CI, confidence interval.

Table 3. Factors associated with Mortality among BC Patients Using Univariable and Multivariable Cox Proportional Hazards Model

Factors	cHR (95% CI)	p-value	aHR (95% CI)	p-value
Employment status at diagnosis				
Employed	Ref		Ref	
Non-employed /Retired	1.78 (1.20 – 2.65)	0.004	1.59 (1.03 – 2.46)	0.038
Presence of liver diseases				
No	Ref		Ref	
Yes	2.98 (1.22 – 7.30)	0.017	3.06 (1.08 – 8.60)	0.034
Progesterone				
PR (+)	Ref		Ref	
PR (-)	2.64 (1.72 – 4.03)	<0.001	2.20 (1.43 – 3.40)	<0.001
<i>Ki-67</i> (%)				
< 30%	Ref		Ref	
≥ 30%	2.83 (1.43 – 5.61)	0.003	2.13 (1.07 – 4.24)	0.031
TNM stage				
Stage 0-II	Ref		Ref	
Stage III-IV	14.51 (8.54 – 24.66)	<0.001	10.27 (5.95 – 17.74)	<0.001
Surgery treatment				
No	Ref		Ref	
Yes	0.25 (0.17 – 0.37)	<0.001	0.40 (0.26 – 0.61)	<0.001

cHR, Crude hazard ratio; aHR, adjusted hazard ratio; CI, confidence interval; PR, progesterone; -, negative; TNM, Tumor – Nodes – Metastasis; Analysis conducted on 1073 available records for all factors in the model; Test of the proportional hazards assumption and concordance statistic for the multivariable model: Global test = 0.984; Harrell's C = 0.847.

survival, likely due to delayed diagnosis and limited access to healthcare [26]. Similarly, a national longitudinal mortality study using SEER registries data reported that lower SES correlates with advanced stage at diagnosis and worse survival [27]. These results suggest that low SES, particularly unemployment, may serve as a proxy for financial barriers, limited health literacy, or poorer overall health. Additionally, patients with liver diseases faced a threefold higher risk of mortality. Comorbidities have been shown to significantly reduce survival in BC patients, possibly due to impaired drug metabolism or an increased risk of treatment-related complications [28]. A prior study also demonstrated that variations in co-morbid conditions can influence mortality risk across different cancer types [29]. Moreover, liver diseases were the strongest predictor of mortality among comorbidities (HR 2.32; 95% CI: 1.97 to 2.73) based on a study using the SEER database [30]. These conditions independently predict higher mortality, underscoring the importance of comprehensive management of coexisting health issues to improve patient outcomes.

Several immunohistochemical markers significantly influenced mortality risk. Specifically, patients with PR-tumors had a 2.2-fold higher risk of mortality, consistent with a previous study describing PR- tumors as associated with poorer disease-free survival, shorter OS time, and endocrine resistance [31]. Furthermore, a high *Ki-67* index (≥30%) was associated with a 2.13-fold increased risk of mortality, highlighting its role as a marker of elevated tumor proliferation. Notably, elevated *Ki-67* expression is linked to poorer clinical outcomes, and reductions in *Ki-67* levels after neoadjuvant endocrine therapy

may help predict long-term prognosis [32]. Among all tumor-related variables, the most significant risk factor was late-stage (TNM stage III–IV), which increased mortality risk over tenfold. This finding is consistent with SEER data [33], emphasizing the critical role of early detection and stage at diagnosis in determining long-term survival outcomes. In addition, treatment-related factors demonstrated differential impacts on survival outcomes. Surgical intervention was associated with a 60% reduction in mortality risk, underscoring its critical role in the management of BC. Moreover, prior studies have consistently supported the survival benefit of surgery, particularly highlighting the timing of the intervention. Delays in surgical treatment have been shown to negatively affect OS, highlighting the importance of timely operative management in improving patient outcomes [34].

This study has several limitations. It was conducted at a single treatment center in Central Vietnam, which may limit generalizability due to differences in demographics, treatment practices, and healthcare resources across institutions. A substantial number of cases were excluded due to missing data or loss to follow-up, potentially introducing selection bias and underestimating mortality. Additionally, reliance on retrospective DHR led to incomplete or inconsistent information for key variables, affecting data accuracy.

In conclusion, this study provides important insights into survival and prognostic factors of mortality among BC patients in Central Vietnam. The observed OS rates were favorable and comparable to global standards, likely reflecting improvements in early detection and treatment.

Key factors influencing mortality included socioeconomic status, with unemployment significantly increasing the risk of mortality, and comorbidities such as liver diseases, which emerged as the strongest predictor of mortality. Tumor characteristics, including PR- status, a high *Ki-67* index, and late-stage diagnosis, were also associated with significantly worse outcomes. Additionally, surgical treatment demonstrated a protective effect, reinforcing its critical role in BC management. However, these findings should be interpreted with caution due to several limitations, including the single-center design, a high exclusion rate due to missing data, and the reliance on incomplete retrospective data from DHR. These limitations highlight the need for future multi-center, prospective studies with standardized data collection with the process of tracking a group of individuals over time to observe the development of a specific event, to improve better the understanding of BC outcomes.

Author Contribution Statement

TDH, TVV, and PS conceptualized and designed the study. TDH and CTMN collected data. TDH analyzed data and drafted the manuscript. TVV and PS co-supervised the manuscript. TVV, CTMN, and PS revised the manuscript. All authors have read and approved the final manuscript.

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Ethical approval

This study was approved by the Ethical Committee of Danang Oncology Hospital, Vietnam (No. 609/BVUBDN-HDDD), and the Khon Kaen University Ethics Committee for Human Research, Thailand (No. 4.3.02: 6/2568).

Availability of data

This study forms part of an approved PhD dissertation in the Epidemiology and Biostatistics Program at Khon Kaen University, Thailand. The data supporting the findings are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no conflicts of interest.

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