

Development and External Validation of a Prognostic Nomogram for Overall Survival in Male Breast Cancer Using SEER and Multicenter Data

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ABSTRACT

Male breast cancer (MBC) represents an uncommonly diagnosed condition. The infrequency of its occurrence has led to a scarcity of investigations examining prognostic outcomes in this population. The present work aimed to develop a nomogram to estimate overall survival in MBC patients, followed by external validation in a Chinese patient sample. Drawing upon records within the Surveillance, Epidemiology, and End Results (SEER) database, all male subjects who first received a breast cancer diagnosis within the window spanning January 2010 to December 2015 were eligible for inclusion. Through random allocation following a 7:3 split, these individuals formed a training subset ($n = 1610$) and an internal validation subset ($n = 713$). An external corroboration cohort was assembled from 22 MBC patients whose diagnoses occurred at the First Affiliated Hospital of Guangxi Medical University across the period from January 2013 through June 2021, applying June 10, 2023, as the conclusion of follow-up observation. Application of the Cox regression methodology permitted identification of statistically meaningful risk determinants, which subsequently informed construction of a nomogram projecting overall survival for MBC patients. The resultant model was tested using data from the test subset. Evaluations of discriminative capacity and dependability incorporated the concordance index (C-index), receiver operating characteristic (ROC) curves, decision curve analysis (DCA), and Kaplan-Meier survival plotting. The analytical sample comprised 2301 MBC cases extracted from the SEER database, along with 22 MBC cases contributed by the participating hospital facility. Seven independent predictors were retained within the finalized model: patient age (hazard ratio [HR] = 1.89, 95% CI: 1.50-2.38), receipt of surgical intervention (HR = 0.38, 95% CI: 0.29-0.51), marital circumstance (HR = 0.75, 95% CI: 0.63-0.89), tumor classification (HR = 1.17, 95% CI: 1.05-1.29), clinical disease stage (HR = 1.41, 95% CI: 1.15-1.74), administration of chemotherapy (HR = 0.62, 95% CI: 0.50-0.75), and HER2 receptor expression (HR = 2.68, 95% CI: 1.20-5.98). For the training, internal validation, and external validation subsets, C-index measurements reached 0.72, 0.747, and 0.981, respectively. Satisfactory calibration properties were evident in the nomogram, and ROC analysis demonstrated the model's superior clinical validity. Results from DCA suggested favorable applicability within clinical settings. Additionally, the risk classification scheme derived from the nomogram permitted sharper demarcation among prognostic subgroups, with individuals stratified into the low-risk tier experiencing considerably more favorable survival trajectories than their medium- and high-risk counterparts ($P < .001$). Through this investigation, a prognostic nomogram incorporating 7 variables was successfully developed to predict survival in MBC patients. The resultant predictive instrument can estimate survival endpoints for affected individuals and provides an evidence-based reference point for diagnostic and therapeutic clinical judgment.

Keywords: Male breast cancer (1), Specific survival (1), Prediction model (121), Nomogram (16), Surveillance, Epidemiology

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Introduction

Carcinoma of the male breast constitutes a rarely encountered malignant entity [1, 2]. Across the entirety of breast cancer (BC) diagnoses, the proportion affecting males falls below 1%, while within the Chinese context, MBC

accounts for merely 0.31% of all BC presentations [3-5]. Notable geographic and ethnic variation characterizes the occurrence patterns of MBC, with African, North American, and Australian populations exhibiting comparatively elevated incidence rates, and Asian groups showing the lowest recorded frequencies [6]. Within China, the annual incidence is only 4 per million inhabitants, albeit with a gradual upward trajectory over more recent years [6]. The uncommon nature of MBC means that contemporary BC research efforts remain heavily oriented toward female patient populations [7]. Consequently, therapeutic management of MBC currently relies on protocols originally designed for treating female BC [8]. It must be recognized, however, that MBC demonstrates distinctive neoplastic, molecular, and clinicopathologic attributes, and consensus remains elusive regarding its diagnostic workup, therapeutic approach, and prognostic determinants. Earlier studies document that the median age at BC presentation in men is 67 years, approximately 5 to 10 years beyond the corresponding median in women [9]. Despite this later onset, overall survival outcomes for MBC trail substantially behind those observed in female BC, an observation largely ascribed to delays in diagnostic identification [10].

The tumor-node-metastasis (TNM) classification framework, which incorporates the extent of primary disease, degree of lymphatic involvement, and presence or absence of distant spread, is the predominant clinical tool used for prognostic evaluation across oncologic conditions [11-13]. With respect to MBC, however, the inherently limited volume of mammary tissue coupled with the tendency toward early chest wall infiltration diminishes the informative value of TNM-based staging alone [14]. Ample published evidence confirms that variables, including but not limited to chronologic age, histopathologic subtype, and additional clinicopathologic parameters, exert meaningful influence on BC outcomes [15, 16]. Compared with exclusive reliance on clinical staging metrics, comprehensive multivariate modeling approaches offer the advantage of generating quantitative, practice-contextualized risk estimates while simultaneously enhancing the prognostic precision achievable for oncology patients [17]. In light of these considerations, synthesizing diverse clinical data elements to develop a dedicated prognostic framework for MBC becomes essential, enabling both more refined outcome prediction and individualized prognostic assessment tailored to each patient.

Modern clinical methodology for constructing risk estimation instruments spans approaches that incorporate nomographic representation, algorithmic scoring, and other statistical techniques, all of which are positioned to inform clinical decision pathways and support individualized treatment selection [18-20]. Nomograms, characterized by their straightforward graphical format and robust predictive performance, deliver notable strengths in both forecasting accuracy and calibration reliability and, as such, have gained widespread acceptance across prognostic research applications [21-23].

This investigation was conceived with the objectives of first delineating meaningful prognostic markers for MBC through systematic exploration of the Surveillance, Epidemiology, and End Results (SEER) database; second, erecting a predictive architecture anchored by independent correlates of overall survival; and third, subjecting the resultant model to rigorous internal alongside external scrutiny, thereby equipping clinical personnel with enhanced capability for prognostic estimation and facilitating formulation of increasingly personalized diagnostic and therapeutic regimens. This manuscript is presented in alignment with the TRIPOD reporting standards.

Materials and Methods

Data sources

Information on newly diagnosed malignancies and corresponding survival figures is compiled in the SEER database from 18 registry sites that draw on defined populations, a network that presently captures data on roughly 30% of the American populace [22]. To construct both a development cohort and an internal testing cohort, clinical records of male individuals whose BC received pathological verification during 2010-2015 were retrieved from the SEER database. Serving as the external corroboration arm, documentation was gathered for MBC cases managed at the First Affiliated Hospital of Guangxi Medical University from 2013 through 2021. A retrospective extraction of MBC-specific clinical parameters from the institutional data repository was conducted, with subsequent follow-up particulars obtained via telephonic outreach. Individuals for whom follow-up records or other indispensable clinical details were incomplete were removed from the analysis.

Patient inclusion and exclusion criteria

Enrollment eligibility rested upon satisfaction of the following stipulations: (1) designation as male; (2) assignment of codes conforming to the International Classification of Diseases for Oncology, Third Revision; (3)

identification of the breast as the originating tumor location; and (4) availability of full survival documentation. Reasons warranting exclusion encompassed (1) absent clinical particulars, among them TNM stage assignment and tumor sidedness; (2) unrecorded demographic attributes, exemplified by diagnostic age and marital circumstance; and (3) the absence of any follow-up record (a survival time entry of 0 months). Eligible subjects were subsequently randomized in a 7:3 ratio, yielding a model-building training set and a dedicated internal validation set. The training partition served as the foundation for predictive model formulation, while the internal validation partition was employed to gauge within-sample performance. Hospital-derived observations constituted the external validation material.

Variable selection

This investigation designated overall survival as its primary endpoint. The pool of candidate predictors was determined through consultation of previously published scholarly work. Abstracted data fields spanned diagnostic year, patient age, marital status, histopathological grade, carcinoma subtype, estrogen receptor positivity, progesterone receptor positivity, human epidermal growth factor receptor 2 (HER2) status, American Joint Committee on Cancer stage classification, administration of chemotherapy, surgical management, radiotherapy delivery, follow-up span, and occurrence of death.

Follow-up of patients

For male BC patients, telephonic follow-up was conducted through the hospital, with the observation window closing on June 10, 2023. The parameter tracked throughout the follow-up period was overall survival, with mortality as the terminal event.

Statistical analysis

All statistical computations were executed within the R software ecosystem, version 4.1.1 (IBM Corp). Categorical descriptors were expressed as percentages, and contrasts of baseline characteristics across the training, internal validation, and external validation groupings used either the χ^2 test or the Fisher exact test, where appropriate. Visualization of overall survival distributions was performed using the Kaplan-Meier method, and the log-rank test assessed heterogeneity in survival across the various categorical strata of each variable. Initially, factors with $P < .05$ on univariable screening were carried forward into a multivariable Cox proportional hazards regression, from which variables independently influencing survival among MBC subjects were identified. Subsequently, a stepwise selection process governed by the Akaike information criterion was applied. The nomogram predictive instrument was assembled using R computational tools (specifically, the rms and survival packages) to quantify the contributions of identified risk determinants to overall survival in the MBC cohort. Using this nomogram, projected probabilities of 1-year, 3-year, and 5-year overall survival for MBC patients were generated.

Assessment of the nomogram's capabilities proceeded through both internal and external validation pathways. A bootstrap resampling regimen comprising 1000 iterations was performed to assess the nomogram's prognostic fidelity internally, thereby safeguarding its stability and reliability. Discriminative capacity was appraised using the Concordance index (C-index) alongside receiver operating characteristic (ROC) curve examination. To verify agreement between predicted and observed outcomes, a calibration graphic was produced, confirming the nomogram's accuracy and reliability. Beyond these assessments, decision curve analysis (DCA) was performed using the ggDCA functionality in R, providing insight into the nomogram's clinical net benefit and translational value. Lastly, using X-tile software (version 3.6.1, Yale University School of Medicine), patients were assigned to risk tiers based on their cumulative nomogram-derived score. Throughout, a statistical significance cutoff of $\alpha = .05$ was maintained.

Ethical considerations

The dataset analyzed in this work was drawn from SEER, an openly accessible repository. Ethical review and endorsement were secured through the Medical Ethics Committee of the First Affiliated Hospital of Guangxi Medical University (2023-E320-01). At the follow-up stage, oral informed consent was solicited from each enrolled participant, with the examining researcher communicating the investigation's objectives to the patient or to a designated caregiver. Participants were apprised that they retained the right to disengage at any time without facing adverse consequences or detriment to their ongoing medical management, a commitment strictly observed

throughout the study. Moreover, those who completed the survey received a complimentary informational resource about the disease as a gesture of appreciation and acknowledgment of their involvement. All personal details were handled with strict confidentiality, and every patient received a coded identifier to ensure that study data and resulting findings remained anonymous.

Results and Discussion

Patients' baseline characteristics

The screening cascade applied to SEER records is displayed schematically in **Figure 1**. After filtering according to the prespecified entry and exclusion thresholds, a pool of 2301 MBC cases meeting all eligibility conditions was culled from SEER and subsequently split via randomization into a model-building subset ($n = 1595$) and a holdout subset for internal testing ($n = 706$). A separate contingent of 22 MBC cases contributed by the partnering hospital facility was designated as the external testing subset. Across the three subsets, a notable discrepancy was detected in the breakdown of patient ages ($P = .01$). Specifically, elderly males comprised a substantially heavier presence within both SEER subsets (model-building: $1180/1595$, 74%; internal testing: $505/706$, 71.5%) than was evident among hospital-derived cases ($9/22$, 41%). Marked inter-subset variation was likewise recorded for chemotherapy delivery, pulmonary metastatic deposits, breast cancer molecular phenotype, and HER2 receptor expression (all $P < .05$). The fraction of MBC patients whose management included chemotherapy reached its zenith in the external testing group ($17/22$, 77%), far outstripping the corresponding proportions in the SEER model-building ($601/1595$, 37.7%) and internal testing ($257/706$, 36.4%) subsets. Spread of disease to the lungs was documented at a considerably higher rate in the hospital cohort ($3/22$, 14%) relative to the SEER model-building ($49/1595$, 3.1%) and internal testing ($24/706$, 3.4%) cohorts. Luminal A emerged as the overwhelmingly prevalent molecular phenotype among males, occurring in 86.7% ($1379/1595$) and 85% ($607/706$) of model-building and internal testing cases, respectively, but in only 41% ($9/22$) of the external testing group. A striking observation is that, within the combined study population, HER2 negativity predominated, accounting for 88.6% ($1413/1595$), 87.5% ($618/706$), and 59% ($13/22$) of the model-building, internal testing, and external testing subsets, respectively. **Table 1** lays out the full demographic and clinicopathologic landscape of the sample.

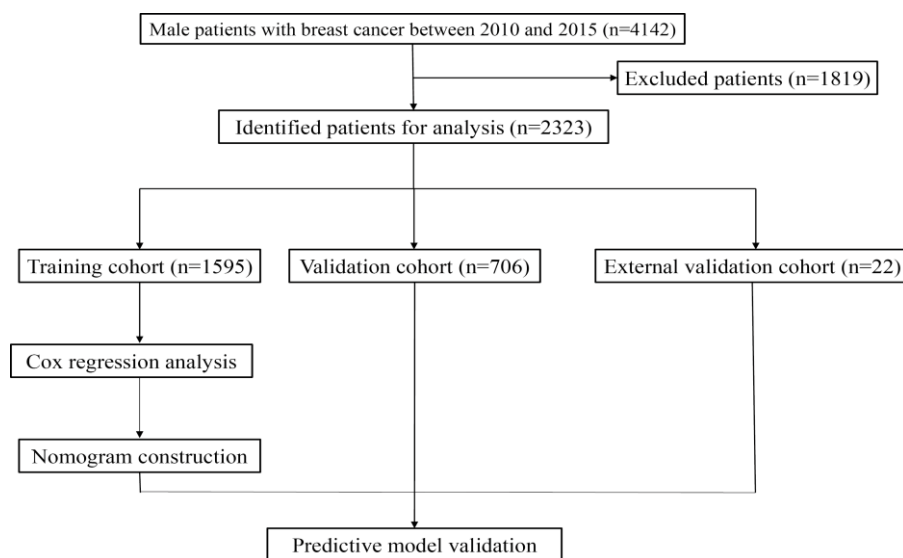


Figure 1. Flow chart for patient inclusion and partitioning.

Table 1. Demographics and clinicopathologic characteristics of male breast cancer.

Variables	P-value	External validation set (n = 22)	Internal validation set (n = 706)	Training set (n = 1595)	Total (n = 2323)
Marital status, n (%)	.10 ^a				
Unmarried		3 (14)	250 (35.4)	544 (34.1)	797 (34.3)
Married		19 (86)	456 (64.6)	1051 (65.9)	1526 (65.7)
Age, n (%)	.01 ^a				

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≤60 years		13 (59)	201 (28.5)	415 (26)	629 (27.1)
>60 years		9 (41)	505 (71.5)	1180 (74)	1694 (72.9)
T^b stage, n (%)	.07 ^c				
T₀		3 (14)	11 (1.6)	25 (1.6)	39 (1.7)
T₁		7 (32)	323 (45.8)	717 (45)	1047 (45.1)
T₂		11 (50)	285 (40.4)	675 (42.3)	971 (41.8)
T₃		1 (5)	23 (3.3)	46 (2.9)	70 (3)
T₄		0 (0)	64 (9.1)	132 (8.3)	196 (8.4)
N stage, n (%)^d	.30 ^c				
N₀		9 (41)	409 (57.9)	896 (56.2)	1314 (56.6)
N₁		11 (50)	205 (29)	488 (30.6)	704 (30.3)
N₂		0 (0)	56 (7.9)	132 (8.3)	188 (8.1)
N₃		2 (9)	36 (5.1)	79 (5)	117 (5)
M^e stage, n (%)	.53 ^a				
M₀		19 (86)	646 (91.5)	1466 (91.9)	2131 (91.7)
M₁		3 (14)	60 (8.5)	129 (8.1)	192 (8.3)
Clinical stage, n (%)	.79 ^c				
0		0 (0)	0 (0)	1 (0.1)	1 (0)
I		5 (23)	232 (32.9)	496 (31.1)	733 (31.6)
II		12 (55)	304 (43.1)	704 (44.1)	1020 (43.9)
III		2 (9)	110 (15.6)	265 (16.6)	377 (16.2)
IV		3 (14)	60 (8.5)	129 (8.1)	192 (8.3)
Laterality, n (%)	.93 ^c				
Right		11 (50)	331 (46.9)	731 (45.8)	1073 (46.2)
Left		11 (50)	374 (53)	860 (53.9)	1245 (53.6)
Bilateral		0 (0)	1 (0.1)	4 (0.2)	5 (0.2)
Surgery, n (%)	.65 ^a				
Yes		20 (91)	650 (92.1)	1449 (90.8)	2119 (91.2)
No		2 (9)	56 (7.9)	146 (9.2)	204 (8.8)
Radiation, n (%)	.37 ^a				
Yes		4 (18)	228 (32.3)	515 (32.3)	747 (32.2)
No		18 (82)	478 (67.7)	1080 (67.7)	1576 (67.8)
Chemotherapy, n (%)	< .001 ^a				
Yes		17 (77)	257 (36.4)	601 (37.7)	875 (37.7)
No		5 (23)	449 (63.6)	994 (62.3)	1448 (62.3)
Bone metastasis, n (%)	.59 ^c				
Yes		2 (9)	42 (5.9)	89 (5.6)	133 (5.7)
No		20 (91)	664 (94.1)	1503 (94.2)	2187 (94.1)
Unknown		0 (0)	0 (0)	3 (0.2)	3 (0.1)
Brain metastasis, n (%)	.49 ^c				
Yes		0 (0)	2 (0.3)	12 (0.8)	14 (0.6)
No		22 (100)	703 (99.6)	1577 (98.9)	2302 (99.1)
Unknown		0 (0)	1 (0.1)	6 (0.4)	7 (0.3)
Liver metastasis, n (%)	.42 ^c				
Yes		0 (0)	9 (1.3)	15 (0.9)	24 (1)
No		22 (100)	697 (98.7)	1574 (98.7)	2293 (98.7)
Unknown		0 (0)	0 (0)	6 (0.4)	6 (0.3)
Lung metastasis, n (%)	.04 ^a				
Yes		3 (14)	24 (3.4)	49 (3.1)	76 (3.3)
No		19 (86)	682 (96.6)	1539 (96.5)	2240 (96.4)
Unknown		0 (0)	0 (0)	7 (0.4)	7 (0.3)
Breast subtype, n (%)	< .001 ^a				
Luminal A		9 (41)	607 (86)	1379 (86.5)	1995 (85.9)
Luminal B		10 (45)	82 (11.6)	168 (10.5)	260 (11.2)

HER2^f -positive		2 (9)	6 (0.8)	14 (0.9)	22 (0.9)
Triple-negative		1 (5)	11 (1.6)	34 (2.1)	46 (2)
Estrogen receptor status, n (%)	.14 ^a				
Negative		2 (9)	18 (2.5)	52 (3.3)	72 (3.1)
Positive		20 (91)	688 (97.5)	1543 (96.7)	2251 (96.9)
Progesterone receptor status, n (%)	.06 ^a				
Negative		3 (14)	54 (7.6)	167 (10.5)	224 (9.6)
Positive		19 (86)	652 (92.4)	1428 (89.5)	2099 (90.4)
HER2 status, n (%)	.01 ^a				
Negative		13 (59)	618 (87.5)	1413 (88.6)	2044 (88)
Positive		9 (41)	88 (12.5)	182 (11.4)	279 (12)

^aChi-square test was performed.

^bT: tumor.

^cFisher precision probability test was performed.

^dN: lymph nodes.

^eM: metastasis.

^fHER2: human epidermal growth factor receptor 2.

Documentation for 22 male BC patients treated at the study hospital was assembled. When the hospital-derived records were placed alongside the SEER-derived records, statistically significant contrasts were brought into relief for age grouping, depth of primary tumor invasion (T classification), use of systemic chemotherapy, molecular subtype designation, and HER2 receptor display ($P < .05$). Among hospital-acrued cases, a greater relative contribution came from those no older than 60 years, harboring T2 lesions, having been exposed to chemotherapy, belonging to the luminal B category, and carrying HER2-positive tumors.

Univariate and multivariate cox regression analysis

Survival determinants were explored within the model-building subset using Cox proportional hazards regression, beginning with crude single-variable screening and progressing to a fully adjusted multivariable framework. From this process, seven factors emerged as independently tied to MBC survival likelihood: advancing age (hazard ratio [HR] = 1.89, 95% CI: 1.50-2.38), being married (HR = 0.75, 95% CI: 0.63-0.89), increasing T classification (HR = 1.17, 95% CI: 1.05-1.29), higher clinical grading (HR = 1.41, 95% CI: 1.15-1.74), undergoing surgical resection (HR = 0.38, 95% CI: 0.29-0.51), receiving chemotherapy (HR = 0.62, 95% CI: 0.50-0.75), and testing positive for HER2 (HR = 2.68, 95% CI: 1.20-5.98) (all $P < .05$);(**Table 2**).

Table 2. Univariate and multivariate analysis of male breast cancer risk factors in the training set.

Variable	Multivariate		Univariate	
	P-value	HR (95% CI)	P-value	HR ^a (95% CI)
Marital status	.01	0.75 (0.63-0.89)	< .001	0.71 (0.60-0.84)
Age	< .001	1.89 (1.50-2.38)	< .001	1.74 (1.39-2.16)
T^b stage	.04	1.17 (1.05-1.29)	< .001	1.45 (1.33-1.58)
N^c stage	.67	1.03 (0.90-1.17)	< .001	1.23 (1.12-1.35)
M^d stage	.81	1.08 (0.61-1.91)	< .001	5.19 (4.18-6.45)
Clinical stage	.01	1.41 (1.15-1.74)	< .001	1.86 (1.70-2.04)
Laterality	—	— ^e	.99	1.00 (0.85-1.19)
Surgery	< .001	0.38 (0.29-0.51)	< .001	0.18 (0.15-0.22)
Radiation	—	—	.84	0.98 (0.82-1.18)
Chemotherapy	< .001	0.62 (0.50-0.75)	.006	0.78 (0.65-0.93)
Bone metastasis	.12	0.71 (0.46-1.10)	< .001	0.18 (0.14-0.24)
Brain metastasis	.12	0.53 (0.24-1.17)	< .001	0.21 (0.09-0.49)
Liver metastasis	.79	0.91 (0.47-1.80)	< .001	0.20 (0.10-0.41)

Lung metastasis	.93	0.98 (0.69-1.40)	< .001	0.25 (0.17-0.35)
Breast subtype	.07	2.03 (0.95-4.30)	.19	1.16 (0.93-1.44)
Estrogen receptor status	.39	1.86 (0.45-7.76)	<.001	0.44 (0.29-0.65)
Progesterone receptor status	.56	0.91 (0.67-1.24)	<.001	0.64 (0.50-0.83)
HER2^f status	.02	2.68 (1.20-5.98)	.03	1.31 (1.02-1.68)

^aHR: hazard ratio.

^bT: tumor.

^cN: lymph node.

^dM: metastasis.

^eVariables that were not significant in the univariate analysis do not have specific data in the multivariate analysis.

^fHER2: human epidermal growth factor receptor 2.

Construction and validation of nomogram

Grounded in the Cox regression findings from the model-building subset, a graphical prediction tool—the nomogram—was assembled for estimating overall survival duration in MBC (**Figure 2**). The seven factors retained as independent predictors formed the instrument’s constituent axes. A review of the nomogram’s structure indicated that assignment of clinical stage and performance of surgery exerted the greatest influence on projected survival among the variables considered. By totaling the points contributed by each risk factor, a cumulative figure can be translated into expected survival percentages at 1, 3, and 5 years.

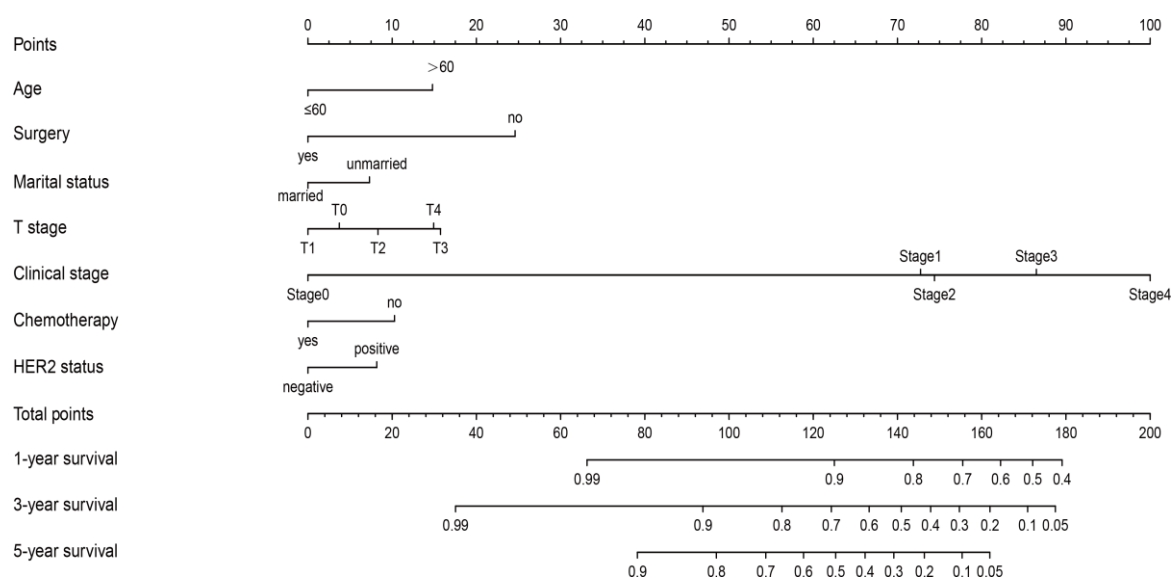


Figure 2. Nomogram for predicting 1-, 3-, and 5-year overall survival in patients with male breast cancer. HER2: human epidermal growth factor receptor 2; T: tumor.

Evaluation of the nomogram’s capacity to separate patients with differing outcomes drew upon ROC curve-derived area under the curve values and the C-index. In the model-building subset, area under the curve estimates for survival at 1, 3, and 5 years reflected robust discrimination (**Figures 3a-3c**). For the internal testing subset, these same metrics were 0.736, 0.773, and 0.765 (**Figures 3d-3f**); for the external testing subset, they were 1, 0.947, and 0.825 (**Figures 3g-3i**). C-index figures calculated via bootstrap resampling for the model-building data and via direct estimation for the external testing data were 0.72, 0.747, and 0.981 for the three respective time horizons, collectively indicating that the nomogram retained meaningful discriminatory accuracy when deployed in both American and Chinese patient groups.

The correspondence between the nomogram’s forecast and the observed data was assessed using calibration graphics. These plots revealed close superimposition of predicted survival curves onto the observed survival experience, a pattern sustained across the model-building (**Figures 4a-4c**) and internal testing (**Figures 4d-4f**) subsets.

Findings from DCA indicated that, compared with a strategy of treating all or none, the nomogram provided meaningful net clinical benefit and more precise predictive accuracy for the 3-year and 5-year endpoints, results that held both in the model-building (Figure 5a) and internal testing (Figure 5b) contexts.

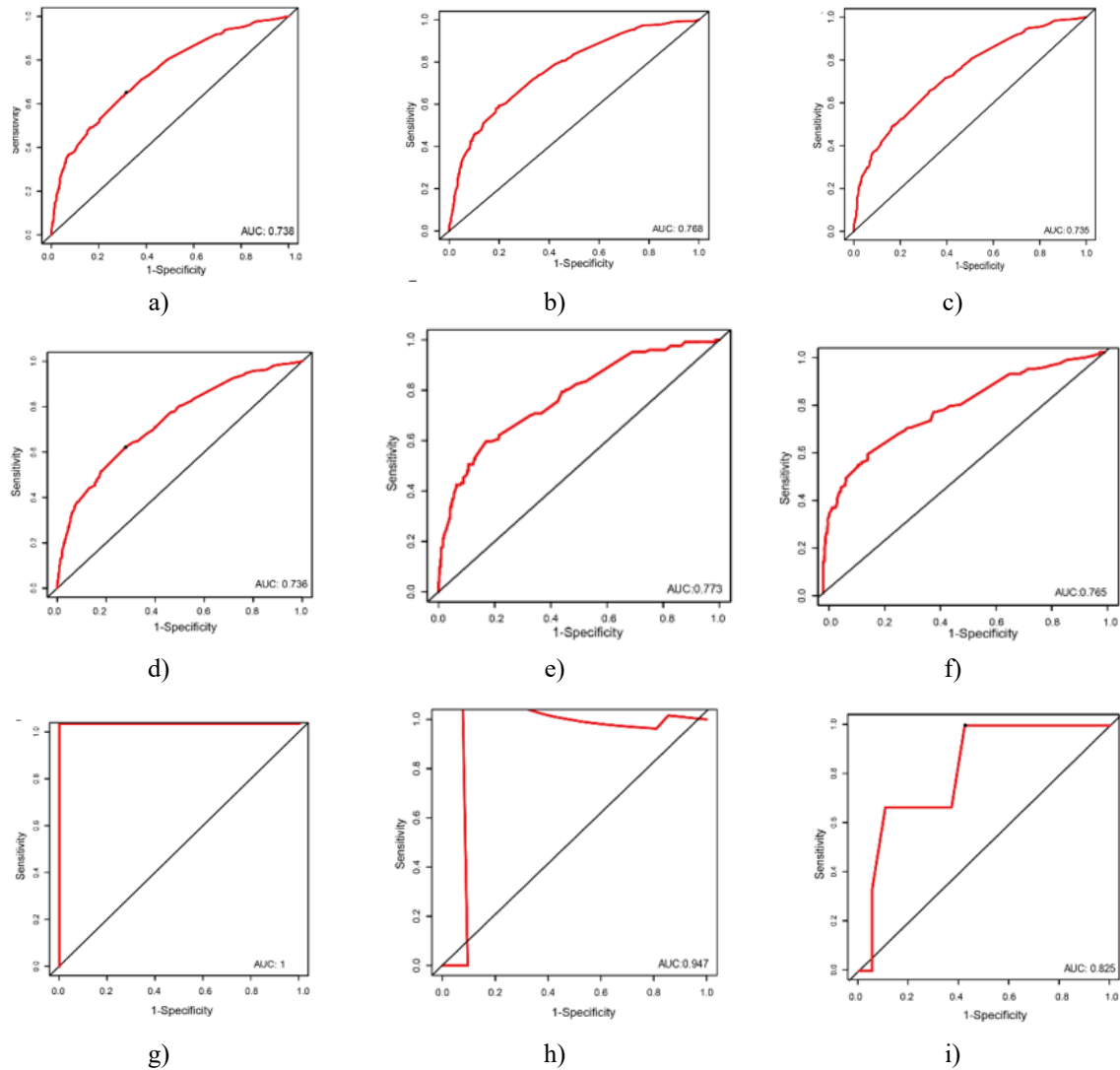
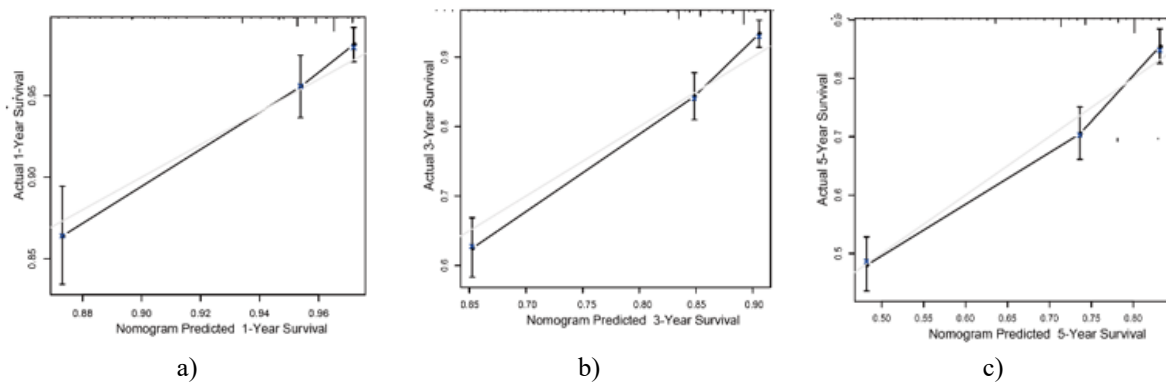


Figure 3. Receiver operating characteristic curve of prediction of 1-, 3-, and 5-year survival in the training set (a-c), internal validation set (d-f), and external validation set (g-i). Abbreviation: AUC = area under the curve.



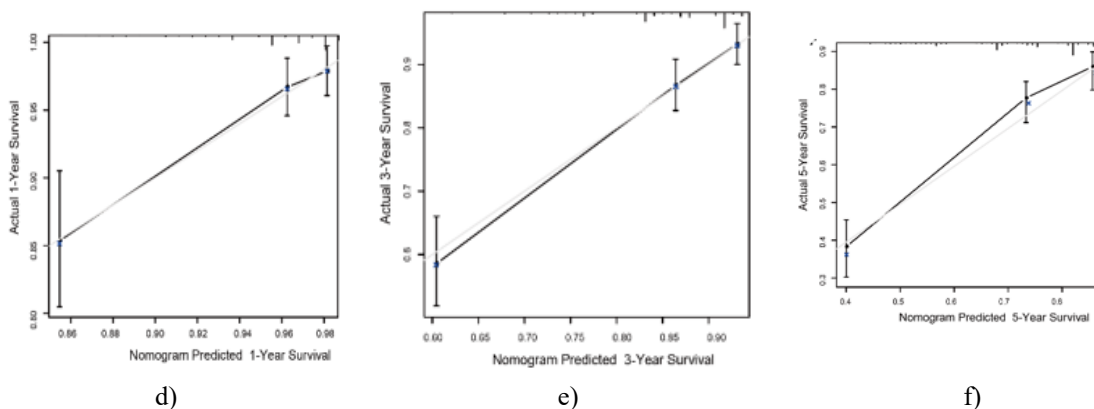


Figure 4. Calibration curve of 1-, 3-, and 5-year overall survival in the training set (a-c) and internal validation set (d-f). The error bars represent the 95% CI of these estimates.

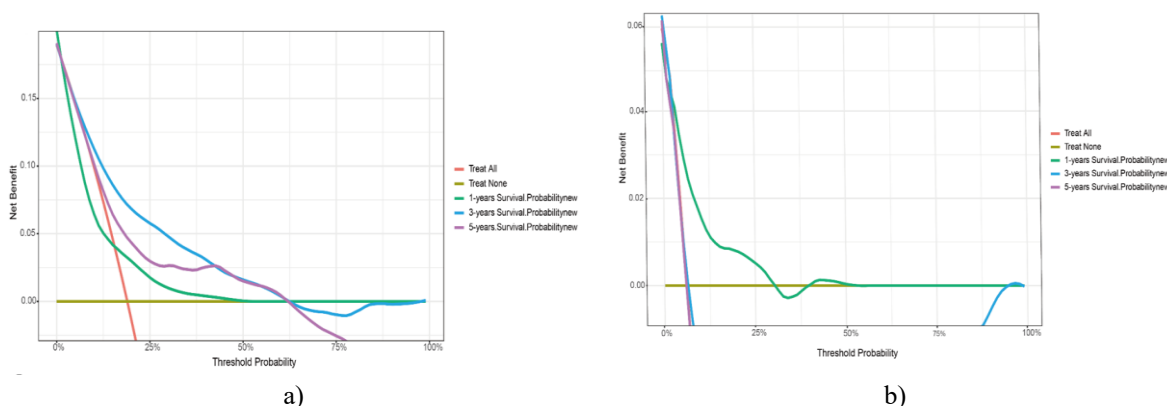


Figure 5. Decision curve analysis of 1-, 3-, and 5-year survival in the training set (a) and the internal validation set (b).

Nomogram prediction score risk stratification

As a culminating analytical step, every patient in the model-building subset was assigned a cumulative risk rating based on their nomogram total score (**Table 3**). Determination of optimal dividing lines using X-tile software permitted grouping of the complete MBC sample into three graded prognostic bands: low risk (points ≤ 93), intermediate risk ($93 < \text{points} \leq 117$), and high risk (points > 117). The Kaplan-Meier methodology was employed to graph the survival experience for each band, with the resultant curves displayed separately for the model-building subset (**Figure 6a**) and the internal testing subset (**Figure 6b**). Application of the log-rank test to assess the degree of separation among these three trajectories confirmed that categorizing patients by their nomogram-generated scores successfully isolated cohorts with starkly divergent prognoses.

Table 3. Nomogram score of male breast cancer survival.

Variable	Points
Age	
≤ 60 years	0
> 60 years	15
Surgery	
Yes	0
No	25
Marital status	
Unmarried	7
Married	0
T^a stage	
T ₀	4
T ₁	0

T ₂	8
T ₃	16
T ₄	15
Clinical stage	
0	0
I	73
II	74
III	86
IV	100
Chemotherapy	
Yes	0
No	10
HER2^b status	
Positive	8
Negative	0

^aT: tumor.

^bHER2: human epidermal growth factor receptor 2.

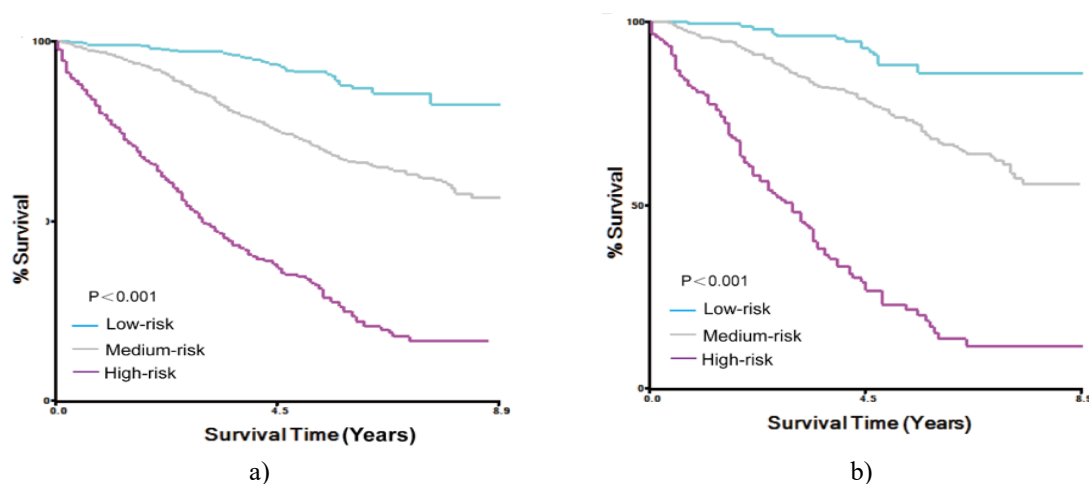


Figure 6. Analysis of survival based on risk stratification. Kaplan-Meier curves for patients categorized as low-, medium-, or high-risk in the training set (a) and the internal validation set (b).

Principal findings

This investigation constructed, anchored in SEER data, a nomogram for projecting MBC survival, subsequently confirming its performance using an internal dataset partitioned from the same registry and an external cohort contributed by a lone treatment center. Filtering candidate predictors yielded seven independent factors, each woven into the nomogram's architecture to estimate how long MBC patients might survive. That the tool performed with commendable accuracy and separation ability across both internal and external testing pathways substantiates the underlying model's resilience.

MBC qualifies as a seldom-diagnosed tumor type, with incidence figures placing it among the rarest of malignancies [24]. Despite this, affected males tend to receive their diagnosis at a more advanced chronological age, exhibit greater disease burden at presentation, and face grimmer survival odds than women with BC [25]. The scarcity of MBC means it often goes unnoticed during routine clinical encounters. Gauging what lies ahead prognostically for these patients is of considerable consequence if comprehensive multidisciplinary management strategies are to be put into effect. For the present work, clinical information on 1595 MBC cases extracted from SEER served as the basis for a survival prognostic nomogram. Internal corroboration was conducted via bootstrap resampling, while external corroboration was conducted using the hospital-sourced series. Discriminatory power and calibration fidelity were assessed using ROC curves, the C-index statistic, and plots comparing expected and observed outcomes. Supplementing these evaluations, clinical net benefit and practical worth were examined through the lens of DCA. Collectively, the findings established that this nomogram can provide individualized, precise projections of survival endpoints for MBC patients. In terms of potential downstream impact, such a

predictive aid could help shape bedside decision-making and direct the formulation of appropriate diagnostic pathways and treatment plans.

Earlier scholarship has examined the determinants of MBC survival using univariate and multivariate Cox proportional hazards models [26, 27]. Set against standard multivariate regression approaches, the least absolute shrinkage and selection operator (LASSO) technique enjoys a widely held reputation as the preferable strategy for predictor selection, a status it owes to its capacity for reducing model complexity—specifically, it reins in overfitting by embedding either a penalty component or a loss term within the function being optimized. In the analysis presented here, the LASSO regression identified seven parameters—chronological age, operative treatment, conjugal situation, T classification, clinical stage, systemic chemotherapy, and tumor HER2 status—as meaningfully associated with MBC outcomes. This tally of prognostic factors resonates with other published investigations [9, 28]. Based on this seven-variable panel, a nomogram-based prediction framework was developed that markedly improved clinical utility across diverse applied settings. The tool demonstrated strong separation capacity, calibration alignment, and clinical validity across both the derivation and testing partitions. It offers more effective support for therapeutic decision-making for these patients.

Placement of age as a prominent risk modifier for MBC survival within the nomogram—whereby men surpassing the 60-year mark experienced elevated death rates—echoes what prior reports have documented [28, 29]. A plausible explanation ties this pattern to the heavier illness burden borne by older individuals [28]. Both surgical management and chemotherapy administration are fundamental in shaping the prognosis of MBC patients who receive active treatment, a concept reinforced by earlier findings [30-32]. A recent contribution from Wang *et al.* [33] reported that MBC patients who received operative intervention or systemic cytotoxic therapy had significantly better survival than those who did not. The role of marital status was also found to be prognostically relevant, with unmarried status associated with less favorable survival trajectories [34-36]. Underlying mechanisms may involve the heavier psychological toll—manifesting as depressive and anxious symptomatology—experienced by unmarried MBC patients when juxtaposed with their married peers [37], coupled with what tends toward stricter medical regimen adherence among those with spouses [38]. These factors together could translate into superior oncologic outcomes. Beyond these elements, the evidence assembled here further buttresses the view that both depth of primary tumor invasion (T classification) and overall clinical stage function as meaningful harbingers of outcome in MBC [39, 40]. Clinical stage weighed most heavily among the seven nomogram inputs in terms of its influence on overall survival, with disease classified as stage III or IV conferring the worst outlook. Serbian researchers previously reported that modest initial disease extent, combined with low histologic grading, serves as an independent marker of favorable prognosis in the MBC setting [41]. Meanwhile, the designation of a tumor as HER2-positive is broadly accepted as a consequential prognostic determinant in MBC, a thread corroborated across several independent lines of inquiry [42-44].

In the context of this research, the typical age at which Chinese MBC patients first received their diagnosis appeared somewhat lower than the corresponding figure embedded in SEER records, mirroring what has been described for female BC onset patterns [45]. Beyond age, the institutional registry showed a greater relative representation of individuals with tumors diagnosed at an early T stage than SEER-derived data. Moreover, the fraction of patients whose treatment plan encompassed chemotherapy far exceeded that recorded in SEER. This therapeutic intensity plausibly contributes to the comparatively encouraging survival figures seen among Chinese MBC cases.

The act of devising a nomogram tailored to MBC survival estimation furnishes clinical personnel with a visual instrument through which the relative contribution of each risk element, together with the survival probability estimates tied to a given constellation of factors, can be grasped at a glance. These probability outputs can, in turn, serve as the structural basis for stratifying patients into prognostic tiers. Following this logic, the study sample was divided into three graded risk categories: favorable, intermediate, and unfavorable. By way of concrete illustration, consider an MBC patient whose profile includes age exceeding 60 years, married status, receipt of both operative treatment and cytotoxic chemotherapy, T categorization of T2, assignment to clinical stage II, and expression of HER2 by the tumor. Such an individual would accumulate roughly 105 points on the nomogram scale, placing him squarely within the intermediate-risk stratum for survival. This designation would signal to the clinical team that prompt institution of appropriate measures is warranted to manage and improve this patient's longitudinal outlook actively. In day-to-day practice, the model advanced here can be applied to the task of ascertaining and subsequently re-evaluating the survival likelihood and anticipated disease trajectory for MBC patients. The overarching ambition is to furnish bespoke, high-fidelity survival and prognostic appraisals, out of

which individualized and targeted clinical strategies can be devised for men confronting this uncommon malignancy.

Strengths and limitations

Several favorable attributes distinguish the present work. To begin with, prognostic modeling efforts in BC have historically focused on female disease, with comparatively little attention to MBC. This investigation deliberately set out to construct a predictive instrument tailored exclusively to the latter population. A second merit is that the SEER repository provided a cohort that was both expansive and heterogeneous, lending stability and representativeness to the derived findings. Furthermore, the incorporation of an external corroboration step using case material from the authors' own institution reinforced confidence in the model's precision and transportability across settings.

That said, certain constraints must be acknowledged. First, the study's retrospective design makes it susceptible to selection bias. Second, the SEER database lacks entries for several prognostically relevant parameters—endocrine-directed therapy, body mass index, and the proliferation marker Ki-67 stand as examples—omissions that may curtail the nomogram's fidelity and overall performance ceiling. Finally, the external validation arm rested on a modest sample size derived exclusively from the retrospective records of a single healthcare facility; the degree to which the model yields accurate predictions when applied to the broader Chinese population, therefore, awaits confirmation through larger-scale data.

Future directions

Moving forward, investigations would benefit from pooling information across multicenter networks, thereby expanding sample volume and, in turn, boosting both the precision and the generalizability of survival estimation frameworks for MBC. By sourcing data from geographically dispersed sites, investigators can capture a richer spectrum of clinical inputs, strengthening the model's durability and breadth of applicability. In parallel, prospective cohort designs ought to be mounted to subject the model to external vetting within real-world practice environments and to gauge its tangible utility during day-to-day clinical deliberation for MBC. Beyond these measures, incorporating supplementary data repositories that house pivotal covariates—such as body mass index and the proliferation index Ki-67—would further enhance the instrument's predictive capacity.

Conclusion

To summarize, a nomogram integrating seven variables was constructed to forecast outcomes among MBC patients, with chronologic age, operative intervention, marital status, T classification, clinical stage, and HER2 status identified as independent factors associated with MBC survival. Both internal cross-checking and external validation confirmed that the resulting tool possesses acceptable accuracy and dependability. On these grounds, it holds promise as a precise, individually tailored resource for clinicians to draw on when formulating management decisions.

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