Heliyon 10 (2024) e28864

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Development and external validation of a nomogram for predicting overall survival of patients with non-endometrioid endometrial cancer: A population-based analysis

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A B S T R A C T

Objectives: The main objective of this study was to identify the key predictors and construct a nomogram that can be used to predict the overall survival of individuals with non-endometrioid endometrial cancer.
Methods: A total of 2686 non-endometrioid endometrial cancer patients confirmed between 1988 and 2018 were selected from the Surveillance, Epidemiology, and End Results database. They were divided into a training cohort and an internal validation cohort. Independent risk factors were chosen by Cox regression analyses. A predictive nomogram model for overall survival was constructed based on above factors. A Chinese cohort of 41 patients was collected to be an external validation cohort.
Results: Eight variables were estimated as independent predictors for overall survival. A nomogram was established using these factors. The *C*-index for predicting the overall survival of patients with non-endometrioid endometrial cancer from the nomogram was 0.734, 0.700, and 0.767 in training, internal, and external validation cohort, respectively. Calibration plots and decision curve analysis showed that the nomogram was valuable for further clinical application.
Conclusion: We constructed a nomogram which can be used as an effective tool to predict the 3- and 5-year overall survival of Non-endometrioid endometrial cancer patients.

1. Introduction

Endometrial cancer (EC) is the most common gynecological malignancy globally [1], which accounts for about 30% of malignancies in the female reproductive system. And more notably, the incidence of EC is still on the risecurrently [1]. At present, it is considered that the prognosis of EC mainly depends on the cancerhistological type and stage [2]. EC is mainly classified into endometrioid endometrial cancer (EEC) and non-endometrioid endometrial cancer (NEEC) [3]. Histological subtypes of NEEC include serous, clear cell, neuroendocrine, undifferentiated carcinoma, and carcinosarcoma. Compared with EEC, NEEC only accounts for about 15%, however, it causes more than 50% of EC-related deaths, and NEEC patients bear poorer outcomes [4]. Moreover, there are several researches focused on EC or EEC [5–7], while fewer on NEEC. Therefore, it is very necessary to establish an individual

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https://doi.org/10.1016/j.heliyon.2024.e28864
Received 15 November 2022; Received in revised form 25 March 2024; Accepted 26 March 2024
Available online 29 March 2024

prediction model to evaluate the prognosis for NEEC patients.

The use of nomograms for building predictive models has become prevalent in recent times, proving to be beneficial in clinical prognosis prediction. The objective of this research was to develop and validate a nomogram for predicting the 3- and 5-year overall survival (OS) of patients with NEEC, utilizing an extensive dataset from the Surveillance, Epidemiology, and End Results (SEER) database.

2. Methods

2.1. Patient selection

All the information of patients confirmed with EC between 1998 and 2018 was acquired using SEER*Stat software (version 8.3.9.1; USA) from the SEER database. The informed consent was waived since the data available in this program were anonymous. The study protocol for this research was reviewed and approved by the Ethical Committee and Institutional Review Board of the Jiangsu Provincial Hospital of Chinese Medicine (JSHCM). Informed consent was waived for this retrospective study (2022NS-KS018).

The following were the inclusion criteria: (1) primary site: C54.1-Endometrium, (2) histologic record ICD-*O*-3: 8441\8480 (serous and mucinous), 8005\8310 (clear cell), 8002\8013\8041\8045\8246\8574(neuroendocrine), 8980–8981(carcinosarcoma), 8020\8805 (undifferentiated), (3) year of diagnosis: 1998–2018, (4) cause of death or survival time unknown.

The exclusion criteria were as follows: (1) Grade unknown; (2) Surgical stage unknown; (3) AJCC stage unknown; (4) Tumor size unknown; (5) Unknown marital status; (6) Lymphnode metastasis status unknown; (7) Myometrium invasion unknown; (8) Race unknown.

Patients with NEEC confirmed by postoperative pathology from January 2000 to December 2020 in the JSHCM and Women's Hospital of Nanjing Medical University (WHNMU) were consecutively included. The exclusion criteria are consistent with the criteria employed in the SEER cohort.

2.2. Cohort definition and variable recode

SEER database records included details on survival time, survival status, variables of age, race, marital status, histological subtype, histological grade, surgical stage, AJCC stage, surgical stage, lymph node metastasis status (LNM), radiotherapy (RT), chemotherapy (CT), tumor size, deep myometrium invasion (DMI), and cause of death, were gathered. The flowchart of the data process was shown in Fig. 1. The optimal cut-off values for age (31～, 58～, and 66～ years) and tumor size (40 and 57 mm) were identified by X-tile software. OS was the endpoint of interest that was examined in this study.

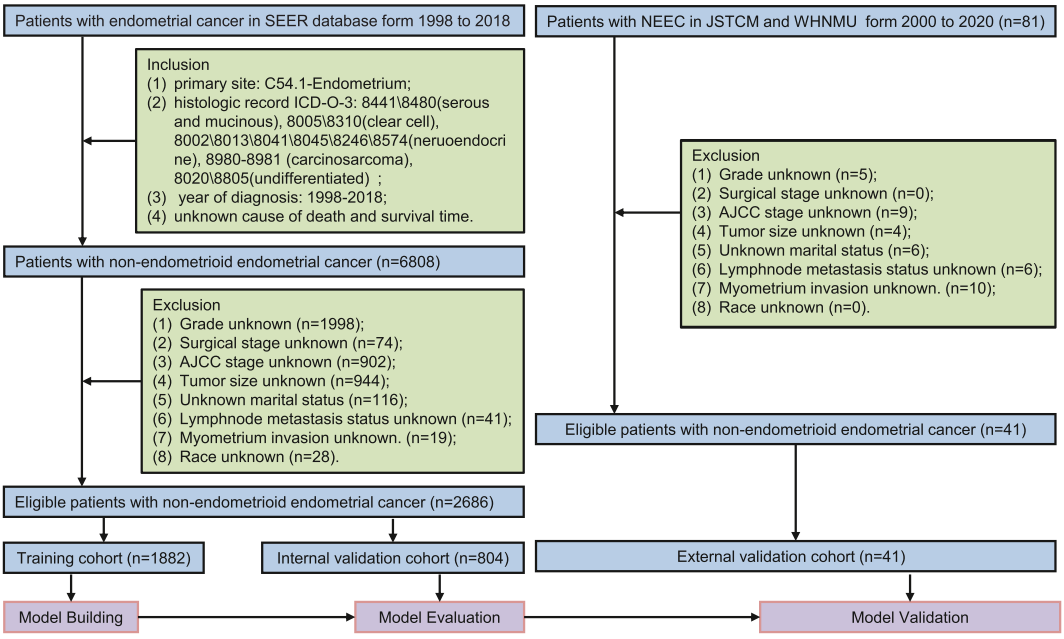

Fig. 1. Flowchart displaying the selection procedure of non-endometrioid endometrial cancers in the Surveillance, Epidemiology, and End Results database and local institute.

2.3. Statistical analysis

Frequencies with percentages were used to express continuous and categorical data. The clinical features were compared between the training and internal validation groups using a chi-square test. The Kaplan-Meier method was used in X-tile software to determine the optimal cut-off values for age and tumor size. The Kaplan-Meier method was utilized to plot survival curves, which were subsequently compared using the log-rank test. In the training cohort, a univariate cox regression analysis was carried out to identify the variables that were statistically significant. Then these variables were evaluated using multivariate Cox regression analysis and significant predictors associated with OS were identified. The prognostic nomogram was created by utilizing the significant predictors and then was validated internally and externally. To determine the prognostic performance and accuracy of the nomogram in predicting 3-year and 5-year OS, the *C*-index and receiver operating characteristic (ROC) curve were employed. The calibration plot was used to show the consistency between the actual and predicted 3- year and 5-year OS of the nomogram. Decision curve analysis (DCA) was performed to evaluate the net benefit and clinical utility of the nomogram. Nomogram, calibration plot, ROC, and DCA curves were developed and modified using the R version. All the statistical analyses were performed by the R program (http://www.r-project.org/).

Table 1
Baseline characteristics and treatment information of training, and validation cohorts.

	Training cohort	Internal Validation cohort	External validation cohort
Number of cases	1882	804	41
Age,years, median (IQR)	67 (62–74)	67 (61.5–74)	69.4 (61–80)
age n (%)			
31-58	293 (15.57)	140 (17.41)	5 (12.2)
59-65	505 (26.83)	180 (22.39)	6 (14.6)
66~	1084 (57.60)	484 (60.20)	30 (73.2)
Race n (%)			
White	1249 (66.37)	515 (64.05)	33 (80.5)
Black	355 (18.86)	164 (20.40)	5 (12.2)
Other	278 (14.77)	125 (15.55)	3 (7.3)
Marital status n (%)			
Single (never married)	306 (16.26)	113 (14.05)	4 (9.8)
Married	1576 (83.74)	691 (85.95)	37 (90.2)
Histological subtype n (%)			
serous and mucinous	1276 (67.80)	543 (67.54)	26 (63.4)
clear cell	297 (15.78)	123 (15.30)	3 (7.3)
neruoendocrine	25 (1.33)	11 (1.37)	1 (2.4)
carcinosarcoma	211 (11.21)	97 (12.06)	9 (22.0)
undifferentiated	73 (3.88)	30 (3.73)	2 (4.9)
Histological grade n (%)			
1	117 (6.22)	56 (6.97)	2 (4.9)
2	79 (4.20)	34 (4.23)	2 (4.9)
3	1686 (89.59)	714 (88.81)	37 (90.2)
Surgical Stage n (%)			
I	876 (46.55)	357 (44.40)	21 (51.2)
II	720 (38.26)	320 (39.80)	14 (34.1)
III	286 (15.20)	127 (15.80)	6 (14.6)
AJCCStage n (%)			
I	894 (47.50)	364 (45.27)	22 (53.7)
II	178 (9.46)	62 (7.71)	1 (2.4)
III	522 (27.74)	251 (31.22)	12 (29.3)
IV	288 (15.30)	127 (15.80)	6 (14.6)
Distant metastasis n (%)			
No	1616 (85.87)	685 (85.20)	35 (85.4)
Yes	266 (14.13)	119 (14.80)	6 (14.6)
Lymph node metastasis n (%)			
No	1395 (74.12)	595 (74.00)	30 (73.2)
Yes	487 (25.88)	209 (26.00)	11 (26.8)
Radiotheraphy n (%)			
Yes	855 (45.43)	348 (43.28)	15 (36.6)
No	1027 (54.57)	456 (56.72)	26 (63.4)
Chemotherapy n (%)			
Yes	1199 (63.71)	526 (65.42)	26 (63.4)
No	683 (36.29)	278 (34.58)	15 (36.6)
Tumorsize n (%)			
≤40 mm	996 (52.92)	405 (50.37)	15 (36.6)
40–57 mm	371 (19.71)	169 (21.02)	9 (22.0)
≥57 mm	515 (27.36)	230 (28.61)	17 (41.5)
Myometrium invasion n (%)			
Superficial	585 (31.08)	235 (29.23)	16 (39.0)
Deep	1297 (68.92)	569 (70.77)	25 (61.0)

3. Results

3.1. Patients' characteristics

A total of 6808 NEEC patients who met the inclusion criteria were extracted from the SEER database. According to the exclusion criteria, 2686 patients were finally obtained. The Chinese cohort included a total of 81 NEEC patients. After excluding 40 patients who did not meet the criteria, a total of 41 patients were included in the final analysis. The patients from the SEER database were randomly split into two cohorts using the R software: a training cohort consisting of 1882 patients and a test cohort consisting of 804 patients, in a ratio of 7:3. The model was established using the training cohort, while the internal and external validation cohort were utilized to validate the results obtained from the training cohort.

The median follow-up time recorded in the SEER database was 40.9 months, varying from 0 to 179 months, and the estimated 3-year survival rate was 40.2%. In the local cohort, the median follow-up times were 25.6 months, varying from 0 to 129 months, and the estimated 3-year survival rate was 48.7% in the whole population. The demographic and clinical features of these NEEC patients are detailed in Table 1. The median ages of patients with NEEC in the entire population, training cohort, internal validation cohort, and external validation cohort were 67 (IQR: 62–74), 67 (IQR: 62–74), and 67 (IQR: 61.5–74) years, the median tumor size of NEEC was 40 (IQR: 25–60), 40 (IQR: 25–60), and 40 (IQR: 25–63.25) millimeter, respectively. Optimal cut-off values were identified at 58 and 66 years for age, and at 40 and 57 mm for tumor size. The number of patients ≤58-, 59–65, ≥66 years of age were 433 (16.12%), 685 (25.5%), 1568 (58.38%). The survival time of three cohorts were 40.9 ± 38.4 months. The number of people of never married and married were 419 (15.6%) and 2267 (84.4%), respectively. There were 1764 (65.67%) white people, 519 (19.32%) black, and 403 (15%) other races. Those with tumor diameter ≤40, 41–56, and ≥57 mm were 1401 (52.16%), 540 (20.1%), and 745 (27.74%). The

Table 2
Univariate and multivariate Cox analyses of prognostic factors for building the model.

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
age		<0.001		
31-58	Reference		Reference	
59-65	1.09 (0.84–1.41)		1.15 (0.88–1.5)	0.296
66~	1.73 (1.38–2.16)		1.64 (1.3–2.08)	**<0.001**
Race		0.359		
Marital status		0.702		
Histological subtype		0.007		
serous and mucinous	Reference		Reference	
clear cell	1.3 (1.08–1.58)		1.16 (0.95–1.42)	0.141
neruoendocrine	2.46 (1.52–4)		1.82 (1.11–2.98)	0.017
carcinosarcoma	1.92 (1.44–2.55)		2.77 (2.03–3.78)	**<0.001**
undifferentiated	2.03 (1.48–2.78)		2.29 (1.64–3.19)	**<0.001**
Histological grade		0.003		
1	Reference		Reference	
2	2.07 (1.14–3.74)		1.73 (0.94–3.17)	0.077
3	3.65 (2.36–5.65)		1.53 (1.13–2.41)	**0.038**
Surgical Stage		0.005		
I	Reference		Reference	
II	2.34 (1.96–2.81)		1.66 (0.9–3.09)	0.106
III	6.12 (4.99–7.5)		1.14 (0.14–9.07)	0.904
AJCC Stage		0.009		
I	Reference		Reference	
II	1.73 (1.31–2.29)		0.77 (0.39–1.52)	0.457
III	2.51 (2.08–3.04)		0.67 (0.35–1.28)	0.227
IV	6.02 (4.92–7.37)		1.06 (0.12–9.1)	0.955
Distant metastasis		<0.001		
No	Reference		Reference	
Yes	3.95 (3.33–4.7)		1.51 (0.84–2.75)	0.172
LNM		<0.001		
No	Reference		Reference	
Yes	2.08 (1.78–2.44)	0	1.37 (1.11–1.67)	**0.003**
Radiotheraphy		<0.001		
Yes	Reference		Reference	
No	1.6 (1.37–1.88)		1.6 (1.35–1.89)	**<0.001**
Chemotherapy		0.162		
Tumor size		<0.001		
≤40 mm	Reference		Reference	
40–57 mm	1.75 (1.44–2.13)		1.11 (0.9–1.36)	0.332
≥57 mm	2.59 (2.18–3.07)		1.24 (1.02–1.49)	**0.030**
Myometrium invasion		0.001		
Superficial	Reference		Reference	
Deep	2.69 (2.17–3.33)		1.3 (1.06–1.69)	0.036

number of patients with surgical stage localized, regional extension, and distant metastasis was 1233(45.9%), 1040(38.72%), and 413 (15.38%). According to the AJCC stage, there were 1258 (46.84%) patients in Stage 1, 240 (8.94%) in stage 2, 773 (28.78%) in stage 3 and 415 (15.45%) in Stage 4. The number of patients with histological grade G1, G2, and G3 was 173 (6.44%), 113 (4.21%), and 2400 (89.35%). Those with the serous type, clear cell type, neuroendocrine, carcinosarcoma, and undifferentiated type were 1819(67.72%), 420(15.64%), 36(1.34%), 308(11.47%) and 103(3.83%). 820(30.53%) patients were identified to have DMI (≥50% myometrial invasion) and the lymph node status was negative in 1990 (74.09%) patients. Distant metastasis was found in 385 (14.33%) patients. Those who performed radiation therapy and chemotherapy were 1203 (44.79%) and 1725 (64.22%), respectively. No significant variances ($P > 0.05$) were found in the variables between the training and validation cohorts.

3.2. Cox regression analyses of variables for OS

Both univariate and multivariate Cox regression analyses were conducted, utilizing all the characteristics (Table 2). Age, AJCC stage, histological subtype, DMI, grade, LNM, distal metastasis, radiotherapy, surgical stage, tumor size were identified as significant predictors based on the univariable analysis. Age, histological type, histological grade, radiotherapy, LNM, tumor size and DMI were independent risk factors based on the multivariable analysis.

3.3. Construction and validation of the nomogram

The predictive model was created by integrating all the independent prognostic factors mentioned above, and they were represented as a nomogram (Fig. 2). The most important factor affecting OS in NEEC patients from the nomogram was the tumor grade, followed by the DMI and RT. The pathological subtype, tumor size, lymph node metastasis, and age had moderate effects on OS. Each predictive factor in the nomogram was given a score for a specific patient, and the total score was determined by adding together the scores of all the factors. A vertical line was drawn on the point of total score to obtain 3- and 5-year overall survival probability. In the training cohort, the nomogram exhibited good performance in predicting 3-year and 5-year OS, and this was subsequently validated in both the internal and external validation cohorts. The ROC curve was used to evaluate the discrimination ability of the nomogram (Fig. 3A–C). In the training cohort, the *C*-index for the 3-year OS of the nomogram was 0.79 (95% CI: 0.75–0.83), while in the internal validation cohort it was 0.76 (95% CI: 0.74–0.79) and in the external validation cohort it was 0.65 (95% CI: 0.45–0.85). In the training cohort, the *C*-index for the 5-year OS of the nomogram was 0.78 (95% CI: 0.74–0.82), while in the internal validation cohort it was 0.77 (95% CI: 0.75–0.80), and in the external validation cohort, it was 0.73 (95% CI: 0.52–0.95). The calibration curves for the 3-year and 5-year OS probabilities exhibited good agreement between the actual and the predicted status of the model, based on the nomogram in both the training, internal and external validation cohorts (Fig. 4A–C). Kaplan–Meier overall survival curves of NEE patients of risk factors in different statuses were further plotted (Fig. 5A–I). Risk factors including age, AJCC stage, deep myometrium invasion (DMI), grade, histology type, LNM, distant metastasis, RT, surgical stage, and tumor size showed significant effects on 3-year OS in different subgroups of NEEC patients. Moreover, the DCA results for both the training and validation sets indicated that this nomogram provided favorable net benefits across a range of threshold probabilities, indicating that the nomogram may be extended to clinical utility (Fig. 6A–C).

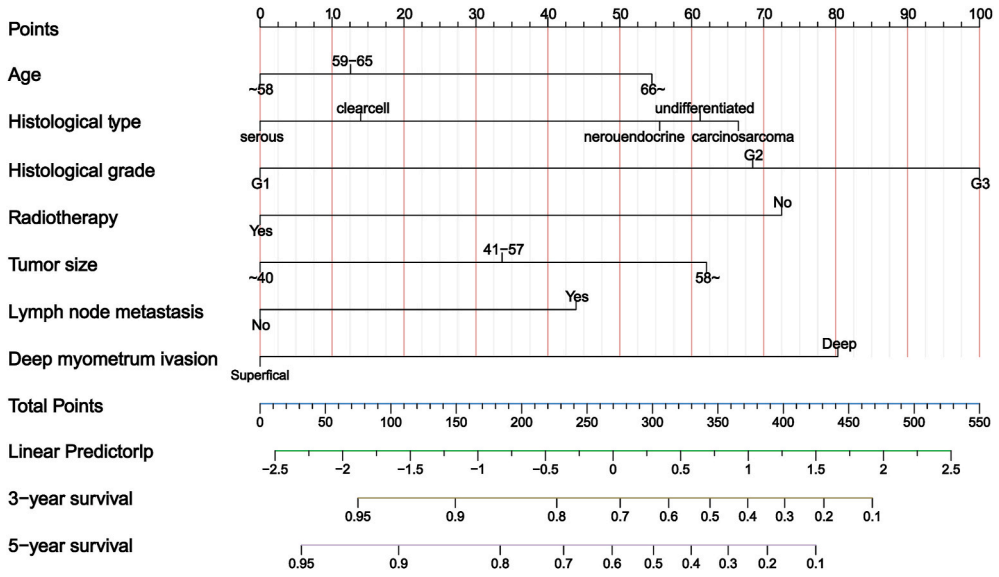

Fig. 2. Nomograms predicting 3- and 5-year rates of overallsurvival. Summarizing the scores of each variable together and the total points projected on the bottom scales indicate the probabilities of 3- and 5-year overall survival.

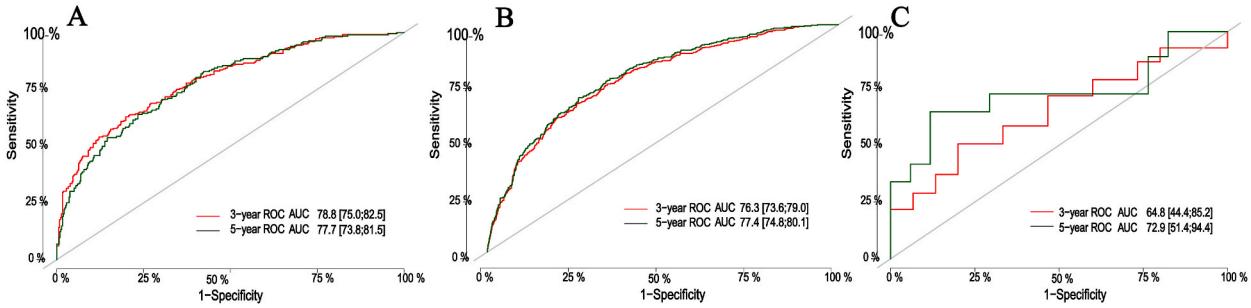

Fig. 3. The receiver operating characteristic curve of the nomogram in training cohort (A), internal validation cohort (B) and external validation cohort (C).

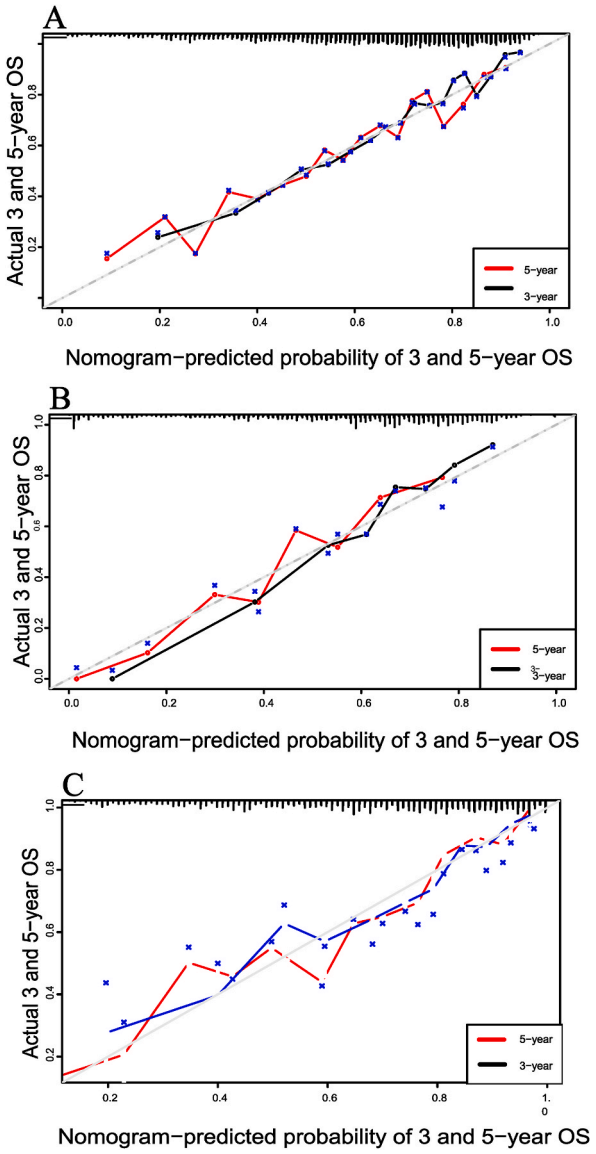

Fig. 4. Calibration curves showed the probability of 3- and 5-year overallsurvival between the nomogram prediction and the practical observation in the training cohort (A), and the internal validation cohort (B).

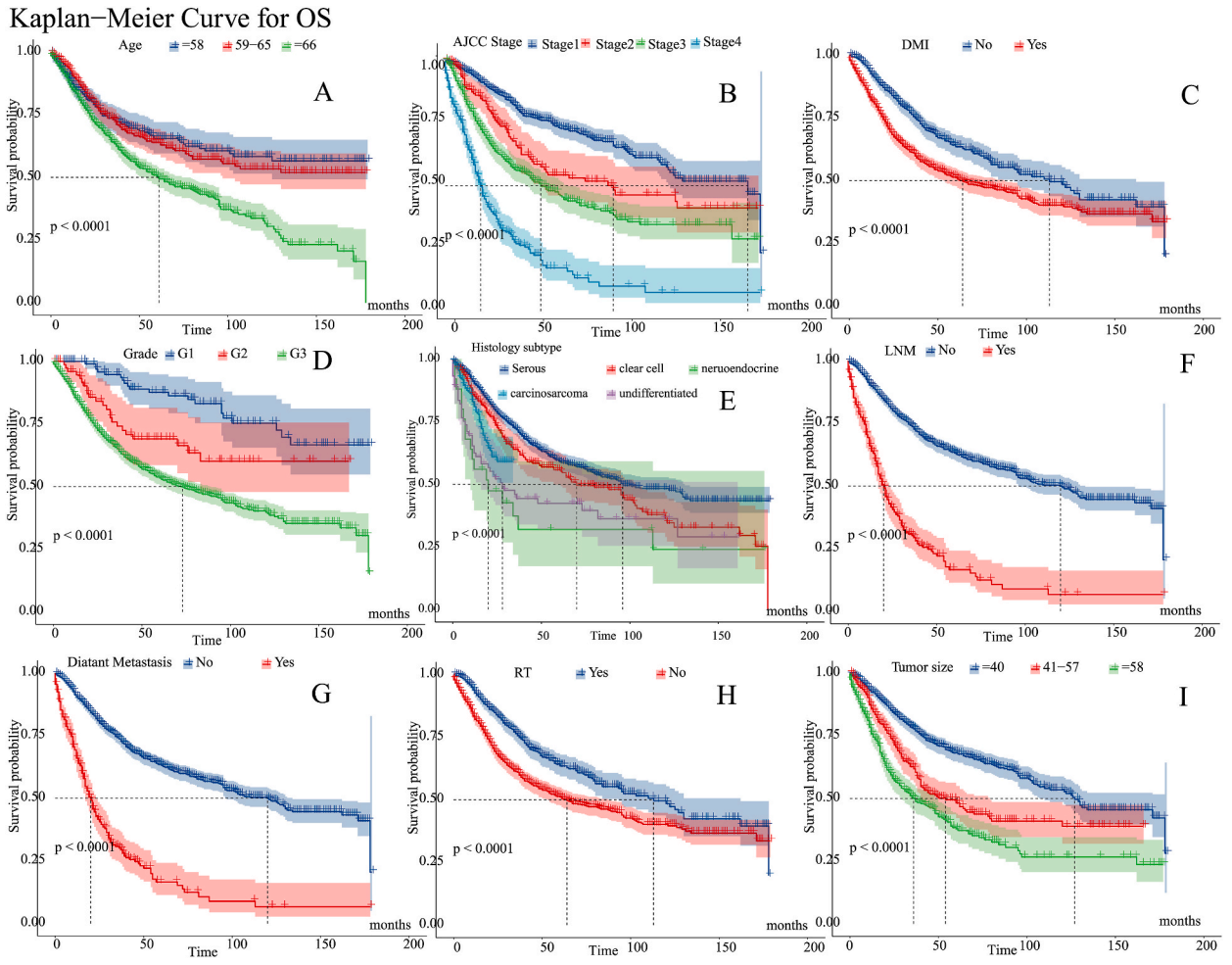

Fig. 5. Kaplan–Meier curves of 3-year overallsurvival according to (A) age, (B) AJCC stage, (C) deep myometrium invasion (DMI), (D) histological grade, (E) histological subtype, (F) lymph node metastasis (LNM), (G) Distant metastasis, (H) radiotherapy (RT) and (I) tumor size.

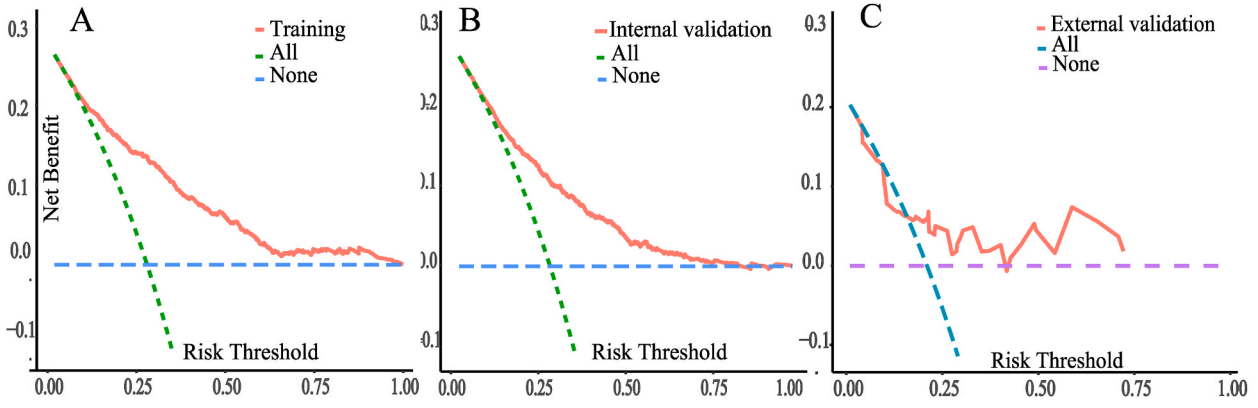

Fig. 6. Decision curves showed clinical benefits of the nomogram predicting overallsurvival in the training cohort (A), in the internal validation cohort (B) and in the external validation cohort (C).

3.4. Prognostic risk stratification

By summing the points assigned to each factor on the nomogram, the total points were calculated. This allowed for the easy determination of the estimated 3- and 5-year probabilities of OS for the individual patient from the nomogram. Patients were stratified into low-risk (<112.3) and high-risk (≥112.3) groups using the cutoff value identified by the X-tile software (version 3.6.1; https://medicine.yale.edu/lab/rimm/research/x-tile). This classification was maintained across all three cohorts, with patients being assigned to either high-risk or low-risk categories. According to the Kaplan–Meier plot (Fig. 7A–C), patients classified in the low-risk group demonstrated a superior prognosis in comparison to those in the high-risk group.

4. Discussion

The study identified the significant predictors of NEEC through population analysis and developed a nomogram model using prognostic factors to forecast the 3-year and 5-year OS of NEEC patients. This model is helpful for survival prediction of NEEC patients. For a given patient, a score was assigned for each predictive factor in the nomogram, and the total score was obtained to evaluate 3- and 5-year overall survival probability. This study contributes to determining high-risk patients and providing more personalized guidance for patient care.

Due to its rarity in clinical settings, evaluating prognostic factors for NEEC accurately is difficult with data from only one institution. So far, few studies based on the SEER database have reported the risk factors related to the prognosis of EC and clinical survival. However, in these studies, most of the patients were EEC. A few reports focus on NEEC patients who have a worse prognosis. Although prognostic factors of specific histological types for NEEC have been reported, such as serous carcinoma and clear cell carcinoma, an easy-to-use prognostic model to help clinicians and patients in a simpler and more accurate way has not been constructed. Our study included all the subtypes of NEEC and more comprehensive clinical information such as radiotherapy and chemotherapy which may relate to the prognosis. So, this model could predict the OS of NEEC and identify differences between groups more accurately.

While there have been gradual improvements in the OS of NEEC patients in recent decades, it remains unsatisfactory. The median overall survival of NEEC patients in this study is 28 months, which outperforms the results of the other two large population-based studies [1,5]. We deduce that it is mainly due to the relatively high proportion of patients receiving adjuvant therapy in this cohort. Our research also shows that chemotherapy has no significant effect on the prognosis of NEEC patients. Adjuvant radiotherapy and chemotherapy are controversial topics for the treatment of endometrial cancer. And there were several clinical trials performed, and the results were inconsistent. The findings align with the PORTEC-3 study [1], which suggests that there is no substantial disparity in overall survival among EC patients who were administered adjuvant radiotherapy versus chemoradiotherapy (CRT). This result indicates that the survival of NEEC patients can benefits from radiotherapy but not chemotherapy. However, the quality of life of NEEC patients could be improved by CRT. Interestingly, the same trials also conducted a post-hoc study. The updated analysis exhibited significantly improved overall survival and failure-free survival with CRT versus RT alone. They concluded that the treatment schedule of CRT should be recommended for women with stage III or serous cancers. A systematic review was carried out to assess the clinical effectiveness of adjuvant chemoradiotherapy compared to radiotherapy alone for high-risk endometrial cancer [2]. Despite the lack of statistically significant differences in OS between the CRT and RT groups, the review did show that CRT led to a prolongation of 5-year progression-free survival (PFS) and 5-year cancer-specific survival. However, CRT prolonged 5-year progression-free survival (PFS) and 5-year cancer-specific survival. In contrast, another study focused on the outcome of patients with advanced EC who received post-operative RT after CT [3]. They concluded that the RCT group have longer OS compared with CRT or RT groups. Tatebe et, al [4] also evaluated the benefit of EC patients with CRT vs. RT. Superior OS was observed in patients with early-stage serous carcinoma. So, a comprehensive evaluation should be carefully considered for an adjuvant therapy strategy for NEEC patients. More studies should be performed to make sure the actual benefits of RT and CRT.

In this study, seven independent prognostic risk factors, including age, histological type, tumor grade, radiotherapy, tumor size, lymph node metastasis status, and deep myometrium invasion were identified using univariate and multivariate analysis. The independent prognostic factors in our study are consistent with previous studies. It has been reported that poor differentiation of tumors is

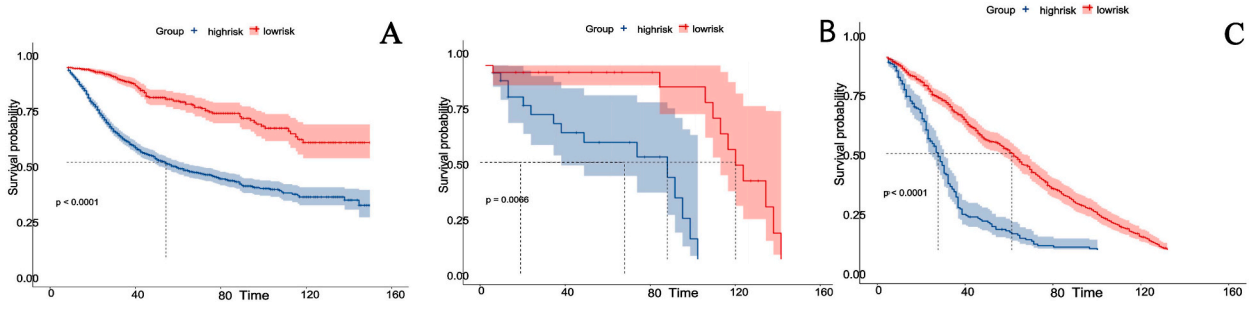

Fig. 7. Kaplan–Meier survival curves categorized into low-risk (totalrisk score< 112.3) and high-risk groups (total risk score≥ 112.3) basedon cut of value according to prognostic score of the nomogram in the training (a), internal validation (b) and external validation (c) cohorts. Log-rank test, P < 0.05 was considered statistically significant.

an independent factor of poor prognosis in EC patients [5,6]. Similarly, larger tumor size is correlated with the increased risk of tumor-related death and recurrence rate in EC patients [7–10]. Scharlet al. [11] found that clear cell carcinoma of the uterus has a higher death risk than serous carcinoma, which is similar to our result. As depicted in the nomogram, serous carcinoma has the lowest score of all the histological subtypes. Previous studies have confirmed that NEEC has no significant correlation with estrogen compared with EEC, and it is more commonly occurred in menopausal and postmenopausal women [12,13]. Therefore as shown in this study, older patients (66-) are more possible developed NEEC, and the prognosis were worse than that of younger patients. Radiotherapy is considered to be the recommended adjuvant treatment plan after surgery, the NCCN guidelines of the 2021 edition also recommend radiotherapy as the standard postoperative treatment [14]. And it has shown obvious benefits in our study. The presence of lymph node metastasis independently increases the risk of patient mortality. In consistent with previous studies [15], distant metastasis is more commonly seen in NEEC patients with lymph node metastasis than lymph node-negative patients, which results in significant differences in OS. DMI is also a manifestation of tumor aggressiveness. The risk stratification of the patient will rise to a medium-to-high risk level when deep muscle infiltration occurs. Prior research has also demonstrated that EC patients with deep myometrial invasion (DMI) have a notably lower overall survival rate compared to those without DMI [16–19]. This highlights the importance of accurately assessing the depth of myometrium invasion for proper tumor staging and prognosis prediction. Nevertheless, as noted by Cao et al. patients with advanced disease have limited treatment options following standard therapy [20]. And immunotherapy in advanced EC or with metastatic disease is playing a key role currently. In addition, the prognostic model in this study is useful to select patients with high-risk EC, thus assisting clinicians in selecting personalized immunotherapy for NEEC patients.

To the best of our knowledge, this is the first nomogram designed to forecast the overall survival of NEEC patients, and we have confirmed the accuracy of this prognostic model with a local external cohort. The calibration curve indicates a strong alignment between the nomogram's prediction and the real status. The TNM staging system did not divide EC into different risk subgroups according to different pathological subtypes. Therefore, this nomogram can help physicians predict the individualized survival of NEEC patients with different pathological subtypes.

Our research has some limitations. To begin with, it is important to note that the data for this study were collected retrospectively, which could potentially introduce bias. Further studies with prospective data are needed to improve the clinical beneficial. Second, some important covariates are not included in the SEER database, such as oral contraceptives, lymphatic vascular invasion, genomic classification, and targeted therapy information, which are all important prognostic parameters of EC. In addition, the performance of external validation of our nomogram is not satisfactory. The wide range of 95% CI may lead to a certain deviation in the predictive performance of specific patients, thereby restricting the nomogram's applicability in clinical practice. The reason may be the small number of our external validation set. More cases should be collected in the future to construct and verify the prognostic models for better clinical application. Lastly, Future studies that integrate multidimensional data to predict the prognosis of NEEC patients should be performed to improve the accuracy of the nomograms.

5. Conclusion

We have established and validated a nomogram to the predict the overall survival of NEEC, which is a convenient tool for survival prediction and personalized treatment planning. We identified eight variables including age, histological type, histological grade, radiotherapy, chemotherapy, LNM, tumor size and DMI as independent predictors for patients with NEEC. They are helpful in patient management and clinical decision-making for NEEC patients. More prospective studies are needed to confirm these results in the future.

Funding

This work is funded by National Natural Science Foundation of China, Grant/Award Number: 82,171,925, 82,372,017 and 81,971,681; Innovation and Development Fund of Jiangsu Hospital of TCM, Grant/Award Number: k2023ycx28.

Author contributions

Hu Chen: Conceptualization. Wei Zhang: Project administration. Zhongqiu Wang: Methodology. ying tian: Validation, Supervision. Wenwei Tang: Supervision. Hailei Gu: Software, Data curation. xiaorong wang: Writing – original draft. jingya chen: Writing – original draft. Qinfeng Xu: Data curation

Data availability statement

All data used in the generation of the results presented in this manuscript will be made available upon reasonable request from the corresponding author.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Abbreviations

EC	Endometrial cancer
EEC	Endometrioid endometrial cancer
NEEC	Non-endometrioid endometrial cancer
OS	Overall survival
SEER	Surveillance, Epidemiology, and End Results
JSHCM	Jiangsu Provincial Hospital of Chinese Medicine
WHNMU	Women's Hospital of Nanjing Medical University
LNM	Lymph node metastasis status
RT	Radiotherapy
CT	Chemotherapy
CRT	Chemoradiotherapy
DMI	Deep myometrial invasion
ROC	Receiver operating characteristic
DCA	Decision curve analysis
IQR	Interquartile range

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e28864.

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