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A Nomogram for Predicting Chemotherapy-Induced Myelosuppression Risk in Colorectal Cancer Patients

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Abstract

Objective

To explore the risk factors associated with chemotherapy-induced myelosuppression (CIM) in patients with colorectal cancer, and to develop and validate a nomogram for predicting CIM risk.

Methods

Clinical data of 3126 hospitalized colorectal cancer patients who received chemotherapy at West China Hospital of Sichuan University from March 2023 to March 2025 were retrospectively collected. The patients were divided into a training set (n = 2188) and a validation set (n = 938) at a 7:3 ratio. Independent predictors were identified using univariate and multivariate logistic regression analyses, and a nomogram was constructed based on the training set. Discrimination was evaluated using the area under the receiver operating characteristic curve (AUC). Calibration was assessed with the Hosmer-Lemeshow test and calibration plots. Clinical utility was evaluated using decision curve analysis (DCA).

Results

The overall incidence of CIM in this cohort of colorectal cancer patients receiving chemotherapy was 15.1%. Univariate and multivariate logistic regression analyses identified eight independent risk factors: prior history of febrile neutropenia, hepatic insufficiency, chronic immunosuppression, ECGO score, NRS2002 score, cetuximab use, self-care defict, and body mass index (BMI). The nomogram developed from these factors showed good discrimination and accuracy, with AUCs of 0.82 in the training set and 0.84 in the validation set. The Hosmer-Lemeshow test indicated good model calibration. Decision curve analysis further confirmed the model's favorable predictive performance, calibration, and clinical utility.

Conclusion

Based on large-scale real-world data from Chinese colorectal cancer patients, we have developed and validated the first nomogram for predicting CIM risk that integrates both pharmacological and non-pharmacological factors. The model performs well and, beyond chemotherapy-related factors, highlights patients' nutritional and performance status as key predictors. It can serve as an innovative tool for identifying high-risk patients and guiding early intervention.

1. Introduction

Colorectal cancer (CRC) is a common malignancy in China. According to the national cancer report released by the National Cancer Center, the total number of new CRC cases in China in 2022 was 517,100, accounting for 10.72% of all cancer cases and ranking second in cancer incidence nationwide (Han et al. 2024). Due to the insidious onset of early symptoms, most patients are already at an advanced stage at the time of diagnosis, and chemotherapy remains an indispensable component of comprehensive treatment (Li et al. 2021b; Roshandel et al. 2024). However, while killing tumor cells, chemotherapy is often accompanied by severe toxicities, among which chemotherapy-induced myelosuppression (CIM) is particularly dangerous. Data show that the prevalence of neutropenia and febrile neutropenia (FN) after chemotherapy is approximately 40% and 15–25%, respectively (Expert consensus on the out-of-hospital management of myelosuppression associated with oncological treatment (2025 edition) 2025). CIM not only directly worsens patients' quality of life and reduces treatment tolerance but also becomes a key factor in treatment failure or death due to life-threatening infections, while also increasing the financial burden on patients and their families (Crawford et al. 2024; Epstein et al. 2020; Epstein et al. 2021).

Currently, the clinical management of CIM is mostly "reactive" — interventions are initiated only after myelosuppression occurs, lacking proactive, individualized prevention strategies for high-risk patients (Abraham et al. 2022). Compared with chemotherapy-induced nausea and vomiting (CINV), for which mature prediction models and prevention systems have been

established, risk prediction for CIM after colorectal cancer chemotherapy lags behind. The Chinese *Guidelines for the Standardized Management of Neutropenia Related to Tumor Radiotherapy and Chemotherapy (2021)* clearly recommend conducting CIM risk assessment before the first cycle of chemotherapy, emphasizing the importance of prevention. However, most domestic studies to date have focused on comparing chemotherapy regimens (Zhang et al. 2025; Chen et al. 2016), and systematic analyses of risk factors for CIM in the Chinese population remain insufficient. Clinicians lack effective quantitative tools when formulating prevention strategies, making it difficult to accurately identify the target population for prophylactic medication. In fact, the occurrence of CIM is not only related to the chemotherapy regimen but is also significantly influenced by non-pharmacological factors such as patients' nutritional status, performance status, and self-care ability (Chen et al. 2016). This study innovatively introduces multidimensional tools including the NRS2002 nutritional screening scale, the ECOG performance status score, and the self-care ability rating scale (Wang et al. 2024; Matsuura 2025) to systematically evaluate the impact of non-pharmacological factors on CIM, aiming to overcome the limitation of previous studies that focused only on drug-related factors.

The nomogram, as a visualization tool based on a multivariate regression model, has the advantages of being intuitive, easy to use, and individualized. It has shown good application value in predicting CINV, cancer pain, and postoperative complications (Tong et al. 2023). Therefore, this study intends to develop and validate a nomogram model for predicting CIM risk in Chinese colorectal cancer patients based on large-scale real-world data. By screening high-risk individuals, we aim to provide an accurate and prospective risk assessment tool for clinical practice, facilitating a shift in CIM management from "reactive treatment" to "proactive warning." This study not only helps optimize the comprehensive management of colorectal cancer patients and reduce complication rates but also provides a scientific basis for individualized prophylactic medication strategies, thus carrying important clinical translation value and innovative significance.

2. Methods

1. **Patient Selection**

This study was a retrospective study. Patients with colorectal cancer who received inpatient chemotherapy at West China Hospital of Sichuan University from March 2023 to March 2025 were enrolled. The sample size was calculated based on the events-per-variable (EPV) principle, which required that the number of events be at least 10–15 times the number of candidate independent variables. A total of 40 risk factors were included as independent variables in the multivariate analysis. The loss to follow-up and sampling error were controlled at approximately 20%. Based on previous studies reporting that the prevalence of febrile neutropenia and severe post-chemotherapy neutropenia in colorectal cancer patients are approximately 15–25% and 40%, respectively, we assumed a myelosuppression incidence of 20% for sample size calculation. A minimum of 2,400 patients was required for risk factor modeling. The actual sample size of this study was 3126, which met the requirement.

2. Inclusion Criteria

 Histologically or cytologically confirmed diagnosis of colorectal malignancy;

 Age ≥ 18 years;

 Blood routine examination results before the current chemotherapy (within 7 days before initiation) were essentially normal or acceptable for chemotherapy: absolute neutrophil count (ANC) ≥ 2×10^9/L, platelet count ≥ 100×10^9/L, hemoglobin ≥ 90 g/L;

 Received at least one cycle of chemotherapy;

 All patients underwent a blood routine examination within 7–21 days after chemotherapy;

 Complete medical records.

3. Exclusion Criteria

 Concomitant severe liver or kidney dysfunction or systemic infectious disease;

 Prophylactic use of white blood cell-raising drugs before or after chemotherapy;

 Participation in other clinical trials that could affect myelosuppression;

 Interruption of chemotherapy or non-standard chemotherapy regimen;

 More than 20% missing data in medical records.

4. Variable Collection

Candidate variables were selected based on a literature review. Through a systematic review of the mechanisms, management strategies, and related studies of CIM in colorectal cancer patients receiving chemotherapy (Wang et al. 2024; Matsuura 2025; Tong et al. 2023; Zhang et al. 2019; Banck-Petersen et al. 2018; Qin et al. 2024; Ruan et al. 2023), we included 40 candidate variables covering eight dimensions, incorporating both pharmacological and non-pharmacological factors:

 Basic characteristics: sex, age, ethnicity.

 Medical history: cardiovascular disease, malignant hematologic/lymphatic disease, hypertension, diabetes, smoking history, alcohol use history, liver dysfunction, renal dysfunction, allergy history, chronic immunosuppression, prior history of febrile neutropenia (FN).

 Tumor characteristics: TNM stage, bone marrow involvement by tumor, tumor metastasis.

 Activity status: self-care ability, ECOG performance status score, Borg Rating of Perceived Exertion, fall risk score.

 Nutritional status: BMI, NRS2002, brief dietary score.

 Psychological status: anxiety status, sleep disturbance, West China Mood Index.

 Prior treatment history: recent surgery, prior radiotherapy, prior chemotherapy, prior targeted therapy, prior immunotherapy.

 Current chemotherapy regimen: high-risk regimens (CAPOX/XELOX, FOLFOXIRI), intermediate-risk regimens (FOLFOX, FLOT, other intermediate-risk regimens), immunotherapy agent cetuximab, full-dose use of chemotherapy drugs, first-time use of chemotherapy drugs.

5. Data Collection Method

Data were extracted from the medical database of the Hospital Information System (HIS) of West China Hospital of Sichuan University. Clinical data of colorectal cancer patients who received chemotherapy at West China Hospital between March 2023 and March 2025 were retrieved. A total of 5,531 patients with 25,323 hospitalization records were initially identified. After applying the inclusion and exclusion criteria, 3126 patients were finally enrolled. Clinical information included patients' basic demographics, admission diagnosis, past medical history, current illness history, cancer treatment details, relevant assessment forms (e.g., nursing and medical electronic records), medication orders, laboratory results, imaging findings, and pathology reports. The observation period was 21 days after chemotherapy. The aim was to evaluate and explore the risk factors for myelosuppression in colorectal cancer patients receiving chemotherapy.

6. Statistical Analysis

All statistical analyses were performed using R software (version 4.3.1). Continuous variables with normal distribution were expressed as mean ± standard deviation, and comparisons between groups were made using the t-test. Categorical variables were expressed as frequencies and percentages, and group comparisons were performed using the chi-square test or Fisher's exact test. Patients were randomly divided into a training set and a validation set in a 7:3 ratio. Univariate logistic regression analysis was first used to screen potential predictors ($P < 0.05$). Significant variables were then entered into a multivariate logistic regression model (forward stepwise method) to identify independent predictors. A nomogram was constructed based on the regression coefficients of the final model. Discrimination was evaluated using the AUC. Calibration was assessed using calibration plots and the Hosmer-Lemeshow test. Clinical utility was evaluated using decision curve analysis (DCA). All tests were two-sided, and a P value < 0.05 was considered statistically significant.

3. Results

1. **Baseline Characteristics of Patients**

A total of 3126 colorectal cancer patients receiving chemotherapy were finally included in this study and randomly divided into a training set (n = 2188) and a validation set (n = 938) at a 7:3 ratio. The overall incidence of CIM was 15.1% (14.6% in the training set and 16.3% in the validation set), with no statistically significant difference between the two groups (P = 0.271), indicating balanced dataset partitioning. The overall incidence of febrile neutropenia (FN) was 6.5%, and there was no significant difference between the training set (5.6%) and the validation set (6.2%) (P = 0.625), suggesting balanced distribution of this outcome event and excellent predictive stability of the model.

Baseline characteristic analysis showed that the two groups were balanced in terms of demographic data, tumor characteristics, medical history, psychological status, nutritional and performance status, and treatment-related factors, with all P values > 0.05. Regarding comorbidities, except for diabetes (12.4% vs. 8.6%, P = 0.0026), all other comorbidities showed no significant differences between the training and validation sets. Overall, the baseline characteristics of the training and validation sets were well comparable, meeting the basic requirements for model development and validation (see Table 1).

2. Univariate Analysis Results

As shown in Table 2, univariate logistic regression analysis in the training set identified 22 variables significantly associated with CIM risk ($P < 0.05$). Regarding demographic characteristics and lifestyle, female sex, age > 65 years, smoking history, and alcohol use history were associated with significantly increased CIM risk. Among clinical comorbidities, hypertension, diabetes, liver dysfunction, renal dysfunction, and chronic immunosuppression were all significant risk factors. Functional status assessments showed that self-care ability score ≤ 40, ECOG performance status score ≥ 3, Borg RPE score > 3, and fall risk score > 3 all indicated a high risk of CIM. For nutritional and psychological indicators, BMI < 18.5 kg/m², NRS2002 score > 3, anxiety status, sleep disturbance, and abnormal West China Mood Index were also significantly associated with increased CIM risk. Prior history of FN showed a very high risk intensity, and prior radiotherapy, targeted therapy, or immunotherapy also significantly increased CIM risk. At the chemotherapy regimen level, use of the FLOT regimen and cetuximab combined with chemotherapy were identified as significant risk factors.

3. Multivariate Analysis Results

The 22 variables that were statistically significant in the univariate analysis were entered into a multivariate logistic regression model. The results showed that eight variables were confirmed as independent predictors of CIM in colorectal cancer patients receiving chemotherapy (all $P < 0.05$; see Table 3). These included: prior history of FN, chronic immunosuppression, liver dysfunction, ECOG performance status score ≥ 3, self-care ability < 40, BMI < 18.5 kg/m², NRS2002 score ≥ 3, and cetuximab use. Regarding past history and clinical comorbidities, prior FN history had the highest risk intensity (OR = 9.310), and chronic immunosuppression (OR = 4.026) and liver dysfunction (OR = 3.075) also significantly increased CIM risk. For nutritional, activity, and psychological status, ECOG performance status score ≥ 3 (OR = 3.274), self-care ability < 40 (OR = 3.183), BMI <

18.5 kg/m² (OR = 2.433), and NRS2002 score ≥ 3 (OR = 1.855) were all significant risk factors. Notably, BMI > 23.9 kg/m² (OR = 0.363) showed a protective effect. Among treatment-related factors, cetuximab combined with chemotherapy (OR = 1.998) significantly increased the risk of myelotoxicity, whereas completion of full-dose chemotherapy (OR = 0.514) showed a protective effect.

4. Construction of the Nomogram

Based on the eight independent predictors identified by multivariate logistic regression analysis, we developed a nomogram to quantitatively estimate the risk of CIM after chemotherapy in colorectal cancer patients (Fig. 1). The model converts each predictive variable into a visualized point scale weighted by the regression coefficients; the sum of the points corresponds to an individual's probability of CIM. In clinical application, according to the patient's specific conditions, the corresponding score is found on each variable axis, all scores are summed to obtain a total score, and finally the total score is mapped to the risk probability axis at the bottom to obtain the individual predicted probability of CIM. Clinical application example: a patient with a prior history of FN and BMI < 18.5, but with normal performance status, NRS2002 ≤ 3, normal liver function, normal self-care ability, and no cetuximab use, would have an estimated total score of 148 points according to the nomogram, corresponding to a predicted CIM risk of approximately 55%–58%.

5. Calibration Curves

The prediction model showed excellent calibration in both the training set (Fig. 2) and the validation set (Fig. 3). Both calibration curves closely followed the 45° ideal line, indicating high consistency between predicted probabilities of CIM and actual observations, with minimal systematic bias. The model performed particularly accurately in the intermediate-to-high risk range (0.3–1.0). These results confirm that the model can reliably quantify individual risk and has high clinical decision-making value.

6. ROC Curve Analysis

ROC curve analysis showed that in the training set (Fig. 4), the model achieved an AUC of 0.825 (95% CI: 0.7958–0.8546), with a well-shaped curve, indicating good discriminative ability for identifying patients with CIM and an ideal balance between sensitivity and specificity. In the validation set (Fig. 5), the model achieved an AUC of 0.842 (95% CI: 0.8001–0.8849), which was highly consistent with the training set results, confirming that the model has no overfitting and has strong generalizability. This model can serve as a risk assessment tool for CIM in colorectal cancer chemotherapy.

7. Clinical Utility of the Model

Decision curve analysis (DCA) was performed in both the training and validation sets. The results showed that over a wide threshold range of 5%–95% (training set, Fig. 6; validation set, Fig. 7), the model curve was superior to both the "intervention for all" and "intervention for none" lines, indicating that applying the model provides significant net benefit within this risk probability range. From a clinical perspective, the model has better decision-making efficacy than traditional strategies in the 5%–95% range, effectively assisting physicians in identifying high-risk patients for CIM after colorectal cancer chemotherapy and optimizing intervention strategies, thereby providing evidence-based support for improving patient outcomes.

4. Discussion

Based on large-scale real-world data from 3126 colorectal cancer patients at West China Hospital of Sichuan University, we developed and validated the first nomogram model for predicting post-chemotherapy myelosuppression (CIM) specifically for the Chinese population. The innovative value of this model lies in its departure from the traditional "drug-centered" concept, as it systematically integrates non-pharmacological factors including nutritional status, functional reserve, and psychological

function as core dimensions of CIM risk prediction. As shown in Fig. 1, the model achieved AUCs of 0.825 and 0.842 in the training and validation sets, respectively. The calibration curves showed that predicted probabilities were highly consistent with actual risks, and DCA confirmed significant clinical net benefit over a wide threshold range of 5%–95%. These findings strongly suggest that under current clinical conditions where chemotherapy regimens are increasingly standardized and homogenized (Tong et al. 2023), the true “differentiator” of CIM risk is not the drug itself but the patient’s own functional reserve status.

Our multivariate analysis identified eight independent predictors of CIM. Notably, except for cetuximab use, the remaining seven variables belonged to non-pharmacological dimensions, covering four domains: prior hematopoietic injury, nutritional status, physical function, and psychological status. This finding provides a new perspective for understanding the mechanisms of CIM. Prior history of FN (OR = 9.310) was the strongest independent predictor of CIM, with an effect size far exceeding that of other variables. This finding has deep clinical implications: a history of FN is not merely a record of past chemotherapy toxicity but also indicates that the compensatory capacity of the patient’s hematopoietic stem cells is at the verge of exhaustion. Studies by Schelenz et al. have confirmed that patients who have experienced FN often have persistent damage to the bone marrow microenvironment, including telomere shortening in hematopoietic stem cells, stromal cell dysfunction, and inflammatory cytokine dysregulation (Schelenz et al. 2012; Imlay et al. 2023). For such “high-risk reserve” individuals, even subsequent moderate-intensity chemotherapy can easily trigger severe bone marrow decompensation. In addition, chronic immunosuppression (OR = 4.026) and liver dysfunction (OR = 3.075) exacerbate hematopoietic damage through different pathways: the former disrupts the hematopoietic regulatory network via T-cell subset disturbances and persistently elevated inflammatory cytokines (Chadda und Puthucheary 2024); the latter delays the clearance of chemotherapy drugs (e.g., the active metabolite SN-38 of irinotecan), prolonging bone marrow exposure to high drug concentrations (Faugeras et al. 2017; Ambulkar et al. 2025).

This study systematically assessed the impact of nutritional status on CIM from two dimensions. BMI < 18.5 kg/m² (OR = 2.433) was identified as an independent risk factor. The mechanism can be explained from a pharmacokinetic perspective: underweight patients have a smaller volume of drug distribution and lower plasma albumin levels, leading to relatively higher free concentrations of chemotherapeutic drugs, which aggravates toxicity to the bone marrow stroma (Powis et al. 1987; Li et al. 2021a). NRS2002 ≥ 3 (OR = 1.855) captures a broader state of nutritional metabolic derangement, including disease-related hypercatabolism and micronutrient deficiencies, which collectively constrain the rapid repair capacity of hematopoietic cells after injury. Notably, BMI > 23.9 kg/m² (OR = 0.363) showed a significant protective effect. This “obesity paradox” suggests that under the stress of chemotherapy, appropriate energy reserves can serve as a “buffer” for bone marrow hematopoiesis (Kamimura et al. 2016; Li et al. 2017). Studies by Kamimura et al. in gynecologic malignancies also confirmed that patients with moderate body weight had better chemotherapy tolerance than underweight patients, further supporting the key role of nutritional reserves in bone marrow protection (Kamimura et al. 2016).

This study innovatively introduced the ECOG performance status score and self-care ability score, translating the multidimensional concept of “frailty” into actionable predictive indicators. ECOG ≥ 3 (OR = 3.274) and severely limited self-care ability (OR = 3.183) were identified as independent risk factors, with effect sizes second only to prior FN history. These two indicators point to a core pathological state — depletion of physiological reserves (Qin et al. 2024; Ruan et al. 2023; Jiang et al. 2013). Jiang et al. in non-small cell lung cancer confirmed that patients with poor performance status usually have sarcopenia, chronic low-grade inflammation (elevated IL-6 and TNF-α), and neuroendocrine disorders (Jiang et al. 2013). These three factors together form a vicious cycle of “frailty-inflammation-myelosuppression”: chronic inflammation directly suppresses the proliferation of hematopoietic progenitor cells, while sarcopenia impairs the body’s ability to repair chemotherapy-induced damage (Ruan et al. 2023). Banck-Petersen et al. pointed out that unlike traditional models relying solely on hematological indicators, “mobility capacity” captures the patient’s underlying, dynamically changing frailty status; in such patients, the bone marrow microenvironment is aged and hematopoietic compensatory mechanisms fail, making it difficult to recover rapidly after stem cell injury (Banck-Petersen et al. 2018). From a clinical assessment perspective, the value of the ECOG score and self-care ability score lies in their dynamic and comprehensive nature — they provide a real-time “snapshot” of the patient’s overall function, which cannot be replaced by static laboratory indicators.

Regarding treatment-related factors, our findings further highlight the central role of non-pharmacological factors. In the univariate analysis, high-risk chemotherapy regimens (e.g., FOLFOXIRI, CAPOX) were significantly associated with CIM but did not enter the multivariate model. This result truly reflects clinical decision-making logic: physicians have already "prescreened" chemotherapy regimens based on the patient's baseline status — patients with poor performance status and high nutritional risk are mostly assigned to lower-intensity regimens. Therefore, the contribution of the chemotherapy regimen itself to CIM risk is "diluted," and it is the patient's own factors that truly determine individual risk differences. In this context, cetuximab combined with chemotherapy (OR = 1.998) was the only treatment-related variable that entered the multivariate model. As an EGFR antibody, cetuximab is not traditionally considered to have major myelotoxicity, but it may weaken the protective effect of EGFR signaling on hematopoietic stem cells, or the skin toxicity and inflammatory reactions it induces may indirectly suppress hematopoiesis through systemic inflammatory factors (Bou-Assaly und Mukherji 2010). Notably, completion of full-dose chemotherapy (OR = 0.514) showed a protective effect. This reveals a "seesaw" relationship between tumor burden and bone marrow function: full-dose chemotherapy rapidly reduces tumor burden, thereby relieving the negative regulation of hematopoiesis by tumor-derived factors and indirectly preserving bone marrow reserve (Zhang et al. 2025; Chen et al. 2016). This suggests that, as long as the patient can tolerate it, ensuring full-dose, full-course chemotherapy is itself an active bone marrow protection strategy.

The nomogram model developed in this study is not only a statistical tool but also a carrier of a clinical thinking framework that integrates pharmacological and non-pharmacological predictors. Based on the findings, the model establishes a multidimensional assessment system covering four domains: prior hematopoietic injury, nutritional status, physical function, and psychological status. This visualization tool is simple and easy to use. By incorporating screening of past medical history, NRS2002 nutritional screening, ECOG performance status score, and self-care ability assessment into the routine pre-chemotherapy workflow, it can accurately identify a triple high-risk population characterized by "insufficient nutritional reserve + declining physical function + prior hematopoietic injury" and initiate an early warning mechanism, thereby providing a systematic solution to reduce CIM incidence. The model shows good predictive performance and clinical applicability, helping clinicians quickly identify high-risk patients. Future external validation using prospective, multicenter cohort studies is needed, as well as exploration of integrating the model into clinical decision support systems or electronic health records, to promote a fundamental shift in CIM management from "reactive treatment" to "proactive, individualized prevention."

5. Innovations

This study breaks through the limitation of traditional risk prediction models that focus only on chemotherapy regimens. It innovatively introduces a "frailty" assessment framework and reveals the significant impact of prior hematopoietic injury, mobility capacity, and nutritional status on CIM in colorectal cancer patients receiving chemotherapy. Regarding treatment factors, the study identifies cetuximab as having a unique CIM risk and confirms that completion of full-dose chemotherapy is protective, providing new breadth and perspective for CIM risk prediction.

6. Limitations

Although this study developed and validated a CIM risk prediction model for colorectal cancer patients based on a large sample size, several limitations exist. First, as a single-center retrospective study, the population source has limited geographic and ethnic diversity, and only hospitalized patients were included, which may affect the generalizability and external validity of the model. Future external validation using multicenter, cross-population independent cohorts is needed. Second, the study variables relied on electronic medical records, and some non-pharmacological factors (e.g., psychological status, self-care ability) were subject to assessment variability. Moreover, dynamic nutritional indicators and serum drug concentration monitoring data were lacking, making it difficult to precisely dissect the mechanisms. Although we confirmed strong associations between several functional indicators and CIM, basic molecular experiments are lacking to precisely elucidate the specific biological pathways by which cetuximab interferes with the hematopoietic microenvironment. Third, the outcome CIM was determined mainly based on inpatient medical records, without a prospective, standardized assessment tool. In addition, the study did not include more comprehensive information on immunotherapy and targeted therapy, nor did it cover

dynamically changing nutritional and physiological indicators during chemotherapy. The evolution of bone marrow reserve capacity during long-term treatment requires further exploration. Future studies should validate the applicability and robustness of the model in broader tumor types, populations, and clinical settings, and develop risk prediction systems suitable for other cancer types.

7. Conclusions

As the first CIM risk model for colorectal cancer patients receiving chemotherapy that systematically integrates both pharmacological and non-pharmacological predictors in a Chinese population, this nomogram demonstrates good predictive performance and clinical applicability. This simple-to-use visualization tool enables individualized, multidimensional assessment of prior hematopoietic injury, mobility capacity, and nutritional status in colorectal cancer patients undergoing chemotherapy. It suggests that clinical attention should not be limited to the choice of chemotherapy regimen; routine screening of patient's own status should be incorporated into standard practice. The model provides a scientific basis for prospective prevention and helps clinicians rapidly identify high-risk patients and optimize supportive treatment strategies. Future external validation using prospective, multicenter studies and exploration of integration into clinical decision support systems or electronic health records are needed to advance CIM management into a new era of "individualized prevention."

Declarations

Conflict of Interest

The authors declare that they have no conflict of interest.

Name of Approval Committee/IRB in Ethics declaration

Biomedical Ethics Review Committee of West China Hospital of Sichuan University

Consent to Participate declaration

The requirement for informed consent was waived by the Biomedical Ethics Review Committee of West China Hospital of Sichuan University because this was a retrospective study using anonymised clinical data without any direct patient intervention.

Clinical trial number

This study is not a clinical trial. Therefore, clinical trial registration is not applicable.

Ethical Accordance Declaration

This study was conducted in accordance with the Declaration of Helsinki and its later amendments.

Funding

declaration

No funding was received for this study.

Author Contribution

ZY and LT contributed equally to this work. ZY was responsible for data collection and collation, study supervision, and manuscript refinement. LT performed data analysis, generated the figures, and wrote the manuscript. QY, LP, XS, and YH participated in data collection and collation. JZ and YS contributed to study supervision and manuscript refinement. YS is the corresponding author. All authors reviewed and approved the final manuscript.

Data Availability

The data used in this study were derived from the clinical records of colorectal cancer patients who received chemotherapy at the West China Hospital of Sichuan University, as retrieved from the hospital's inpatient Hospital Information System (HIS) between March 2023 and March 2025. The raw dataset comprises patient demographic characteristics, medical history, tumor characteristics, treatment information, and laboratory test results. Due to patient privacy concerns and compliance requirements under China's Personal Information Protection Law, the dataset is subject to regulation by the Ethics Committee of West China Hospital of Sichuan University, and the raw data cannot be publicly shared.Anonymized aggregated statistical data, variable definitions, and the statistical analysis code (R version 4.3.1) are available as supplementary material accompanying this article, or may be obtained from the corresponding author upon reasonable request (Email: sunyu0828@wchscu.cn), pending written approval from the Ethics Committee of West China Hospital of Sichuan University.

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Tables

Table 1. Balance test of demographic data and clinical baseline characteristics between the training set and the validation set

Variables	Total (n=3126)	Training set (n=2188)	Testing set (n=938)	Statistic	*P*
Gender, n(%)				χ^2=1.22	0.269
Male	1990 (63.7%)	1407 (64.2%)	583 (62.0%)		
Female	1136 (36.3%)	781 (35.7%)	355 (37.8%)		
Age, n(%)				χ^2=0.50	0.482
=65	2046 (65.5%)	1423 (65.0%)	623 (66.3%)		
65	1080 (34.5%)	765 (34.9%)	315 (33.5%)		
Ethnicity, n(%)				χ^2=0.30	0.584
Han	2964 (94.8%)	2071 (94.6%)	893 (95.0%)		
Ethnicity minority	162 (5.2%)	117 (5.3%)	45 (4.8%)		
TNM stage n(%)				χ^2=2.18	0.537
Stage1	23 (0.7%)	16 (0.7%)	7 (0.7%)		
Stage2	113 (3.6%)	83 (3.8%)	30 (3.2%)		
Stage3	646 (20.7%)	464 (21.2%)	182 (19.4%)		
Stage4	2344 (75.0%)	1625 (74.2%)	719 (76.5%)		
Tumor metastasis, n(%)				χ^2=0.00	0.966
No	1173 (37.5%)	820 (37.4%)	353 (37.6%)		
Yea	1953 (62.5%)	1368 (62.5%)	585 (62.2%)		
Cardiovascular disease, n(%)				χ^2=0.02	0.888
No	2579 (82.5%)	1807 (82.5%)	772 (82.1%)		
Yes	547 (17.5%)	381 (17.4%)	166 (17.7%)		
Malignant hematologic/lymphatic disease, n(%)				--	1
No	3114 (99.6%)	2179 (99.5%)	935 (99.5%)		
Yes	12 (0.4%)	9 (0.4%)	3 (0.3%)		
Hypertension, n(%)				χ^2=0.41	0.522
No	2506 (80.2%)	1747 (79.8%)	759 (80.7%)		
Yes	620 (19.8%)	441 (20.1%)	179 (19.0%)		
Diabetes mellitus, n(%)				χ^2=9.07	0.003
No	2773 (88.7%)	1916 (87.5%)	857 (91.2%)		
Yes	353 (11.3%)	272 (12.4%)	81 (8.6%)		
Smoking history, n(%)				χ^2=0.31	0.576
No	2150 (68.8%)	1512 (69.0%)	638 (67.9%)		
Yes	976 (31.2%)	676 (30.9%)	300 (31.9%)		
Alcohol consumption history, n(%)				χ^2=0.00	0.960

Variables	Total (n=3126)	Training set (n=2188)	Testing set (n=938)	Statistic	*P*
No	2383 (76.2%)	1669 (76.2%)	714 (76.0%)		
Yes	743 (23.8%)	519 (23.7%)	224 (23.8%)		
Hepatic insufficiency, n(%)				χ^2=0.26	0.608
No	2927 (93.6%)	2045 (93.4%)	882 (93.8%)		
Yes	199 (6.4%)	143 (6.5%)	56 (6.0%)		
Renal insufficiency, n(%)				χ^2=1.14	0.285
No	3027 (96.8%)	2124 (97.0%)	903 (96.1%)		
Yes	99 (3.2%)	64 (2.9%)	35 (3.7%)		
Tumor involvement of bone marrow, n(%)				χ^2=0.00	1.000
No	3108 (99.4%)	2175 (99.3%)	933 (99.3%)		
Yes	18 (0.6%)	13 (0.6%)	5 (0.5%)		
Allergy history, n(%)				--	0.522
No	3115 (99.6%)	2179 (99.5%)	936 (99.6%)		
Yes	11 (0.4%)	9 (0.4%)	2 (0.2%)		
Chronic immunosuppression, n(%)				χ^2=0.05	0.827
No	3044 (97.4%)	2132 (97.4%)	912 (97.0%)		
Yes	82 (2.6%)	56 (2.6%)	26 (2.8%)		
History of febrile neutropenia (FN), n(%)				χ^2=1.27	0.260
No	2778 (88.9%)	1954 (89.2%)	824 (87.7%)		
Yes	348 (11.1%)	234 (10.7%)	114 (12.1%)		
Self-care ability, n(%)				χ^2=2.26	0.520
100	1595 (51.0%)	1099 (50.2%)	496 (52.8%)		
95-65	1265 (40.5%)	897 (41.0%)	368 (39.1%)		
60-45	112 (3.6%)	79 (3.6%)	33 (3.5%)		
40	154 (4.9%)	113 (5.2%)	41 (4.4%)		
ECOG performance status, n(%)				χ^2=1.30	0.862
0	1960 (62.7%)	1370 (62.6%)	590 (62.8%)		
1	845 (27.0%)	598 (27.3%)	247 (26.3%)		
2	109 (3.5%)	76 (3.5%)	33 (3.5%)		
3	168 (5.4%)	112 (5.1%)	56 (6.0%)		
4	44 (1.4%)	32 (1.5%)	12 (1.3%)		
BORG Rating of Perceived Exertion ≥ 3, n(%)				χ^2=0.09	0.768
≤3	2627 (84.0%)	1842 (84.1%)	785 (83.5%)		

Variables	Total (n=3126)	Training set (n=2188)	Testing set (n=938)	Statistic	*P*
≥3	499 (16.0%)	346 (15.8%)	153 (16.3%)		
Fall risk score, n(%)				χ^2=0.00	1.000
≤3	2847 (91.1%)	1993 (91.0%)	854 (90.9%)		
≥3	279 (8.9%)	195 (8.9%)	84 (8.9%)		
Anxiety status, n(%)				χ^2=2.32	0.128
No	2920 (93.4%)	2054 (93.8%)	866 (92.1%)		
Yes	206 (6.6%)	134 (6.1%)	72 (7.7%)		
Athens Insomnia Scale score, n(%)				χ^2=1.07	0.300
≤6	2392 (76.5%)	1686 (77.0%)	706 (75.1%)		
≥6	734 (23.5%)	502 (22.9%)	232 (24.7%)		
Athens Insomnia Scale score, n(%)				χ^2=1.82	0.610
Normal	1152 (36.9%)	801 (36.6%)	351 (37.3%)		
Mild	789 (25.2%)	559 (25.5%)	230 (24.5%)		
Moderate	804 (25.7%)	553 (25.3%)	251 (26.7%)		
Severe	381 (12.2%)	275 (12.6%)	106 (11.3%)		
BMI, n(%)				χ^2=4.23	0.121
18.5—23.9	281 (9.0%)	188 (8.6%)	93 (9.9%)		
<18.5	2306 (73.8%)	1605 (73.3%)	701 (74.6%)		
>23.9	539 (17.2%)	395 (18.0%)	144 (15.3%)		
NRS2002 score, n(%)				χ^2=0.04	0.838
≤3	1836 (58.7%)	1282 (58.5%)	554 (58.9%)		
≥3	1290 (41.3%)	906 (41.4%)	384 (40.9%)		
Brief Dietary Assessment score, n(%)				χ^2=0.29	0.867
4-5	1938 (62.0%)	1363 (62.2%)	575 (61.2%)		
1	729 (23.3%)	507 (23.2%)	222 (23.6%)		
2-3	459 (14.7%)	318 (14.5%)	141 (15.0%)		
Recent surgery, n(%)				χ^2=3.67	0.056
No	771 (24.7%)	518 (23.7%)	253 (26.9%)		
Yes	2355 (75.3%)	1670 (76.3%)	685 (72.9%)		
Prior radiotherapy, n(%)				χ^2=0.73	0.392
No	2254 (72.1%)	1588 (72.5%)	666 (70.9%)		
Yes	872 (27.9%)	600 (27.4%)	272 (28.9%)		
Prior chemotherapy, n(%)				χ^2=0.63	0.427

Variables	Total (n=3126)	Training set (n=2188)	Testing set (n=938)	Statistic	*P*
No	192 (6.1%)	129 (5.9%)	63 (6.7%)		
Yes	2934 (93.9%)	2059 (94.0%)	875 (93.1%)		
Prior targeted therapy, n(%)				χ^2=0.66	0.417
No	2786 (89.1%)	1957 (89.4%)	829 (88.2%)		
Yes	340 (10.9%)	231 (10.5%)	109 (11.6%)		
Prior immunotherapy, n(%)				χ^2=0.48	0.487
No	3047 (97.5%)	2136 (97.5%)	911 (96.9%)		
Yes	79 (2.5%)	52 (2.4%)	27 (2.9%)		
CAPOX or XELOX regimen, n(%)				χ^2=0.78	0.379
No	855 (27.4%)	609 (27.8%)	246 (26.2%)		
Yes	2271 (72.6%)	1579 (72.1%)	692 (73.6%)		
FOLFOXIRI regimen, n(%)				χ^2=0.93	0.335
No	2950 (94.4%)	2071 (94.6%)	879 (93.5%)		
Yes	176 (5.6%)	117 (5.3%)	59 (6.3%)		
FOLFOX regimen, n(%)				χ^2=0.72	0.398
No	3052 (97.6%)	2140 (97.7%)	912 (97.0%)		
Yes	74 (2.4%)	48 (2.2%)	26 (2.8%)		
FLOT regimen, n(%)				--	0.331
No	3121 (99.8%)	2183 (99.7%)	938 (99.8%)		
Yes	5 (0.2%)	5 (0.2%)	0 (0.0%)		
Other chemotherapeutic agents, n(%)				χ^2=2.04	0.154
No	2554 (81.7%)	1773 (81.0%)	781 (83.1%)		
Yes	572 (18.3%)	415 (18.9%)	157 (16.7%)		
Cetuximab, n(%)				χ^2=0.07	0.794
No	2447 (78.3%)	1716 (78.4%)	731 (77.8%)		
Yes	679 (21.7%)	472 (21.6%)	207 (22.0%)		
Full-dose chemotherapy, n(%)				χ^2=0.55	0.459
No	161 (5.2%)	108 (4.9%)	53 (5.6%)		
Yes	2965 (94.8%)	2080 (95.0%)	885 (94.1%)		
First-time chemotherapy use, n(%)				χ^2=0.63	0.427
No	2934 (93.9%)	2059 (94.0%)	875 (93.1%)		
Yes	192 (6.1%)	129 (5.9%)	63 (6.7%)		
CIM myelosuppression, n(%)				χ^2=1.404	0.236

Variables	Total (n=3126)	Training set (n=2188)	Testing set (n=938)	Statistic	*P*
No	2654 (84.8%)	1869 (85.3%)	785 (83.5%)		
Yes	472 (15.1%)	319 (14.6%)	153 (16.3%)		
Neutropenia, n(%)				χ^2=3.29	0.0696
No	2764 (88.4%)	1950 (89.1%)	814 (86.8%)		
Yes	362 (11.6%)	238 (10.9%)	124 (13.2%)		
Febrile neutropenia, n(%)				χ^2=0.28	0.594
No	2945 (94.2%)	2065 (94.4%)	880 (93.8%)		
Yes	181 (5.8%)	123 (5.6%)	58 (6.2%)		
Thrombocytopenia, n(%)				χ^2=0.06	0.802
No	3064 (98.0%)	2146 (98.1%)	918 (97.9%)		
Yes	62 (2.0%)	42 (1.9%)	20 (2.1%)		
Hemoglobin reduction, n(%)				χ^2=0.25	0.619
No	2989 (95.6%)	2089 (95.5%)	900 (95.9%)		
Yes	137 (4.4%)	99 (4.5%)	38 (4.1%)		

χ^2: Chi-square test

Table 2. Univariate logistic regression analysis of factors influencing CIM in the training set

Variables	β	S.E	|Z|	P	OR (95%CI)
Gender					
Male					1.000 (Reference)
Female	0.495	0.123	4.040	<0.001	1.64(1.290 ~ 2.085)
Age					
≤65					1.000 (Reference)
≥65	0.473	0.123	3.848	<0.001	1.605(1.261 ~ 2.041)
Ethnicity					
Han					1.000 (Reference)
Ethnicity minority	-0.327	0.301	1.088	0.277	0.721(0.400 ~ 1.300)
TNM stage					
Stage1					1.000 (Reference)
Stage2	-0.807	0.428	1.885	0.060	0.446(0.193 ~ 1.033)
Stage3	-0.082	0.151	0.541	0.589	0.9217(0.680 ~ 1.239)
Stage4	0.222	0.145	1.533	0.125	1.248(0.940 ~ 1.657)
Tumor metastasis					
No					1.000 (Reference)
Yes	0.385	0.131	2.935	0.003	1.469(1.136 ~ 1.899)
Cardiovascular disease					
No					1.000 (Reference)
Yes	-0.147	0.166	0.886	0.376	0.8637(0.624 ~ 1.195)
Malignant hematologic/lymphatic disease					
No					1.000 (Reference)
Yes	1.081	0.710	1.523	0.128	2.948(0.734 ~ 11.850)
Hypertension					
No					1.000 (Reference)
Yes	0.295	0.143	2.064	0.039	1.343(1.015 ~ 1.776)
Diabetes mellitus					
No					1.000 (Reference)
Yes	0.406	0.167	2.437	0.015	1.501(1.083 ~ 2.081)
Smoking history					
No					1.000 (Reference)
Yes	0.417	0.126	3.320	0.001	1.517(1.186 ~ 1.940)

Variables	β	S.E	|Z|	P	OR (95%CI)
Alcohol consumption history					
No					1.000 (Reference)
Yes	0.665	0.130	5.112	<0.001	1.944(1.506 ~ 2.508)
Hepatic insufficiency					
No					1.000 (Reference)
Yes	2.497	0.185	13.500	<0.001	12.14(8.449 ~ 17.450)
Renal insufficiency					
No					1.000 (Reference)
Yes	2.544	0.271	9.389	<0.001	12.73(7.485 ~ 21.650)
Tumor involvement of bone marrow	Complete separation				
Allergy history					
No					1.000 (Reference)
Yes	0.518	0.804	0.644	0.520	1.678(0.347 ~ 8.115)
Chronic immunosuppression					
No					1.000 (Reference)
Yes	2.465	0.286	8.615	<0.001	11.76(6.713 ~ 20.600)
History of febrile neutropenia (FN)					
No					1.000 (Reference)
Yes	2.962	0.159	18.670	<0.001	19.34(14.170 ~ 26.400)
Self-care ability assessment					
100					1.000 (Reference)
95-65	0.154	0.122	1.258	0.208	1.166(0.918 ~ 1.482)
60-45	-0.169	0.344	0.492	0.623	0.8442(0.430 ~ 1.657)
≤40	3.121	0.226	13.800	<0.001	22.68(14.560 ~ 35.340)
ECOG performance status					
1					1.000 (Reference)
2	-0.908	0.467	1.946	0.052	0.4032(0.162~ 1.007)
3	1.444	0.204	7.078	<0.001	4.238(2.841 ~ 6.321)
4	Complete separation				
BORG Rating of Perceived Exertion					
≤3					1.000 (Reference)
≥3	1.825	0.135	13.530	<0.001	6.2(4.760 ~ 8.076)
Fall risk score					
≤3					1.000 (Reference)

Variables	β	S.E	|Z|	P	OR (95%CI)
≥3	1.785	0.160	11.140	<0.001	5.96(4.354 ~ 8.158)
Anxiety status					
No					1.000 (Reference)
Yes	2.950	0.202	14.630	<0.001	19.1(12.870 ~ 28.360)
Athens Insomnia Scale score					
≤6					1.000 (Reference)
≥6	0.870	0.129	6.749	<0.001	2.387(1.854 ~ 3.073)
West China Health Index					
Normal					1.000 (Reference)
Mild	-1.336	0.199	6.727	<0.001	0.2629(0.178 ~ 0.388)
Moderate	-0.367	0.150	2.446	0.014	0.6926(0.516 ~ 0.930)
Severe	0.335	0.167	1.986	0.047	1.398(1.004 ~ 1.945)
BMI					
18.5—23.9					1.000 (Reference)
<18.5	1.262	0.168	7.516	<0.001	3.532(2.542 ~ 4.908)
>23.9	-1.800	0.289	6.228	<0.001	0.165(0.094 ~ 0.2913)
NRS2002 score					
≤3					1.000 (Reference)
≥3	0.742	0.123	6.052	<0.001	2.101(1.652 ~ 2.672)
Brief Dietary Assessment score					
4-5					1.000 (Reference)
1	0.477	0.133	3.578	<0.001	1.611(1.241 ~ 2.093)
2-3	1.930	0.138	14.040	<0.001	6.889()
Surgery within one month					
No					1.000 (Reference)
Yes	0.179	0.148	1.213	0.225	1.196(0.896 ~ 1.598)
Prior radiotherapy					
No					1.000 (Reference)
Yes	0.410	0.129	3.179	0.002	1.506(1.170 ~ 1.938)
Prior chemotherapy					
No					1.000 (Reference)
Yes	0.443	0.299	1.482	0.138	1.558(0.867 ~ 2.799)
Prior targeted therapy					
No					1.000 (Reference)

Variables	β	S.E	|Z|	P	OR (95%CI)
Yes	0.667	0.169	3.947	<0.001	1.948(1.399 ~ 2.712)
Prior immunotherapy					
No					1.000 (Reference)
Yes	1.082	0.302	3.581	<0.001	2.95(1.632 ~ 5.332)
CAPOX or XELOX regimen					
No					1.000 (Reference)
Yes	-0.401	0.129	3.123	<0.001	0.6695(0.521 ~ 0.861)
FOLFOXIRI regimen					
No					1.000 (Reference)
Yes	0.441	0.237	1.856	0.064	1.554(0.976 ~ 2.474)
FOLFOX regimen					
No					1.000 (Reference)
Yes	0.570	0.349	1.634	0.102	1.768(0.893 ~ 3.504)
FLOT regimen					
No					1.000 (Reference)
Yes	2.182	0.915	2.385	0.017	8.862(1.475 ~ 53.25)
Other chemotherapeutic agents					
No					1.000 (Reference)
Yes	0.195	0.149	1.311	0.190	1.215(0.908 ~ 1.625)
Cetuximab					
No					1.000 (Reference)
Yes	0.921	0.130	7.079	<0.001	2.512(1.947 ~ 3.242)
Full-dose chemotherapy					
No					1.000 (Reference)
Yes	-1.290	0.210	6.133	<0.001	0.2752(0.182 ~ 0.416)
First-time chemotherapy use					
No					1.000 (Reference)
Yes	-0.443	0.299	1.482	0.138	0.642(0.357 ~ 1.154)

OR: Odds Ratio, CI: Confidence Interval

Table 3. Multivariate logistic regression analysis of factors influencing CIM in the training set

Variables	β	S.E	|Z|	P	OR(95% CI)
Hepatic insufficiency					
No					
Yes	1.123	0.301	3.737	<0.001	3.075(1.706 to 5.543)
Chronic immunosuppression					
No					1.000 (Reference)
Yes	1.393	0.510	2.729	0.006	4.026 (1.481 ~ 10.940)
History of febrile neutropenia (FN)					
No					1.000 (Reference)
Yes	2.231	0.208	10.740	<0.001	9.310 (6.197 ~ 13.990)
Self-care ability assessment					
≥40					1.000 (Reference)
40□	1.158	0.360	3.213	0.001	3.183 (1.571 ~ 6.448)
ECOG performance status					
□3					1.000 (Reference)
≥3	1.186	0.298	3.984	<0.001	3.274 (1.827 ~ 5.868)
BMI					
18.5—23.9					1.000 (Reference)
<18.5	0.889	0.226	3.931	<0.001	2.433 (1.562 ~ 3.790)
>23.9	-1.014	0.315	3.216	0.001	0.363 (0.196 ~ 0.673)
NRS2002 score					
≤3					1.000 (Reference)
□3	0.618	0.162	3.804	<0.001	1.855 (1.349 ~ 2.549)
Cetuximab					
No					1.000 (Reference)
Yes	0.692	0.220	3.148	0.002	1.998 (1.298 ~ 3.073)

OR: Odds Ratio, CI: Confidence Interval

Figures

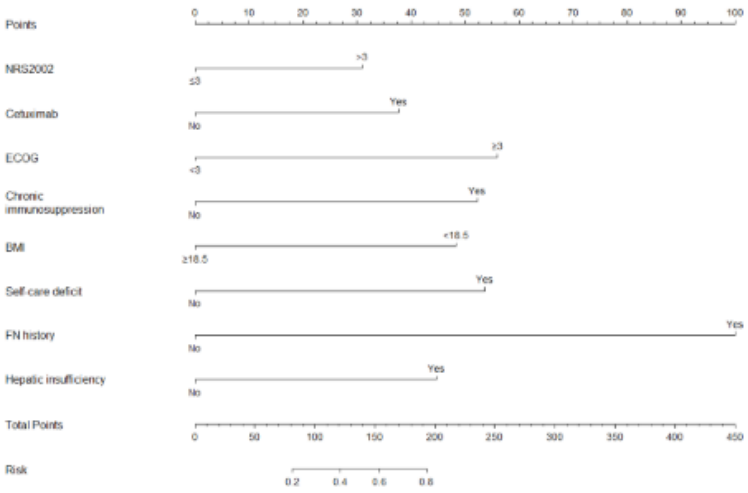

Figure 1

Nomogram for predicting the risk of CIM in the training set

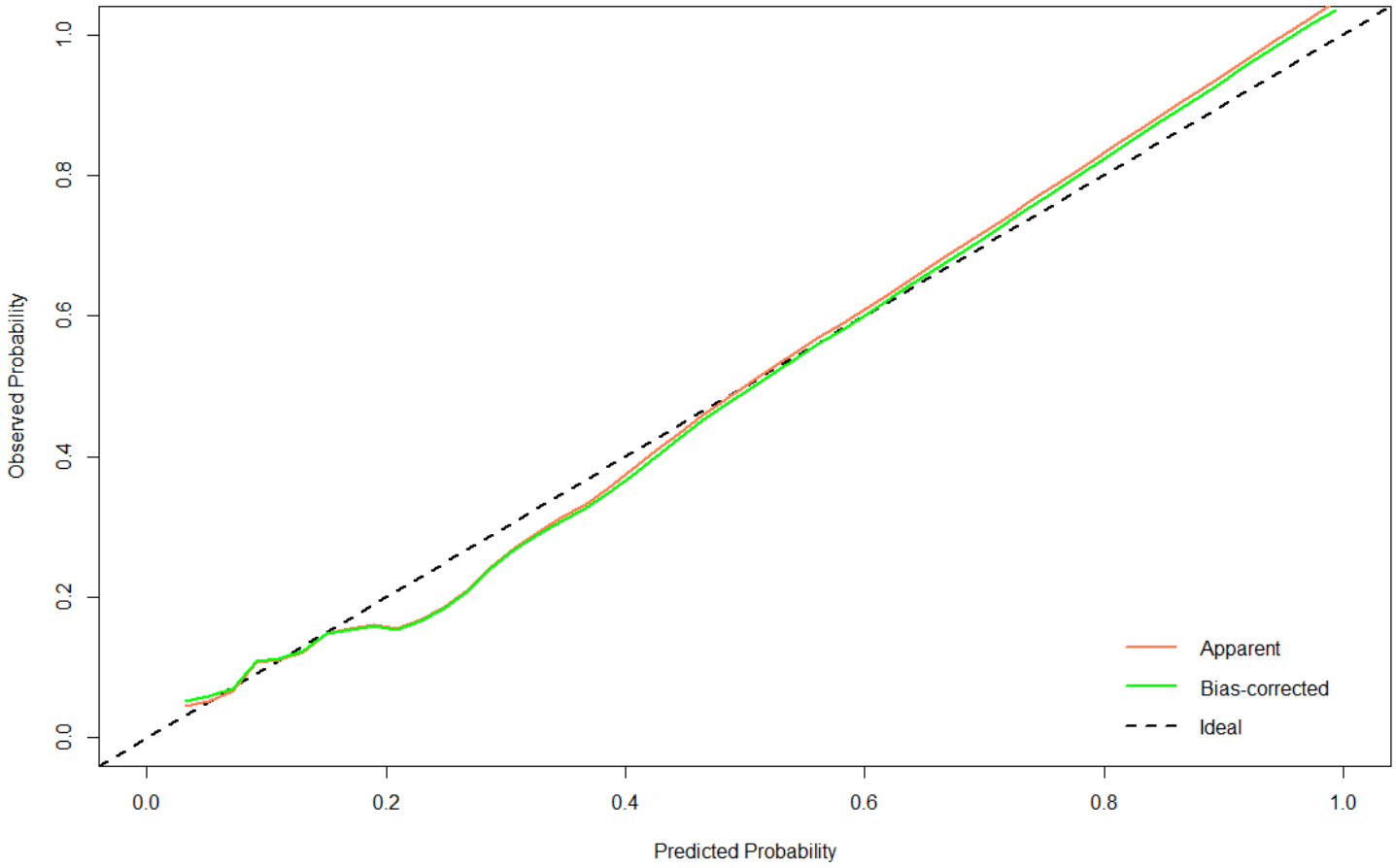

Figure 2

Calibration curve for the training set

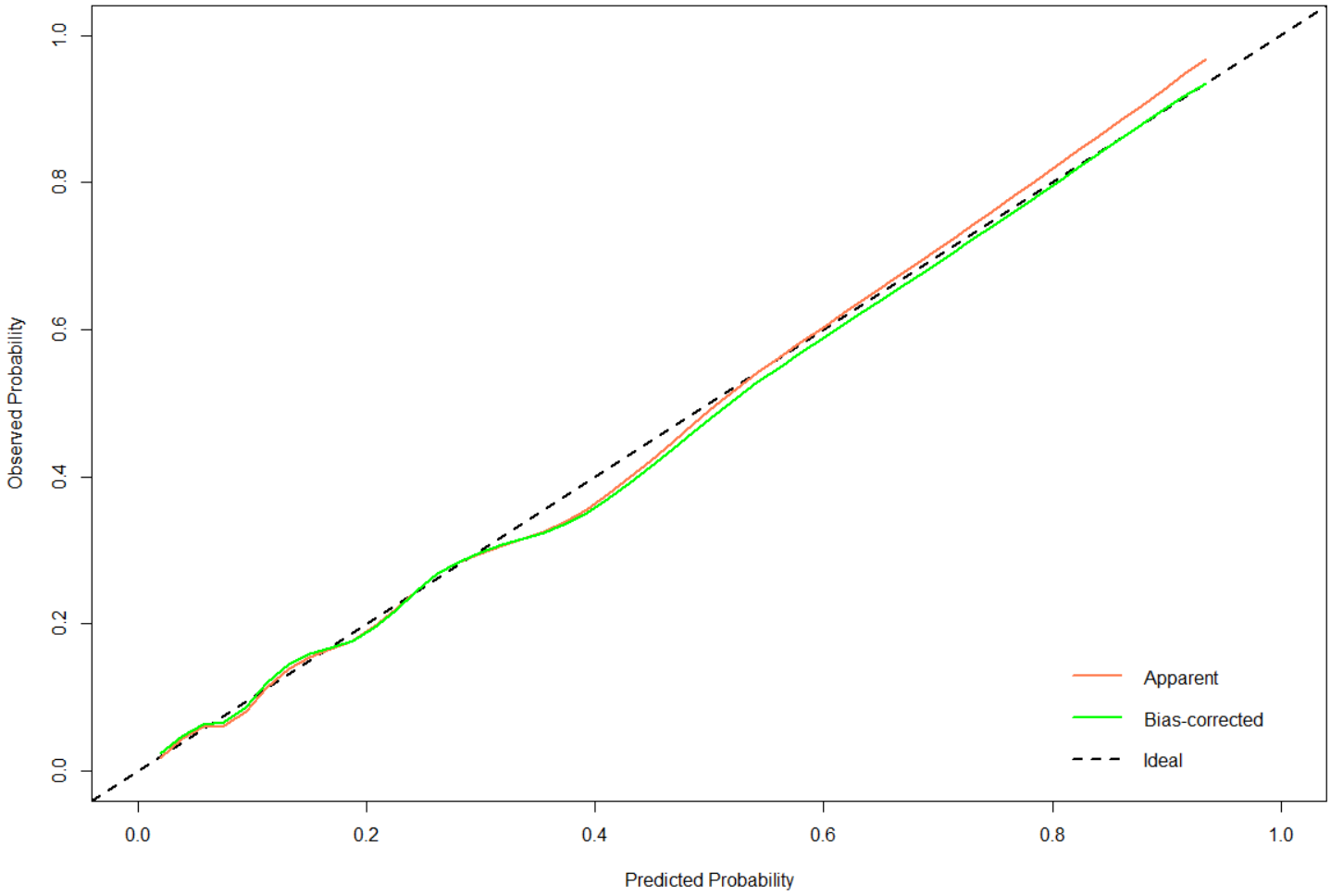

Figure 3

Calibration curve for the testing set

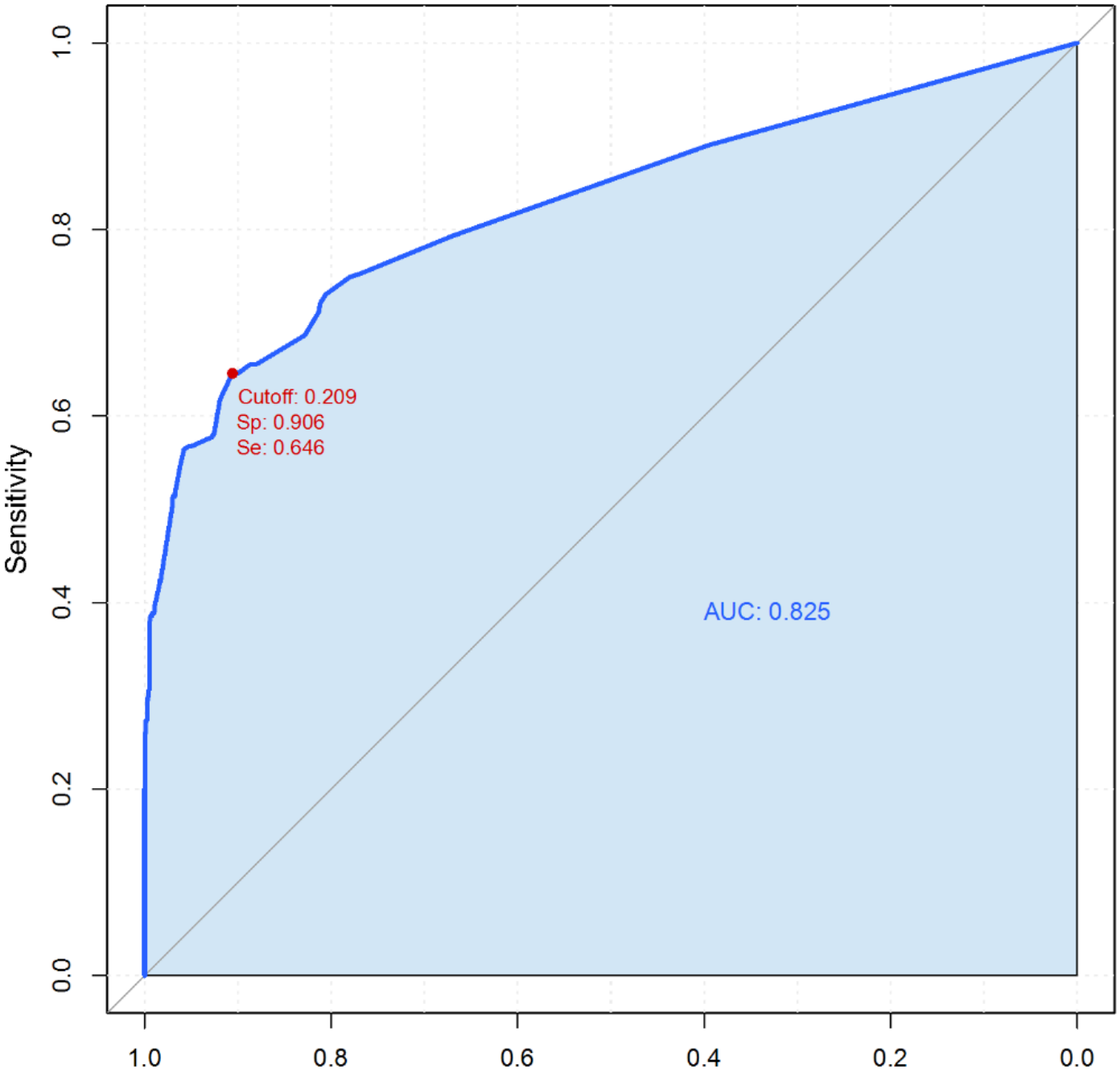

Figure 4

ROC curve for the training set

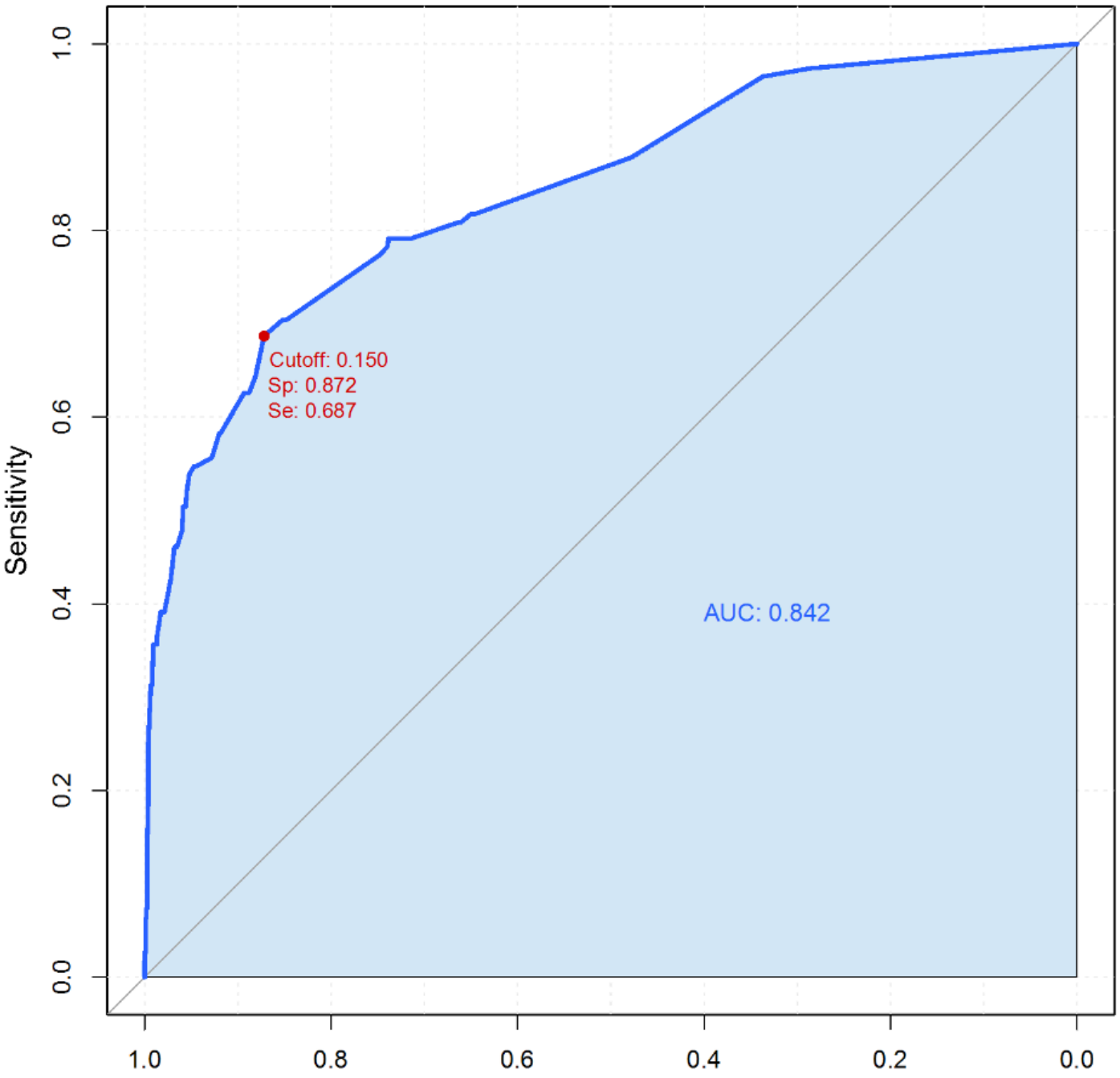

Figure 5

ROC curve for the testing set

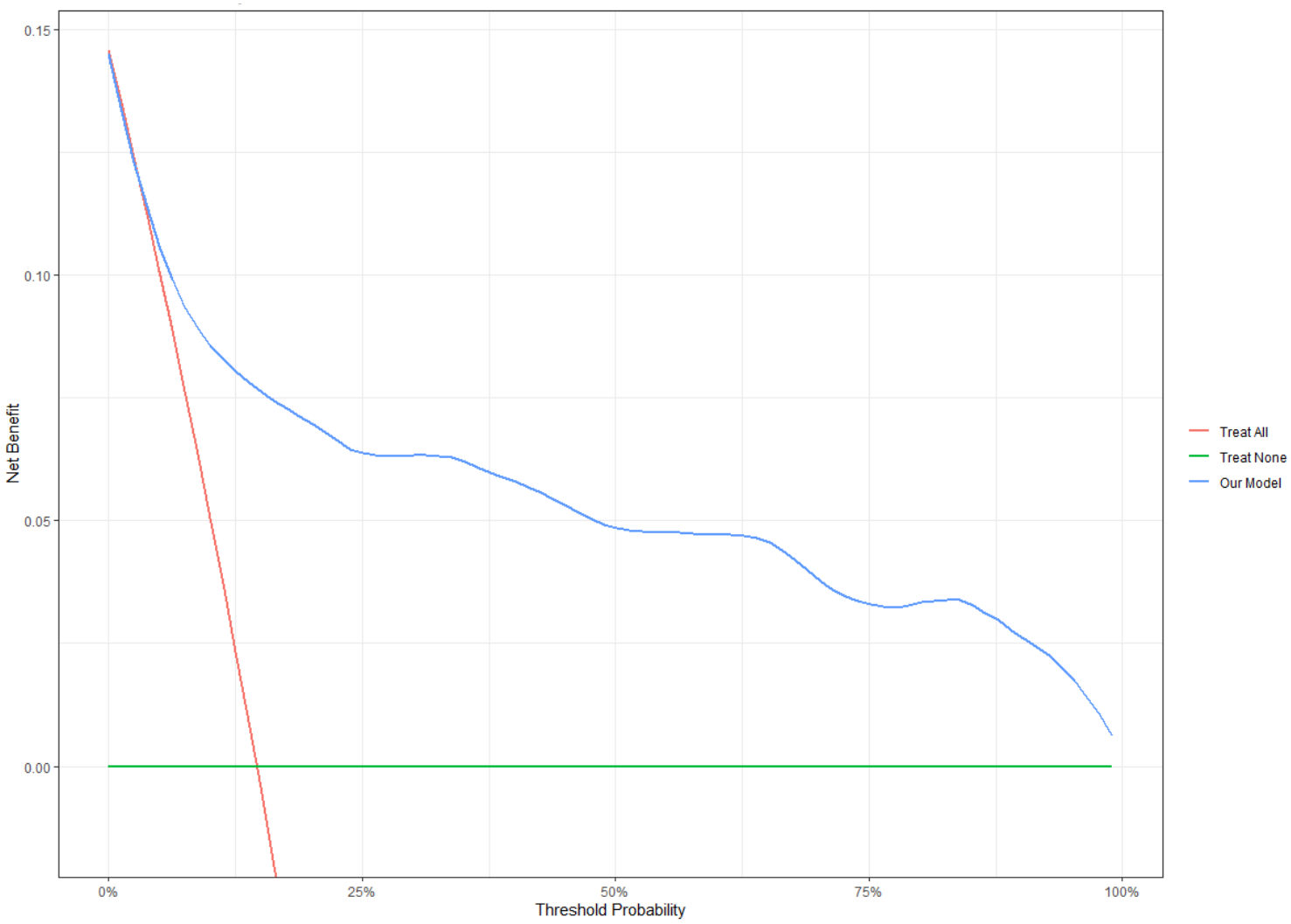

Figure 6

DCA curve for the training set

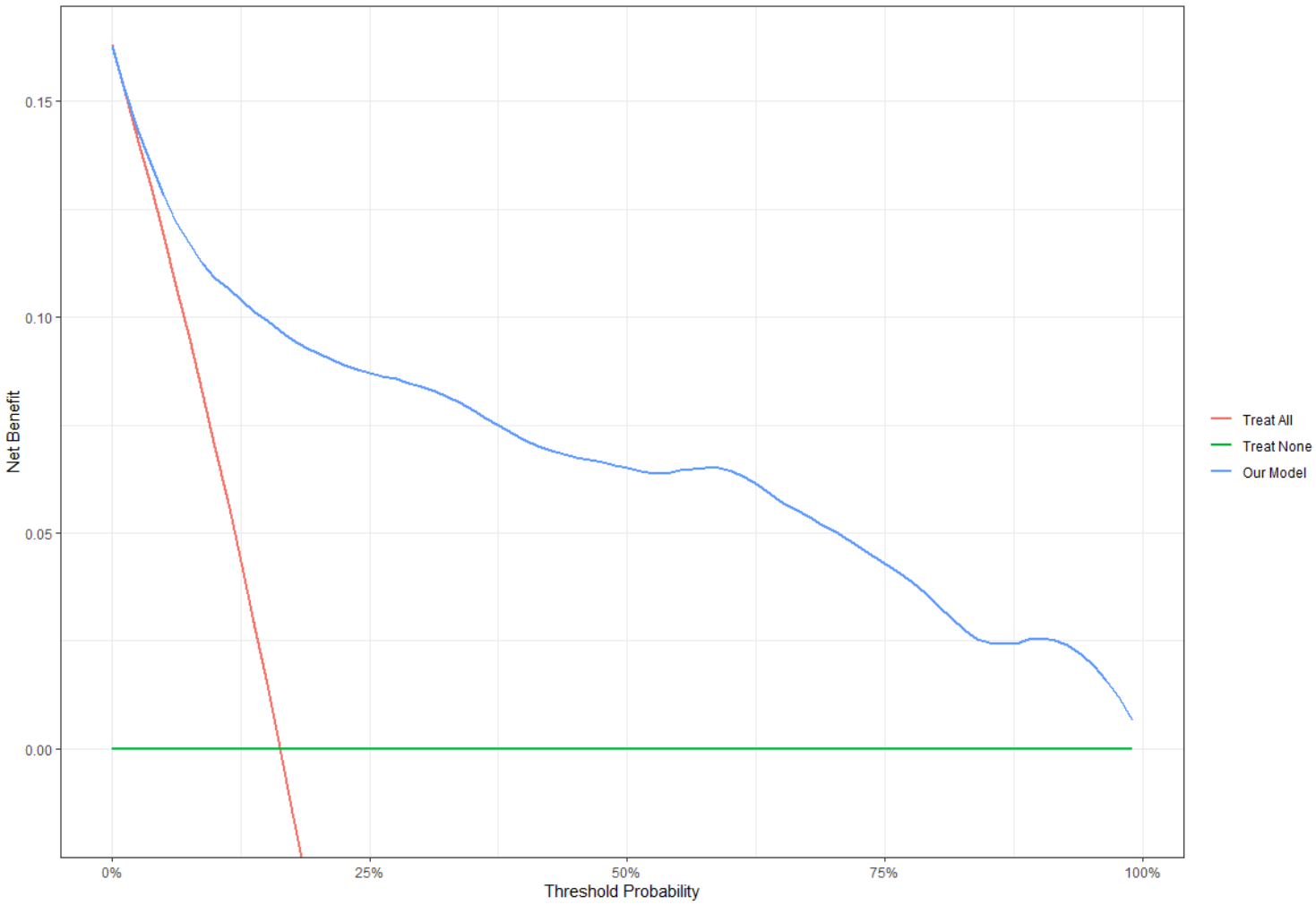

Figure 7

DCA curve for the testing set