

Construction and Verification of A Prediction Model for Stranded Risk Nomograms in Emergency Department Patients

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Research Article

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Abstract

Objective To investigate the risk factors for emergency department (ED) stranded duration and develop a predictive nomogram model.

Methods We retrospectively analyzed 25,391 ED patients from January 2021 to August 2023. Univariate and binary logistic regression identified influencing factors, followed by nomogram construction. Model performance was assessed via ROC-AUC, calibration curves, and decision curve analysis.

Results Median stranded time was 15.69 (5.64-26.73) hours. Key predictors included arrival method, triage level/direction, specialty, time period, wait-time compliance, ICD-10 diagnosis, and tests performed. The nomogram showed good discrimination (internal/external AUC: 0.748/0.732) and calibration. Decision curves confirmed clinical utility.

Conclusion This validated nomogram effectively predicts ED stranded risk, offering practical decision-support for overcrowding management.

1. Introduction

As a crucial component of the medical and healthcare system, the emergency department (ED) plays a vital role in safeguarding patients' lives. However, with the rapid development of society and the continuous growth of the population, the demand for ED services is increasing annually. In many countries and cities, the number of visits to the ED rises each year, and the influx of emergency patients has become an urgent challenge in the field of medical and health management^[1, 2]. This issue is particularly pronounced in the emergency rooms of large general hospitals, where the phenomenon of prolonged patient wait times is becoming increasingly severe^[3]. In recent years, there has been increasing attention to the issue of patients stranded in ED, both domestically and internationally. The root causes of this problem, along with potential solutions, have been thoroughly examined. In this context, the risk early warning model has emerged as a crucial assessment tool, gradually being applied to analyze and predict issues related to patients stranded in emergency settings. This predictive model not only assists medical staff in accurately assessing the risks of patient stranding within the ED but also provides early warnings to clinical personnel, enabling them to implement timely interventions to address these challenges^[4, 5]. Additionally, the model offers valuable insights for ED managers, helping them better understand operational dynamics and staffing needs, thereby facilitating more effective human resource allocation and quality management. Building on this foundation, this study investigates and analyzes the risk factors associated with patient stranding times in emergency rooms and develops a predictive model for stranded risk.

2. Data and Methods

2.1 Research object

A total of 25,391 patients were admitted to the emergency room of Fujian Medical University Union Hospital from January 2021 to August 2023 and were retrospectively selected for this study. Among these, 19,057 patients admitted from January 2021 to October 2022 comprised the modeling group, which was utilized to identify the factors influencing the length of stay and to construct a risk prediction model. Additionally, 6,334 patients admitted from March to August 2023 were designated as the validation group to evaluate the predictive performance of the model.

2.2 Inclusion and exclusion criteria

Inclusion criteria: patients in the ED from January 2021 to October 2022 and from March to August 2023, as well as patients who met the International Classification of Diseases, 10th Revision (ICD-10) diagnostic criteria^[6].

Exclusion criteria: patients admitted between November 2022 and February 2023 were excluded due to a significant influx of pneumonia cases associated with the COVID-19 epidemic during this period. To maintain the rigor of the study and ensure the integrity of the data, it was decided to omit data from this timeframe. Additionally, patients with missing critical information—such as duration of residence, unknown disease diagnosis, and unclear mode of hospital arrival—were also excluded from the study.

2.3 Methods

First, it is essential to understand the current situation of patients in the ED. Secondly, using stranded time as the dependent variable, the data was categorized into two groups: the normal group (≤ 16 hours) and the stranded group (> 16 hours), based on the median. Factors significantly associated with stranded time were identified through univariate analysis, and binary logistic regression was employed to investigate the key influencing factors affecting patient stranding. Finally, the receiver operating characteristic (ROC) curve, along with its area under the curve (AUC), calibration curve, and the risk ratio of net benefit (clinical decision curve and clinical impact curve), were utilized to assess the efficacy of the model.

The independent variables of this study consist of a total of 13 factors categorized into three groups. The first category includes four patient factors: the patient's gender, age, admission method, and frequency of visits to the emergency department. The second category comprises five disease factors: pre-examination triage level, MEWS score, ICD-10 classification, and test items. The third category includes four factors related to medical institutions: the location of patients, the attribution of specialties, the time of treatment, and whether the waiting time meets standard criteria. In this study, age is categorized according to China's age stratification criteria. The modes of transportation to the hospital are classified as walking, support, carrying, wheelchair, flatbed, or ambulance (120). Patients who visit the emergency department four or more times a year are classified as regulars. The pre-examination and triage levels are divided into four categories based on the national emergency department pre-examination and triage classification standards: Grade I for acute and critical patients, Grade II for critical patients, Grade III for emergency patients, and Grade IV for subacute or non-

emergency patients. The Modified Early Warning Score (MEWS) is a diagnostic tool that dynamically monitors changes in a patient's condition and can identify potential risks early. It consists of five parameters: body temperature, heart rate, level of consciousness, systolic blood pressure, and respiration rate. A higher score indicates a more severe condition. The tenth edition of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) categorized conditions with a prevalence of $\geq 3\%$, while those with a prevalence of less than 3% were grouped under other systemic diseases. The test items included a complete blood count, urinalysis, liver function tests, renal function tests, electrolyte levels, myocardial enzyme tests, and coagulation function tests. Based on the median, these were classified into two groups: fewer test items (≤ 12 items) and more test items (> 12 items). The examination procedures included X-rays, ultrasounds, CT scans, magnetic resonance imaging, lung function tests, endoscopies, and angiographies. According to the median, these examination items were also divided into two categories: fewer examination items (≤ 2 items) and more examination items (> 2 items). Depending on the patient's condition and the preferences of the patient or their family members, the treatment pathways were categorized as hospitalization, discharge, transfer, or death. The specialty was designated to the clinical specialist ward, and the treatment duration was classified according to nursing schedules. The standard waiting times were established based on the levels of pre-examination and triage, with patients classified as grade I, II, III, and IV having standard waiting times of 2, 5, 10, and 30 minutes, respectively.

2.4 Statistical analysis

SPSS version 26.0 statistical software was used to analyze the data. Count data for the single factor were expressed as the number of cases (n) and percentages (%), and the chi-square (χ^2) test was performed. Measurement data that did not follow a normal distribution were represented by the median and interquartile range, and the rank-sum test was utilized for group comparisons. A multivariate analysis of residence time was conducted using binary logistic regression. A p-value of less than 0.05 was considered statistically significant.

R software and the rms package were used to construct a nomogram. Additionally, a receiver operating characteristic (ROC) curve, calibration curve, clinical decision curve, and clinical impact curve were generated to evaluate the model's performance.

3. Results

3.1. General information

The median stranded time for all study subjects was 15.69 (5.64, 26.73) hours. The cohort comprised 15,528 males and 9,863 females. Ages ranged from 0.1 to 101 years, with a median age of 62 years (47, 72). The stranded time varied from 0 to 434.71 hours, with 12,832 cases (50.54%) lasting 16 hours or less, 8,008 cases (31.54%) lasting between 17 and 32 hours, and 4,551 cases (17.92%) exceeding 32 hours. At the pre-examination triage level, 20,481 patients (80.66%) were classified as grade IV, with a

median stranded time of 14.75 (5.30, 26.20) hours. Among the 120 patients admitted to the ED, 2,820 (11.11%) had a median stranded time of 11.65 (4.55, 24.37) hours. A total of 16,277 patients (64.11%) were transferred to the hospital, with a median stranded time of 18.01 (6.50, 27.44) hours.

3.2 Single-factor analysis of stranded time in modeling groups

There were statistically significant differences in the distribution of risk factors, including age, mode of admission, pre-examination and triage level, diversion destination, specialty attribution, treatment time period, modified early warning score (MEWS), standard waiting time, ICD-10 classification, test items, and frequent ED visitors, between the normal group and the stranded group ($P<0.05$), as shown in Table 1.

Table 1 Univariate analysis of length of stay for stranded patients in the ED

Variables	Normal group (≤ 16 h)	Retention group (> 16 h)	χ ² value	P value
	<i>n</i> = 9 673	<i>n</i> = 9 384		
Gender				
Male	5 957(61.58%)	5 776(61.55%)	0.002	0.964
Female	3 716(38.42%)	3 608(38.45%)		
Age (years)				
0~17	522(5.40%)	430(4.58%)	19.391	<0.001
18~65	5 272(54.50%)	4 924(52.47%)		
66~79	2 831(29.27%)	2 955(31.49%)		
≥80	1 048(10.83%)	1 075(11.46%)		
Way of coming to the hospital				
Walking	6 662(68.87%)	6 647(70.83%)	96.906	<0.001
Supporting	400(4.14%)	514(5.48%)		
Embrace	60(0.63%)	36(0.38%)		
Wheelchair	129(1.33%)	170(1.81%)		
Flat car	1 195(12.35%)	1 184(12.62%)		
120 incoming	1 227(12.68%)	833(8.88%)		
Frequent guests in emergency department				
No	9 558(98.81%)	9 241(98.48%)	4.002	0.045
Yes	115(1.19%)	143(1.52%)		
Pre-examination triage level				
Grade I	297(3.07%)	354(3.77%)	125.762	<0.001
Grade II	537(5.55%)	660(7.03%)		
Grade III	941(9.73%)	1 322(14.09%)		
Grade IV	7 898(81.65%)	7 048(75.11%)		
MEWS score				
0	5 889(60.88%)	4 997(53.25%)	133.742	<0.001
1~2	2 696(27.87%)	2 940(31.33%)		

3~5	1 025(10.60%)	1 335(14.23%)		
>5	63(0.65%)	112(1.19%)		
ICD-10 Classification				
Some infectious and parasitic diseases	1 629(16.84%)	2 741(29.21%)	1786.81	<0.001
Tumors	769(7.95%)	1 184(12.62%)		
Blood and hematopoietic organ diseases and some diseases involving immune mechanisms	418(4.32%)	759(8.09%)		
Endocrine, nutritional and metabolic diseases	815(8.43%)	1 276(13.59%)		
Circulatory system diseases	2 865(29.62%)	1 615(17.21%)		
Respiratory diseases	434(4.49%)	651(6.94%)		
Digestive system diseases	721(7.45%)	504(5.37%)		
Symptoms, signs and clinical and experimental abnormalities seen, can not be classified	1 090(11.27%)	191(2.04%)		
other systemic diseases	932(9.63%)	463(4.93%)		
Inspection items				
Less	6 518(67.38%)	4 025(42.89%)	1155.923	<0.001
More	3 155(32.62%)	5 359(57.11%)		
Examination items				
Less	5 467(56.52%)	4 235(45.13%)	247.175	<0.001
More	4 206(43.48%)	5 149(54.87%)		
Diversion destination				
Discharged from hospital	4 080(42.18%)	2 644(28.18%)	426.678	<0.001
Hospitalization	5 531(57.18%)	6 688(71.27%)		
Transferring hospital	13(0.13%)	23(0.24%)		
Death	49(0.51%)	29(0.31%)		
Belong to specialty				
Emergency internal medicine	6 395(66.11%)	6 425(68.47%)	82.38	<0.001
Emergency surgery	1 706(17.64%)	1 283(13.67%)		

Neurology	1 241(12.83%)	1 432(15.26%)		
Pediatric internal medicine	331(3.42%)	244(2.60%)		
Time period of treatment				
8:00~15:59	4 386(45.34%)	4 076(43.44%)	695.825	<0.001
16:00~23:59	3 346(34.59%)	4 540(48.38%)		
0:00~7:59	1 941(20.07%)	768(8.18%)		
Is the waiting time standard				
Yes	7 328(75.76%)	6 354(67.71%)	152.288	<0.001
No	2 345(24.24%)	3 030(32.29%)		

3.3 Binary logistic regression analysis of stranded time in the modeling group

Before conducting the multivariate logistic regression analysis, a multicollinearity test was performed on the included independent variables, which revealed no collinearity among them (the variance inflation factor, or VIF, values ranged from 0.5 to 1.0). The independent variables were then assigned, and the Wald chi-square test (backward: Ward) was selected for the multivariate logistic regression analysis. The results indicated that the method of arriving at the hospital, the level of pre-examination and triage, the direction of diversion, specialty affiliation, treatment time period, waiting time, ICD-10 classification, test items, and inspection items were independent factors influencing stranded time, as shown in Table 2.

Table 2 Binary logistic regression analysis of the length of stay for stranded patients in the ED

Variables	B value	P value	OR95%CI
Way of coming to the hospital			
120 incoming		0.007	
Embrace	-0.118	0.633	0.888 0.547~1.443
Flat car	0.1	0.147	1.105 0.965~1.264
Walking	0.157	0.004	1.170 1.051~1.303
Supporting	0.325	<0.001	1.384 1.157~1.657
Wheelchair	0.155	0.264	1.168 0.890~1.532
Pre-examination triage level			
Grade I		0	
Grade II	0.135	0.223	1.144 0.921~1.421
Grade III	0.384	<0.001	1.468 1.201~1.794
Grade IV	0.354	<0.001	1.425 1.174~1.731
ICD-10 Classification			
Symptoms, signs and clinical and experimental abnormalities seen, can not be classified		<0.001	
Other systemic diseases	0.983	<0.001	2.674 2.183~3.274
Circulatory system diseases	0.873	<0.001	2.393 2.012~2.846
Digestive system diseases	1.439	<0.001	4.218 3.433~5.183
Respiratory diseases	2.064	<0.001	7.875 6.402~9.686
Tumors	2.011	<0.001	7.468 6.188~9.011
Endocrine, nutritional and metabolic diseases	1.837	<0.001	6.277 5.215~7.555

Some infectious and parasitic diseases	2.297	<0.001	9.944 [8.317~11.888]
Blood and hematopoietic organ diseases and some diseases involving immune mechanisms	2.132	<0.001	8.431 [6.858~10.366]
Inspection items			
More	0.838	<0.001	2.312 [2.139~2.500]
Examination items			
More	0.175	<0.001	1.192 [1.106~1.284]
Diversion destination			
Death		<0.001	
Discharged from hospital	0.275	0.302	1.317 [0.781~2.221]
Hospitalization	0.815	0.002	2.260 [1.342~3.808]
Transferring hospital	0.794	0.084	2.212 [0.899~5.442]
Belong to specialty			
Emergency surgery		<0.001	
Pediatric internal medicine	0.206	0.054	1.229 [0.997~1.516]
Emergency internal medicine	0.443	<0.001	1.558 [1.407~1.725]
Neurology	1.262	<0.001	3.533 [3.090~4.040]
Time period of treatment			
0:00~7:59		<0.001	
8:00~15:59	0.8	<0.001	2.226 [2.007~2.469]
16:00~23:59	1.278	<0.001	3.589 [3.233~3.984]
Is the waiting time standard			
No	0.523	<0.001	1.686 [1.544~1.841]
constant	-4.685	<0.001	

3.4 Construction of a risk prediction model for patient stranded in the ED

According to the variables selected through binary logistic regression analysis, a nomogram prediction model for patient stranding was constructed, as illustrated in Figure 1. The application of the nomogram is as follows: Based on the scores (points) corresponding to each predictive index, the total points are calculated by summing each score, which then yields the predicted probability associated with the total score.

3.5 Evaluation and verification of the stranded risk prediction model

The results of this study indicated that the area under the curve (AUC) value was 0.737, with a sensitivity of 67.3% and a specificity of 67.7% (Fig. 2a). The chi-squared (χ^2) value from the goodness-of-fit test was 0.086, and the p-value was 0.931, suggesting that the predicted incidence rate of the model closely aligned with the actual incidence rate. The constructed model accurately represented the occurrence of stranded events and demonstrated a good fit (Figure 2b). According to the decision curve analysis (DCA), when the probability of predicting a prolonged hospital stay falls between 0.35 and 0.65, the use of the nomogram for prediction yields a higher net benefit rate, facilitating a more accurate assessment of patient stranded time (Figure 2c). Furthermore, when the threshold probability exceeds 65%, the prediction model's ability to identify high-risk groups for prolonged stranded time closely corresponds with the actual situation (Figure 2d).

The external validation results indicated that the model demonstrated good performance, with an AUC of 0.730, a sensitivity of 67.0%, and a specificity of 67.6% (Fig 3a). The results of the goodness-of-fit test further confirmed the model's accuracy, with a χ^2 value of 0.193 and a *P* value of 0.847. This suggests that the predicted incidence from the model closely aligns with the actual incidence (Figure 3b). Additionally, the decision curve analysis (DCA) curve illustrates that when the probability of predicting patient retention falls between 0.35 and 0.60, utilizing the nomogram tool is more advantageous (Figure 3c). The clinical impact curve indicates that when the threshold probability of the predicted score exceeds 60%, the model's assessment of the high-risk population is highly consistent with the actual situation, thereby demonstrating the strong clinical effectiveness of the prediction model (Figure 3d).

4. Discussion

The phenomenon of patients crowding ED is prevalent in many medical institutions, both domestically and internationally, particularly in densely populated and resource-constrained areas. Due to the uneven distribution of medical resources, a shortage of emergency physicians, and patients' excessive reliance on emergency services, the issue of ED congestion is especially pronounced in China. Furthermore, some patients, in search of better medical care, opt to visit the ED even when their conditions are not serious, thereby exacerbating congestion in these facilities. According to the results of several studies on emergency stranded times, this phenomenon is prevalent in major hospitals. For instance, Shen Q. (2019) investigated the stranded time in the ED of the First Affiliated Hospital of Anhui Medical

University, analyzing a total of 9,569 patients. The findings indicated that the stranded time reached up to 6,970 minutes, with 1,469 cases exceeding 240 minutes and 643 cases surpassing 360 minutes^[7]. Additionally, from June 2021 to June 2022, Zhou W. studied 210 patients in the ED of Huai'an Second People's Hospital and found that 45 patients experienced a stranded time longer than 6 hours, accounting for 21.43% of the total^[8]. Furthermore, data from the Affiliated Hospital of Xuzhou Medical University in 2019 revealed that 4.40% of patients required emergency treatment, with the proportion of those stranded for over 6 hours reaching as high as 30.29%. These statistics underscore the seriousness and urgency of the issue of ED stranding in large public hospitals across China.

Since 2006, the American Institute of Medicine has warned that the stranding of critically ill patients in ED will pose a significant challenge in the field of emergency medicine in the future. In recent years, the number of emergency visits in the United States has increased at a rate that far exceeds the population growth rate. For instance, between 2010 and 2014, the number of ED visits in the United States surged from 128.9 million to 137.8 million^[9]. Similarly, in Switzerland, the number of ED visits rose by 26% between 2007 and 2011, with outpatient visits increasing by 32% and inpatient numbers rising by 16%^[10]. A substantial body of research has identified several factors contributing to the stranding of critically ill patients in the ED^[11-13]. Firstly, elderly patients constitute a significant portion of emergency cases, and their treatment often involves greater complexity. Secondly, there is a high volume of non-emergency patients who do not require urgent medical attention, further straining resources. Lastly, the issue of patient stranding is critical; after initial emergency treatment, many patients cannot be effectively transferred to appropriate care, leading to extended stranding in the ED. This prolonged stranding not only increases the overall length of hospital stays and medical expenses for patients but may also diminish their satisfaction with medical services. Therefore, addressing the issue of critically ill patient stranding in the ED is essential for enhancing the quality of emergency medical services.

The results of this study indicate that among various patient factors, age, mode of arrival at the hospital, and frequent visits to the ED significantly impact the length of time patients remain in the ED. As age increases, the median length of stay also tends to rise ($P<0.05$), which aligns with findings from previous studies^[14, 15], further confirming that age is a crucial factor influencing length of stay. The increase in age reflects a gradual decline in bodily and organ functions. Additionally, elderly patients often present with more cardiovascular risk factors, which can further extend their length of stay. Furthermore, arrival via emergency medical services (120 admissions) was identified as an independent protective factor for patients in this study. In comparison to other methods of hospital admission, patients arriving by ambulance had a shorter overall length of stay ($P<0.05$). Consistent with previous studies^[16], patients admitted via ambulance received appropriate treatment and care more quickly after emergency medical assistance, leading to faster discharges following the completion of necessary medical procedures. The median length of stay was significantly longer for patients in the ED ($P<0.05$). An analysis of the causes revealed that patients with chronic conditions, such as diabetes and hypertension, may experience acute episodes requiring urgent medical intervention if their daily management and disease control are inadequate. Additionally, certain sudden acute conditions, including heart attacks, strokes, severe

infections, or accidental injuries, compel patients to frequently seek help from the ED. Finally, some patients with non-emergency conditions may misjudge the severity of their illness or seek immediate medical treatment, prompting them to visit the ED^[17, 18].

Among the factors contributing to disease, the pre-examination triage level, MEWS score, ICD-10 classification of various diseases, and examination items significantly influenced the stranded time of patients in the ED. In this study, the stranded risk for patients with pre-screening triage levels III and IV was 1.468 times and 1.425 times higher, respectively, than that of patients with pre-screening triage level I. A substantial influx of non-emergency patients into the ED has led to an increased workload and extended stranded times. There are three primary reasons for this: self-perceived ED, inadequate access to other medical resources, and the convenience of the ED^[19]. With an increase in the MEWS, the duration of patient stranded in the ED also correspondingly increased. Specifically, patients with a MEWS score of 0 had a median stranded of 13.82 hours in the ED, while those with a MEWS score greater than 5 had a median stranded of 20.73 hours.

Among the factors contributing to disease, the pre-examination triage level, MEWS score, ICD-10 classification of various diseases, and examination items significantly influenced the duration of patients' stay in the ED. In this study, the risk of prolonged stay for patients with pre-screening triage levels III and IV was 1.468 times and 1.425 times higher, respectively, than that of patients with pre-screening triage level I. A substantial influx of non-emergency patients into the ED has resulted in an increased workload and extended wait times. There are three primary reasons for this: self-perception of needing emergency care, inadequate access to other medical resources, and the convenience of the ED. As the MEWS increases, the duration of patients' stay in the ED also correspondingly rises. Specifically, patients with a MEWS score of 0 had a median stay of 13.82 hours in the ED, while those with a MEWS score greater than 5 had a median stay of 20.73 hours. The study conducted by Zhao TB and Zhang YH et al.^[20, 21] indicated that a MEWS score exceeding 5 points serves as a critical threshold. Patients with MEWS scores above 5 exhibited a significantly elevated risk of in-hospital mortality and death in the ICU. Additionally, the 6-month survival rate for these patients was notably low, and they required extended periods of observation in the ICU. Among various diseases, certain infectious and parasitic diseases posed the highest risk for prolonged observation, with a median duration of 20.85 hours. These cases typically presented with infectious fever as the primary symptom and necessitated prompt medical intervention. Following these, blood and hematopoietic organ diseases, along with conditions involving immune mechanisms, had a median observation time of 21.50 hours.

Among the factors affecting medical institutions, the destination of diversion, the timing of treatment during different periods, and the waiting time directly influence the duration of patients stranded in the ED. The risk of hospitalization is 2.26 times higher for patients who are discharged. Those who opt for transfer to a hospital often experience longer wait times than patients who choose to be discharged directly or pursue alternative treatment methods, primarily due to the extended waiting and treatment periods required. The study found significant differences in patient wait times in the ED across various time periods. Patients typically seek medical treatment during the day, leading to an increase in the

number of patients during the morning shift. This surge means that medical staff must manage a higher volume of cases, including reception, diagnosis, treatment, and follow-up tracking. Consequently, substantial time and energy must be invested during the early shift, which may result in prolonged patient wait times in the ED. The risk of non-compliance with the standard waiting time for stranded patients is 1.686 times greater than that of compliance. For many patients, the waiting time may encompass not only the duration after pre-examination and triage but also the time taken for referrals from hospitals or other medical institutions, as well as the time spent waiting for a doctor's diagnosis, the formulation of a treatment plan, and the preparation of medication.

5. Conclusion

Based on logistic regression, this study developed a nomogram to predict the duration of patients' stay in the ED. The nomogram exhibits strong accuracy in forecasting the risk of patient delays, making it a valuable tool for clinical emergency response efforts.

Abbreviations

ED: Emergency Department

ROC: Receiver Operating Characteristic

AUC: Area Under the Curve

ICD-10: International Classification of Diseases, 10th Revision

COVID-19: Coronavirus Disease 2019

MEWS: Modified Early Warning Score

CT: Computed Tomography

SPSS: Statistical Product and Service Solutions

OR: Odds Ratio

CI: Confidence Interval

DCA: Decision Curve Analysis

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Fujian Medical University Union Hospital (Approval Number:

2025KY089). The need for informed consent to participate was waived by the same ethics committee (Fujian Medical University Union Hospital) due to the retrospective and anonymized nature of the data analysis.

Consent for publication

Not applicable. Consent for publication of anonymized data was obtained as part of the informed consent process.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Shang Manman contributed substantially to the study conception and design, analyzed and interpreted the data, and drafted and critically revised the manuscript. Wei Qin was responsible for data collection and manuscript revision. All authors read and approved the final manuscript.

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Figures

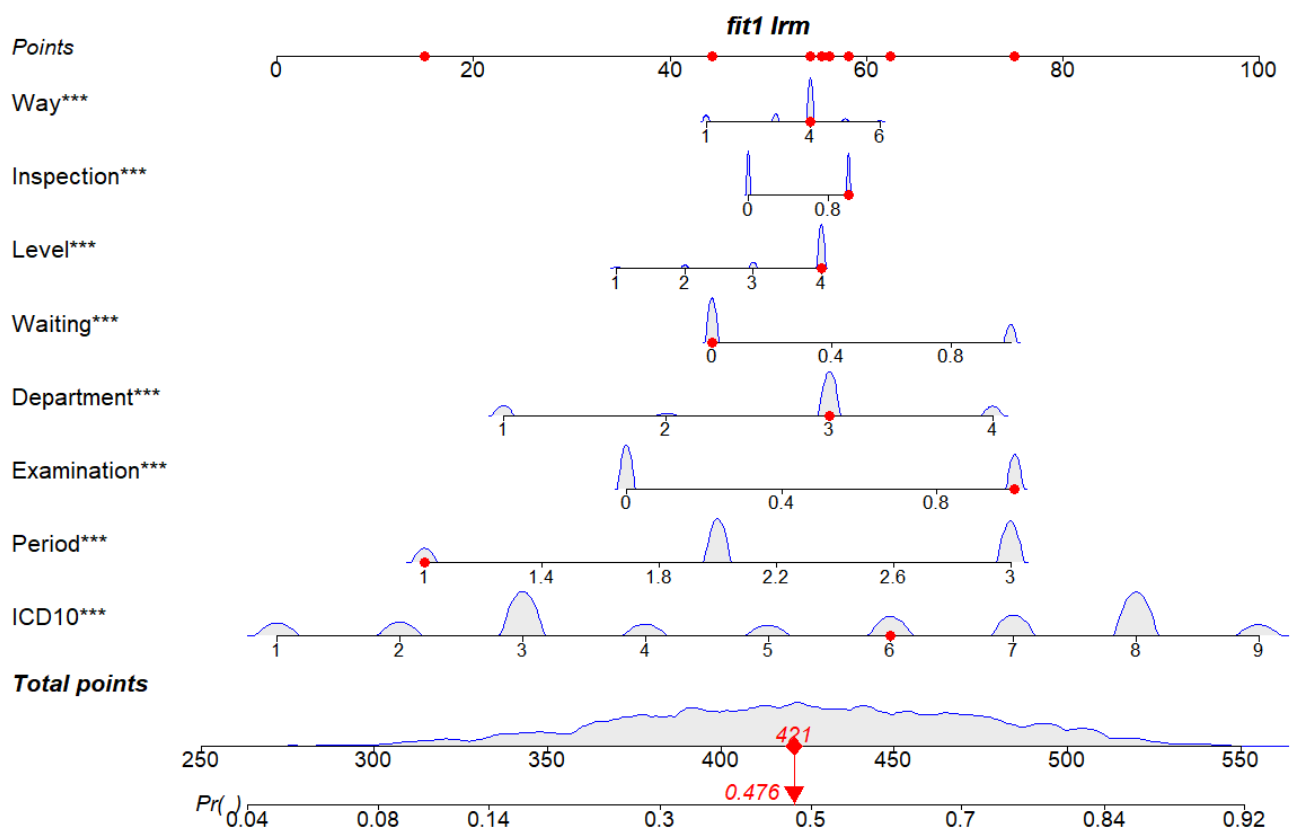


Figure 1

Prediction model of a nomogram for stranding risk of patients in the ED

Annotation: Way: route to the hospital, Level: pre-examination triage level, Endpoint: diversion, Department: specialist affiliation, Period: duration of treatment, Waiting: whether the waiting time meets the standard, ICD10: disease classification, Examination: items to be inspected, Inspection: items to be examined.

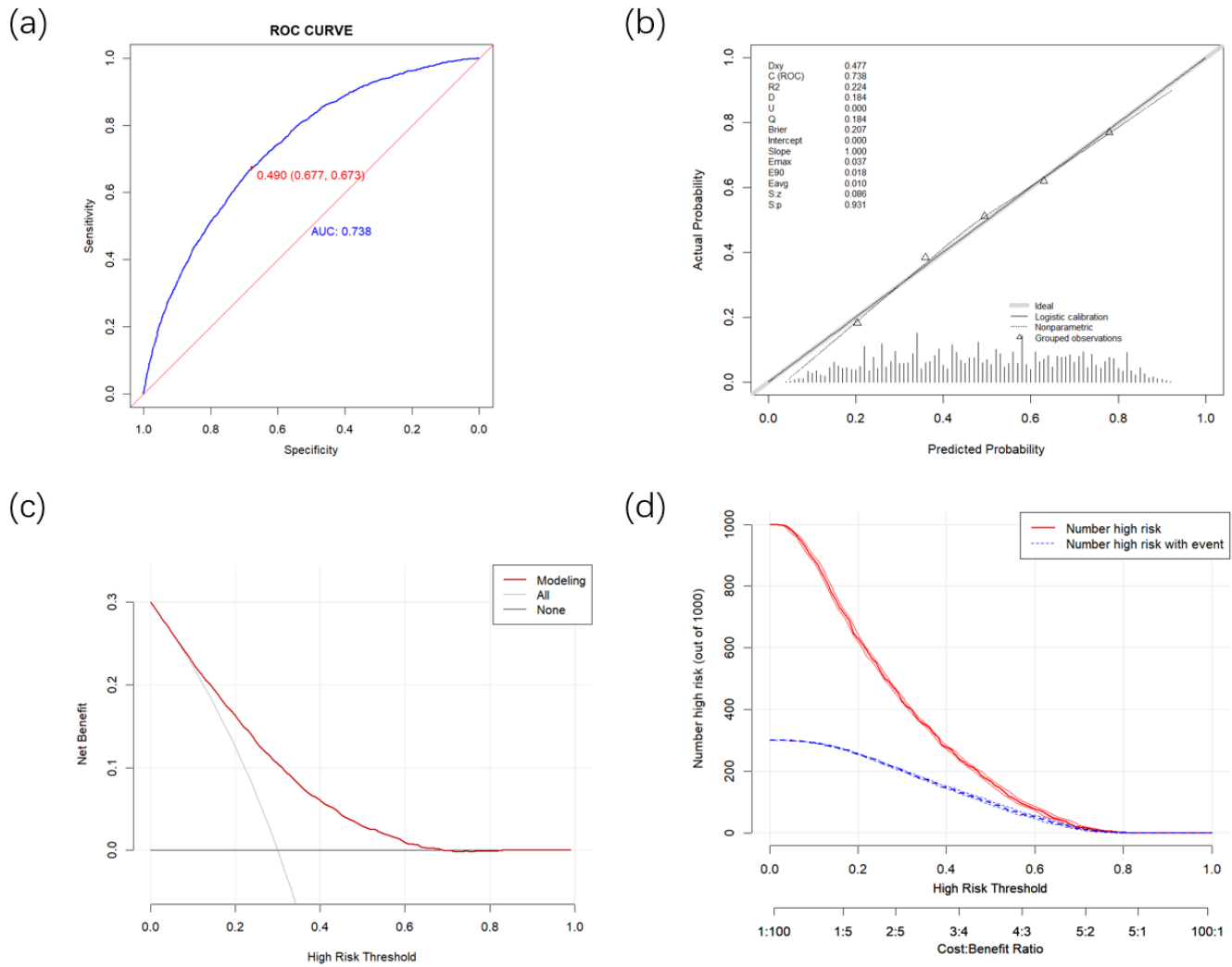


Figure 2

Evaluation and verification results of the stranded risk prediction model in the modeling group

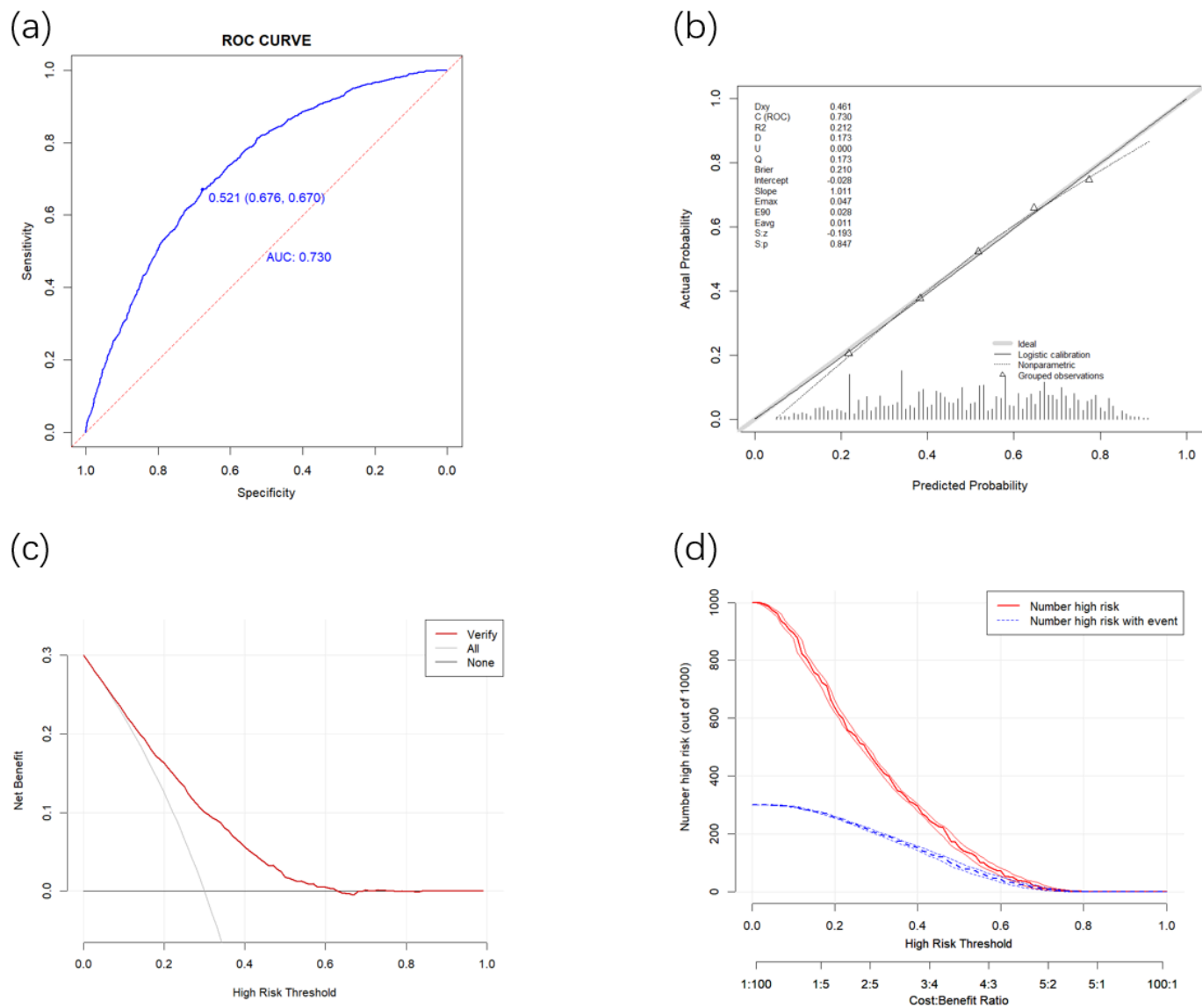


Figure 3

Validation group stranded risk prediction model evaluation and verification results