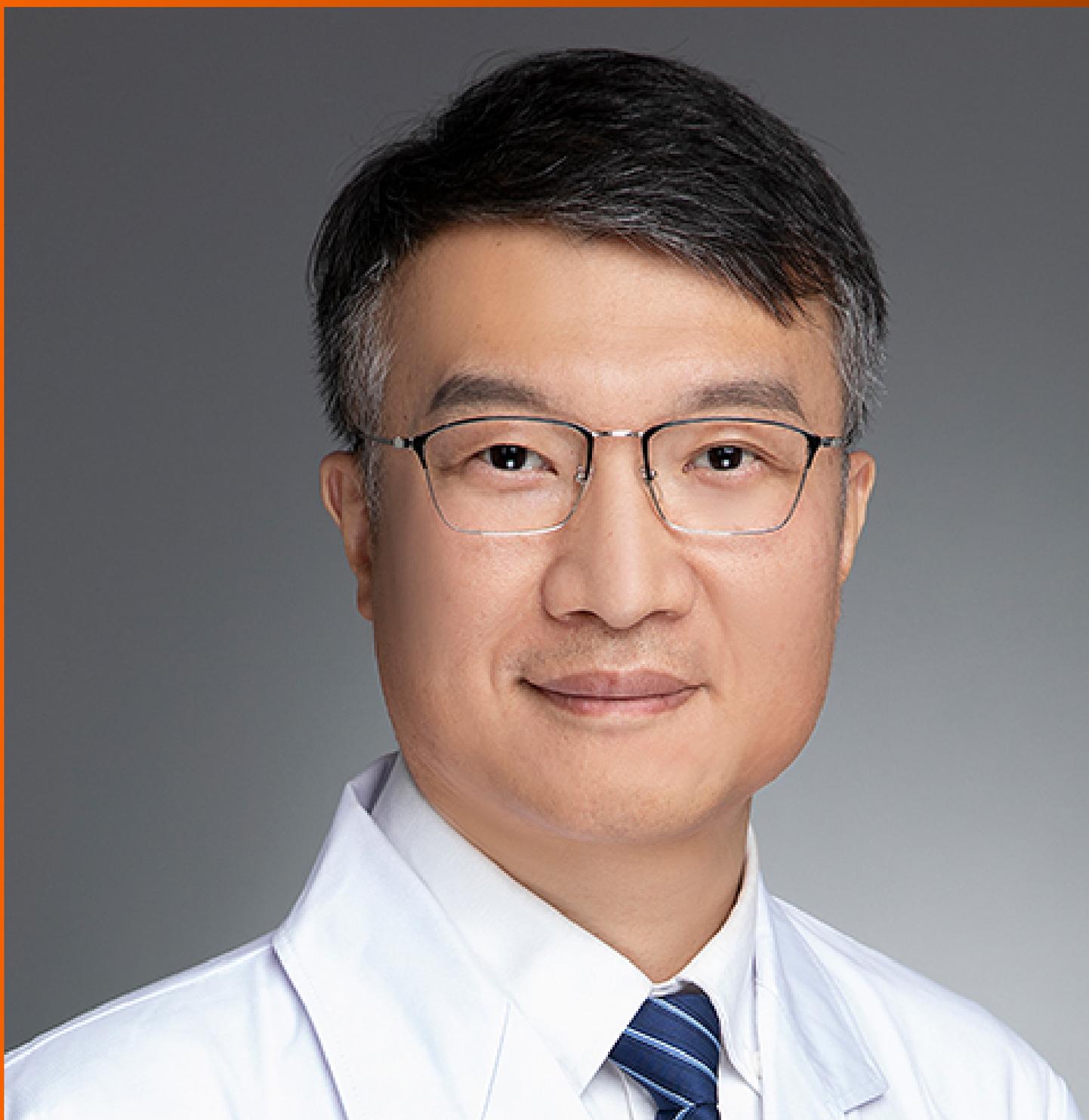


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## Retrospective Cohort Study

## Development and validation of a nomogram model for predicting the risk of pre-hospital delay in patients with acute myocardial infarction

Jiao-Yu Cao, Li-Xiang Zhang, Xiao-Juan Zhou

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Acute myocardial infarction (AMI) is a severe cardiovascular disease caused by the blockage of coronary arteries that leads to ischemic necrosis of the myocardium. Timely medical contact is critical for successful AMI treatment, and delays increase the risk of death for patients. Pre-hospital delay time (PDT) is a significant challenge for reducing treatment times, as identifying high-risk patients with AMI remains difficult. This study aims to construct a risk prediction model to identify high-risk patients and develop targeted strategies for effective and prompt care, ultimately reducing PDT and improving treatment outcomes.

**AIM**

To construct a nomogram model for forecasting pre-hospital delay (PHD) likelihood in patients with AMI and to assess the precision of the nomogram model in predicting PHD risk.

**METHODS**

A retrospective cohort design was employed to investigate predictive factors for PHD in patients with AMI diagnosed between January 2022 and September 2022. The study included 252 patients, with 180 randomly assigned to the development group and the remaining 72 to the validation group in a 7:3 ratio. Independent risk factors influencing PHD were identified in the development group, leading to the establishment of a nomogram model for predicting PHD in patients with AMI. The model's predictive performance was evaluated using the receiver operating characteristic curve in both the development and validation groups.

**RESULTS**

Independent risk factors for PHD in patients with AMI included living alone, hyperlipidemia, age, diabetes mellitus, and digestive system diseases ( $P < 0.05$ ). A

nomogram model incorporating these five predictors accurately predicted PHD occurrence. The receiver operating characteristic curve analysis indicated area under the receiver operating characteristic curve values of 0.787 (95% confidence interval: 0.716–0.858) and 0.770 (95% confidence interval: 0.660–0.879) in the development and validation groups, respectively, demonstrating the model's good discriminatory ability. The Hosmer-Lemeshow goodness-of-fit test revealed no statistically significant disparity between the anticipated and observed incidence of PHD in both development and validation cohorts ( $P > 0.05$ ), indicating satisfactory model calibration.

## CONCLUSION

The nomogram model, developed with independent risk factors, accurately forecasts PHD likelihood in AMI individuals, enabling efficient identification of PHD risk in these patients.

**Key Words:** Pre-hospital delay; Acute myocardial infarction; Risk prediction; Nomogram

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**Core Tip:** The study developed a nomogram model to predict pre-hospital delay (PHD) in acute myocardial infarction (AMI) patients. Independent risk factors for PHD were identified, and a nomogram was constructed using these predictors. The model showed good discriminatory ability and satisfactory calibration. This nomogram can effectively identify PHD risk in AMI patients.

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## INTRODUCTION

Acute myocardial infarction (AMI), a cardiovascular condition often stemming from coronary artery disease, arises when the abrupt blockage of the coronary artery disrupts blood circulation, leading to localized myocardial ischemic necrosis. Existing research underscores the critical impact of timely medical contact, revealing that every hour of delay increases the risk of death in patients with AMI by approximately 10% [1]. Swift restoration of blood flow in the infarct-related artery is pivotal for effective AMI treatment, with the efficacy of infarct-related artery recanalization treatment being significantly time-dependent. The shorter the duration between AMI onset and treatment, the more favorable the therapeutic outcomes [2].

The temporal aspect of AMI treatment encompasses pre-hospital delay time (PDT) and in-hospital delay time [3,4]. While measures such as optimizing hospital emergency procedures and establishing green channels have successfully reduced in-hospital delay time [5], PDT remains a challenge due to various influencing factors. Creating a universally applicable treatment protocol to minimize PDT proves challenging, given the diverse circumstances. Treating all patients with pre-hospital AMI with efficient measures poses a logistical challenge, potentially straining first aid resources and impacting the treatment of other emergency cases.

Therefore, the crux of shortening PDT lies in the identification of high-risk patients with AMI and the swift implementation of emergency measures [6]. This study aims to delve into the determinants of pre-hospital delay (PHD) in patients with AMI, with a specific focus on constructing a robust risk prediction model. The ultimate objective was to gain insights and leverage them for devising targeted and efficient strategies to mitigate PDT in patients with AMI, ensuring prompt and effective care.

## MATERIALS AND METHODS

### Research objects

This retrospective cohort study spanned from January 2022 to September 2022 and focused on patients with AMI admitted to a tertiary hospital in Anhui Province, China. The inclusion criteria mandated that patients were transported by ambulance and diagnosed with AMI based on clinical symptoms, electrocardiogram, and myocardial enzyme dynamic observation. The exclusion criteria comprised patients with missing data or mental disorders. The study received approval from the Institutional Review Board (IRB) of the research institution (ID: 2023-RE-124), and due to its retrospective nature, informed consent requirements were exempted by the IRB.

### Data collection methods

Data encompassed diverse factors such as age, sex, coronary artery lesions, Killip classification, family monthly income, body mass index, stent count, comorbidities (hypertension, cerebral infarction, hyperlipidemia, diabetes, renal insufficiency, digestive system diseases), Timi classification, medical expenses payment method, history of AMI, onset time (daytime: 8:00–17:00, nighttime: 17:01–07:59), living arrangements, work status, heart failure, education level, marital status, alcohol consumption, smoking, atrial fibrillation—totaling 26 indicators. Predefined as the interval from myocardial infarction symptom onset to seeking medical care, PDT was set at 6 h, a threshold for thrombolytic therapy [7]. Thus, patients were categorized into two groups: PDT ≤ 6 h (non-PHD) and PDT > 6 h (PHD).

### Statistical analysis

Data analysis utilized Epidata 3.1 and SPSS 23.0. Quantitative variables with normal distribution were presented as mean ± standard deviation; non-normally distributed variables were denoted as M(P25, P75), signifying the median value alongside the 25th and 75th percentiles. Counting data were expressed as case numbers and percentages. Independent risk factors influencing PHD were identified through univariate and multivariate logistic regression analysis. The nomogram model was constructed using R software (version 4.0.1), and its predictive efficacy was assessed using the receiver operating characteristic (ROC) curve. The degree of calibration of the nomogram model was evaluated through calibration curve and Hosmer–Lemeshow goodness-of-fit tests. Clinical applicability was assessed through decision curve analysis (DCA).  $P < 0.05$  was considered statistically significant.

## RESULTS

### Comparison of population characteristics between development and validation groups

Out of the total 252 patients with AMI, 84 (33.33%) experienced PHD. The study population was randomly divided into a development group ( $n = 180$ ) and a validation group ( $n = 72$ ) in a 7:3 ratio. Upon comparing demographic and clinical characteristics between the two groups, no statistically significant disparities were observed ( $P > 0.05$ ), between both groups, indicating homogeneity (Table 1).

### Univariate and multivariate analysis of PHD risk in patients with AMI

In the development group, univariate and multivariate Logistic regression methods were employed to identify risk factors associated with post-hospital discharge (PHD) in patients with AMI. Univariate analysis revealed significant associations ( $P < 0.05$ ) with PHD for variables like living alone, nighttime onset, combined hypertension and hyperlipidemia, urban residence, age, combined diabetes, smoking, combined digestive system diseases, and female sex. Multivariate analysis identified living alone, hyperlipidemia, advancing age, diabetes, and digestive system diseases as independent risk factors for PHD in patients with AMI ( $P < 0.05$ ), as detailed in Table 2.

### Development of nomogram prediction model for PHD risk in patients with AMI

Construction of the nomogram prediction model for PHD risk in the development group involved utilizing the "rms" package in R software. Five predictors were identified through multivariate Logistic regression analysis, as depicted in Figure 1. The nomogram developed in this study is a valuable tool for assessing the risk of PHD in patients with AMI. The interpretation of the nomogram involves a systematic process. Each indicator in the nomogram corresponds to a specific vertical line that ascends from the respective score on the horizontal axis labeled "Points." Along each indicator's line, a specific score is assigned based on the patient's characteristics. Four specific scores from different indicators are added together to calculate the total score.

The total score is located on the horizontal axis labeled "Total Points." A vertical line is drawn downward from the total score to intersect with the axis labeled "Risk of Pre-hospital Delay." The value corresponding to the intersection point indicates the estimated risk of pre-hospital delay for the patient. As an example, consider a 65-year-old patient with the following scores: age (65 years): 60 points, hyperlipidemia: 27.5 points, digestive system diseases: 35 points, living with family (not living alone): 0 points. The total score for this patient would be 122.5 points. Locating 122.5 points on the "Total Points" axis and drawing a line downward intersects with the "Risk of Pre-hospital Delay" axis. The corresponding value on the "Risk of Pre-hospital Delay" axis (*e.g.*, 0.67 points) indicates the estimated risk of pre-hospital delay for this patient.

### ROC curve analysis of the nomogram model

To evaluate the discrimination performance, the nomogram model's area under the ROC curve was calculated. In the development group, the area under the ROC curve was 0.787 (95% confidence interval: 0.716–0.858), and in the validation group, it was 0.770 (95% confidence interval: 0.660–0.879). These results signify favorable discrimination, as illustrated in Figure 2.

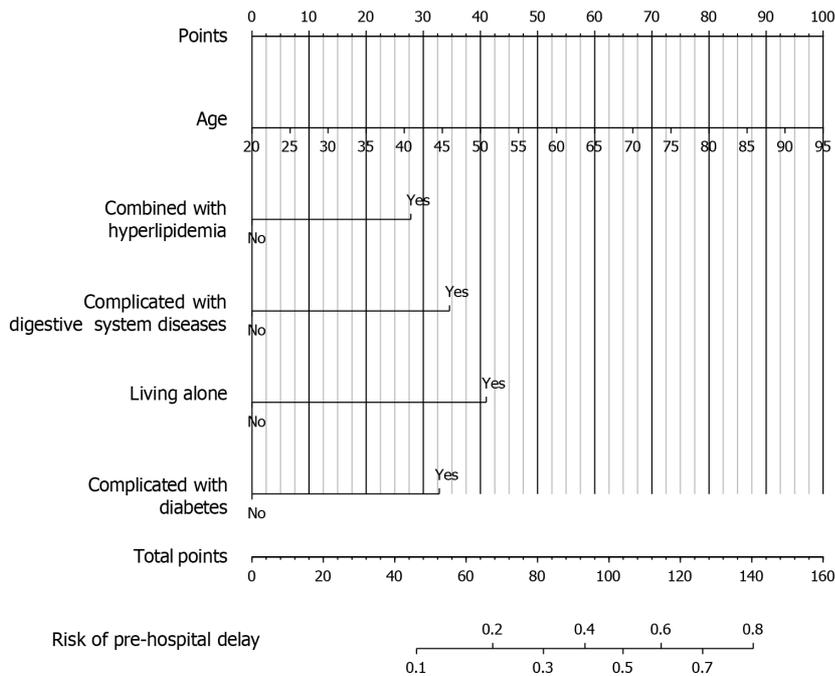
### Calibration curve analysis of the nomogram model

The calibration curve and the Hosmer–Lemeshow goodness of fit test were used to assess the calibration degree of the nomogram model. The results from the Hosmer–Lemeshow goodness of fit test indicated no statistically significant deviation between the predicted probability of PHD from the nomogram model and the actual occurrence in both the development and validation groups ( $P > 0.05$ ). This implies that the nomogram model exhibits favorable calibration, as

Table 1 Comparison of related data between development group and validation group, *n* (%)

Variable	Category	Total	Development group	Validation group	<i>P</i> value
<i>n</i>		252	180	72	
Sex (%)	Male	197 (78.2)	142 (78.9)	55 (76.4)	0.664
	Female	55 (21.8)	38 (21.1)	17 (23.6)	
Age, mean (SD)		61.09 (14.55)	60.94 (14.82)	61.46 (13.94)	0.798
Killip grade (%)	1	195 (77.4)	141 (78.3)	54 (75.0)	0.914
	2	42 (16.7)	29 (16.1)	13 (18.1)	
	3	10 (4.0)	7 (3.9)	3 (4.2)	
	4	5 (2.0)	3 (1.7)	2 (2.8)	
Monthly household income (%)	< 3000 yuan	125 (49.6)	82 (45.6)	43 (59.7)	0.125
	3000–5000 yuan	85 (33.7)	66 (36.7)	19 (26.4)	
	> 5000 yuan	42 (16.7)	32 (17.8)	10 (13.9)	
Number of stents placed, mean (SD)		1.47 (0.91)	1.40 (0.89)	1.64 (0.94)	0.059
Number of coronary artery lesions, mean (SD)		1.89 (0.79)	1.83 (0.79)	2.03 (0.79)	0.078
Combined with hypertension (%)	No	114 (45.2)	88 (48.9)	26 (36.1)	0.066
	Yes	138 (54.8)	92 (51.1)	46 (63.9)	
Combined with cerebral infarction (%)	No	227 (90.1)	166 (92.2)	61 (84.7)	0.072
	Yes	25 (9.9)	14 (7.8)	11 (15.3)	
Combined with hyperlipidemia (%)	No	214 (84.9)	156 (86.7)	58 (80.6)	0.221
	Yes	38 (15.1)	24 (13.3)	14 (19.4)	
Diabetes mellitus (%)	No	164 (65.1)	121 (67.2)	43 (59.7)	0.259
	Yes	88 (34.9)	59 (32.8)	29 (40.3)	
Combined with renal insufficiency (%)	No	227 (90.1)	162 (90.0)	65 (90.3)	0.947
	Yes	25 (9.9)	18 (10.0)	7 (9.7)	
Combined digestive system diseases (%)	No	217 (86.1)	155 (86.1)	62 (86.1)	1
	Yes	35 (13.9)	25 (13.9)	10 (13.9)	
Timi classification (%)	0	136 (54.0)	100 (55.6)	36 (50.0)	0.491
	1	15 (6.0)	11 (6.1)	4 (5.6)	
	2	27 (10.7)	21 (11.7)	6 (8.3)	
	3	74 (29.4)	48 (26.7)	26 (36.1)	
Payment method (%)	Self-paid	17 (6.7)	11 (6.1)	6 (8.3)	0.525
	Medical insurance reimbursement	235 (93.3)	169 (93.9)	66 (91.7)	
History of acute myocardial infarction (%)	No	242 (96.0)	175 (97.2)	67 (93.1)	0.126
	Yes	10 (4.0)	5 (2.8)	5 (6.9)	
Time of onset (%)	Daytime	110 (43.7)	73 (40.6)	37 (51.4)	0.117
	Nighttime	142 (56.3)	107 (59.4)	35 (48.6)	
Living alone (%)	No	227 (90.1)	162 (90.0)	65 (90.3)	0.947
	Yes	25 (9.9)	18 (10.0)	7 (9.7)	
Type of residence (%)	Rural	94 (37.3)	67 (37.2)	27 (37.5)	0.967
	Town	158 (62.7)	113 (62.8)	45 (62.5)	
Regular jobs (%)	No	170 (67.5)	120 (66.7)	50 (69.4)	0.671
	Yes	82 (32.5)	60 (33.3)	22 (30.6)	

History of heart failure (%)	No	227 (90.1)	165 (91.7)	62 (86.1)	0.183
	Yes	25 (9.9)	15 (8.3)	10 (13.9)	
Education level (%)	Junior high school and below	153 (60.7)	108 (60.0)	45 (62.5)	0.321
	Senior high school	45 (17.9)	36 (20.0)	9 (12.5)	
	University and above	54 (21.4)	36 (20.0)	18 (25.0)	
Marriage (%)	Married	228 (90.5)	165 (91.7)	63 (87.5)	0.114
	Divorce or widow	20 (7.9)	11 (6.1)	9 (12.5)	
	Unmarried	4 (1.6)	4 (2.2)	0 (0.0)	
Drinking (%)	No	177 (70.2)	125 (69.4)	52 (72.2)	0.663
	Yes	75 (29.8)	55 (30.6)	20 (27.8)	
Smoking (%)	No	133 (52.8)	93 (51.7)	40 (55.6)	0.576
	Yes	119 (47.2)	87 (48.3)	32 (44.4)	
Body mass index, mean (SD)		24.46 (3.35)	24.54 (3.37)	24.25 (3.33)	0.526
Combined with atrial fibrillation (%)	No	236 (93.7)	169 (93.9)	67 (93.1)	0.806
	Yes	16 (6.3)	11 (6.1)	5 (6.9)	



**Figure 1** The nomogram prediction model for the risk of pre-hospital delay. Each indicator in the nomogram corresponds to a specific vertical line that ascends from the respective score on the horizontal axis labeled "Points." Along each indicator's line, a specific score is assigned based on the patient's characteristics. Four specific scores from different indicators are added together to calculate the total score. The total score is located on the horizontal axis labeled "Total Points." A vertical line is drawn downward from the total score to intersect with the axis labeled "Risk of Pre-hospital Delay." The value corresponding to the intersection point indicates the estimated risk of pre-hospital delay for the patient.

depicted in [Figure 3](#).

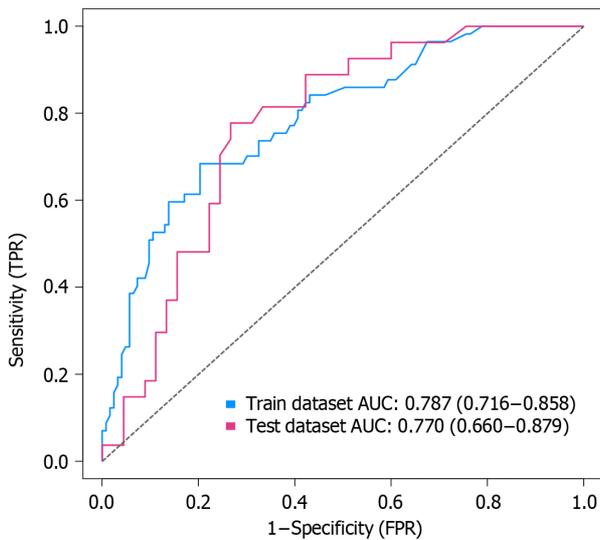
### Clinical applicability of the nomogram model

The clinical applicability of the nomogram model was assessed using the DCA curve. The DCA curve analysis indicated that the nomogram model achieved the highest clinical net rate when the threshold probability of PHD in the development group ranged from 0.09 to 0.68 and that in the validation group ranged from 0.16 to 0.59. This performance surpassed both "full intervention" and "no intervention" schemes, affirming the favorable clinical applicability of the nomogram model, as shown in [Figure 4](#).

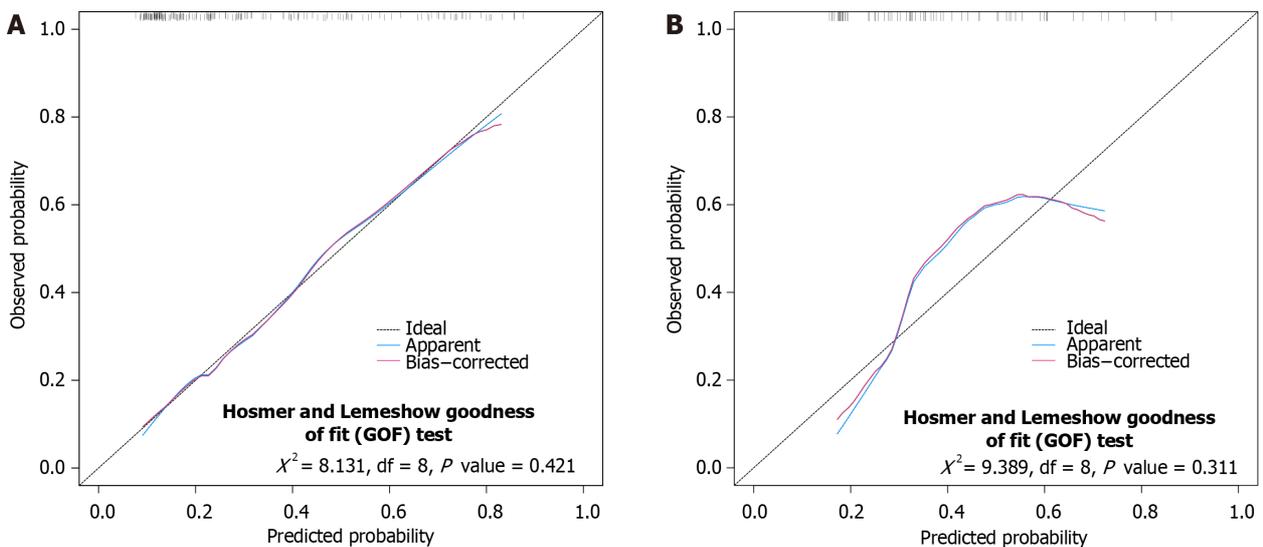
**Table 2 Results of univariate and multivariate Logistic regression analysis on risk of pre-hospital delay in development group**

Variables	Univariate logistic regression		Multivariate logistic regression	
	OR (95%CI)	P value	OR (95%CI)	P value
BMI	0.956 (0.867, 1.050)	0.35		
Killip Grade 1	Reference			
Killip Grade 2	1.061 (0.429, 2.464)	0.894		
Killip Grade 3	3.143 (0.666, 16.536)	0.145		
Killip Grade 4	4.714 (0.440, 103.073)	0.211		
Timi Grade 0	Reference			
Timi Grade 1	1.855 (0.501, 6.615)	0.337		
Timi Grade 2	0.890 (0.294, 2.420)	0.826		
Timi Grade 3	1.012 (0.474, 2.109)	0.975		
Living alone	3.059 (1.138, 8.476)	0.027	4.654 (1.386, 16.957)	0.015
Daytime onset	Reference			
Nighttime onset	2.831 (1.434, 5.853)	0.004	2.200 (0.968, 5.188)	0.064
Combined with atrial fibrillation	1.875 (0.520, 6.497)	0.317		
Combined with hypertension	2.862 (1.493, 5.649)	0.002	1.990 (0.906, 4.473)	0.089
Combined with hyperlipidemia	2.467 (1.024, 5.957)	0.042	3.151 (1.095, 9.373)	0.035
Have a regular job	0.791 (0.395, 1.541)	0.497		
Number of diseased coronary artery	1.109 (0.743, 1.656)	0.61		
Marital status: married	Reference			
Marriage: Divorced or widowed	0.792 (0.168, 2.864)	0.739		
Marriage: Unmarried	0.704 (0.034, 5.648)	0.764		
Prior history of AMI	3.361 (0.542, 26.068)	0.191		
Family monthly income < 3000 yuan	Reference			
The monthly income of the family = 3000–5000 yuan	0.922 (0.449, 1.872)	0.822		
Family monthly income > 5000 yuan	1.560 (0.660, 3.636)	0.304		
Type of residence: town	0.387 (0.201, 0.737)	0.004	0.576 (0.258, 1.281)	0.175
Complicated with cerebral infarction	1.691 (0.533, 5.112)	0.353		
Age	1.043 (1.020, 1.069)	< 0.001	1.034 (1.004, 1.065)	0.027
Complicated with renal insufficiency	1.845 (0.668, 4.959)	0.225		
Complicated with diabetes	3.211 (1.662, 6.278)	0.001	3.208 (1.466, 7.228)	0.004
Education level is junior high school or below	Reference			
High school education	1.669 (0.766, 3.610)	0.193		
Education level is university or above	0.417 (0.146, 1.035)	0.076		
Smoking	0.404 (0.207, 0.771)	0.007	0.682 (0.279, 1.652)	0.395
Complicated with digestive system diseases	2.733 (1.154, 6.533)	0.022	3.937 (1.433, 11.236)	0.009
Complicated with heart failure	1.490 (0.478, 4.355)	0.471		
Female sex	2.737 (1.309, 5.753)	0.007	1.419 (0.531, 3.776)	0.482
Drinking	0.841 (0.413, 1.659)	0.622		
Payment method: medical insurance reimbursement	1.252 (0.347, 5.886)	0.747		
Number of stents placed	1.300 (0.916, 1.856)	0.142		

AMI: Acute myocardial infarction; BMI: Body mass index; OR: Odds ratio.



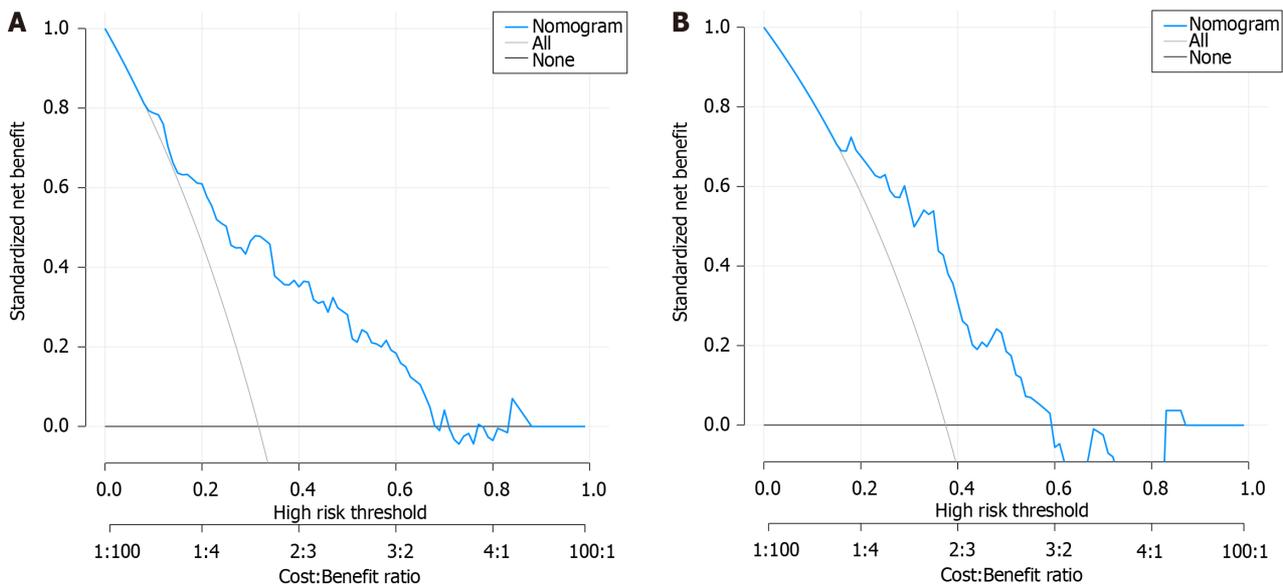
**Figure 2 Receiver operating characteristic curve analysis of the nomogram model.** The figure displays the receiver operating characteristic (ROC) curve analysis of the developed nomogram model. The area under the ROC curve (AUC) is used as a measure of the model's discriminatory ability. The false positive rate is plotted on the x-axis, while the true positive rate is plotted on the y-axis. The AUC values indicate the accuracy of the model in distinguishing between individuals who experienced pre-hospital delay and those who did not. A higher AUC value suggests a better predictive performance of the model. TPR: True positive rate; FPR: False positive rate.



**Figure 3 Calibration curve of the nomogram model.** A and B: The figure illustrates the calibration curve analysis of the developed nomogram model in both the development group (A) and the validation group (B). The calibration curve assesses the agreement between the predicted and observed probabilities of pre-hospital delay likelihood. The x-axis represents the predicted probabilities, while the y-axis represents the observed probabilities. The goodness-of-fit is evaluated to determine the accuracy of the model. A well-calibrated model would show a close alignment of the predicted probabilities with the observed probabilities along the 45-degree diagonal line. GOF: Goodness-of-fit.

## DISCUSSION

AMI represents a common emergency with high morbidity and mortality, particularly affecting a younger demographic, posing a substantial threat to patients' lives[8]. Studies have underscored the significance of recanalization in restoring cardiovascular supply, enhancing cardiac oxygen delivery, and improving patient prognosis[9]. However, the success of reperfusion therapy is contingent upon its timeliness; the earlier the patient reaches the hospital, the better the treatment outcomes[10]. Despite the recognized importance of prompt intervention, delays in treatment time, including PHD and in-hospital delay, contribute to a significant proportion of cases where myocardial infarction patients fail to receive timely treatment[11]. Currently, 30%-40% of patients with AMI experience PHD, presenting a challenge due to numerous



**Figure 4 Decision curve analysis curve of the nomogram model.** A and B: The figure presents the decision curve analysis (DCA) curve of the developed nomogram model in both the development group (A) and the validation group (B). The DCA curve measures the net benefit of the model by plotting the threshold probability on the x-axis against the net benefit on the y-axis. The net benefit is calculated by weighting the true-positive and false-positive classifications based on the clinical consequence of each classification. The DCA curve assesses the clinical usefulness of the nomogram model by comparing it to the strategies of treating all or no patients with the condition of interest. A higher net benefit value indicates a better clinical utility of the model.

interference factors that impede the development of a unified and efficient treatment process[12,13]. To address this challenge and reduce the time interval from symptom onset to percutaneous coronary intervention, it is imperative to identify individuals at high risk before discharge and administer specific interventions to enhance the efficacy of treatment for myocardial infarction. In the present study, potential risk factors influencing the occurrence of post-hospital discharge were identified through univariate analysis and subsequently adjusted using multivariate logistic regression analysis. Consequently, five distinct risk factors were identified as independent predictors of PHD in patients with AMI: advanced age, living alone, comorbidity with digestive system diseases, comorbidity with hyperlipidemia, and comorbidity with diabetes.

This study has provided evidence supporting the role of age as an independent determinant of PHD in patients with AMI, aligning with findings reported by Ouellet *et al*[14]. Atypical symptoms in the elderly were identified as a significant cause of PHD[15]. Older patients, often burdened with comorbidities such as hypertension, diabetes, and cerebrovascular disease, may present with atypical symptoms and symptoms of pre-infarction angina pectoris, contributing to a misperception of a general mild disease. Additionally, traditional ideas influencing the elderly's choice to be sent to the hospital by their children can lead to delays in medical treatment. This hesitation, especially prevalent in cases where children are not around to assist, may result in the use of self-administered oral drugs or waiting for symptoms to naturally disappear, further increasing the risk of PHD with serious consequences[16]. The study substantiates the association between living alone and an elevated risk of PHD, establishing it as an independent risk factor.

The challenges posed by China's burgeoning aging population, marked by a rising number of elderly individuals residing alone and empty nesters, necessitate innovative approaches to address healthcare concerns, particularly in cases of acute and severe illnesses[17,18]. For patients living alone, the potential delay in medical treatment due to the inability to take necessary self-help measures, especially in cases affecting their activities, poses a serious risk, with potential life-threatening consequences. In this context, the study highlights the potential utility of remote monitoring systems, such as smart watches and bracelets, to control the health of elderly individuals living alone in real-time. This technological intervention holds promise in effectively reducing the risk of PHD in patients living alone, thereby enhancing timely medical intervention and improving outcomes.

The study also brings attention to the significant impact of co-occurring digestive system diseases as an autonomous risk factor for PHD in patients with AMI. Diseases like chronic gastritis and gastrointestinal ulcers are identified for their potential to cause pain and mask symptoms of myocardial infarction[19], leading to missed treatment opportunities. To address this, the study advocates for tailored AMI health education for patients with digestive system diseases, particularly ulcer diseases. Concrete measures proposed include the preparation of a basic knowledge manual about heart disease, emphasizing causes, symptoms, and preventive measures. Additionally, the involvement of medical staff for in-home health talks, encouraging participation in mutual support groups, and imparting knowledge on developing good daily habits are suggested strategies to empower the elderly living alone with digestive system diseases to better understand and cope with heart disease.

Furthermore, the study substantiates a positive association between hyperlipidemia and the susceptibility to PHD among patients with AMI. This finding aligns with a cross-sectional investigation on PHD in patients with AMI in Saudi Arabia, as reported by Alahmadi *et al*[20]. Hyperlipidemia, a common cause of AMI, is elucidated as a contributor to atherosclerosis, leading to the formation of lipid plaques on arterial walls. The instability of these plaques can result in

rupture and thrombus formation, culminating in the occurrence of AMI. The study underscores the multifaceted impact of hyperlipidemia on vascular function, inducing endothelial cell injury and inflammatory reactions, ultimately affecting the occurrence and prognosis of AMI and increasing the risk of PHD. Previous studies[21-23] have highlighted prolonged PDT in patients with AMI with diabetes, aligning with the current study's findings indicating that diabetes can increase the risk of PHD in patients with AMI. The study by Ängerud *et al*[24] emphasized a significantly longer median PDT in diabetic patients compared to non-diabetic patients (75 min), suggesting the need for targeted strategies to address the unique challenges faced by this subgroup. Additionally, the study in China proposed that the atypical presentation of chest pain symptoms in diabetic patients, with a higher proportion of NSTEMI patients, contributes to the PHD risk in this population[25].

The cumulative evidence from this study highlights the necessity for comprehensive strategies addressing the diverse risk factors influencing PHD in patients with AMI, including technological interventions, tailored education programs, and targeted management approaches for specific comorbidities. The integration of clinical prediction models into medical practice, particularly nomograms, has become pivotal in risk and benefit assessments, providing a more objective and precise means of information acquisition[26,27]. Within cardiovascular research, nomograms have proven effective in predicting various outcomes, ranging from in-hospital mortality to the risk of specific complications post-diagnosis[28-31]. Despite these advancements, there exists a notable gap in literature pertaining to nomogram studies specifically examining the risk of post-hospital discharge in patients with AMI. Addressing this void, our study utilized univariate and multivariate Logistic regression to identify independent risk factors for PHD in patients with AMI, culminating in the development of a nomogram model tailored to predict this risk. Notably, our findings underscore the nomogram model's favorable calibration, discrimination, and clinical applicability, as evidenced by the Hosmer-Lemeshow goodness of fit test, ROC curve analysis, and DCA curve.

The nomogram model developed in this study fills a crucial gap in predicting the risk of PHD in patients with AMI, providing a valuable tool for rapid risk assessment and more targeted treatment strategies. By identifying high-risk patients, the nomogram facilitates swift and effective intervention, ultimately enhancing patient prognosis.

However, it is imperative to acknowledge certain limitations inherent in this study. The retrospective nature of the research introduces potential issues such as incomplete data, low data quality, and case selection bias, which may impact result accuracy. Additionally, the study's reliance on data from a single medical institution raises concerns about its representativeness for broader populations. The limited sample size and consideration of only a subset of predictors further necessitate caution in generalizing the results. Future endeavors should prioritize large-scale, multi-center, and multi-regional studies to enhance result representativeness and generalizability.

## CONCLUSION

In conclusion, this study, despite its limitations, successfully identified five independent risk factors associated with PHD in patients with AMI. The subsequent construction of a nomogram model exhibited robust predictive value, offering valuable insights for pre-hospital treatment strategies in patients with AMI and mitigating the risk of PHD. The results emphasize the significance of incorporating nomograms into clinical practice for enhanced risk assessment and tailored interventions in the context of AMI.

## ARTICLE HIGHLIGHTS

### Research background

Acute myocardial infarction (AMI), a lethal heart condition, results from coronary artery blockages that cause myocardial ischemia and necrosis. Treatment delays heighten death risks, making prompt medical response critical. This study focuses on reducing pre-hospital delays by identifying high-risk AMI patients, developing a risk prediction model, and implementing tailored strategies for timely care.

### Research motivation

The timely management of AMI is crucial for improving patient outcomes, yet pre-hospital delay time (PDT) poses a significant challenge, leading to increased morbidity and mortality rates. This research is motivated by the need to understand the determinants of PDT in AMI patients and develop a robust risk prediction model. By identifying high-risk individuals and implementing targeted strategies to reduce PDT, this study aims to enhance the delivery of prompt and effective care. Its significance lies in addressing a critical knowledge gap in cardiovascular medicine and offering practical solutions to optimize AMI treatment outcomes for future research in this field.

### Research objectives

The main objective is to investigate determinants of pre-hospital delay (PHD) in AMI patients and construct a risk prediction model. Realizing these objectives has significant implications for future research in this field, allowing refinement of models, development of evidence-based guidelines, and optimization of AMI treatment strategies for improved patient outcomes.

**Research methods**

This retrospective cohort study investigated determinants of PHD in AMI patients and developed a risk prediction model. Data on 26 indicators were collected from AMI patients admitted to a tertiary hospital in Anhui Province, China. Statistical analysis involved logistic regression, nomogram modeling, receiver operating characteristic curve analysis, calibration tests, and decision curve analysis. The study contributes to advancing AMI management research.

**Research results**

This study identified risk factors for post-hospital discharge in acute myocardial infarction patients. Living alone, hyperlipidemia, age, diabetes, and digestive system diseases were significant predictors. A nomogram model accurately predicted the risk of post-hospital discharge. This model can help healthcare professionals identify high-risk patients and provide targeted interventions, but further validation is needed in larger populations.

**Research conclusions**

This study concludes that the newly developed nomogram model, incorporating independent risk factors, accurately predicts the likelihood of post-hospital discharge in acute myocardial infarction patients. This model offers a valuable tool for efficiently identifying individuals at risk of post-hospital discharge, providing potential benefits for targeted interventions and improved patient outcomes in clinical practice.

**Research perspectives**

Future research should address limitations of the retrospective design, limited sample size, and subset of predictors. Large-scale, multi-center studies with comprehensive data are needed to enhance generalizability. Exploring additional risk factors and refining predictive models can improve accuracy for forecasting post-hospital discharge outcomes in acute myocardial infarction patients, benefiting clinical decision-making.

**FOOTNOTES**

**Co-first authors:** Jiao-Yu Cao and Li-Xiang Zhang.

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