scientific reports

Check for updates

OPEN

Nomogram predicts in-hospital mortality in patients with emergency gastrointestinal bleeding: A multicenter retrospective study

Ying Li[1,3], Mengmeng Wu[1,2,3], Lanxin Ouyang[1,3], Wei Jiang[1] & Di Liu[1]✉

Gastrointestinal bleeding (GIB) is frequently encountered in emergency departments and is associated with high morbidity and mortality rates. This study developed and internally validated an emergency department–based nomogram to estimate the risk of in-hospital mortality in patients presenting with emergency GIB. Additionally, risk factors influencing mortality rates were identified to provide emergency clinicians with an accurate prognostic tool. A retrospective cohort analysis was conducted using data from patients with GIB admitted to three branches of Wuhan Central Hospital (Nanjing Road, Houhu, and Yangchunhu) between January and December 2023. Patient data were obtained from the hospital information system. Key predictive variables were selected using least absolute shrinkage and selection operator regression, and a nomogram was constructed via multivariable logistic regression. Model discrimination was assessed by calculating the area under the receiver operating characteristic curve (AUC). Calibration and decision curve analyses were also performed to evaluate model performance. A total of 847 patients were included, with 75 (8.85%) experiencing in-hospital mortality. Non-survivors were older (median age 73 *vs.* 65.5 years, $p < 0.001$) and had lower systolic and diastolic blood pressure, higher heart rate, and elevated shock index at presentation (all $p < 0.001$). Ambulance arrival ($p < 0.001$), Emergency Severity Index Level 1 classification ($p < 0.001$), and the presence of malignancy ($p < 0.001$) were more common among those who died. Fewer non-survivors underwent surgical ($p = 0.003$) or hemostatic procedures ($p < 0.001$). Ambulance arrival, shock index > 1, ICU admission, malignancy, and hemostatic procedures were identified as independent predictors of mortality. The nomogram demonstrated good discrimination, with AUC values of 0.862 (95% CI: 0.786–0.939) in the training cohort and 0.846 (95% CI: 0.787–0.904) in the validation cohort. The developed nomogram demonstrated good discrimination and calibration and may have potential clinical utility for risk stratification in ED patients with GIB. Integration of this model into clinical information systems may assist in risk stratification and optimize patient management.

Keywords Gastrointestinal bleeding, Emergency department, In-Hospital mortality, Nomogram, Risk assessment, Predictors, Outcomes

Gastrointestinal bleeding (GIB) is a common and potentially life-threatening emergency in clinical practice; patients frequently present with symptoms such as hematemesis, melena, or hematochezia[1]. Despite substantial advances in pharmacotherapy, endoscopic techniques, and interventional treatments, rapid and accurate risk stratification remains essential to optimize outcomes and reduce mortality rates[2].

Current risk stratification tools typically address upper (UGIB) and lower gastrointestinal bleeding (LGIB) separately[3]. Regarding UGIB, scoring systems such as the Glasgow–Blatchford, Rockall, and AIMS65 scores have been validated to predict the need for clinical intervention, hospitalization, or suitability for outpatient management[4–6]. However, these systems demonstrate only moderate accuracy for in-hospital mortality

[1]Emergency Department, The Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430014, China. [2]Key Laboratory for Molecular Diagnosis of Hubei Province, The Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430014, China. [3]Ying Li, Mengmeng Wu and Lanxin Ouyang contributed equally to this work. ✉email: 1347865116@qq.com

prediction, with areas under the receiver operating characteristic curve (AUROC) generally below 0.80[7]. Similarly, tools such as the BLEED score for LGIB show suboptimal predictive accuracy for mortality, with reported AUROCs typically ranging from 0.66 to 0.73[8–10]. In clinical practice, distinguishing between UGIB and LGIB at initial presentation is frequently challenging, limiting the clinical utility of these site-specific scores[8]. Notably, approximately 35% of emergency GIB patients have indeterminate bleeding sites upon initial assessment, further complicating early risk stratification and management[8,11]. Consequently, there is an unmet need for a more accurate and broadly applicable risk prediction tool that is effective regardless of the bleeding location[12].

Nomograms are graphical statistical tools that integrate multiple clinical predictors and have recently emerged as valuable instruments for individualized risk prediction across various medical disciplines[13]. Their clinical utility derives from the ability to incorporate diverse, patient-specific variables, generating precise and individualized risk estimates. Recent studies have highlighted the successful application of nomograms in emergency and critical care, demonstrating superiority over traditional scoring systems in certain settings. For example, Sharif et al. developed a nomogram for ICU disposition in acute clozapine intoxication[14]. Lashin et al. constructed a nomogram predicting the need for mechanical ventilation in acutely intoxicated patients[15]. Moreover, Heba I. Lashin et al. validated a nomogram predicting adverse cardiovascular events in acute cardiotoxic poisoning, further demonstrating the method's versatility and clinical significance[16].

Given the limitations of existing scoring systems and the demonstrated advantages of nomogram-based modeling, we conducted this multicenter retrospective study to develop and validate a nomogram for accurately predicting in-hospital mortality risk in emergency GIB patients, irrespective of bleeding site. The primary objective was to facilitate rapid risk stratification and support clinical decision-making in the emergency department (ED).Moreover, major guidelines recommend the use of validated risk-stratification tools at ED presentation-for UGIB[17], pre-endoscopic assessment with the Glasgow-Blatchford score; for LGIB[18], the Oakland score-to aid early decision-making, while acknowledging evidence and implementation limitations. These gaps, together with frequent uncertainty about bleeding site at first contact, highlight the need for practical and generalizable models applicable across GIB presentations. Accordingly, we developed and internally validated a site-agnostic, ED-ready nomogram to estimate in-hospital mortality using variables available at presentation.

Research methods

Study design

This retrospective cohort study involved patients with gastrointestinal bleeding who visited the ED and were subsequently admitted between January 1, 2023, and December 31, 2023. The study was approved by the Ethics Committee of Wuhan Central Hospital (Approval No. WHZXKYL2024-117). Due to the retrospective nature of the study, informed consent was waived by the Ethics Committee of Wuhan Central Hospital. This study was performed in accordance with the principles outlined in the Declaration of Helsinki.

Study participants

Patients meeting the following criteria were included in the study: (1) aged 18 years or older at the time of ED presentation; (2) presented to the ED with symptoms suggestive of gastrointestinal bleeding (such as hematemesis, melena, hematochezia, or coffee-ground vomiting); (3) admitted to the hospital from the ED for inpatient care; and (4) discharged with a final diagnosis of gastrointestinal bleeding confirmed by the attending physician. The exclusion criteria were as follows: (1) incomplete or missing key clinical data necessary for analysis; (2) gastrointestinal bleeding secondary to trauma or postoperative complications; and (3) declined or withdrew from inpatient treatment during hospitalization.

Data collection

Data were collected from the hospital information systems of Wuhan Central Hospital: Nanjing Road Branch, Houhu Branch, and Yangchunhu Branch, from January to December 2023. The emergency triage system included triage information such as the patient's name, sex, age, chief complaint, diagnosis, mode of arrival, time of arrival, triage level, vital signs, and admitting department. The Hospital Information System contained the patient's basic information, such as length of stay, surgical procedures, hemostatic interventions and their timing, the types of comorbidities, and discharge status. The patient's visit number was used to link the data across different systems. The visit number represents the index for a single hospital visit during the patient's stay. The final baseline data were matched using the data closest to the visit time. In this study, hemostatic procedures included any endoscopic, interventional radiology, or surgical intervention performed to achieve hemostasis for gastrointestinal bleeding during the entire hospitalization following ED admission.

Statistical methods

Data analysis, model construction, and validation were conducted as described by Wang S, Tu J (2020)[19]. Descriptive statistics were used to summarize the patients' baseline characteristics. The Kolmogorov–Smirnov test was used to assess the normality of the data. Normally distributed continuous variables are expressed as the mean ± standard deviation ($\bar{x} \pm s$) and compared using an independent samples *t* test. Non-normally distributed continuous variables are expressed as medians (Q1, Q3) and compared using the Wilcoxon rank-sum test. Categorical variables are expressed as frequencies and percentages, and comparisons were made using the χ^2 test or Fisher's exact test. Least absolute shrinkage and selection operator (LASSO) regression, suitable for high-dimensional data[20], was used for predictor selection and regularization. Logistic regression analysis was employed to develop a predictive model for the risk of in-hospital mortality among patients with gastrointestinal bleeding admitted through the ED, and a nomogram was constructed according to this model. The model's discriminative performance was evaluated by calculating the area under the curve (AUC), with internal validation performed

using 1,000 bootstrap resamples. For further validation, patients were randomly divided into training (70%) and validation (30%) sets. The DeLong method was used to compare the statistical differences in AUCs. The clinical utility of the model was assessed using decision curve analysis (DCA) to quantify the net benefit at different probability thresholds[21]. Statistical analyses were conducted using EmpowerStats (www.empowerstats.com) and R version 4.2.2 (www.r-project.org). A p value < 0.05 was considered to indicate significance.

Sample size and model complexity

Because this was a retrospective cohort, we included all consecutive eligible patients during the study period (N = 847). A formal a priori sample-ize calculation was not performed. To ensure adequate model development, we limited model complexity and quantified optimism. We targeted ≥ 10 events per effective[22,23] parameter given 75 outcome events, and fitted a penalized multivariable logistic regression, with 1,000-bootstrap internal validation to estimate optimism-corrected performance (AUROC and calibration slope/intercept). In the full cohort, the events-per-parameter for the final model was 15.0; after the 70/30 split used for secondary validation, the training set contained≈52.5 events, corresponding to≈10.5 events-per-parameter. These values are compatible with stable estimation. Details of discrimination and calibration are reported in the Results.

Results

A total of 847 patients participated in this study. The flow of information collection from the target population is shown in Fig. 1. Among these patients, 75 (8.85%) died during their hospitalization after being admitted to the ED. In-hospital deaths were more frequent among older patients (median age 73 years versus 65.5 years among survivors; $p < 0.001$). Patients who died had lower systolic and diastolic blood pressure, higher heart rates, and higher shock indices per initial vital sign monitoring upon ED admission ($p < 0.001$). These patients were also more likely to arrive by ambulance ($p < 0.001$) and to be classified as Emergency Severity Index (ESI) level 1 ($p < 0.001$). Additionally, the incidence of malignancy was higher among those who died ($p < 0.001$), and they underwent fewer surgical ($p = 0.003$) and hemostatic ($p < 0.001$) procedures. These findings suggest that age, vital signs, mode of arrival, triage level, presence of malignancy, and types of clinical interventions are important factors associated with in-hospital mortality in this patient population. The demographic and clinical characteristics of the study participants are shown in Table 1.

Of the 21 variables collected from patients, five were selected according to non-zero coefficients in the LASSO regression analysis (Fig. 2): ambulance ED arrival, shock index > 1, admission to ICU, malignancy, and hemostatic procedure. Multivariable logistic regression analysis was performed on these five variables using LASSO regression techniques to develop a predictive model for in-hospital mortality among patients with gastrointestinal bleeding. We constructed a mortality risk prediction model using the aforementioned five predictors (Table 2). The dataset was split into a training set (70%) and a validation set (30%) to assess the model's generalizability. In the training set, the model's AUC was 0.8619, with a confidence interval (CI) of [0.7858, 0.9381]; in the validation set, the AUC was 0.8455, with a 95% CI of [0.7871, 0.9039]. These results indicate that the model maintains high and consistent performance across different datasets, demonstrating good statistical stability (Fig. 3). A nomogram was constructed using the training data to visually represent the model's predictive capability (Fig. 4). To further assess model calibration, calibration curves were plotted for both the training and validation sets (Fig. 5). In the training set, the calibration curve's slope was 1.02 with an intercept of − 0.03, indicating a high agreement between predicted and observed probabilities. In the validation set, the calibration curve's slope was 1.05 with an intercept of − 0.05, also showing good calibration. Finally, DCA was used to evaluate the clinical utility of the model (Fig. 6). In the training set, DCA results showed that when the threshold probability was between 0.1 and 0.9, our model significantly improved net benefit compared

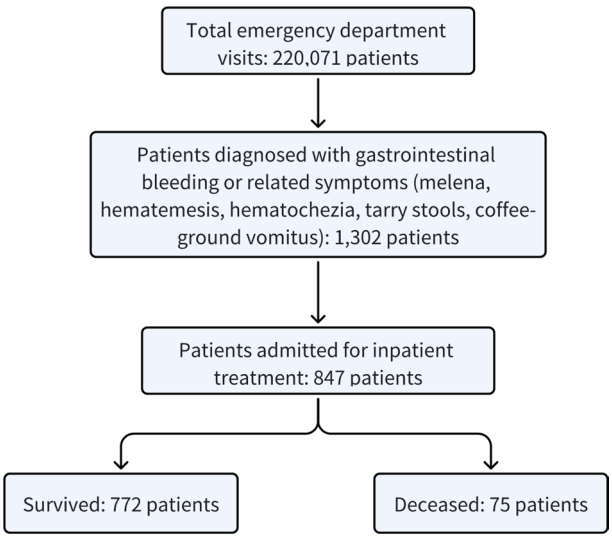

Fig. 1. Flow diagram of patient selection for the study.

Variables	Total (n = 847)	Survived (n = 772)	Deceased (n = 75)	*p*
Sex, male, n (%)	575 (68)	520 (67)	55 (73)	0.353
Age, median (Q1, Q3)	67 (55, 76)	65.5 (54, 76)	73 (65, 80.5)	< 0.001
Ambulance ED arrival, n (%)				< 0.001
Yes	353 (42)	295 (38)	58 (77)	
No	494 (58)	477 (62)	17 (23)	
Heart rate, median (Q1, Q3)	92 (80, 106)	91 (80, 105)	100 (85, 116)	0.004
Systolic pressure, median (Q1, Q3)	122 (107, 141)	123 (108, 141)	115 (93, 130.5)	< 0.001
Diastolic pressure, median (Q1, Q3)	70 (60, 81)	70 (60, 81)	63 (50, 75.5)	< 0.001
Shock index > 1, n (%)	154 (18)	131 (17)	23 (31)	0.005
Triage level (ESI), n (%)				< 0.001
ESI Level 1	17 (2)	4 (1)	13 (17)	
ESI Level 2	709 (84)	647 (84)	62 (83)	
ESI Level 3	72 (9)	72 (9)	0 (0)	
ESI Level 4	49 (6)	49 (6)	0 (0)	
Type of health insurance for hospitalization, n (%)				0.01
Employee health insurance	759 (90)	694 (90)	65 (87)	
Resident health insurance	40 (5)	32 (4)	8 (11)	
Self-payment	36 (4)	36 (5)	0 (0)	
Other	12 (1)	10 (1)	2 (3)	
Season of admission to emergency department, n (%)				0.762
Spring	222 (26)	203 (26)	19 (25)	
Summer	205 (24)	190 (25)	15 (20)	
Fall	225 (27)	204 (26)	21 (28)	
Winter	195 (23)	175 (23)	20 (27)	
Time of admission to emergency department, n (%)				0.033
08:01–16:00	382 (45)	344 (45)	38 (51)	
16:01–24:00	324 (38)	305 (40)	19 (25)	
00:01–08:00	141 (17)	123 (16)	18 (24)	
Emergency admission (ICU), n (%)				< 0.001
Yes	90 (11)	67 (9)	23 (31)	
No	757 (89)	705 (91)	52 (69)	
Type of gastrointestinal bleeding, n (%)				0.687
Upper gastrointestinal bleeding	703 (83)	639 (83)	64 (85)	
Lower gastrointestinal bleeding	144 (17)	133 (17)	11 (15)	
Comorbidities, n (%)				
Diabetes	190 (22)	172 (22)	18 (24)	0.845
Hypertension	313 (37)	286 (37)	27 (36)	0.957
Cerebral infarction	160 (19)	143 (19)	17 (23)	0.471
Coronary artery disease	204 (24)	185 (24)	19 (25)	0.902
Malignancy	153 (18)	114 (15)	39 (52)	< 0.001
In-hospital interventions, n (%)				
Surgical procedure	626 (74)	582 (75)	44 (59)	0.003
Hemostatic procedure performed, n (%)	536 (63)	509 (66)	27 (36)	< 0.001
Hemostatic procedure within 24 h of emergency admission, n (%)	316 (37)	296 (38)	20 (27)	0.061

Table 1. Baseline demographic and clinical characteristics of the study participants. Data are n (%) or median (Q1, Q3) unless stated. Two-sided tests; $\alpha = 0.05$; p-values compare survivors vs non-survivors; no multiplicity adjustment (descriptive). ED, emergency department; ESI, Emergency Severity Index; ICU, intensive care unit; SI, shock index (heart rate/systolic blood pressure); GIB, gastrointestinal bleeding; UGIB, upper gastrointestinal bleeding; LGIB, lower gastrointestinal bleeding.

with the strategies of treating all or none. Specifically, at a threshold probability of 0.1, the model's net benefit was 0.741 higher than the treat-all strategy and 74.10% higher than the treat-none strategy. In the validation set, DCA similarly indicated that our model outperformed the treat-all and treat-none strategies when the threshold probability was between 0.1 and 0.9. At a threshold probability of 0.1, the model's net benefit was 0.814 higher than the treat-all strategy and 81.4% higher than the treat-none strategy. These data suggest that

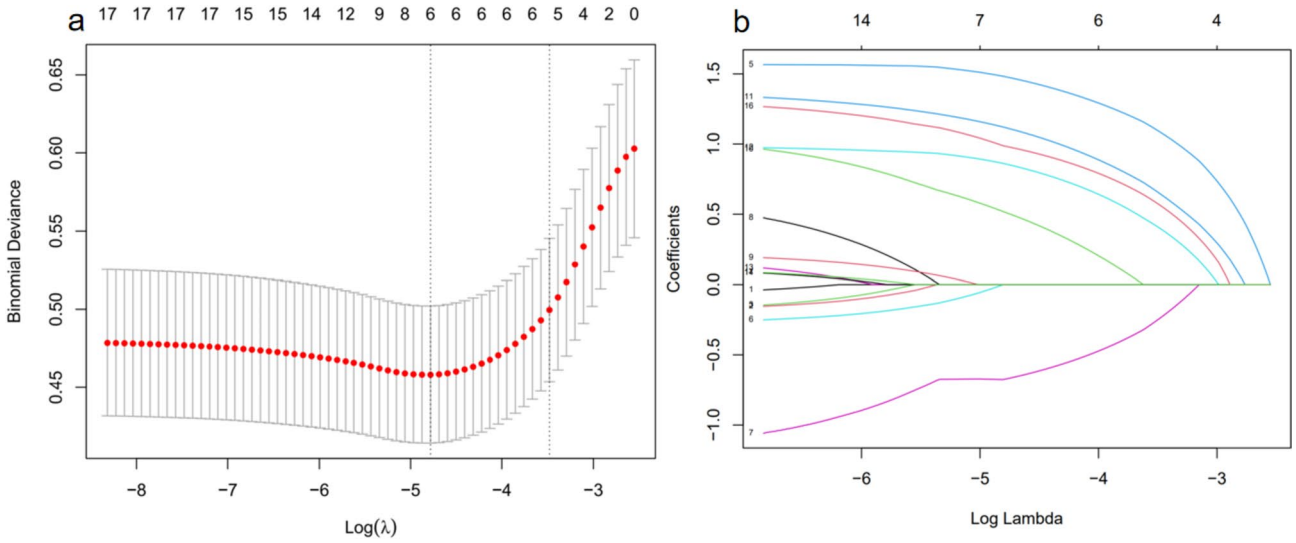

Fig. 2. Predictor selection using LASSO regression with tenfold cross-validation. (**A**) Selection of tuning parameter (lambda) by minimum and 1-SE criteria. (**B**) Coefficient profile against log(lambda). Five nonzero predictors were retained. LASSO, least absolute shrinkage and selection operator; SE, standard error.

Variable	*β*	*SE*	*Wald*	*OR*	95%*CI*	*P*
Mode of Arrival to Emergency Department, By Ambulance	1.28	0.42	3.01	3.59	[1.56, 8.71]	0.003
Shock Index > 1	0.95	0.39	2.43	2.58	[1.20, 5.56]	0.015
Emergency Admission Departments, ICU	0.98	0.44	2.25	2.67	[1.13, 6.28]	0.025
Malignancy, yes	1.70	0.37	4.57	5.46	[2.64, 11.29]	< 0.001
Hemostatic Surgery, yes	−0.99	0.38	−2.59	0.37	[0.19, 0.78]	0.010
Intercept	4.86	2.40	2.02	-	-	0.043

Table 2. Logistic regression model and the Odds ratio of predictors. Notes: Logistic regression model: 1.28 × (Mode of Arrival to Emergency Department, By Ambulance) + 0.95 × (Shock Index > 1) + 0.98 × (Emergency Admission Departments, ICU) + 1.70 × (malignancy, yes) —0.99 × (Hemostatic Surgery, yes) + 4.86. CI, confidence interval; OR, odds ratio.

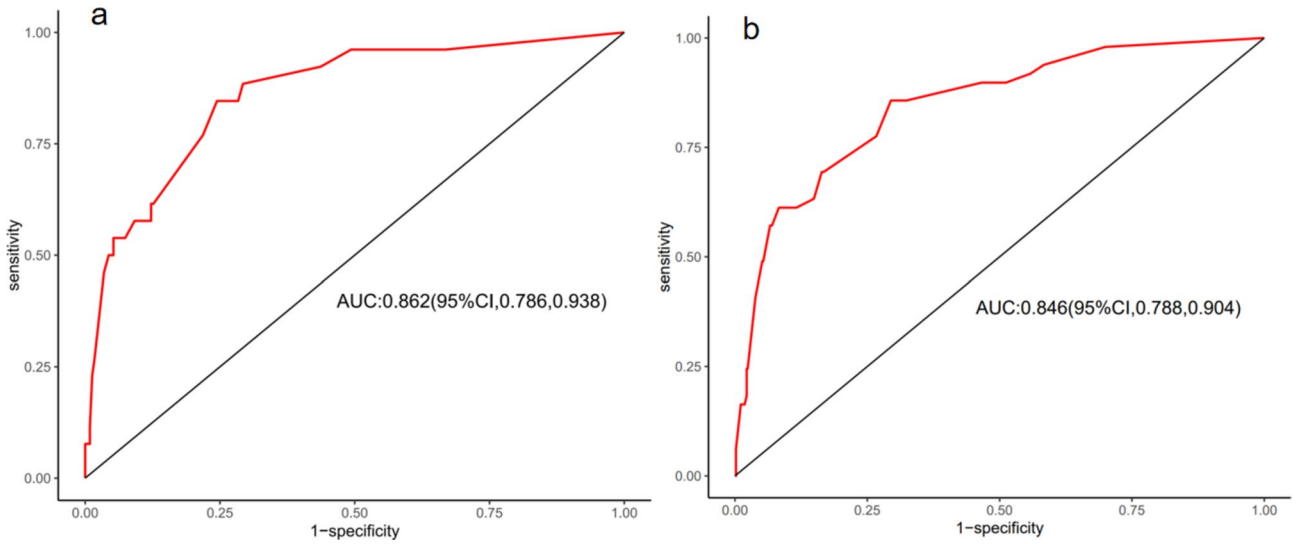

Fig. 3. ROC curves for mortality prediction in the training (**A**) and validation (**B**) cohorts.

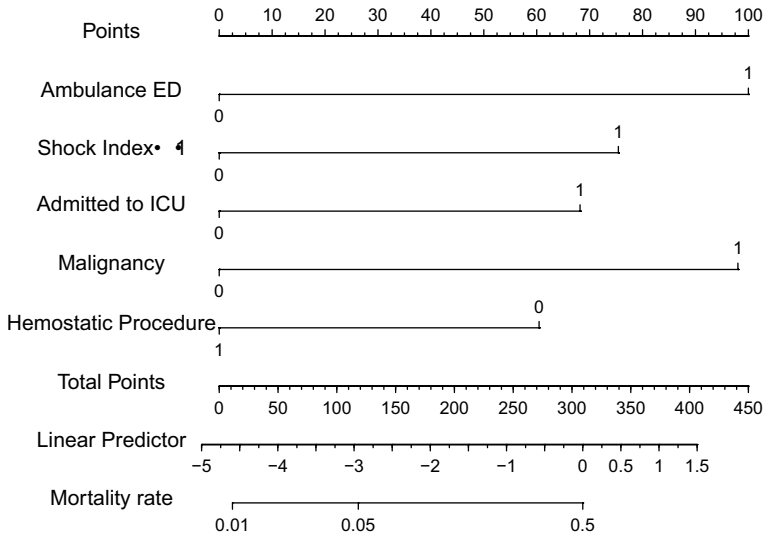

Fig. 4. Nomogram for predicting in-hospital mortality in ED patients with GIB.

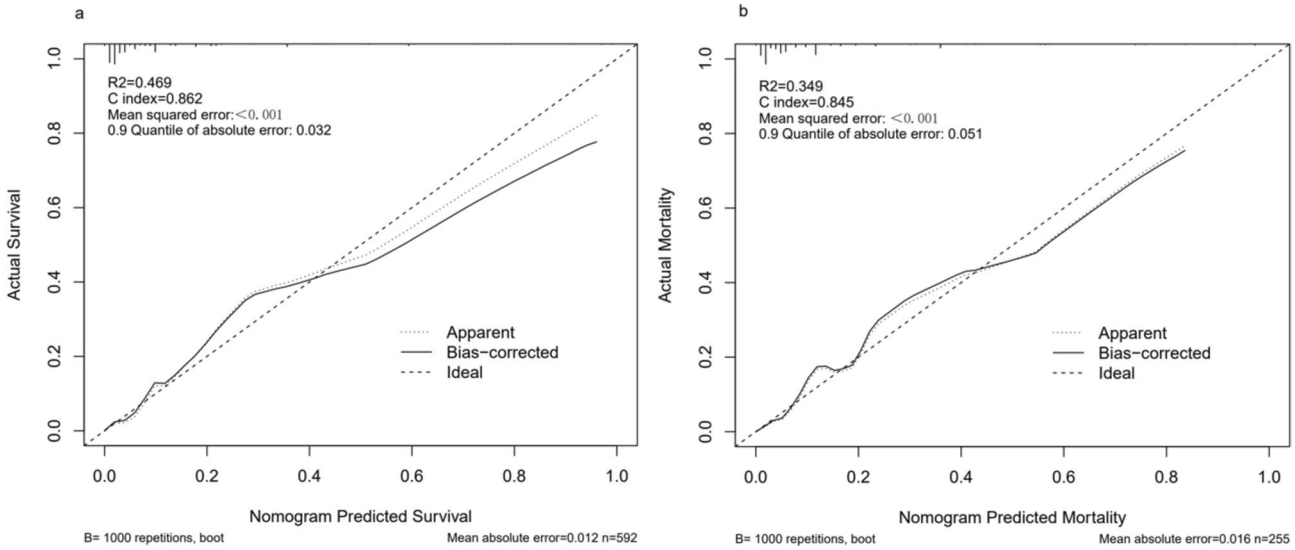

Fig. 5. Calibration curves for the nomogram in the training (**A**) and validation (**B**) cohorts.

our model performs well statistically and may have potential clinical utility in clinical decision-making; however, prospective evaluation is required to confirm impact on outcomes.

Discussion

In this study, a nomogram was developed to predict in-hospital mortality risk for patients with gastrointestinal bleeding in the ED. This nomogram includes five variables: ambulance ED arrival, shock index > 1, admitted to ICU, malignancy, and hemostatic procedure. The nomogram demonstrated good discriminative ability and calibration, and the DCA suggests potential clinical utility. To our knowledge, most current prediction models for mortality in patients with gastrointestinal bleeding focus on hospitalized UGIB or LGIB patients. Mortality in gastrointestinal bleeding patients admitted through the ED cannot be accurately predicted by emergency physicians, especially when the bleeding location is unclear. In this study, we developed a nomogram predicting all-cause mortality during hospitalization for such patients, incorporating five variables collected from patients admitted through the ED. The variables included in the nomogram were selected through LASSO regression analysis, which is considered superior to univariate analysis for predictor selection[24,25].

Additionally, we evaluated the clinical significance of these predictive factors. The factors "arrival by ambulance to the emergency department" and "shock index > 1" reflect the urgency and severity of the patient's condition and are associated with poorer outcomes in gastrointestinal bleeding patients[26,27]. The shock index is calculated by dividing the heart rate by the systolic blood pressure, with a normal range considered to be 0.5–0.7.

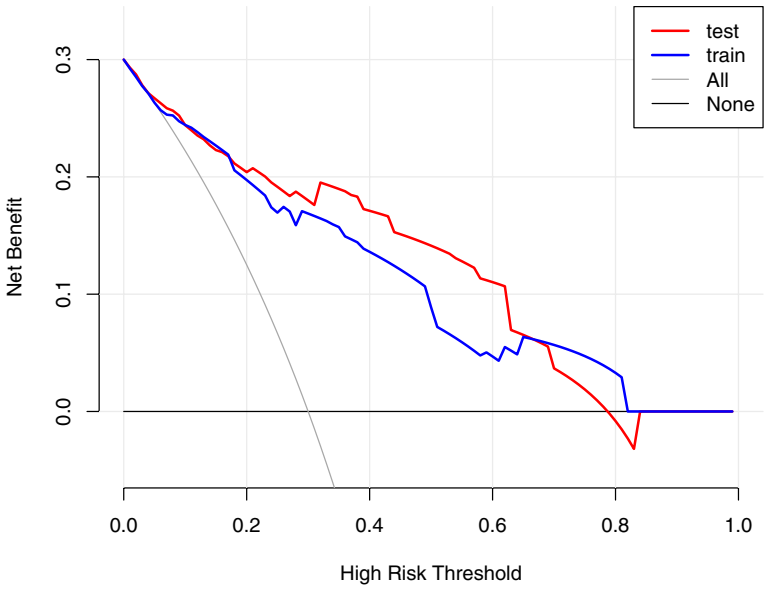

Fig. 6. Decision curve analysis (DCA) of the nomogram in the training (**A**) and validation (**B**) cohorts.

A shock index > 1 has significant potential in predicting short-term adverse outcomes in upper gastrointestinal bleeding patients[28]. Dogru U, Yuksel et al. found that the shock index can serve as an important quantitative indicator for assessing mortality risk in gastrointestinal bleeding patients[29]. Emergency medical staff should prioritize patients arriving by ambulance and those with a shock index > 1, as these patients may require more urgent care. It is recommended to establish a fast-track system for such patients, optimize emergency procedures, and reduce the time spent in the ED to ensure timely and prioritized care for high-risk patients.

Admission to the ICU typically indicates that a patient's condition is very severe, requiring close monitoring and advanced life support. Thus, "admitted to ICU" as an independent risk factor in predictive models reflects the severity of the patient's condition. Although the ICU provides more medical resources, the mortality rate remains high due to the severity of these patients' conditions. This severity underscores the importance of early identification and intervention, aiming to take effective measures before the condition worsens. Furthermore, ICU treatment is not solely focused on gastrointestinal bleeding; patients often have other systemic complications, the presence and treatment complexity of which can also affect prognosis[30]. ICU patients often require invasive procedures, such as mechanical ventilation and central venous catheterization, which can increase the risk of infections and other complications, further affecting prognosis[31]. While "admitted to ICU" is a significant independent risk factor, it does not necessarily mean that ICU treatment itself leads to higher mortality risk. Rather, it likely reflects the severity of the patient's condition[32]. Therefore, for emergency clinical teams, the early identification of high-risk patients who may need ICU admission and proactive intervention before their condition deteriorates may help reduce in-hospital mortality rates.

Patients with co-existing malignancy generally have poorer overall health and more complex, variable conditions. Therefore, "malignancy" as an independent risk factor in predictive models reflects the complexity of the patient's condition and poor prognosis. Despite the comprehensive treatment and care provided by medical teams, the patient mortality rate remains high due to the invasive nature of tumors and their systemic impact[33]. This finding highlights the necessity of fully considering the effects of systemic diseases and the importance of early, comprehensive treatment when managing such patients. Additionally, patients with malignancy often have other systemic complications such as anemia, malnutrition, and compromised immune function, in addition to requiring treatment for gastrointestinal bleeding[34]. The presence of these complications and the complexity of their management can significantly affect the patient's prognosis. These patients may require multiple treatments, such as chemotherapy and radiation therapy, and the side effects of these treatments can further increase the complexity and risk of treatment[35]. Although "malignancy" is a significant independent risk factor, malignancy itself does not necessarily directly lead to higher mortality risk. It is more likely a reflection of the deterioration of the patient's overall health status. Therefore, for patients with both malignancy and gastrointestinal bleeding, early identification of their complex conditions and the implementation of comprehensive treatment measures may help improve their prognosis. In clinical practice, individualized treatment strategies are particularly important for these high-risk patients. Multidisciplinary collaboration, including close coordination between oncology, gastroenterology, and surgery departments, can ensure that patients receive comprehensive and effective treatment, thereby potentially reducing in-hospital mortality rates.

Regarding "hemostatic procedure," the execution of hemostasis surgery in patients with gastrointestinal bleeding is closely related to adverse survival outcomes during hospitalization after being admitted through the ED. The success of hemostasis procedures directly affects bleeding control and the patient's chance of survival[36]. Our study results showed that performing hemostasis surgery on gastrointestinal bleeding patients transferred from the ED to inpatient care increased survival rates by 62.76% compared with those observed

when the procedure was not performed. This finding also reflects the severity and complexity of bleeding in nonsurgical patients, who may not tolerate surgery due to significant blood loss, difficult-to-control bleeding sites, or other serious comorbidities. Additionally, nonsurgical patients may have advanced tumors or other factors affecting surgical decisions, such as overall health status or tumor biology. Although studies have shown that hemostasis within 24 h significantly reduces mortality[37,38], timely and effective hemostasis interventions during hospitalization remain crucial for saving lives in certain high-risk gastrointestinal bleeding patients who cannot be treated within 24 h[18,39]. For such patients, it is recommended to stabilize their condition as quickly as possible through multidisciplinary collaboration. The risk of bleeding-related complications and mortality can be minimized through a combination of pharmacological, endoscopic, and interventional treatments to achieve early hemostasis.

These five predictive indicators are readily obtainable in clinical settings. Our nomogram demonstrates good discrimination and calibration, and the DCA highlights its potential clinical utility. This freely accessible nomogram may provide emergency clinical teams with a practical tool for the early assessment and management of in-hospital mortality risk among patients admitted with gastrointestinal bleeding through the ED. This nomogram, built from variables available at ED presentation, may assist clinicians and nursing staff in the early identification of higher-risk patients and in prioritizing monitoring, level of care, and the timing of diagnostic evaluation. Any implementation (e.g., within an electronic health record) should follow external validation, local calibration, and prospective impact assessment. Whether use of the model improves patient outcomes remains to be determined In our cohort, the nomogram achieved AUROC 0.862 in the training set and 0.846 in the validation set, with good calibration (slope ≈1.0; intercept ≈0), indicating acceptable/clinically useful risk estimation at ED presentation, pending external validation. Because several data elements required for established scores were not consistently captured, we did not perform head-to-head comparisons; the model is intended to complement, rather than replace, existing tools.Unlike existing tools such as the Glasgow–Blatchford, Rockall, AIMS65, or BLEED scores, which are site-specific (focusing only on UGIB or LGIB) and generally achieve AUROCs below 0.80[8–10], our model was developed specifically for the emergency department setting and is applicable to all GIB presentations, regardless of bleeding site. With an AUC > 0.84 in both training and validation cohorts, it may offer clinicians a more versatile option for early mortality risk prediction when the bleeding source is uncertain. Any impact on clinical outcomes will require external validation and prospective evaluation. However, whether this approach will lead to improved patient outcomes remains to be confirmed in future prospective studies and real-world clinical implementation. Notably, previous research has demonstrated that validated clinical prediction models can outperform subjective judgment in predicting in-hospital mortality in the emergency setting[40]. Our nomogram provides objective risk stratification; thus, it may serve as a valuable adjunct to emergency clinical decision-making for patients with gastrointestinal bleeding.

This study has some limitations. First, due to the study's retrospective nature, the clinical utility of the nomogram requires external validation. Second, we did not integrate the model with existing clinical guidelines and practices. Further research is needed to validate this model. Nevertheless, we developed a model that demonstrated good internal performance on our dataset. Finally, our study results pertain to in-hospital mortality risk following admission from the ED. Further research is needed to determine if this model can predict in-hospital mortality for patients admitted directly from outpatient settings. In addition, as with all observational studies of clinical interventions, our analysis may be subject to confounding by indication and unmeasured confounders. For example, the observed association between hemostatic procedures and improved survival could be influenced by patient selection, as healthier patients are more likely to tolerate and receive such interventions. Therefore, this finding should be interpreted with caution, and further prospective studies are needed to validate our results.

Conclusion

A nomogram model was developed and validated to predict in-hospital mortality risk for patients with GIB in the ED. The model demonstrated good classification performance in the validation set, with an AUC of 0.847, indicating potential clinical utility that requires further confirmation in future studies. By integrating key clinical variables, such as age and shock index, the model provides the emergency clinical team with a potentially useful aid for rapid risk assessment and optimizing treatment decisions, especially for GIB patients with unclear bleeding sites. Despite the limitations associated with single-center, retrospective studies, the model may offer value for improving emergency risk stratification and the prognostic assessment of GIB patients. Future research should include external, multicenter, prospective validation to confirm generalizability and determine its real-world clinical impact.

Data availability

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

Received: 13 August 2024; Accepted: 17 September 2025
Published online: 22 October 2025

References

1. Nable, J. V. & Graham, A. C. Gastrointestinal bleeding. *Emerg. Med. Clin. N. Am.* **34**(2), 309–325. https://doi.org/10.1016/j.emc.2015.12.001 (2016).
2. Thakral, D., Stein, D. J. & Saltzman, J. R. Diagnosis of occult and obscure gastrointestinal bleeding. *Gastrointest. Endosc. Clin. N. Am.* **34**(2), 317–329. https://doi.org/10.1016/j.giec.2023.09.006 (2024).

3. Jeon, H. J. et al. Which scoring system should be used for non-variceal upper gastrointestinal bleeding? Old or new?. *J. Gastroenterol. Hepatol.* **36**(10), 2819–2827. https://doi.org/10.1111/jgh.15555 (2021).
4. Yuan, L. & Yao, W. Development and validation of a risk prediction model for in-hospital mortality in patients with acute upper gastrointestinal bleeding. *Clin. Appl. Thromb. Hemost.* **29**, 10760296231207806. https://doi.org/10.1177/10760296231207806 (2023).
5. Stanley, A. J. et al. Outpatient management of patients with low-risk upper-gastrointestinal haemorrhage: Multicentre validation and prospective evaluation. *Lancet* **373**(9657), 42–47. https://doi.org/10.1016/S0140-6736(08)61769-9 (2009).
6. Laursen, S. B. et al. Performance of new thresholds of the Glasgow Blatchford score in managing patients with upper gastrointestinal bleeding. *Clin. Gastroenterol. Hepatol.* **13**(1), 115–121. https://doi.org/10.1016/j.cgh.2014.07.023 (2015).
7. Laursen, S. B. et al. ABC score: A new risk score that accurately predicts mortality in acute upper and lower gastrointestinal bleeding: An international multicentre study. *Gut* **70**(4), 707–716. https://doi.org/10.1136/gutjnl-2019-320002 (2021) (**Epub 2020 Jul 28 PMID: 32723845**).
8. Colorectal Group of the Gastrointestinal Endoscopy Branch of the Chinese Medical Association, Colorectal Group of the Gastroenterologists Branch of the Chinese Physicians Association, National Clinical Medical Research Center for Digestive Diseases. Guidelines for the Diagnosis and Treatment of Lower Gastrointestinal Bleeding (2020) [J]. Chinese Journal of Gastrointestinal Endoscopy, 2020, 37(10): 685–695. https://doi.org/10.3760/cma.j.cn321463-20200618-00544.
9. Oakland, K. et al. Acute lower GI bleeding in the UK: Patient characteristics, interventions and outcomes in the first nationwide audit. *Gut* **67**(4), 654–662. https://doi.org/10.1136/gutjnl-2016-313428 (2018) (**Epub 2017 Feb 1 PMID: 28148540**).
10. Tominaga, N. et al. A novel prediction tool for mortality in patients with acute lower gastrointestinal bleeding requiring emergency hospitalization: A large multicenter study. *Sci. Rep.* **14**(1), 5367. https://doi.org/10.1038/s41598-024-55889-7. (2024).
11. Oakland, K. et al. Derivation and validation of a novel risk score for safe discharge after acute lower gastrointestinal bleeding: A modelling study. *Lancet Gastroenterol. Hepatol.* **2**(9), 635–643. https://doi.org/10.1016/S2468-1253(17)30150-4 (2017) (**Epub 2017 Jun 23 PMID: 28651935**).
12. Chen, L., Zheng, H. & Wang, S. Prediction model of emergency mortality risk in patients with acute upper gastrointestinal bleeding: A retrospective study. *PeerJ* **24**(9), e11656. https://doi.org/10.7717/peerj.11656 (2021).
13. Time to Get Control. A review of the care received by patients who had a severe gastrointestinal haemorrhage. UK: NCEPOD, 2015.
14. Sharif, A. F., Aouissi, H. A., Kasemy, Z. A., Byeon, H. & Lashin, H. I. Development and validation of a risk prediction nomogram for disposition of acute clozapine intoxicated patients to intensive care unit. *Hum. Exp. Toxicol.* **42**, 9603271231186154. https://doi.org/10.1177/09603271231186154 (2023).
15. Lashin, H. I., Sobeeh, F. G. & Sobh, Z. K. Development and validation of a nomogram for predicting mechanical ventilation need among acutely intoxicated patients with impaired consciousness. *Hum. Exp. Toxicol.* **43**, 9603271241267214. https://doi.org/10.1177/09603271241267214 (2024).
16. Lashin, H. I., Elgazzar, F. M., El Sharkawy, S. I., Elsawaf, S. M. & Sobh, Z. K. Development of a risk-prediction nomogram for in-hospital adverse cardiovascular events in acute cardiotoxic agents poisoning. *Toxicol. Rep.* **13**, 101826. https://doi.org/10.1016/j.toxrep.2024.101826 (2024).
17. Laine, L., Barkun, A. N., Saltzman, J. R., Martel, M. & Leontiadis, G. I. ACG clinical guideline: Upper Gastrointestinal and Ulcer Bleeding. *Am. J. Gastroenterol.* **116**(5), 899–917. https://doi.org/10.14309/ajg.0000000000001245 (2021).
18. Sengupta, N. et al. Management of patients with acute lower gastrointestinal bleeding: An Updated ACG Guideline. *Am. J. Gastroenterol.* **118**(2), 208–231. https://doi.org/10.14309/ajg.0000000000002130 (2023).
19. Wang, S. & Tu, J. Nomogram to predict multidrug-resistant tuberculosis. *Ann. Clin. Microbiol. Antimicrob.* **19**(1), 27. https://doi.org/10.1186/s12941-020-00369-9 (2020).
20. Huang, Y. Q. et al. Development and validation of a radiomics nomogram for preoperative prediction of lymph node metastasis in colorectal cancer. *J. Clin. Oncol.* **34**(18), 2157–2164. https://doi.org/10.1200/JCO.2015.65.9128 (2016).
21. Vickers, A. J., Cronin, A. M., Elkin, E. B. & Gonen, M. Extensions to decision curve analysis, a novel method for evaluating diagnostic tests, prediction models and molecular markers. *BMC Med. Inform. Decis. Mak.* **8**(1), 53. https://doi.org/10.1186/1472-6947-8-53 (2008).
22. Peduzzi, P., Concato, J., Kemper, E., Holford, T. R. & Feinstein, A. R. A simulation study of the number of events per variable in logistic regression analysis. *J. Clin. Epidemiol.* **49**(12), 1373–1379. https://doi.org/10.1016/s0895-4356(96)00236-3 (1996).
23. Vittinghoff, E. & McCulloch, C. E. Relaxing the rule of ten events per variable in logistic and Cox regression. *Am. J. Epidemiol.* **165**(6), 710–718. https://doi.org/10.1093/aje/kwk052 (2007).
24. Song, P. et al. NLCIPS: Non-Small cell lung cancer immunotherapy prognosis score. *Cancer Manag. Res.* **12**, 5975–5985. https://doi.org/10.2147/CMAR.S257967 (2020).
25. Luo, Y., Mei, D., Gong, J., Zuo, M. & Guo, X. Multiparametric MRI-Based radiomics nomogram for predicting lymphovascular space invasion in endometrial carcinoma. *J. Magn. Resonance imag.: JMRI* **52**(4), 1257–1262. https://doi.org/10.1002/jmri.27142 (2020).
26. Bost, N., Crilly, J., Wallis, M., Patterson, E. & Chaboyer, W. Clinical handover of patients arriving by ambulance to the emergency department - a literature review. *Int. Emerg. Nurs.* **18**(4), 210–220. https://doi.org/10.1016/j.ienj.2009.11.006 (2010).
27. Cai, J. X. & Saltzman, J. R. Initial assessment, risk stratification, and early management of acute nonvariceal upper gastrointestinal hemorrhage. *Gastrointest. Endosc. Clin. N. Am.* **28**(3), 261–275. https://doi.org/10.1016/j.giec.2018.02.001 (2018) (**Epub 2018 Apr 17 PMID: 29933774**).
28. Dogru, U. et al. The effect of the shock index and scoring systems for predicting mortality among geriatric patients with upper gastrointestinal bleeding: A prospective cohort study. *Sao Paulo Med. J. Revista Paulista De Medicina* **140**(4), 531–539. https://doi.org/10.1590/1516-3180.2021.0735.13102021 (2022).
29. Dogru, U. et al. The effect of the shock index and scoring systems for predicting mortality among geriatric patients with upper gastrointestinal bleeding: A prospective cohort study. *Sao Paulo Med. J.* **140**(4), 531–539. https://doi.org/10.1590/1516-3180.2021.0735.13102021 (2022).
30. Zullo, A. et al. Clinical outcomes in cirrhotics with variceal or nonvariceal gastrointestinal bleeding: A prospective, multicenter cohort study. *J. Gastroenterol. Hepatol.* https://doi.org/10.1111/jgh.15601 (2021).
31. Leontiadis, G. I., Molloy-Bland, M., Moayyedi, P. & Howden, C. W. Effect of comorbidity on mortality in patients with peptic ulcer bleeding: systematic review and meta-analysis[J]. *Am. J. Gastroenterol.* **108**(3), 331–345 (2013).
32. Kupfer, Y., Cappell, M. S. & Tessler, S. Acute gastrointestinal bleeding in the intensive care unit: The intensivist's perspective. *Gastroenterol. Clin. N. Am.* **29**(2), 275–307. https://doi.org/10.1016/s0889-8553(05)70117-5 (2000).
33. Sun, D. et al. Cancer burden in China: Trends, risk factors and prevention. *Cancer Biol. Med.* **17**(4), 879–895. https://doi.org/10.20892/j.issn.2095-3941.2020.0387 (2020).
34. Wu, W. D. et al. Rare cause of upper gastrointestinal bleeding owing to hepatic cancer invasion: A case report. *World J. Gastroenterol.* **20**(35), 12704–12708. https://doi.org/10.3748/wjg.v20.i35.12704 (2014).
35. Peterson, D. E. & Cariello, A. Mucosal damage: A major risk factor for severe complications after cytotoxic therapy. *Semin. Oncol.* **31**, 35–44. https://doi.org/10.1053/j.seminoncol.2004.04.006 (2004) (**PMID: 15181607**).
36. Gralnek, I. M. et al. Endoscopic diagnosis and management of nonvariceal upper gastrointestinal hemorrhage (NVUGIH): European Society of Gastrointestinal Endoscopy (ESGE) Guideline - Update 2021. *Endoscopy* **53**(3), 300–332. https://doi.org/10.1055/a-1369-5274 (2021) (**Epub 2021 Feb 10 PMID: 33567467**).

37. Wilkins, T., Wheeler, B. & Carpenter, M. Upper gastrointestinal bleeding in adults: Evaluation and management. *Am. Fam. Physician* **101**(5), 294–300 (2021).
38. Lanas, A. et al. Non-variceal upper gastrointestinal bleeding. *Nat. Rev. Dis. Primers.* **19**(4), 18020. https://doi.org/10.1038/nrdp.2018.20 (2018) (**PMID: 29671413**).
39. Hawks, M. K. & Svarverud, J. E. Acute lower gastrointestinal bleeding: Evaluation and management. *Am. Fam. Physician* **101**(4), 206–212 (2020) (**PMID: 32053333**).
40. Rahmatinejad, Z. et al. Comparing In-Hospital mortality prediction by senior emergency resident's judgment and prognostic models in the emergency department. *Biomed. Res. Int.* **2023**, 6042762. https://doi.org/10.1155/2023/6042762 (2023).

Acknowledgements
We thank LetPub (www.letpub.com.cn) for its linguistic assistance during the preparation of this manuscript.

Author contributions
Y.L., M.W., and L.O. contributed equally to this work. Y.L. conceptualized and designed the study, performed data collection, and conducted statistical analysis. M.W. assisted in data collection, conducted the literature review, and contributed to the interpretation of the results. L.O. was involved in designing the nomogram, drafting the manuscript, and revising it for important intellectual content. D.L.supervised the study, provided critical insights into the methodology, and ensured adherence to ethical standards. W.J. reviewed and edited the manuscript, contributing to its final version. All authors participated in revising the manuscript and approved the final version for submission.

Declarations

Competing interests
The authors declare no competing interests.

Additional information
Correspondence and requests for materials should be addressed to D.L.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.