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Original Article

A simplified scoring model for predicting bacteremia in the unscheduled emergency department revisits: The SADFUL score

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Abstract *Background:* Bacteremia is a severe complication of infectious disease. Patients with a high bacteremia risk in the emergency department (ED) but misidentified would lead to the unscheduled revisits. This study aimed to develop a simplified scoring model to predict bacteremia in patients with unscheduled ED revisits.
Methods: Adult patients with unscheduled ED revisits within 72 h with a final diagnosis of infectious disease were retrospectively included. The development cohort included patients visiting the ED from January 1, 2019 to December 31, 2021. Internal validation was performed in patients visiting the ED from January 1, 2022 to March 31, 2022. Variables including demographics, pre-comorbidities, triage levels, vital signs, chief complaints, and laboratory data in the index visit were analyzed. Bacteremia was the primary outcome determined by blood culture in either index visits or revisits.
Results: The SADFUL score for predicting bacteremia comprised the following predictors: "S"egmented neutrophil percentage (+3 points), "A"ge > 55 years (+1 point), "D"iabetes mellitus (+1 point), "F"ever (+2 points), "U"pper respiratory tract symptoms (−2 points), and "L"eukopenia (2 points). The area under receiver operating characteristic curve with 95% confidence interval in the development (1802 patients, 190 [11%] with bacteremia) and the validation cohort (134 patients, 17 [13%] with bacteremia) were 0.78 (0.74–0.81) and 0.79 (0.71–0.88), respectively.

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Conclusions: The SADFUL score is a simplified useful tool for predicting bacteremia in patients with unscheduled ED revisits. The scoring model could help ED physicians decrease misidentification of patients at a high risk for bacteremia and potential complications.

Introduction

Bacteremia is among the common complications of infectious disease that may cause sepsis and high mortality.[1] Early diagnosis and timely treatment are beneficial to outcomes. Although positive blood culture is the golden standard for confirming diagnosis, it requires several days to obtain results.[2] Furthermore, patients with occult bacteremia may present mild clinical signs and symptoms, making the diagnosis challenging.[3] Potential deteriorated sepsis by occult bacteremia causes the unscheduled revisit to the emergency department (ED), increases medical burden, and worsens outcomes.[4] Predicting bacteremia with a simplified score model is required in the current crowded ED practice. Therefore, earlier prediction of patients with bacteremia is crucial for ED physicians to prevent unscheduled revisits or guide timely treatment after revisits.

Several prediction models for bacteremia in ED have been developed previously.[5–10] Su et al. combined fever, tachycardia, laboratory biomarkers, and diagnostic categories of infection to predict bacteremia.[5] The 5MPB-Toledo model developed by Jiménez et al. identified five predictors of bacteremia including fever, high Charlson comorbidity index, tachypnea, leukocytosis, and high serum procalcitonin level.[9] The well-known scoring systems such as systemic inflammatory response syndrome (SIRS) and quick Sequential Organ Failure Assessment (qSOFA) were also investigated and widely used for sepsis prediction.[11] However, none of these prediction models were applied to patients with unscheduled ED revisits.

For patients, unscheduled ED revisits indicate the presence of unsolved problems causing clinical deterioration after being discharged from their index visits.[12] The significance of focusing on the revisit group included: 1) if symptoms deteriorate and bacteremia developed after the index visit discharge, identifying high risk patients could ensure timely treatment after the revisits; and 2) identifying low-risk patients avoided over-treatment, such as aimless and prolonged use of the antibiotics. However, prediction models for bacteremia focusing on patients with ED revisits are lacking. The current study aimed to develop a simplified prediction model with the identified risk factors for bacteremia in patients with unscheduled ED revisits.

Methods

Study design and setting

We conducted a 3-year retrospective cohort study at the ED of National Taiwan University Hospital, Hsin-Chu Branch. This tertiary medical center has approximately 60,000 ED visits annually, with a revisit rate of 4%—5%. Our study was approved by the hospital's Institutional Review Board (no. 109-003-E). The requirement for obtaining patient informed consent was waived because of the study design and minimal intervention.

Case selection

Patients were preliminarily selected from January 2019 to March 2022 if they satisfied the following inclusion criteria: (1) patients with unscheduled ED revisit within 72 h after the index visit; (2) patients with infectious diseases (determined after reviewing the whole medical chart, including clinical presentations, laboratory data, image reports, treatments and final diagnosis); and (3) adult patients aged $\geq$18 years. The final diagnosis was made by the independent ED attending physicians and retrospectively extracted through a chart review. Patients who discharged against medical advice or whose documented medical record was missed were eventually excluded from the analysis. The final cohort was further divided into the development cohort (patients visiting the ED from January 1, 2019 to December 31, 2021) and the validation cohort (patients visiting the ED from January 1, 2022 to March 31, 2022).

Data collection and processing

To acquire high-quality data, all data in the current study were collected by ED attending physicians from reviewing the medical records of each patient, instead of from medical databases. Before initiating data collection, the data collectors were trained and instructed of the definition and coding rules of each variable. Periodic study meetings were also held to discuss any disputes or ambiguous records to achieve consistency on each controversial medical record.

Variables

Variables collected from the medical charts included demographics, precomorbidities, and clinical information from the index visits including triage levels, vital signs, chief complaints, and laboratory data. Preexisting diseases included hypertension, diabetes mellitus (DM), coronary artery disease, cerebrovascular accident, cancer, and chronic kidney disease. The abovementioned medical history was determined if the patient was diagnosed and received regular treatments in the follow-ups. The triage nurse used a validated Taiwan Triage and Acuity Scale computerized triage system, which categorized cases as resuscitation, emergent,

urgent, less urgent, or nonurgent, from level 1 to 5.[13] The vital signs, including body temperature (BT), heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), and Glasgow coma scale (GCS), were objectively measured using standard protocols and physiological monitors. We categorized BT into three levels (<36 °C, 36°C–37.9 °C, and ≥38 °C). Patients whose BT was ≥38 °C were considered as having fever. We further divided patients into binary groups according to HR, RR, SBP, and GCS score with cutoff values of 90/min, 20/min, 100 mmHg, and 15, respectively. Chief complaints recorded in medical charts were categorized into upper respiratory tract symptoms (cough, rhinorrhea, or sore throat), gastrointestinal tract symptoms (abdominal pain, nausea, vomiting, or diarrhea), and urinary tract symptoms (flank pain, dysuria, or urinary frequency). Other infection-associated chief complaints, including dyspnea and chills, were also recorded. Laboratory tests investigated in this study included serum white blood cell count (WBC, K/μL) and neutrophil percentage (Seg, %). Patients were considered as having leukopenia (<4 K/μL), normal (4–12 K/μL), and leukocytosis (>12 K/μL) based on the WBC count. The following scoring systems/index for sepsis were also calculated using information obtained from the index visits: 1) SIRS: ≥2 clinical criteria of HR > 90/min, RR > 20/min, BT < 36 °C or ≥38 °C, and WBC count >12 or <4 K/μL considered as positive; 2) qSOFA: ≥2 clinical criteria of SBP ≤100 mmHg, RR ≥ 22/min, and altered mental status considered as positive; and 3) shock index (SI): HR/SBP ≥1 considered as positive.[14–16]

Outcomes

The primary outcome was bacteremia, based on the blood culture results, either in the index visits or revisits. Each set of blood samples consisted of one aerobic culture bottle and one anaerobic culture bottle. The BACTEC 9240 system [Becton Dickinson and Company (BD), Franklin Lakes, NJ, USA] was used in the department of Laboratory Medicine, with blood samples incubated for 5 days or until bacterial growth was detected. The bacteremia group included 1) patients with two sets of positive blood culture results of samples collected from different sites, or 2) patients with one set of positive blood culture results of gram-negative bacteria pathogens.[17] A call back system was implemented for all patients with positive blood culture results obtained during the index visit but were discharged.[18] For best quality control of medical care in the ED, our physicians or nurse practitioner would call them by the phones and suggested the return to the ED for further evaluation and treatment within 8 h (one duty shift). Patients discharged after the revisits without undergoing blood culture in both visits were categorized into the nonbacteremia group. Patients with only one set of positive blood culture results of gram-positive pathogens were further reviewed by the senior attending ED physicians to determine the group. Additionally, the ED disposition, in-hospital mortality, and length of hospital stay were recorded.

Statistical analysis

The normality of all continuous data was assessed using the Kolmogorov–Smirnov test. All variables were not normally distributed. Dichotomous and categorical variables were presented as absolute sample size (percentage) and compared using Pearson Chi-square or Fisher exact test. Continuous variables were expressed as median (interquartile range [IQR]) and compared using Mann–Whitney U test. A simplified integral scoring model was developed as follows: 1) using receiver operating characteristic (ROC) curve and Youden index (YI) to determine the best cutoff values of the continuous variables, including age and neutrophil percentage, for predicting bacteremia and dichotomized the variable based on the cutoff value[19]; 2) conducting univariable logistic regression analysis on each variable; 3) conducting multivariable logistic regression with a backward stepwise method on variables whose p value < 0.1 in the univariable analysis; and 4) using the beta-coefficient of each variable in the final model and converting it into an integral score.[5] The result of the regression model was presented as crude odds ratio, adjusted odds ratio (aOR), and 95% confidence interval (CI). The model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test and the discrimination was assessed by c-statistics. Whether collinearity existed in the final selected variables was decided by calculating correlation coefficients and variance inflation factor (VIF) among variables. Area under ROC curve (AUC) was used to assess the predictive accuracy of the scoring model in both development and validation cohorts. The best cutoff score of the proposed model for predicting bacteremia was determined by the score with the maximum YI.[19] Additionally, we compared the predictive accuracy of our prediction model with those of SIRS, qSOFA, and SI, and further tested the predictive accuracy in different types of bacteremia. All statistical analyses were performed using the Statistical Package for the Social Sciences software version 26.0 (IBM, Armonk, NY, the USA) with two-sided p value of <0.05 considered as statistical significance.

Results

Characteristics of the participants

Among the 8267 patients with unscheduled ED revisits within 72 h between January 2019 and March 2022 with medical record, 1936 adult patients with an infectious disease were included in the final analysis. The development cohort consisted of 1802 patients, and 190 (11%) patients had bacteremia. The validation cohort consisted of 134 patients, and 17 (13%) patients had bacteremia (Fig. 1). Gram-negative bacteria accounted for the majority of the isolated pathogens (77.4%). The most common isolated bacteria group was *Escherichia* (44.2%), followed by *Staphylococcus* (12.1%), and *Klebsiella* (10.5%) (Supplementary Table 1). In patients with bacteremia, most of the positive blood cultures were obtained in index visits (68.9% in the development cohort; 82.4% in the validation cohort) (Supplementary Figure 1).

Table 1 demonstrates the demographics, vital signs, laboratory data, and other clinical information of patients during the index visits of the development cohort. The median age of the study cohort is 57.0 years old, and 53.6% patients were men. The bacteremia group was significantly older than the nonbacteremia group (median age, 66.6 vs. 55.0 years, p < 0.001). The bacteremia group also had a

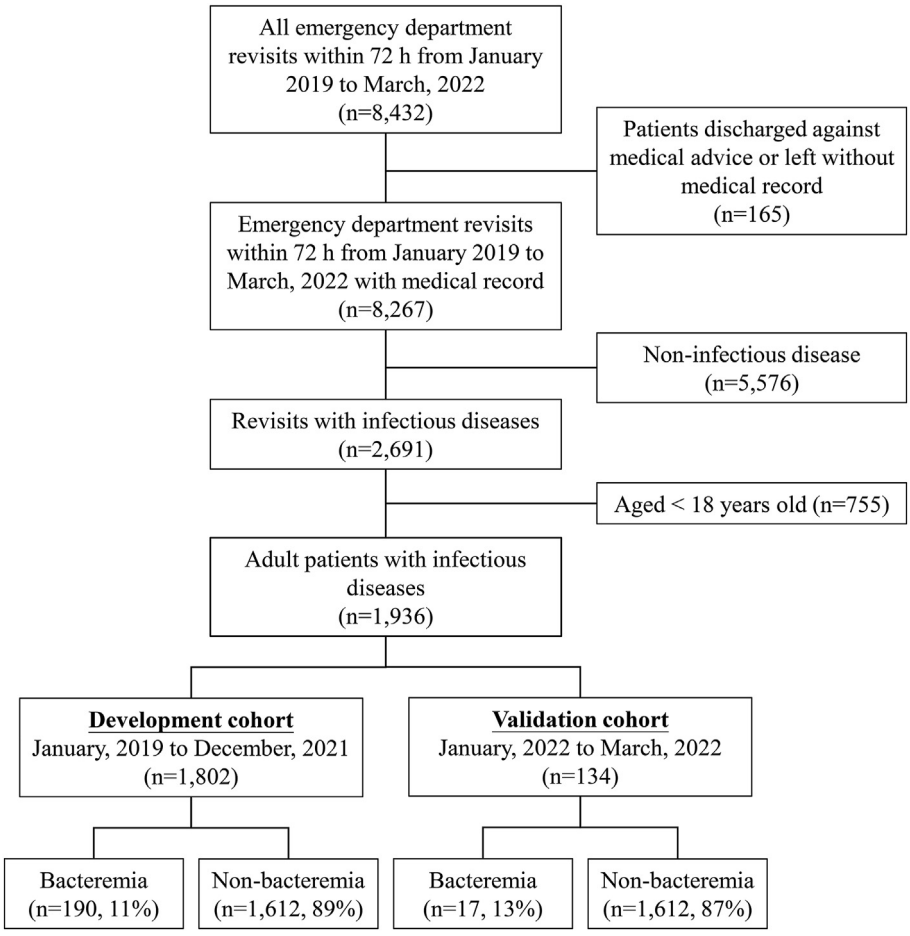

Figure 1. Flow diagram of the included patients.

higher rate of precomorbidities including hypertension (43.7% vs. 29.7%, $p < 0.001$), DM (34.7% vs. 21.0%, $p < 0.001$), and cancers (21.1% vs. 15.0%, $p = 0.030$). The bacteremia group was more likely to have abnormal vital signs and GCS in their index visits. The bacteremia group presented more gastrointestinal tract symptoms (38.9% vs. 30.2%, $p = 0.014$), urinary tract symptoms (15.3% vs. 6.6%, $p < 0.001$), and chills (22.6% vs. 10.7%, $p < 0.001$) but less upper respiratory tract symptoms (11.6 vs. 22.3%, $p < 0.001$). The bacteremia group had a higher segmented neutrophil percentage (88.1% vs. 79.2%, $p < 0.001$). Patients with bacteremia had higher admission rate after ED revisit and longer hospital length of stay after admission.

The demographics of the development and validation cohorts were compared. Although patients in the validation cohort had lower rate in URI symptoms (8.2% vs. 20.5%, $p < 0.001$), no significant differences were found between two cohorts including age, sex, triage levels, laboratory data, rate of bacteremia and ED disposition (Supplementary Table 2).

Associated factors and development of an integral scoring model for bacteremia

The optimal cutoff age and segmented neutrophil percentage for predicting bacteremia were determined as 55 years old and 85.7%, respectively (Supplementary Figure 2).

Table 2 shows the univariable and multivariable logistic regression models. After adjusting for potential confounders using a backward stepwise method, a parsimonious model was obtained. The risk factors associated with bacteremia were age >55 years (aOR: 1.96, 95% CI: 1.31–2.93, $p < 0.001$), DM (aOR: 1.56, 95% CI: 1.03–2.38, $p = 0.038$), fever (aOR: 2.86, 95% CI: 1.94–4.21, $p < 0.001$), leukopenia (aOR: 2.61, 95% CI: 1.20–5.69, $p < 0.016$) and segmented neutrophil percentage >85% (aOR: 3.82, 95% CI: 2.58–5.66, $p < 0.001$). Contrarily, patients with upper respiratory tract symptoms were less likely to develop bacteremia (aOR: 0.34, 95% CI: 0.19–0.61, $p < 0.001$). There was no collinearity among selected variables (Pearson correlation coefficient <0.1, VIF<2). The proposed model for predicting bacteremia, shown in Table 3, had a good fit (Hosmer–Lemeshow test $p = 0.855$) and fair discrimination (c-statistics: 0.78, 95% CI: 0.74–0.82). The lowest beta-coefficient value in the final model was 0.447 for DM and assigned as +1 point. Then, the beta-coefficient value of other variables was divided by 0.447 and rounded to the nearest integral as its score. The SADFUL scoring model included "S"egmented neutrophil >85% (+3 points), "A"ge > 55 years (+1 point), "D"M (+1 point), "F"ever (+2 points), "U"pper respiratory tract symptoms (−2 points), and "L"eukopenia (+2 points).

Table 1 Demographics, vitals, laboratory data and outcomes in the development cohort at the index visit.

Variables [a]	Total (n = 1802)	Non-bacteremia (n = 1612)	Bacteremia (n = 190)	*p*
Age (in years)	57.0 (34.8)	55.0 (35.8)	66.6 (30.0)	<0.001
>55	938 (52.1)	803 (49.8)	135 (71.1)	<0.001
Male (%)	966 (53.6)	866 (53.7)	100 (52.6)	0.776
Pre-comorbidities				
Hypertension	562 (31.2)	479 (29.7)	83 (43.7)	<0.001
Diabetes mellitus	405 (22.5)	339 (21.0)	66 (34.7)	<0.001
Coronary artery disease	143 (7.9)	122 (7.6)	21 (11.1)	0.093
Cerebrovascular accident	85 (4.7)	71 (4.4)	14 (7.4)	0.068
Cancer	282 (15.6)	242 (15.0)	40 (21.1)	0.030
Chronic kidney disease	132 (7.3)	112 (6.9)	20 (10.6)	0.073
Triage levels 1 or 2	285 (15.8)	238 (14.8)	47 (24.7)	<0.001
Vital signs				
GCS<15	77 (4.3)	62 (3.8)	15 (7.9)	0.009
Body temperature (°C)				<0.001
<36	79 (4.4)	72 (4.5)	7 (3.7)	
36.0−37.9	1173 (65.2)	1089 (67.6)	84 (44.2)	
≥38	548 (30.4)	449 (27.9)	99 (52.1)	
Heart rate >90/min	1152 (64.1)	1015 (63.1)	137 (72.5)	0.011
Breath rate >20/min	272 (15.1)	235 (14.6)	37 (19.6)	0.071
SBP <100 mmHg	60 (3.3)	50 (3.1)	10 (5.3)	0.114
Symptoms in chief complaints				
Upper respiratory tract	382 (21.2)	360 (22.3)	22 (11.6)	0.001
Gastrointestinal tract	561 (31.1)	487 (30.2)	74 (38.9)	0.014
Urinary tract	135 (7.5)	106 (6.6)	29 (15.3)	<0.001
Dyspnea	121 (6.7)	110 (6.8)	11 (5.8)	0.590
Chills	215 (11.9)	172 (10.7)	43 (22.6)	<0.001
Laboratory data				
White blood cell (K/μL)				0.028
<4	60 (4.8)	49 (4.4)	11 (6.9)	
4-12	846 (67.0)	755 (68.4)	91 (56.9)	
>12	357 (38.3)	199 (27.1)	58 (36.3)	
Neutrophil (%)	80.3 (15.0)	79.2 (14.9)	88.1 (10.4)	<0.001
Scoring system/index				
SIRS (≥2)	1025 (56.9)	893 (55.4)	132 (69.5)	<0.001
qSOFA (≥2)	36 (2.0)	29 (1.8)	7 (3.7)	0.078
Shock index (>1)	133 (7.4)	113 (7.0)	20 (10.6)	0.077
Disposition after ED revisit				<0.001
Discharged	888 (55.1)	888 (55.1)	0 (0.0)	
General ward admission	885 (49.1)	700 (43.4)	185 (97.4)	
ICU admission	25 (1.4)	21 (1.3)	4 (2.1)	
Died in ED	4 (0.2)	3 (0.2)	1 (0.5)	
In-hospital mortality	39 (4.5)	33 (4.9)	6 (3.2)	0.310
Hospital LOS (days)[b]	6.7 (6.9)	6.4 (6.6)	8.4 (7.3)	<0.001

[a] Continuous variables were reported as median (interquartile range) whereas categorical variables were reported as number (percentage).
[b] Patients who were discharged after ED revisit or died in ED were excluded in this analysis.
ED = emergency department, GCS = Glasgow Coma Scale, LOS = length of stay, qSOFA = quick Sequential Organ Failure Assessment, SBP = systolic blood pressure, SIRS=Systemic Inflammatory Response Syndrome.

Predictive accuracy of the SADFUL score

Table 4 demonstrates the predictive accuracy of the SADFUL score in the development and validation cohorts, the sensitivity and specificity on different cutoff values. The scoring model had an AUC of 0.78 (95% CI: 0.74−0.81) in the development cohort. When applied to the validation cohort, the model performed almost consistent with the development cohort (AUC: 0.79, 95% CI: 0.71−0.88). In the development cohort, the best cutoff value of the SADFUL score for predicting bacteremia was +3 points with sensitivity of 0.76 and specificity of 0.68. In the validation cohort, the best cutoff value was +4 points with sensitivity of 0.88 and specificity of 0.68.

Table 2 Risk factors associated with bacteremia.

	Crude OR (95% CI)	*P*	aOR (95% CI)	*p*
Age >55 years old	2.47 (1.78–3.43)	<0.001	1.96 (1.31–2.93)	0.001
Male (%)	0.96 (0.71–1.29)	0.776		
Pre-comorbidities				
Hypertension	1.84 (1.35–2.49)	<0.001		
Diabetes mellitus	2.00 (1.45–2.76)	<0.001	1.56 (1.03–2.38)	0.038
Coronary artery disease	1.52 (0.93–2.48)	0.095		
Cerebrovascular accident	1.73 (0.95–3.13)	0.072		
Cancer	1.51 (1.04–2.20)	0.031		
Chronic kidney disease	1.58 (0.95–2.60)	0.076		
Triage levels 1 or 2	1.90 (1.33–2.71)	<0.001		
Vital signs				
GCS<15	2.14 (1.19–3.85)	0.011		
Body temperature (°C)				
<36	1.26 (0.56–2.83)	0.574	0.95 (0.32–2.81)	0.923
36.0–37.9	Reference		Reference	
≥38	2.86 (2.10–3.90)	<0.001	2.86 (1.94–4.21)	<0.001
Heart rate >90/min	1.52 (1.09–2.12)	0.014		
Breath rate >20/min	1.42 (0.96–2.08)	0.076		
SBP <100 mmHg	1.74 (0.87–3.50)	0.118		
Symptoms				
Upper respiratory tract	0.46 (0.29–0.72)	0.001	0.34 (0.19–0.61)	<0.001
Gastrointestinal tract	1.47 (1.08–2.01)	0.014		
Urinary tract	2.56 (1.65–3.98)	<0.001		
Dyspnea	0.84 (0.44–1.59)	0.590		
Chills	2.45 (1.68–3.56)	<0.001		
Laboratory data				
White blood cell (K/μL)				
<4	1.86 (0.94–3.71)	0.077	2.61 (1.20–5.69)	0.016
4-12	Reference		Reference	
>12	1.61 (1.13–2.30)	0.009	1.02 (0.68–1.52)	0.934
Neutrophil>85%	5.22 (3.82–7.13)	<0.001	3.82 (2.58–5.66)	<0.001

aOR = adjusted odds ratio, GCS = Glasgow Coma Scale, OR = odds ratio, qSOFA = quick Sequential Organ Failure Assessment, SBP = systolic blood pressure, SIRS=Systemic Inflammatory Response Syndrome.

Table 3 The SADFUL score for predicting bacteremia.

	β-coefficient	aOR (95% CI)	*p*	Score
Seg (neutrophil) > 85%	1.345	3.84 (2.64–5.58)	<0.001	3
Age >55 years old	0.669	1.95 (1.31–2.92)	0.001	1
Diabetes mellitus	0.447	1.56 (1.03–2.38)	0.036	1
Fever (body temperature≥38 °C)	1.053	2.87 (1.96–4.19)	<0.001	2
Upper respiratory tract symptoms	−1.074	0.34 (0.19–0.61)	<0.001	−2
Leukopenia (WBC<4 K/μL)	0.956	2.60 (1.20–5.63)	0.015	2

aOR = adjusted odds ratio, CI = confidence interval, WBC = white blood cell count.

The predictive accuracy of the SADFUL scoring model was compared with those of SIRS ≥2, qSOFA ≥2, and SI ≥ 1 (Supplementary Figure 3). The predictive accuracy of the SADFUL score was superior to those of SIRS (AUC: 0.61, 95% CI: 0.56–0.65), qSOFA (AUC: 0.50, 95% CI: 0.47–0.56), and SI (AUC: 0.51, 95% CI: 0.47–0.56). Additionally, the predictive accuracy of SADFUL score in different types of bacteremia was tested (Supplementary Table 3). The model performed better in predicting gram-negative bacteremia, such as the *Escherichia* spp.

Discussion

In this study, we developed a six-variable simplified score (the SADFUL score), which included segmented neutrophil percentage, age, DM, fever, upper respiratory tract symptoms, and leukopenia, to predict bacteremia. This model had fair predictive accuracy and could aid earlier identification of bacteremia.

Older patients were vulnerable to bacteremia and even sepsis due to complicated preexisting comorbidities, poor

Table 4 Sensitivity and Specificity on different cutoff value of our scoring model in development and validation cohorts.

	Development cohort AUROC (95% CI) = 0.78 (0.74–0.81)		Validation cohort AUROC (95% CI) = 0.79 (0.71–0.88)	
Cutoff value [a]	Sensitivity	Specificity	Sensitivity	Specificity
≥1	0.956	0.292	1.000	0.103
≥2	0.875	0.490	1.000	0.197
≥3	0.756	0.675	1.000	0.436
≥4	0.631	0.789	0.882	0.675
≥5	0.463	0.861	0.588	0.769
≥6	0.275	0.948	0.294	0.838
≥7	0.106	0.984	0.235	0.889

[a] Cutoff value ≥ 3 has the maximum Youden index (YI) in development cohort and ≥4 has the maximum YI in validation cohort.
AUROC = area under the receiver operating characteristic curve, CI = confidence interval.

performance status, and immunosenescence.[20,21] Moreover, older patients sometimes had an atypical presentation for bacteremia and had an increased risk of developing complications.[21,22] In this study, age of >55 years best predicted bacteremia. Severe infection should always be considered when caring for the elderly. A longer observation time with repeated evaluations is warranted before discharging older patients.

Likely, patients with DM may be relatively immunocompromised and susceptible to severe infections.[23] Infectious diseases, including urinary tract infection, liver abscesses, or soft tissue infections, were more common in DM patients. These patients are at risk of bacteremia caused by pathogens including *Escherichia*, *Klebsiella*, and *Staphylococcus*.[23,24] In this study, among all included preexisting diseases, DM was the only significant risk factor of bacteremia after adjusted for potential confounders in the multivariable regression model.

In the SADFUL score, fever accounts for +2 points on bacteremia prediction. Fever, a common symptom in severe infections, was also the most frequently used predictor in previous studies.[5,6,9] Chills is the associated symptom of fever and was reported as a significant risk factor for bacteremia in previous studies.[6,25] However, our result did not support any association between chills and bacteremia. Chills, a subjective complaint, may easily cause bias in the analysis. Additionally, our result did not report any other vital signs as significant predictors of bacteremia, even though tachycardia and tachypnea were shown to increase the risk of bacteremia in the previous models.[5,9] There was no denying that different cutoff values may lead to different results.

Patients with upper respiratory tract infections were less likely to develop bacteremia while those with urinary tract infections were more vulnerable to bacteremia.[5,26] Our study reported various chief complaints as potential indicators, showing that upper respiratory tract symptoms, including cough, rhinorrhea and sore throat, were negative predictors of bacteremia. Upper respiratory tract infections were mostly caused by viruses. Bacterial infections from the respiratory tract also seldom developed into bacteremia.[27]

Serum biomarkers could be involved in bacteremia prediction. In our study, leukopenia and high segmented neutrophil percentage (>85%) were indicators for bacteremia. Similarly, Su et al. found that patients with lymphocytopenia (lymphocyte count ≤1 K/μL) were at risk of bacteremia.[5] Inversely, the 5MPB-Toledo model reported leukocytosis (WBC >12 K/μL) as a predictor of bacteremia.[9] In the SIRS criteria, both leukopenia and leukocytosis were signs of severe infection. Leukopenia in sepsis may result from suppression or destruction of the immune system.[28] Generally, as compared to those with leukocytosis, patients with leukopenia were considered as immunocompromised; thus, their mortality risk may be higher.[29] Additionally, our study indicated that segmented neutrophil percentage had a high weighting in the prediction model. In previous studies, higher percentage of neutrophils, or higher neutrophil-to-lymphocyte ratio, had a good predictive accuracy of bacteremia.[30]

The SADFUL score yielded an AUC of 0.79 on bacteremia prediction. Cutoff value of around +3 to +4 point has the best prediction (i.e., maximum YI). However, a lower cutoff point may be considered to increase the sensitivity in predicting bacteremia. For predicting bacteremia, the SADFUL score exhibited better performance than the SIRS, qSOFA, or SI.[11] Although some developed scoring models in previous studies performed slightly better than the SADFUL score,[5,6,9] those models mostly used C-reactive protein and/or procalcitonin. Whether these biomarkers are cost effective requires further investigation in general ED setting. The model performed better in predicting gram-negative bacteremia. Clinical risk factors, etiologies and presentations among different types of bacteremia may varied, and the utility of the SADFUL score on different bacteria types may require further investigation.

Our study has several strengths. First, the similar prediction performance in both cohorts implies that the current results are solid and generalizable. Second, our study is the first study that focused on patients with ED revisits. This patient group may be potentially misidentified or even misdiagnosed; thus, they require special attention from ED physicians. Third, our study included a 3-year cohort and the number of included patients was larger than those of previous studies. Lastly, the SADFUL score consisted of easily accessible clinical information and used simplified integral scores achieving a fair discrimination. There were also some limitations. The single-center, retrospective nature of our study may present selection and inherent biases. Misinterpretation may also occur. Additionally, we

regarded patients who safely discharged after revisits without blood culture as nonbacteremia patients, which may lead to potential partial and differential verification biases.[31] We also did not consider the effect of antibiotic use during ED visits. This may potentially influence the yield rate of blood cultures. Furthermore, this study did not include either CRP or procalcitonin to predict bacteremia. Further investigations are needed to determine if these biomarkers could increase the predictive accuracy of the SADFUL score. Finally, although the internal validation of our scoring model yielded a consistent result, a multicenter, prospective external validation may be required to test the predictive accuracy of SADFUL score in different clinical scenarios and different populations. Whether the SADFUL scoring model could apply to all ED patients may be further investigated.

In conclusion, the SADFUL score that included segmented neutrophil percentage, age, DM, fever, upper respiratory tract symptoms, and leukopenia could predict bacteremia in ED patients with unscheduled revisits. Before considering to discharge a patient with a suspected infectious disease in ED, the SADFUL score may be utilized to decrease the misidentification of these patients with a high risk of bacteremia. The SADFUL scoring model has consistent performance in the internal validation. Further multicenter external validation would be warranted and is expected soon.

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Declaration of competing interest

The authors declared no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jmii.2023.04.002.