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Supplementary Table 1. List of analyzed variables.

Variables	Descriptions	Type of raw data	Category	Preprocessing
Gender	Sex of the patients	Binary	Male, Female	
Age	Age of patients	Continuous	15-39 years, 40-59 years, 60-79 years, and 80- years	Discretization and one hot encoding
Job	Job of patients	Categorical	Unemployed, Student/Housewife; Office/Commercial/Service workers; Industrial/Agricultural/Fishery/Miner worker; Others	One hot encoding Missing data were classified into others
Diabetes	History of diabetes mellitus	Binary	Yes, No	Missing data were classified into no
Hypertension	History of hypertension	Binary	Yes, No	Missing data were classified into no
Location of injury	Location of injury	Categorical	home/residential area/medical facility/school/gym; Road/highway; Off-road traffic area; Others	One hot encoding Missing data were classified into others
Season	Season when injury occurred	Categorical	Spring, Summer, Fall, Winter	One hot encoding
Weekend	Whether Injury occurred on weekday or weekend	Binary	Weekday, Weekend	
Daytime	When injury was occurred	Categorical	Night (Midnight to 5AM), Morning (6AM to 11AM), Afternoon (Midday to 5PM), Evening (6PM to 11PM)	One hot encoding Missing time were imputed using EMS call time
Mechanism of injury	Mechanism of injury	Categorical	Slip down, Fall down, Traffic accident, Other	One hot encoding Missing data were classified into others
Glasgow coma scale eye	Eye element of Glasgow coma scale	Categorical	1;2;3;4;Unknown	One hot encoding
Glasgow coma scale Verbal	Verbal element of Glasgow coma scale	Categorical	1;2;3;4;5;Unknown	One hot encoding
Glasgow coma scale Motor	Motor element of Glasgow coma scale	Categorical	1;2;3;4;5;6;Unknown	One hot encoding
Light Reflex any Abnormal	Any abnormality of light reflex on any side	Categorical	No, Yes, Unknown	One hot encoding Missing data were classified into unknown

Systolic blood pressure	Systolic blood pressure	Continuous	-107 mmHg, 108-130 mmHg, 131-145 mmHg, 146- mmHg, Unknown	Discretization and one hot encoding Cutoff values for categories were calculated from median and interquartile range of training cohort Missing data were classified into unknown
Diastolic blood pressure	Diastolic blood pressure	Continuous	-69 mmHg, 70-80 mmHg, 81-91 mmHg, 92- mmHg, Unknown	Discretization and one hot encoding Cutoff values for categories were calculated from median and interquartile range of training cohort Missing data were classified into unknown
Heart rate	Heart rate	Continuous	-74/min, 75-86/min, 87-99/min, 100-/min, Unknown	Discretization and one hot encoding Cutoff values for categories were calculated from median and interquartile range of training cohort Missing data were classified into unknown
Respiratory rate	Respiratory rate	Continuous	-16/min, 17-18/min, 19-20/min, 21-/min, Unknown	Discretization and one hot encoding Cutoff values for categories were calculated from median and interquartile range of training cohort Missing data were classified into unknown
Oxygen saturation	Oxygen saturation	Continuous	-95%, 96-98%, 99%, 100%, Unknown	Discretization and one hot encoding Cutoff values for categories were calculated from median and interquartile range of training cohort Missing data were classified into unknown
Body temperature	Body temperature	Continuous	-36°C, 36.1-36.3°C, 36.4-36.8°C, 36.9-°C, Unknown	Discretization and one hot encoding Cutoff values for categories were calculated from median and interquartile range of training cohort Missing data were classified into unknown
Chest pain or abdominal pain	Symptom of chest pain or abdominal pain	Binary	Yes, No	

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Fracture, abrasion, or laceration	Symptom of fracture, abrasion, or laceration	Binary	Yes, No	
Loss of consciousness	Symptom of loss of consciousness (whether patients had loss of consciousness between injury and EMS provider's assessment)	Binary	Yes, No	
Dyspnea	Symptom of dyspnea	Binary	Yes, No	
Nose bleeding	Symptom of nose bleeding	Binary	Yes, No	
Nausea or vomiting	Symptom of nausea or vomiting	Binary	Yes, No	
Headache, paralysis or dizziness	Symptom of headache, paralysis or dizziness	Binary	Yes, No	

Supplementary Table 2. Demographic characteristics of development and test cohorts

Characteristics	N (%) or Median (IQR)			P-value
	Total	Development	Test	
Total	1169	867	302	
Demographics				
Male	809 (69.2)	592 (68.3)	217 (71.9)	0.25
Age, years	53 (36-66)	52 (35-66)	56 (40-69)	<0.01
Job of patients				<0.01
Unemployed	299 (25.6)	197 (22.7)	102 (33.8)	
Student/Housewife	161 (13.8)	129 (14.9)	32 (10.6)	
Office/Commercial/Service worker	283 (24.2)	176 (20.3)	107 (35.4)	
Industrial/Agricultural/Fishery/Minery worker	36 (3.1)	25 (2.9)	11 (3.6)	
Others	390 (33.4)	340 (39.2)	50 (16.6)	
Past medical history				
Diabetes	62 (5.3)	35 (4.0)	27 (8.9)	<0.01
Hypertension	105 (9.0)	61 (7.0)	44 (14.6)	<0.01
Circumstances of Trauma				
Location of trauma				0.52
Residential/Nursing/Education/Exercise facility	303 (25.9)	218 (25.1)	85 (28.1)	
Road/Highway	444 (38.0)	326 (37.6)	118 (39.1)	
Off-road traffic area	181 (15.5)	140 (16.1)	41 (13.6)	
Others	241 (20.6)	183 (21.1)	58 (19.2)	
Season of trauma				<0.01
Spring	249 (21.3)	167 (19.3)	82 (27.2)	
Summer	336 (28.7)	253 (29.2)	83 (27.5)	
Fall	304 (26.0)	242 (27.9)	62 (20.5)	
Winter	280 (24.0)	205 (23.6)	75 (24.8)	
Weekday	811 (69.4)	599 (69.1)	212 (70.2)	0.72
Time of trauma				0.83
6A-MD	281 (24.0)	206 (23.8)	75 (24.8)	
MD-6P	266 (22.8)	203 (23.4)	63 (20.9)	
6P-MN	361 (30.9)	265 (30.6)	96 (31.8)	
MN-6A	261 (22.3)	193 (22.3)	68 (22.5)	
Mechanism of Trauma				0.60
Traffic accident	500 (42.8)	375 (43.3)	125 (41.4)	
Slip down	325 (27.8)	232 (26.8)	93 (30.8)	
Fall down	171 (14.6)	129 (14.9)	42 (13.9)	
Others	173 (14.8)	131 (15.1)	42 (13.9)	
Chief complaint				
Altered mentality	279 (23.9)	223 (25.7)	56 (18.5)	0.01
Facture/Abrasion/Laceration	302 (25.8)	204 (23.5)	98 (32.5)	<0.01
Chest/Abdominal pain	47 (4.0)	31 (3.6)	16 (5.3)	0.19
Dyspnea	25 (2.1)	20 (2.3)	5 (1.7)	0.50

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Epistaxis	44 (3.8)	30 (3.5)	14 (4.6)	0.36
Headache/Paralysis/Dizziness/Vertigo	95 (8.1)	64 (7.4)	31 (10.3)	0.11
Nausea/Vomiting	32 (2.7)	20 (2.3)	12 (4.0)	0.13
EMS Vital sign assessment				
SBP, mmHg	130 (109-150)	130 (104-146)	131 (115-150)	<0.01
Missing	65 (5.6)	56 (6.5)	9 (3.0)	0.02
DBP, mmHg	80 (70-91)	80 (69-90)	80 (70-92)	<0.01
Missing	75 (6.4)	65 (7.5)	10 (3.3)	0.01
HR, /min	86 (75-99)	86 (74-99)	86 (76-100)	<0.01
Missing	31 (2.7)	28 (3.2)	3 (1.0)	0.04
RR, /min	18 (16-20)	18 (16-20)	18 (16-20)	<0.01
Missing	36 (3.1)	33 (3.8)	3 (1.0)	0.01
SpO2, %	98 (95-99)	98 (95-99)	98 (96-99)	<0.01
Missing	38 (3.3)	33 (3.8)	5 (1.7)	0.07
Temperature, ℃	36.5 (36-36.8)	36.5 (36-36.8)	36.5 (36-36.7)	<0.01
Missing	94 (8.0)	65 (7.5)	29 (9.6)	0.25
AVPU scale				<0.01
Alert	714 (61.1)	504 (58.1)	210 (69.5)	
Verbal	168 (14.4)	136 (15.7)	32 (10.6)	
Pain	199 (17.0)	158 (18.2)	41 (13.6)	
Unresponsive	88 (7.5)	69 (8.0)	19 (6.3)	
Abnormal light reflex	165 (14.1)	132 (15.2)	33 (10.9)	<0.01
Missing	66 (5.6)	57 (6.6)	9 (3.0)	
GCS scale component				
Glasgow coma scale eye				<0.01
4	558 (47.7)	380 (43.8)	178 (58.9)	
3	128 (10.9)	109 (12.6)	19 (6.3)	
2	110 (9.4)	82 (9.5)	28 (9.3)	
1	174 (14.9)	141 (16.3)	33 (10.9)	
Unknown	199 (17.0)	155 (17.9)	44 (14.6)	
Glasgow coma scale Verbal				0.01
5	520 (44.5)	359 (41.4)	161 (53.3)	
4	118 (10.1)	88 (10.1)	30 (9.9)	
3	25 (2.1)	19 (2.2)	6 (2.0)	
2	132 (11.3)	105 (12.1)	27 (8.9)	
1	174 (14.9)	141 (16.3)	33 (10.9)	
Unknown	200 (17.1)	155 (17.9)	45 (14.9)	
Glasgow coma scale Motor				<0.01
6	499 (42.7)	333 (38.4)	166 (55.0)	
5	124 (10.6)	103 (11.9)	21 (7.0)	
4	158 (13.5)	123 (14.2)	35 (11.6)	
3	47 (4.0)	39 (4.5)	8 (2.6)	
2	17 (1.5)	15 (1.7)	2 (0.7)	
1	125 (10.7)	99 (11.4)	26 (8.6)	
Unknown	199 (17.0)	155 (17.9)	44 (14.6)	

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EMS management				
Intravenous route	176 (15.1)	129 (14.9)	47 (15.6)	0.77
Hemorrhage control	586 (50.1)	426 (49.1)	160 (53.0)	0.25
Spinal motion restriction	811 (69.4)	606 (69.9)	205 (67.9)	0.51
Advanced airway management	4 (0.3)	2 (0.2)	2 (0.7)	0.28
Oxygen supply	233 (19.9)	176 (20.3)	57 (18.9)	0.59
Field triage decision scheme criteria*				
Physiological criteria				
SBP<90 mmHg	58 (5.0)	42 (4.8)	16 (5.3)	0.75
RR<10 or >29 /min	11 (0.9)	11 (1.3)	0 (0.0)	0.08
Non-Alert	429 (36.7)	343 (39.6)	86 (28.5)	<0.01
Anatomic criteria				
All penetrating injuries to head, neck, torso and extremities proximal to elbow or knee	34 (2.9)	23 (2.7)	11 (3.6)	0.38
Chest wall instability or deformity	4 (0.3)	4 (0.5)	0 (0.0)	0.58
Two or more proximal long bone fractures	19 (1.6)	13 (1.5)	6 (2.0)	0.60
Crush, degloved, mangled or pulseless extremity	15 (1.3)	13 (1.5)	2 (0.7)	0.38
Amputation proximal to wrist or ankle	9 (0.8)	9 (1.0)	0 (0.0)	0.12
Pelvic fractures	8 (0.7)	6 (0.7)	2 (0.7)	>0.95
Open or depressed skull fracture	17 (1.5)	9 (1.0)	8 (2.6)	0.05
Paralysis	21 (1.8)	11 (1.3)	10 (3.3)	0.02
Mechanism of injury criteria				
Fall > 6 meter	113 (9.7)	84 (9.7)	29 (9.6)	>0.95
High-risk auto crash	96 (8.2)	73 (8.4)	23 (7.6)	0.66
Auto vs pedestrian/bicyclist thrown, run over, or with significant (>30km/h) impact	119 (10.2)	83 (9.6)	36 (11.9)	0.25
Motorcycle crash > 30 km/hour	105 (9.0)	70 (8.1)	35 (11.6)	0.07
ED disposition				0.11
Discharge	320 (27.4)	241 (27.8)	79 (26.2)	
Transfer	444 (38.0)	316 (36.4)	128 (42.4)	
Admitted	366 (31.3)	276 (31.8)	90 (29.8)	
In-hospital mortality	90 (7.7)	74 (8.5)	16 (5.3)	0.07
Outcomes				
TBI	281 (24.0)	215 (24.8)	66 (21.9)	0.30
TBI with intracranial injury	251 (21.5)	195 (22.5)	56 (18.5)	0.15
TBI-related non-discharge	249 (21.3)	192 (22.1)	57 (18.9)	0.23
TBI-related death	43 (3.7)	32 (3.7)	11 (3.6)	>0.95

*EMS providers check specific criteria orderly from physiologic, anatomical, and mechanism of injury. If the

preceding criteria are satisfied, the information of the latter criteria is not collected.

IQR, interquartile range; SBP, systolic blood pressure; RR, respiratory rate; ED, emergency department; TBI,
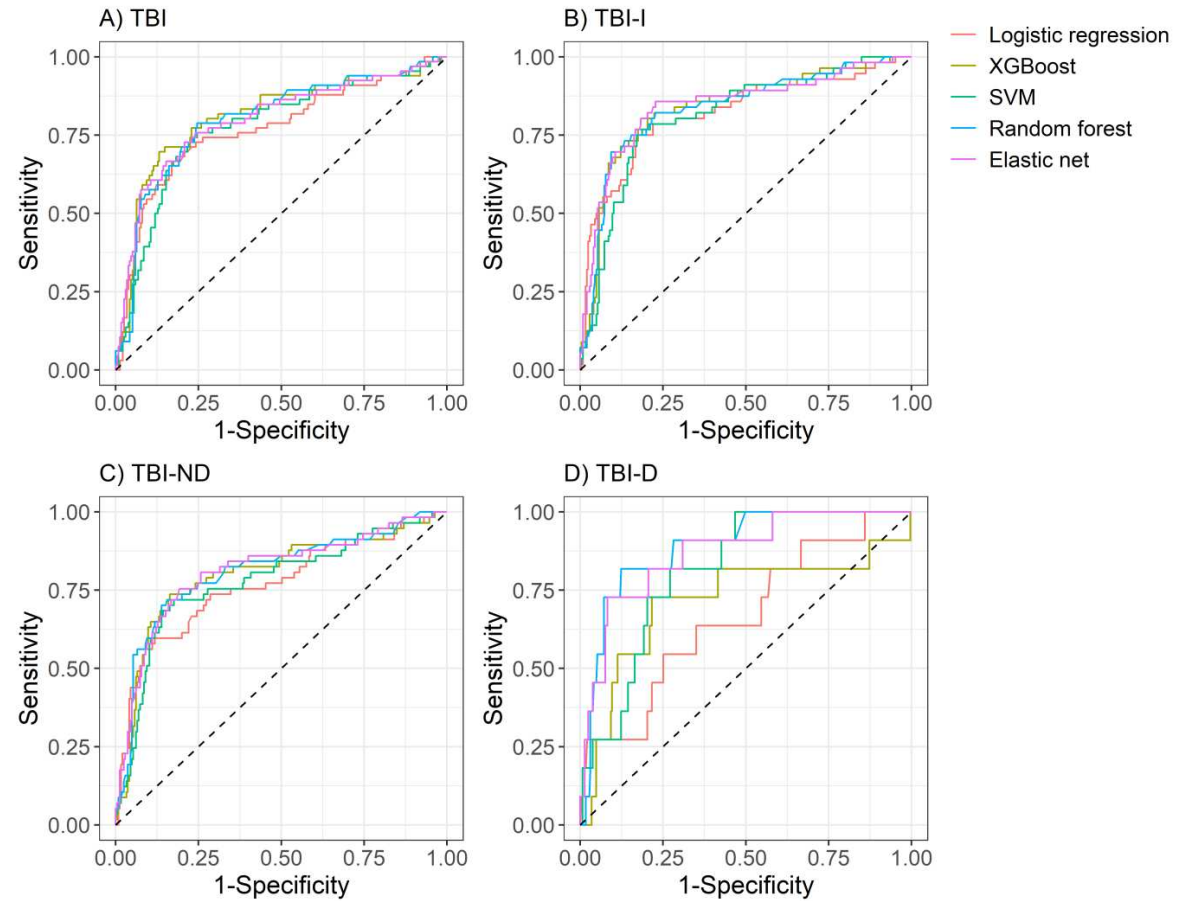
traumatic brain injury.

Supplementary Table 3. Hyperparameters of the final prediction models*

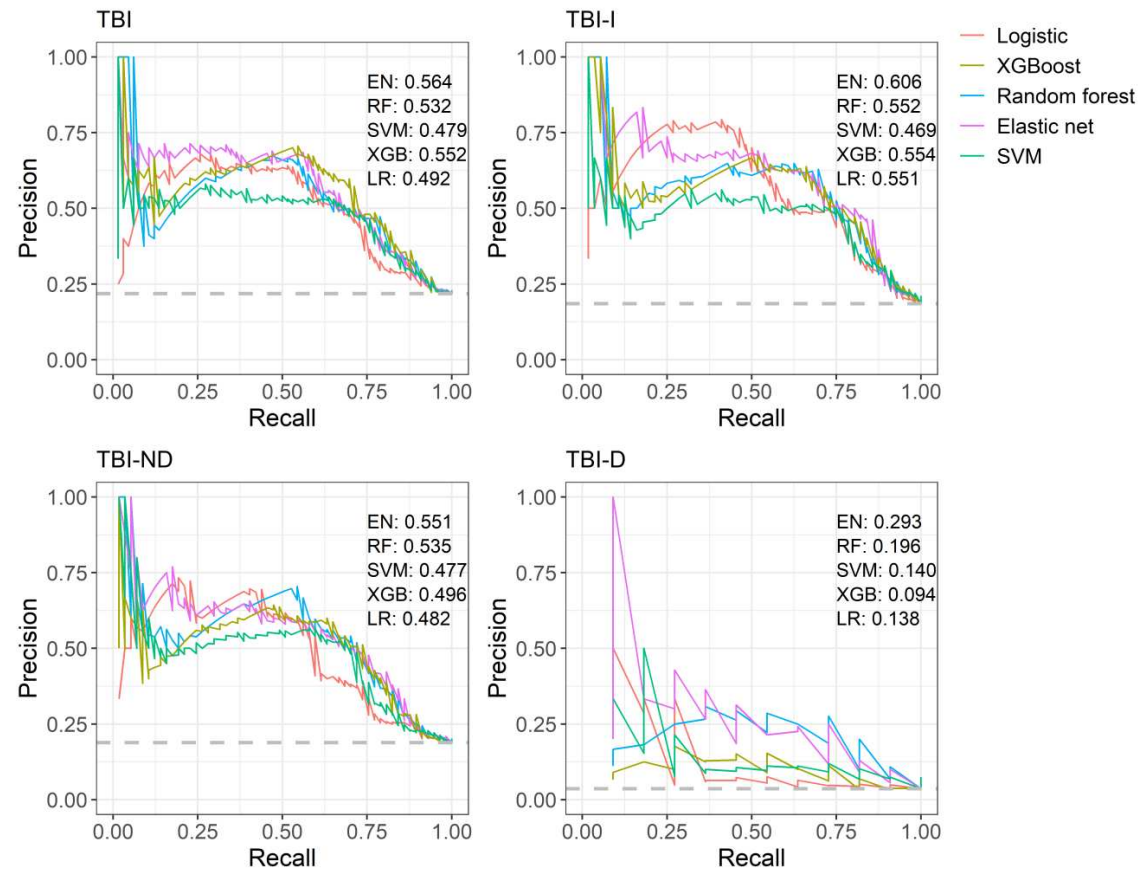| Model	Outcome	Hyperparameters
Elastic net	TBI	alpha: 0.325, lambda: 0.07506346
	TBI-I	alpha: 0.325, lambda: 0.07506346
	TBI-ND	alpha: 0.325, lambda: 0.07017153
	TBI-D	alpha: 0.325, lambda: 0.01565599
Random forest	TBI	ntree:500, mtry: 18
	TBI-I	ntree:500, mtry: 18
	TBI-ND	ntree:500, mtry: 18
	TBI-D	ntree:500, mtry: 15
Support vector machine	TBI	sigma: 0.008047; C: 4
	TBI-I	sigma: 0.008047; C: 4
	TBI-ND	sigma: 0.008047; C: 4
	TBI-D	sigma: 0.008047; C: 4
Extreme gradient boosting	TBI	nrounds: 299; max_depth: 1; eta: 0.4807096; gamma: 2.336623; colsample_bytree: 0.3657893; min_child_weight: 8; subsample: 0.8182623
	TBI-I	nrounds: 299; max_depth: 1; eta: 0.4807096; gamma: 2.336623; colsample_bytree: 0.3657893; min_child_weight: 8; subsample: 0.8182623
	TBI-ND	nrounds: 301; max_depth: 1; eta: 0.02154674; gamma: 4.696105; colsample_bytree: 0.590754; min_child_weight: 1; subsample: 0.5070866
	TBI-D	nrounds: 50; max_depth: 0.3; eta: 0.3; gamma: 0; colsample_bytree: 0.8; min_child_weight: 1; subsample: 0.5510204

*Aside from the hyperparameters mentioned, all other hyperparameters are used as the default value.

TBI, traumatic brain injury; TBI-I, TBI with intracranial hemorrhage or injury; TBI-ND, TBI non-discharge; TBI-D, TBI with death.

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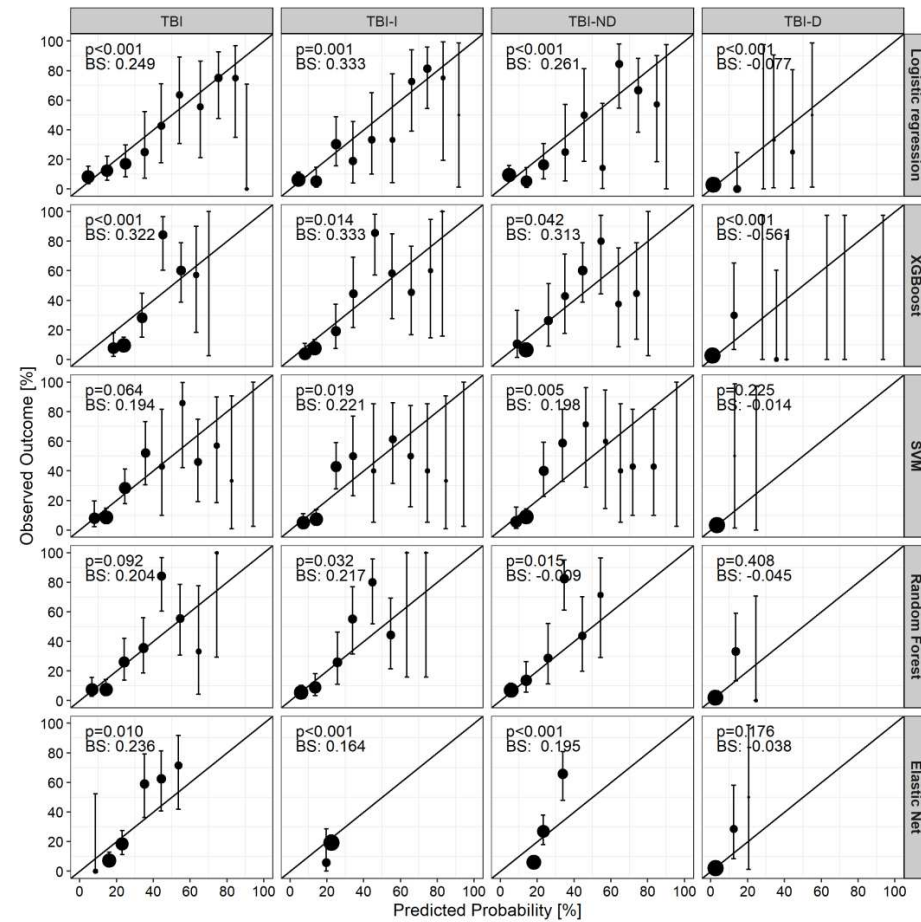
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Supplementary Figure 1. Receiver operating characteristics of prediction models according to outcomes. TBI, traumatic brain injury; TBI-I, TBI with intracranial hemorrhage or injury; TBI-ND, TBI non-discharge; TBI-D, TBI with death.

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Supplementary Figure 2. Precision-recall curve of prediction models according to outcomes. TBI, traumatic brain injury; TBI-I, TBI with intracranial hemorrhage or injury; TBI-ND, TBI non-discharge; TBI-D, TBI with death; LR, logistic regression analysis; XGB, extreme gradient boosting; RF, random forest, EN, elastic net.

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Supplementary Figure 3. Calibration plot of prediction models according to outcomes. TBI, traumatic brain injury; TBI-I, TBI with intracranial hemorrhage or injury; TBI-ND, TBI non-discharge; TBI-D, TBI with death; p, p-value of Hosmer-Lemeshow test; BS, scaled Brier score.

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Supplementary Table 4. Example of calculating false-positive patients for accurately identified patients. TBI, traumatic brain injury; EN, elastic net.
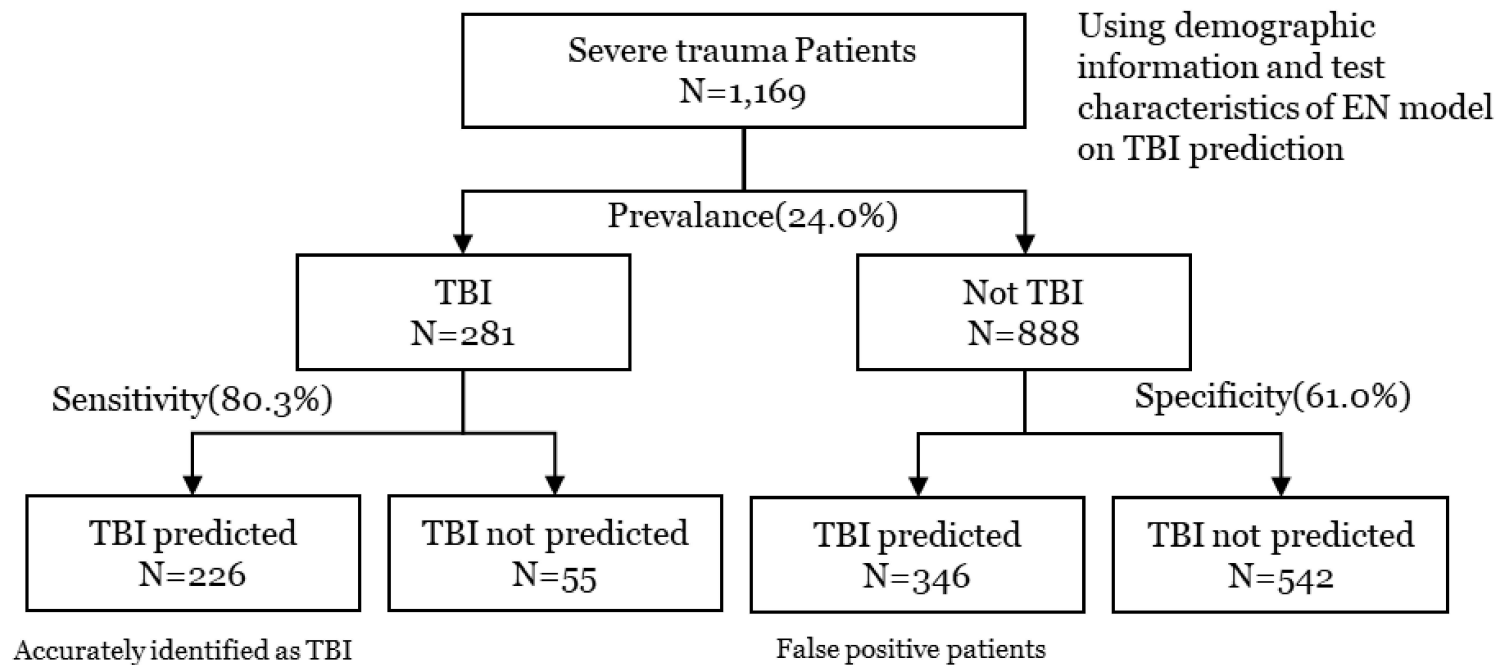
False-positive patients for every 10 patients that are accurately identified as TBI :
346/226 x 10 = 15.3, rounded up to 16 patients