Delirium prediction in patients with trauma and comparison of predictors across trauma center and non-trauma center

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Background

Delirium is an acute disorder of attention and cognitive decline, causing poor outcomes associated with high medical costs, long term cognitive impairment, morbidity, and mortality.[1] It is known to be commonly developed during hospitalization, showing the significantly high prevalence rates in patients with trauma. However, despite that its preventive effect of delirium screening tools is proved through previous studies, delirium is commonly misdiagnosed or unrecognized up to 70% of cases for its multifactor.[2] Also, the tools validated in specific medical settings are used generally for other types of patients including trauma cases. The aim of this study is to develop delirium prediction models for each trauma center, general ward, and intensive care unit, to compare the delirium predictors between them.

Methods

This study used a single electronic health record database of Ajou University School of Medicine (AUSOM) from 1996 to 2021. AUSOM was converted to Observational Medical Outcomes Partnership – Common Data Model (OMOP – CDM) format, a standardized medical database allowing distributed research networks.

We developed delirium prediction models for patients admitted to trauma center, general ward, and intensive care unit, respectively. Each cohort consisted of patients who stayed in each department more than one day, aged over 19 years, and had previous records of at least 365 days before the hospitalization. In addition, those who had a history of delirium, dementia, or organic mental disorder were excluded. The outcome event was defined as the first diagnosis of delirium within 28 days after the admission.

We set the covariates including gender, age, condition, drug, procedure, measurement, observation domains and Charlson Comorbidity index score on the prediction model. Once the model estimates the predictive values of features, we fitted top five most predictive variables into the model. Least Absolute Shrinkage and Selection Operator regression algorithm was explored to select features in 3-fold cross validation and the cohort data was randomly split into train (75%) and test (25%) set into the models. The performance of each model was evaluated in terms of Area Under the Receiver Operating characteristic Curve (AUROC), Area Under Precision – Recall Curve (AUPRC), f1 – score, and accuracy. We additionally examined the consistency of model performance across other patient traits based on AUROC of the model in the train set of other models. An open-source package (PatientLevelPrediction, version 4.3.10) and R software (version 4.0.3) were used to develop and validate the prediction model.

Results

Baseline characteristics

Table 1 shows the number of patients included in each cohort, grouped by delirium occurrence. Sixty four patients (1.3%) in the trauma cohort developed delirium during the observation period (delirium: 43 male

[67.2%]; age year, mean [SD]; 61.0 ± 18.8; non-delirium: 2,867 male [59.7%]; age year, mean [SD]; 57.3 ± 18.3;), and 122 patients [0.1%] in the general ward (delirium: 89 male [73.0%]; age year, mean [SD]; 63.0 ± 16.2; non-delirium: 51,551 male [46.2%]; age year, mean [SD]; 50.1 ± 16.6;). The delirium was occurred in 47 inpatients (0.8%) in the intensive care unit (delirium: 37 male [78.7%]; age year, mean [SD]; 60.6 ± 16.3; non-delirium: 3,540 male [60.6%]; age year, mean [SD]; 60.7 ± 15.6). Also, there were significant differences in the proportion of patients who developed delirium and not in each cohort. (Table 1)

Table 1. Baseline characteristics for study population with and without delirium in trauma center, general ward, and intensive care unit

Model	Trauma center			General ward			Intensive care unit		
Characteristics	**Delirium (n = 64)**	**Non-delirium (n = 4,803)**	**P-value**	**Delirium (N=122)**	**Non-delirium (N=111,693)**	**P-value**	**Delirium (N=47)**	**Non-delirium (N=5,845)**	**P-value**
Sex, n (%)			0.277			0.000*			0.017*
Female	21 (32.8%)	1936 (40.3%)		33 (27.0%)	60142 (53.8%)		10 (21.3%)	2305 (39.4%)	
Male	43 (67.2%)	2867 (59.7%)		89 (73.0%)	51551 (46.2%)		37 (78.7%)	3540 (60.6%)	
Age year, mean (SD)	61.0 ± 18.8	57.3 ± 18.3	0.105	63.0 ± 16.2	50.1 ± 16.6	0.000*	60.6 ± 16.3	60.7 ± 15.6	0.947
Age group, n (%)									
20 – 29	6 (9.4%)	478 (10.0%)	1.000	3 (2.5%)	14207 (12.7%)	0.001*	2 (4.3%)	266 (4.6%)	1.000
30 – 39	4 (6.2%)	414 (8.6%)	0.654	9 (7.4%)	17679 (15.8%)	0.015*	3 (6.4%)	327 (5.6%)	1.000
40 – 49	8 (12.5%)	633 (13.2%)	1.000	18 (14.8%)	23078 (20.7%)	0.134	7 (14.9%)	742 (12.7%)	0.817
50 – 59	8 (12.5%)	1012 (21.1%)	0.129	23 (18.9%)	22495 (20.1%)	0.809	13 (27.7%)	1162 (19.9%)	0.252
≥ 60	38 (59.4%)	2266 (47.2%)	0.069	69 (56.6%)	34234 (30.7%)	0.000*	22 (46.8%)	3348 (57.3%)	0.195
Smoker	4 (6.2)	1027 (21.4)	0.005*	9 (7.4%)	11072 (9.9%)	0.432	3 (6.4%)	800 (13.7%)	0.215
Sedation	0 (0.0%)	8 (0.2%)	1.000	67 (54.9%)	44343 (39.7%)	0.001*	26 (55.3%)	3851 (65.9%)	0.172
Hypertension	6 (9.4%)	1282 (26.7%)	0.003*	13 (10.7%)	22668 (20.3%)	0.011*	4 (8.5%)	1970 (33.7%)	0.000*
Type 2 Mellitus diabetes	3 (4.7%)	484 (10.1%)	0.223	5 (4.1%)	8711 (7.8%)	0.175	2 (4.3%)	773 (13.2%)	0.111
Heart disease	6 (9.4%)	477 (9.9%)	1.000	8 (6.6%)	10146 (9.1%)	0.416	5 (10.6%)	2101 (35.9%)	0.001*
Brain hemorrhage	15 (23.4%)	737 (15.3%)	0.108	7 (5.7%)	1073 (1.0%)	0.000*	7 (14.9%)	384 (6.6%)	0.047*
Infections	3 (4.7%)	221 (4.6%)	0.945	12 (9.8%)	6075 (5.4%)	0.157	4 (8.5%)	626 (10.7%)	0.862

Predictors

Each prediction model had different predictors. Those from the trauma model were nonsmoker, age group of 75–79, normal range of Prothrombin time, patient transfer and multiple injuries. Those selected from non-trauma center model were lorazepam, CT angiography of head, insertion of indwelling urethral catheter, non-smoker and non-drinker in the general ward model and general anesthetics, normal range of potassium in serum, non-drinker, female, and measurement of oxygen saturation in arterial blood by oximetry in the intensive care unit model. From this result, we could notice that the predictors of the trauma cohort were associated with acute and traumatic events, compared to those of the nontraumatic cohorts.

Model performance

The trauma center model had AUROC 0.859 (95% Confidence Interval [CI], 0.815–0.904), AUPRC 0.088, f1-score 0.077, and accuracy 0.720. Those of the general ward model were AUROC 0.797 (95% CI, 0.759–0.835), AUPRC 0.017, f1-score 0.019 and, accuracy 0.945 and, AUROC 0.778 (95% CI, 0.719–0.838), AUPRC 0.028, f1-score 0.034 and, accuracy 0.627 in the intensive care unit model. (Figure 1)

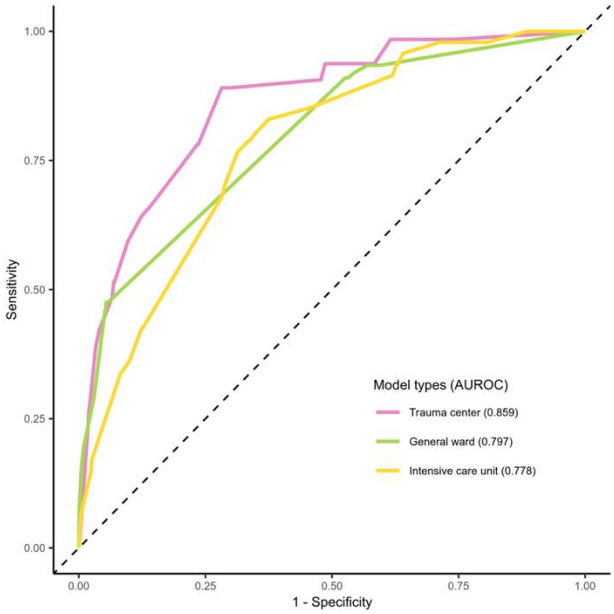

Figure 1. AUROC curves of trauma center, general ward, and intensive care unit delirium prediction model

The external validation was implemented by alternating the validation set of the model with the train set of other models and showed the changes in AUROC. The AUROC values of external validation were 0.677 (95% CI, 0.641–0.712) and 0.596 (95% CI, 0.536–0.655) as the trauma model was validated with the data of the general ward and the intensive care unit, respectively. As the general ward model used the data of trauma center and intensive care unit, the AUROC values were 0.717 (95% CI, 0.669–0.765) and 0.660 (95% CI, 0.591–0.728) respectively, and the intensive care unit model showed the AUROC 0.736 (95% CI, 0.676–0.796) and 0.797 (95% CI, 0.761–0.832) when validated in the data of trauma center and general ward, respectively. (Figure 2)

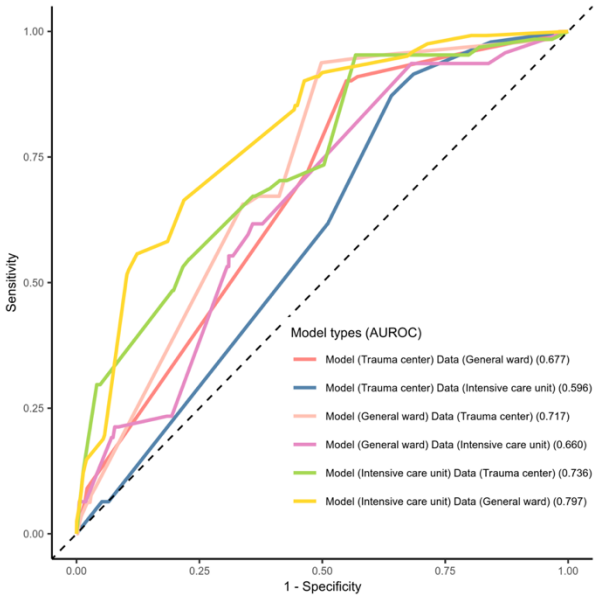

Figure 2. AUROC curve of delirium prediction models in alternative test sets of other models

Conclusion

We developed delirium prediction models for trauma center, general ward, and intensive care unit. The models revealed the remarkable differences in delirium predictors between trauma center and non-trauma center. The prediction models showed the average AUROC 0.811, but it changed in various ranges in external validation. This result suggests the need for development of a trauma specific delirium prediction model that reflects the different patient characteristics.

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