Supplemental Digital Content, Table 1. Studies using machine learning for predicting outcomes in trauma

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| **Author** | **Patients** | **Application** | **Technique(s)** | **Key Features** | **Results** |
| McGonigal et al. [10] | 8300 (Training: 3500, Testing: 4800) | Survival/mortality | ANN | RTS, ISS, age | Se: 0.904, Sp: 0.972 |
| Frye et al. [18] | 1585 (Training: 1427, Testing: 158) | Survival/mortality, LOS | ANN | inhalation injury, age, TBSA | Survival ACC: 0.098, LOS ACC: 0.072 |
| Rutledge et al. [19] | 114000 | Survival/mortality | ANN | data based on ICD-9 codes | Se: 0.994, Sp: 0.502 |
| Hadzikadic et al. [20] | 2155 (Training: 1940, Testing: 215) | Survival/mortality | DT | age, GCS, trauma score, ISS | Se: 0.867, Sp: 0.925 |
| Hadzikadic et al. [21] | 2155 (Training: 1940, Testing: 215) | Survival/mortality | DT | age, GCS, trauma score, ISS | Se: 0.867, Sp: 0.925 |
| Dybowski et al. [22] | 258 (Training:168, Testing: 90) | Survival/mortality | ANN | age, race, indicator for admission | Se: 0.864, Sp: 0.696, AUC: 0.863 |
| Lim et al. [23] | 6321 (Training: 2000, Testing: 4321) | Survival/mortality | ANN | ----- | ACC: 97.0, Se: 0.980, Sp: 0.714 (Dual Mode) |
| Izenberg et al. [24] | 897 (Training: 628, Testing: 269) | Survival/mortality | ANN | data from emergency room | ACC: 0.910 |
| Rutledge et al. [25] | 7276. | Survival/mortality, LOS | ANN | data based on ICD-9 codes | AUC: 0.980, R2: 0.535 |
| Edwards et al. [26] \* | 81 | Survival/mortality | ANN | age, race, GCS, MAP, PP, hematoma data | ACC: 100% |
| Marble et al. [27] | 515 (Training: 256, Testing: 259) | Morbidity | ANN | age, RR, SBP, GCS, RTS, ISS, indicator for admission | Se: 1.000, Sp: 0.965 |
| DiRusso et al. [28] | 10609 (Training: 5168, Testing: 2768, 2673) | Survival/mortality | ANN | GCS, ISS, age, SBP | AUC: 0.912, R2: 0.950 |
| Hunter et al. [29] | 15055 (Training: 7224, Testing: 7831) | Survival/mortality | ANN | age, GCS Motor | AUC: 0.955 |
| Becalick et al. [30] | 2042, (Training: 1365, Testing: 677) | Survival/mortality | ANN | age, GCS, ISS | ACC: 0.896, Se: 0.869, Sp: 0.857, AUC: 0.921 |
| Demsar et al. [31] | 68 | Survival/mortality | DT, NB | pH, thromboplastin time | DT Se: 0.822, Sp: 0.696, NB Se: 0.800, Sp: 0.826 (Entropy) |
| Estahbanati et al. [32] | 2096 (Training: 1572, Testing: 524) | Survival/mortality | ANN | inhalation injury, age, TBSA, gender | ACC: 0.900 |
| DiRusso et al. [33] | 35385 (Training: 27385, Testing: 8000) | Survival/mortality | ANN | ISS, GCS motor, SBP | AUC: 0.961 |
| Paetz et al. [34] | 1698 (Training: 748, Testing: 748) | Septic shock | ANN | CVP, Temp, pH, Sodium, HR, SBP | Testing ACC: 0.690, Se: 0.150, Sp: 0.923 |
| Walczak et al. [35] | 1016 | Transfusion | ANN | data from emergency room | ----- |
| Fuller et al. [36] | 2792 (Training: 1464, Testing: 1328) | Survival/mortality | ANN | ISS, trauma score, age, gender, injury | Training ACC: 0.923, Testing ACC: 0.949 |
| Eftekhar et al. [37] | 1271 (Training: 839, Testing: 432) | Survival/mortality | ANN | GCS, intubation, age, SBP, RR, HR, ISS | ACC: 0.951, AUC: 0.965 |
| Pearl et al. [38] | 7688 | Survival/mortality | ANN | Data based on RTS, GCS motor | ACC: 0.910 |
| Wolfe et al. [39] | 7219 (Training: 4014, Testing: 3205) | Survival/mortality, LOS | DT, ANN | GCS, injury, SBP, RR, HR, ISS | Death DT Se: 0.610, Sp: 0.650, ANN Se: 0.700, Sp: 0.800, AUC: 0.970, LOS DT Se: 0.700, Sp: 0.680, ANN Se: 0.840, Sp: 0.520 |
| Talbert et al. [40] | 27142 | Triage | DT | SBP, RR, GCS | ACC: 0.810, Se: 0.300, Sp: 0.960 (Admission or death prior to admission) |
| Chen et al. [41] | 627 | Hemorrhage | linear classifier | SBP, HR | AUC: 0.750 |
| Pang et al. [42] | 513 (Training: 462, Testing: 51) | TBI | DT, BBN, ANN | age, GCS, pupillary light response | DT ACC: 0.675, BBN ACC: 0.672, ANN ACC: 0.650 (Ten-fold) |
| Pearl et al. [43] | 1433024 (Training: 1217125, Testing: 215899) | Triage | ANN | age, SBP, RR, GCS motor | Survived ACC: 0.850, Died ACC: 0.661 (Gini coefficient: 0.615) |
| Chen et al. [44] | 627 | Hemorrhage | ensemble classifier | HR, RR, SBP, DBP, SaO2 | AUC: 0.760 (100 records) |
| Batchinsky et al. [45] | 262 (Training: 183, Testing: 79) | LSIs | ANN | ECG-derived (HRV, HRC) variables | AUC: 0.868 |
| Najarian et al. [46] | ----- | Hemorrhagic shock | SVM | ECG- and TCD-derived variables | ACC: 0.859 |
| Pearl et al. [47] | 1438035 (Training: 1222300, Testing: 215710) | LOS | ANN | Intubation, age, SBP, RR | Training ACC: 0.871, Testing ACC: 0.871 (Gini coefficient: 0.774) |
| Ji et al. [48] | 4172 | Survival/mortality, LOS | DT, SVM, ANN | age, GCS, SBP, HR, RR, intubation | Survival ACC: 0.897, LOS ACC: 0.931 (using rule-based system) |
| Yang et al. [49] | 1080 (Training: 972, Testing: 108) | LOS | SVM, DT | inhalation injury, age, gender, TBSA, various burn degrees | SVM MAE: 0.090, DT MAE: 0.092 |
| Rughani et al. [50] | 7869 (Training: 7769, Testing: 100) | Survival/mortality | ANN | age, gender, GCS, SBP | ACC: 0.878, Se: 0.986, Sp: 0.741, AUC: 0.860 |
| Tang et al. [51] | 28 | Severe septic shock | SVM | data from cardiovascular spectrum analysis | ACC: 0.8462, Se: 0.944, Sp: 0.625 |
| Jadinovic et al. [52] \* | 32 | Morbidity, LOS | BBN | ISS, albumin, red blood cell count, admission, APACHE II score, biomarkers | Morbidity Se: 0.929, Sp: 0.625, AUC: 0.790, LOS Se: 0.727, Sp: 0.842, AUC: 0.81 (with biomarkers) |
| Patil et al. [53] | 180 | Survival/mortality | BBN, SVM, ANN | age, gender, percentages of burns in eight areas of body | NB ACC: 0.980, DT/SVM ACC: 0.960, ANN ACC: 0.950 |
| Ribas et al. [54] | 400 | Survival/mortality | SVM | data based on SOFA and SAPS scores | SVM ACC: 0.802, Se: 0.793, Sp: 0.832, AUC |
| Hanisch et al. [55] | 382 (Training: 191, Testing: 191) | Survival/mortality | ANN | SBP, DBP, number of thrombocytes | AUC: 0.900 (within three days) |
| Davuluri et al. [56] | 12 | Hemorrhage | SVM | data from CT images (bone and hemorrhage segmentation) | ACC: 0.943 |
| Prichep et al. [57] | 633 | TBI | binary classifier | data from age regression, EEG | Se: 0.960, Sp: 0.780 (CT Group), Se: 0.810, Sp: 0.740 (Normal Group) |
| Stein et al. [58] \* | 52 | Survival/mortality | KNN, SVM | intracranial pressures and blood pressures | 1-NN ACC: 0.870, 3-NN ACC: 0.880, SVM ACC: 0.810 |
| Moulton et al. [59] \* | 184 | LSI, hemorrhage | KNN | data from noninvasive blood pressure waveform | R2: 0.940 (compensatory reserve index), R2: 0.890 (predicted decompensation) |
| Shi et al. [60] | 16956 (Training: 11304, Testing: 5652) | Survival/mortality | ANN | age, gender, comorbidities from ICD-9 codes | ACC: 0.952, AUC: 0.896 |
| Hubbard et al. [61] | 980 | Survival/mortality | SuperLearner | hematocrit, platelets, fibrinogen, sodium | Death AUC: 0.800 to 0.920, R2: 0.819 to 0.792 |
| Convertino et al. [62] \* | 302 | LSI, hemorrhage | KNN | data from photoplethysmogram signal | ----- |
| Schetinin et al. [63] | 571148 | Survival/mortality | BBN, DT | ISS, age, SBP, RR, GCS | ACC: 0.971 to 0.875, Se: 0.474 to 0.447, Sp: 0.994 to 0.956, AUC: 0.954 to 0.894 (injury groups) |
| Schetinin et al. [64] | 14840 | Survival/mortality | BBN, DT | SBP, head injury severity | ACC: 0.867, Se: 0.750, Sp: 0.890 (threshold: 0.74) |
| Kessler et al. [65] | 47466 | PTSD | RF, SuperLearner | traumatic experience variables | RF AUC: 0.960, SuperLearner AUC: 0.98 (Full Sample), RF AUC: 0.970, SuperLearner AUC: 0.96 (No Prior PTSD) |
| Galatzer-Levy et al. [66] | 957 | PTSD | SVM | Data from event characteristics, observations, and early symptoms | AUC: 0.770 (non-remitting PTSD), AUC: 0.780 (all) |
| Liu et al. [67] | 104 | LSIs | ANN | Mean HR, Total GCS, Minimum HRC | AUC: 0.990 |
| Liu et al. [68] | 103 | LSIs | ANN | HR, SBP, DBP, MAP, RR, PP, SI | ACC: 0.955, Se: 0.898, Sp: 0.983 (within 5 minutes) |
| Jiménez et al. [69] | 99 | Survival/mortality | Fuzzy classifier, DT, NB, ANN | TBSA, infections, previous conditions | Fuzzy classifier ACC: 0.930 |
| Scerbo et al. [70] | 1653 (Training: 1157, Testing: 496) | Triage | RF | SBP, HR, GCS | Se: 0.890, Sp: 0.420 |
| Ribas et al. [71] | 400 | Survival/mortality | SVM | data based on SOFA and SAPS scores | SVM ACC: 0.802, Se: 0.793, Sp: 0.832, AUC: 0.822 |
| Chapman et al. [72] | 60 | Triage (end-stage renal disease, trauma) | DT | thrombelastography patterns | ACC: 0.934 |
| Chong et al. [73] | 39 | TBI | ANN, ensemble classifier | traumatic experience variables | AUC: 0.98, Se: 0.949, Sp: 0.974 |
| Karstoft et al. [74] | 957 | PTSD | SVM | Data from event characteristics, observations, and early symptoms | Mean AUC: 0.75 |
| Stylianou et al. [75] | 66,661 | Survival/mortality | ANN, SVM, RF, NB | inhalation injury, age, TBSA, injury type, various burn degrees | Mean AUC: >0.95 |
| Bonds et al. [76] | 132 | TBI (secondary injury) | KNN regression | HR, SBP,MAP, ICP, SI, PP trends | Bland-Altman bias: ±0.02 |
| Karstoft\* [77] | 561 | PTSD | SVM | Data from event characteristics, observations, and early symptoms | AUCs: 0.84, 0.88 |
| Chen et al. [78] | 29 | Morbidity | SVM | Gene expressions | ACC: 0.862 (test set) |
| Mossadegh et al. [79] | 118 | Triage (injury) | NB | anatomical/ physiological parameters | Se: 0.909, Sp: 0.903, ACC: 0.906, AUC: 0.906 |
| Follin et al. [80] | 1160 | Triage | DT | basic variables on scene | Se: 0.940, Sp: 0.480, AUC: 0.820 |
| Sjogren et al. [81] | 20 | Hemorrhage (abdominal free fluid) | SVM | ultrasound image features | Se: 1.000, Sp: 0.900 |
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| \*  denotes prospective observational study. Remaining studies were all retrospective.  ACC: accuracy, ANN: artificial neural network, APACHE: Acute Physiology and Chronic Health Evaluation, BBN: Bayesian belief network, CT: computed tomography, CVP: central venous pressure, DBP: diastolic blood pressure, DT: decision tree, ECG: electrocardiogram, EEG: electroencephalogram, ER: emergency room, GCS: Glasgow coma score, HR: heart rate, HRC: heart-rate complexity, HRV: heart-rate variability, ICD: International Classification of Diseases, ICP: intracranial pressure, ISS: injury severity score, KNN: k-nearest neighbor algorithm, LOS: hospital length of stay, LSIs: life-saving interventions, MAE: mean absolute error, MAP: mean arterial pressure, NB: Naïve Bayes classifier, PP: pulse pressure, PTSD: post traumatic stress disorder, R2: correlation coefficient, RF: random forest, ROC AUC: receiver-operating characteristic curve area under the curve, RTS: revised trauma score, RR: respiratory rate, SaO2: saturation of oxygen, SAPS: simplified acute physiology score, SBP: systolic blood pressure, Se: sensitivity, SI: shock index, SOFA: sequential organ failure assessment, Sp: specificity, SVM: support vector machines, TBI: traumatic brain injury, TBSA: total body surface area burned, TCD: transcranial Doppler, Temp: temperature | | | | | |