

## Appendix I: Monitoring, Detection, and Diagnosis

Article Refs	Learning Models	Variables	Cohort Size	Single center/ Multi center	Infants/Children/Adults	Evaluation Methods
Eshelman LJ, et al.[12]	support vector machines (SVM) and neural nets (NN)	BUN(blood urea nitrogen), WBC (white blood cellcount), PTT (partial thromboplastin time), hematocrit, HR, systolic BP (arterial if available, otherwise noninvasive), and Oxi (oxygenation index = Fraction of Inspired Oxygen*Mean Airway Presssure/PaO2).	12695	Single center, MIMIC II	Adults	sensitivity and specificity
Quinn JA, et al. [13]	(F)SLDS, GS, RBPF, FHMM	Core body temperature(°C), Diastolic blood pressure(mmHg), Heart rate(bpm), Peripheral body temperature(C), Saturation of oxygen in pulse(%), Systolic blood pressure(mmHg), Transcutaneous partial pressure of CO2(kPa), Transcutaneous partial pressure of O2(kPa),	15	Single center	Infants	AUC, EER
Charbonnier S, et al.[14]	decision tree	hemodynamic parameters (systolic, mean and diastolic blood pressures, heart rate, oxygen saturation) or respiratory parameters (volume expired, respiratory rate, minute ventilation, maximal pressure in the airways).	10	Multi center	Adults	External observer evaluation
Zhang Y, et al. [15]	Classification tree and neural network learning	heart rate derived from ECG waveforms, pulse rate fromplethysmography, respiration rate, blood pressure (systolic, diastolic and mean),	11	Single center	Children	sensitivity, specificity, positive predictive value, and accuracy

		either arterial or measured by non-invasive means, arterial and venous oxygen saturation, and oxygen perfusion				
Kwok HF, et al. [16]	A linear regression model and a non-linear adaptive neuro-fuzzy inference system (ANFIS) model	age, gender, weight, height, body temperature, Hb, arterial pH, bicarbonate concentration, CO and VO <sub>2</sub> , FiO <sub>2</sub> , positive end-expiratory pressure (PEEP), ventilatory rate (RR), tidal volume, peak inspiratory pressure (PIP), inspiratory time and inspiratory to expiratory ratio (I:E ratio)	40 (202 data sets)	Single center	Adults	The mean squared control error
Rehm GB, et al. [17]	(i) Random Forest (RF), (ii) Multilayer Perceptron (MLP), (iii) Extremely Randomized Trees classifier (ERTC), (iv) Gradient Boosted classifier (GBC)	TV <sub>i</sub> , TV <sub>e</sub> , TV <sub>e</sub> /TV <sub>i</sub> , I-time, E-time, I:E ratio, RR	35 patients, 9719 breaths	Single center	Adults	true positive, true negative, false positive, and false negative counts, sensitivity and specificity
Gholami B, et al. [18]	Random Forests	mechanical ventilation waveform	11	Single center	Adults	sensitivity, specificity, the kappa coefficients
Koolen N, et al. [19]	support vector machine classifier	Patients (N), Gender (M/F), PSGs per patient, Number of all PSG studies, Birth Weight (g), Gestational Age (wks), Postmenstrual Age (wks), IVH any 14, IVH severe (III-III+)	231 EEG recordings from 67 infants	Single center	Infants	accuracy, sensitivity, specificity
Farzaneh N, et al. [20]	deep convolutional neural	Age, Radial distance, Azimuth angle, Elevation angle, Distance to skull, Minimum, Maximum,	110	Single center	Adults	F1, recall, specificity

	network model, random forest model	Average, Standard deviation, Skewness, Kurtosis, Entropy, Gabor, Laplacian of Gaussian				
Golmohammadi M, et al.[21]	hidden Markov models (HMMs), deep learning	EEG recordings	518	Single center	Adults	Sensitivity, Specificity, DET curve
Sorani MD, et al.[22]	hierarchical clustering	MAP, ABP-systolic, ABP-diastolic, ICP ETCO, SvO, HR, CPP, SpO2, Core Temp PaO2, Brain Temp, Plateau pressure, PEEP breathing pressure, Peak breathing pressure, Tidal volume, Spontaneous minute volume, Minute ventilation, Respiratory rate , Inspired O2	23	Single center	Adults	Heat map
Rueckel J, et al. [11]	deep neural network	Age, Sex, C-reactive protein, Intubated at the time of image acquisition, Tracheal tube inserted, Pneumonia in clinical supine chest radiograph, underlying primary disease, etc.	166	Multi center, the public NIH Chest-XRay14 and PLCO dataset	Adults	receiver-operating characteristic curve, sensitivity, specificity, positive predictive value, negative predictive value, and accuracy
Calvert J, et al. [23]	logistic regression	blood oxygen saturation, heart rate, pH, pulse pressure, respiration rate, systolic blood pressure, temperature, and white blood cell count.	29, 083	Single center, MIMIC III	Adults	AUROC

## Appendix II: Early Identification or Prediction of Clinical Events

Article Refs	Learning	Variables	Cohort Size	Single center/	Infants/	Evaluation
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	Models			Multi center	Children/Adults	Methods
Sun M, et al.[26]	Logistic regression (LR), random forest (RF), multinomial naïve Bayes (NB), supported vector machine (SVM) classifiers and mixed-feature Convolutional Neural Network	Age, Gender, Ethnicity, Heart rate maximum, Heart rate mean, Systolic BP minimum, Systolic BP mean, Diastolic BP minimum, Diastolic BP mean, Temperature maximum, SpO2 minimum, SpO2 mean, Glucose level maximum, Bicarbonate level minimum, Creatinine level minimum, Creatinine level maximum, Hemoglobin level minimum, Platelet count minimum, Potassium level maximum, Partial thromboplastin time minimum, Partial thromboplastin time maximum, International normalized ratio minimum, International normalized ratio maximum, Prothrombin time minimum, Prothrombin time maximum, Blood urea nitrogen level maximum, White blood cell count maximum, Calcium level minimum, Average urine output, Estimated glomerular filtration rate, Mechanical Ventilation	14, 469	Single center, MIMIC III	Adults	AUC
Soliman IW, et al.[25]	multivariable Poisson regression model	serum creatinine, urine output per hour within the first 24 hours, age, sex, pre-ICU hospital length of stay, admission type, Charlson Comorbidity Index, the need for mechanical ventilation, confirmed infection, the acute physiology score (APS, as part of the APACHE II score)	2420	Single center	Adults	RR 95% CI, P value
Sanchez-Pinto LN, et al.[27]	multivariate linear regression models	UIb, VASb, age, BMI, Charlson comorbidity index, hospital days prior ICU admission, APACHE II, SOFA, TISS-28, NEMS, sub oncological, sub	1, 953	Single center	Adults	R2(proportion of explained variance), adjust R2, the root of the cross-

		hematological, sub cirrhosis, sub elderly ( $\geq 80$ years), gender, previous hospitalization in the past 6 months, admission during weekend, admission unplanned, DNR, MV, VP, RRT, surgery, medical imaging, tracheotomy, transfusion, living situation at baseline, ADL, origin of hospital admission, origin of ICU admission, baseline work, main ICU diagnosis				validated prediction error
Fadlalla AM, et al.[28]	decision trees, neural networks, and logistic regression analysis models	Intensive care unit stay, Age, Max. body temperature, Max. leukocyte count, Injury Severity Score, Sex, Mechanism of injury, Presence of a central line, Presence of mechanical ventilation, Use of antibiotics the day prior to cultures, Fever or leukocytosis	510	Single center	Adults	sensitivity, accuracy, discrimination
Nemati S, et al. [29]	a modified Weibull-Cox proportional hazards model	age, gender, ethnicity, Mean Arterial Pressure (MAP), Heart Rate (HR), Peripheral capillary Oxygen Saturation (SpO2), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Respiration Rate (RESP), etc.	27, 000 / 42, 000	Multi center	Adults	AUROC, prediction task (tsepsis, tSOFA, tonset) and prediction window (n = 4, 6, 8, and 12 hr), sensitivity, Accuracy
Kam HJ, et al. [30]	InSight, Deep feedforward networks, LSTM	systolic blood pressure, pulse pressure, heart rate, body temperature, respiration rate, white blood cell count, pH, blood oxygen saturation, age	5, 789	Single center, MIMIC II	Adults	AUROC, Sensitivity, Specificity, Accuracy
Kaji DA, et al. [31]	LSTM	RBCs, WBCs, platelets, hemoglobin, hemocrit, atypical lymphocytes, bands, basophils, etc.	56841	Single center, MIMIC-III	Adults	auroc, positive predictive value, sensitivity
Scherpf M, , et al.[32]	recurrent neural network	patient age, systolic blood pressure, diastolic blood pressure, pH value, blood oxygen saturation (SO2), temperature, heart rate, respiratory	34334	Single center, MIMIC III	Adults	AUROC, sensitivity

		rate, CO2 partial pressure(PaCO2), white blood cell count, etc.				
Wang SL, et al. [33]	SVM	age, gender, cause of sepsis, IL-6, CRP, historical outcomes (mild or severe)	1000	Single center	Adults	sensitivity, specificity, auroc
Desautels T, et al.[34]	InSight	ICU type, Gender, Age, Length of stay , Death during hospital stay, GCS, Heart rate, Respiration rate, Spo2, Temperature, NIDiasABP, NISysABP, SysABP, DiasABP	22, 853	Single center, MIMIC III	Adults	area under the receiver operating characteristic curves (AUROC) and area under precision-recall curves (APR), F1, DOR
Mao Q, et al.[35]	gradient tree boosting	Gender, Age, Length of stay (days) in ICU, Death during hospital stay, ICD-9 code, Gold standard, InSight (95%CI), InSight label definitions removed (95%CI), MEWS, SOFA, SIRS	111, 957	Multi center	Adults	AUROC, Sensitivity, Specificity
Metsvaht T, et al.[36]	stepwise multiple logistic regression (MLR) analysis, classification, regression tree analysis	blood cell count (WBC), differential and ratio of immature to total neutrophil count (I/T ratio), C-reactive protein (CRP), serum glucose and total bilirubin, serum albumin, creatinine, urea and liver function tests(LFT) , birth weight (BW) , gestational age (GA), first and fifth minute Apgar score, need for respiratory support in the delivery room, age at intubation, surfactant administration, need and duration of sustained respiratory support, age on admission to NICU, time and type of initial and subsequent AB regimens, need for vasoactive therapy within the first three days of life with number of agents used, intolerance of enteral feeding, defined as less than	283	Single center	Infants	Sensitivity, Specificity, Positive predictive value, Negative predictive value

		10% of total calories supplied via the enteral route				
Mani S, et al. [37]	support vector machine (SVM), naive Bayes (NB), averaged one dependence estimators (AODE), K-nearest neighbor, decision tree, random forests (RF), logistic regression (LR), lazy Bayesian rules (LBR)	Atyp Lymphs, Ax Temp, Baso (ABS), Base Excess Arterial, Base Excess Venous, Basophils, Base Excess Capillary, Bicarbonate, PCO2 Capillary, pH Capillary, Bilirubin Conjugated, CMB Temperature, C-Reactive Protein, CUM Transfusion, Calcium Ionized, Creatinine Blood, EO Automated Abs, Eosinophil , Glucose Whole Blood, Glucose Blood, etc.	299	Single center	Infants	AUROC, sensitivity, specificity, PPV, NPV
Shahin J, et al. [38]	multivariable logistic regression models	Age, sex, Severe comorbidities, APACHE II Score, ICNARC Physiology Score, Primary reason for admission to the critical care unit, Length of stay , Critical care unit stay, etc.	60, 778	Multi center	Adults	c index, Brier's score
Sauthier MS, et al.[40]	random forests machine learning algorithms and logistic regression	Age, Gender, ICU days, Pediatric Risk of Mortality II score, Hospital mortality, Highest hypoxemia severity (days 1 and 2), None or minimal, Mild, Moderate, Severe, Arterial blood sample, etc.	258	Multi center	Children	AUROC
Messinger AI, et al.[39]	Neural networks	charted PAS score, respiratory support and medications	128	Single center	Children	median absolute error
Le S, et al.[41]	gradient boosted tree models	Age, Antibiotics, Bilirubine, Blood Culture, Creatinine, Diastolic BP, Fluid Bolus, GCS, HR, INR, Lactatey MAP, Organ Dysfuncione PP, Platelets+Resp.Ratev SpO2, Systolic BP, Temp, Urine Outpute WBC, pH	9, 251	Single center, MIMIC III	Adults	AUROC, Sensitivity, Specificity, F1, DOR, LR+, LR-, Accuracy, Recall
Hsu JC, et al. [42]	SVM embedded with a radial basis function	APACHE II Score, GSC, blood biochemistry test (BUN, Cr, Albumin, Hemoglobin), days using	380	Single center	Adults	Sensitivity, accuracy, specificity,

	(RBF) kernel.	mechanical ventilator, ventilatory variable, arterial PaCo <sub>2</sub> , and PaO <sub>2</sub> /FiO <sub>2</sub> . The respiratory variables, including minute ventilation, respiratory rate (f), tidal volume (VT), and P0.1 (pressure of 0.1 second after starting expiration), displayed on the ventilator were recorded at the first minute, 30th minute, 60th minute of the SBT.				log2C, Log2g
Miu T, et al.[43]	logistic regression	Tidal volume, Breathing frequency, Minute ventilation, PEEP, FIO <sub>2</sub> , SpO <sub>2</sub> , Suctioning frequency, Secretions quantity score, Positive cuff leak, Heart rate, Systolic blood pressure, Diastolic blood pressure, Mean arterial pressure, Glasgow coma score, Positive cough, Positive gag, Positive corneal, Pupil size, Pupil reaction, Admission SAPS II, Number of prior spontaneous breathing trials, pH, PaCO <sub>2</sub> , PaO <sub>2</sub> , PaO <sub>2</sub> /FIO <sub>2</sub> , Intracranial pressure, oxygenation	2007	Single center	Adults	auroc
Isbister GK, et al.[44]	A fully Bayesian approach using logistic regression and time-to-event analysis	patient demographics (age, sex), ingestion details [amount (mg) ingested and estimated time of ingestion], major interventions (mechanical ventilation and duration of ventilation, administration and time of SDAC) and cardiovascular support (intravenous fluids, inotropes), etc.	176	Single center	Adults	Adjusted odds ratios
Ghazal S, et al. [45]	ANN classifier, Bootstrap aggregation of complex decision trees	Age, Weight, Heart Rate, Pulse, Ventilator settings, FiO <sub>2</sub> , PEEP, Vt, PS above PEEP, PC above PEEP, Ventilator measures, Expiratory minute volume, 1/E ratio, Measured RR, Mean airway pressure, Peak airway pressure	610	Single center	Adults	Precision, Recall, F-score



Rodríguez A, et al.[46]	CHAID decision-tree analysis	age, sex, comorbidities, Sequential Organ Failure Assessment (SOFA) score, time between symptom onset and ICU or hospital admission, laboratory testing (hemoglobin, count of leukocytes, serum creatinine, etc.	1, 898	Multi center	Adults	sensitivity, specificity, positive and negative predictive values, and positive or negative likelihood ratio.
Lin PC, et al.[47]	xgboost	Sex, age, weight, Glasgow Coma Scale, temperature (Celsius), heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, BUN, creatinine, hemoglobin, WBC count, platelet count, INR, total bilirubin, Hb, pH, SpO2, FiO2, PaCO2, HCO3, CO2 (mEqL), lactate, fluid input, fluid balance, urine output	19275	Single center, MIMIC-III	Adults	AUC, Sensitivity, Specificity, Precision, F-score, Accuracy
Pappada SM, et al.[48]	Artificial Neural Network	24 Hour time stamp, Real-time Sensor Blood Glucose Value, POC Blood Glucose Value, Hours since last POC Value, Blood Oxygen Saturation, Heart Rate, Respiration Rate, Systolic BP, Diastolic BP, etc.	127	Single center	Adults	the percentage of the mean absolute difference (MAD %)
Mamandipoor B, et al.[49]	Lasso regression, Random Forest, LSTM	gender, age, ethnicity, admission weight, Respiratory Rate, O2 Saturation, FiO2, glucose, potassium, sodium, Hgb, chloride, creatinine, BUN, bicarbonate, LPM O2, etc.	13464	Multi center	Adults	Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and R-squared (R2)
Su L, et al.[50]	random forest, support vector machine, adaptive boosting(AdaBoost), extreme gradient boosting, and shallow neural	age, ethnicity, gender, initial heparin dose, interval between initial heparin injection and first measurement of activated partial thromboplastin time, creatinine concentration, type of admission, the aspartate aminotransferase to alanine, aminotransferase ratio (AST/ALT ratio)	3364	Multi center	Adults	precision, recall, F1 score, accuracy

	network					
Yu L, et al.[51]	convolutional neural network (CNN)	Na (sodium), K (potassium), Cl (chloride) and HCO <sub>3</sub> (serum bicarbonate), Ca (total calcium), Mg (magnesium) and PO <sub>4</sub> (phosphate), BUN (blood urea nitrogen), Cr (creatinine), Hgb (hemoglobin), Plt (platelet count), WBC (white blood count)	41113	Single center, MIMIC III	Adults	Accuracy
Cismondi F, et al.[52]	fuzzy modeling	heart rate, oxygen saturation, respiratory rate, temperature, blood pressure, urine collections, infusion products and transfusions, calcium, PTT, hematocrit, fibrinogen, lactate, platelets, INR, hemoglobin.	746	Single center, MIMIC II	Adults	accuracy, Sensitivity, specificity
Li K, et al.[53]	random forest or logistic regression	age and gender, Admission HR divided by SBP	1385	Single center	Adults	The area under the receiver operating characteristic curve (AUROC), classification accuracy, precision, F1 score, and recall
Oh SH, et al.[54]	logistic regression	age, medications, altered levels of consciousness, dependent physical activity, intake and output imbalance, abnormal blood pressure and pulse, PaO <sub>2</sub> , glucose levels, white blood cell counts, platelet counts, levels of potassium, phosphorus, magnesium, low-density lipoprotein, total protein	1835	Single center	Adults	degree of conformity, sensitivity, specificity, negative predictive value, auroc, accuracy, Kappa
Milbrandt EB, et al.[55]	logistic regression	Subjects, Age, Race, Gender, Comorbidity, Diabetes, Pulmonary disease, Renal disease, Liver disease, Peripheral vascular disease, Cerebrovascular disease, Myocardial infarction, BMI, Medical, Emergency surgery, Trauma case, Admission diagnosis, Cardiovascular,	5, 170	Single center	Adults	receiver operating characteristic curve areas

		Respiratory, Gastrointestinal, Neurologic, Sepsis, Nonoperative trauma, Metabolic, Renal, Other medical, Surgical, Other surgical, APACHE II score, ICU LOS, Hospital LOS days, Hospital mortality , Physiologic and therapeutic measures within 6 hours of ICU admission Hemoglobin, Lactate more than 1.5 mg/dl, Creatinine at least 1.6 mg/dl , INR more than 1.9, Inotropes, Mechanical ventilation , Transfusion				
Fialho AS, et al. [56]	Fuzzy Modeling	Arterial base excess, Lactic Acid, Platelets, Sodium, Non-invasive systolic blood pressure, White blood cells, SOFA, BUN, Creatinine SpO2, Temperature	2, 944	Single center, MIMIC II	Adults	Values of AUC, sensitivity, specificity and goodness of fit

### Appendix III: Outcome Evaluation and Prognostic Assessment

Article Refs	Learning Models	Variables	Cohort Size	Single center/ Multi center	Infants/ Children/Adults	Evaluation Methods
Ghose S, et al. [57]	Random Forest	age, gender, height, weight, ICU type, Blood Pressure(diastolic, mean, systolic), Albumin, Alkaline phosphate, Alkaline transaminase, Aspartate transaminase, Bilirubin, Blood urea nitrogen, Cholesterol, Creatinine, Fractional inspired oxygen, Glasgow Coma Score, Glucose, Serum bicarbonate,	4000	Single center, a publicly available dataset released by the PhysioNet challenge	Adults	TPR, FPR, PPV, NPV, accuracy, auroc

		Hematocrit, Heart rate, Serum potassium, Lactate, Serum magnesium, Mechanical ventilation, Serum sodium, PaCO <sub>2</sub> , PaO <sub>2</sub> , pH, Platelets, Respiration rate, SaO <sub>2</sub> , Temperature, Troponin-I, Troponin-T, Urine output, WBC				
Venugopalan J, et al.[58]	logistic regression, feedforward neural networks and conditional random fields	Gender, Age, Height, Weight, Ethnicity, Comorbidity, Urea, Albumin, Bilirubin, Creatinine, Sodium, HR, BP, Arterial PH, Arterial PaCO <sub>2</sub> , Arterial PaO <sub>2</sub> , etc.	32, 331	Single center, MIMIC-II	Adults	Matthews correlation coefficient (MCC) and accuracy
Ting HW, et al. [59]	Linear regression models	Sex, age, Alive/dead, Admission type, Disease type	154	Single center	Adults	t test, receiver operating characteristic (ROC) curve and Wilcoxon signed rank test
Sha Y, et al.[60]	logistic regression, SVM, RNN	sequential diagnostic codes	7, 537	Single center, MIMIC III	Adults	Matthews correlation coefficient, auroc, F1 score
Meiring C, et al. [61]	logistic regression, random forest, adaboost, support vector machine, neural network	Age, sex, admission, APACHE-II score, adrenaline (epinephrine), noradrenaline (norepinephrine), vasopressin, mechanical ventilation, heart rate (HR), arterial pressure (MAP), PaO <sub>2</sub> /FiO <sub>2</sub> ratio, sodium, potassium, lactate, creatinine, CRP, pH	22, 514	Single center	Adults	AUC
Bukan RI, et al. [62]	logistic regression model	age, sex, excessive alcohol consumption, medical or surgical background, APACHE II score, 2 SF-36 and SF-12 scores	318 patients	Single center	Adults	AUC
Hsieh YZ, et al. [63]	Neural Network, SVM	age, systolic arterial blood pressures (SABP), diastolic ABP (D-ABP), mean ABP (M-ABP), systolic noninvasive blood pressures (S-NBP), diastolic NBP (D-NBP), mean	300	Single center	Adults	accuracy, Confidence, Sensitivity, ROC curve

		NBP (M-NBP), respiratory rate (RR), heart rate (HR), body temperature (BT)				
Oeyen S, et al. [64]	multivariate linear regression models, LASSO	demographics, hospital days prior to ICU admission, living and work circumstances before ICU admission, hospitalization in the last 6 months, comorbidity, main ICU admission diagnosis, etc.	1953	Single center	Adults	R <sup>2</sup> , adjusted R <sup>2</sup> and the root of the cross-validated prediction error
de Lange DW, et al.[65]	Multivariable logistic regression	age, sex, reason for ICU admission categorized into 11 options, vasoactive drugs, Clinical Frailty Scale, SOFA score, intubation with mechanical ventilation, RRT	3730	Multi center	Adults	AUC, Brier score
Guidet B, et al. [66]	Principal Component Analysis, multivariable model	age, SOFA score, CPS, IQ code, Katz's scale and clinical frailty scale	3920	Multi center	Adults	HR (95%CI), p
Heyland DK, et al.[67]	multivariable logistic regression	Baseline PPS, Baseline Short Form-36 Physical Function, Age, Sex, Married, Acute Physiology and Chronic Health Evaluation II, Baseline Sequential Organ Failure Assessment score, Medical admission, Charlson Comorbidity Index, Functional Comorbidity Index, Primary diagnosis of trauma, Primary diagnosis of sepsis, Primary diagnosis of stroke, Primary diagnosis of emergency coronary artery bypass grafting or valve replacement, Dementia, Clinical frailty scale, Baseline Informant Questionnaire on Cognitive Decline in the Elderly $\geq 3.6$	434	Multi center	Adults	Odds Ratio, c, p
Puskarich M, et al.[68]	decision tree	age, chronic disease, lactate and five biomarkers	Not available	Multi center	Adults	sensitivity, specificity, positive

						predictive value, negative predictive value, auroc
Wong HR, et al. [69]	decision tree	five candidate biomarkers, admission lactate concentration, age, and chronic disease burden	881	Multi center	Adults	auroc, sensitivity, specificity, positive predictive value, negative predictive value
Jaimes F, et al. [70]	logistic regression and neural networks	age, immunosuppressive systemic disease, general systemic disease, Shock Index, temperature, respiratory rate, Glasgow Coma Scale score, leucocyte counts, platelet counts, creatinine	533 patients	Multi center	Adults	ROC curve and the Hosmer- Lemeshow goodness-of-fit test
Ribas Ripoll VJ, et al.[71]	soft-margin support vector machines Quotient Basis Kernel (QBK)	Gender, Age, ICU length of stay, Mechanical ventilation, Invasive blood pressure, Vasoactive medications, ICU mortality, SOFA , SAPS I	400	Single center, MIMIC II	Adults	correct rate, sensitivity, specificity, AUC
Sha Y, et al.[72]	Smith Waterman	hematocrit, potassium, sodium, creatinine, platelets, urea nitrogen, chloride, bicarbonate, anion gap, leukocytes, point-of-care (POC) glucose, oxygen saturation, arterial POC pH, arterial POC pCO2, arterial POC pO2, sodium, POC ionized calcium, potassium, calcium, glucose.	22, 870 from MIMIC-II; 4, 975 from CHOA	Multi center	Children	sensitivity and F- measure
Yang T, et al. [73]	logistic regression	diabetes, APACHE II score, serum osteopontin, serum interleukin 6, serum interleukin 18, urine output, urinary creatinine, serum neutrophil gelatinase-associated lipocalin, urinary IL-18, serum cystatin C, serum creatinine, urinary neutrophil gelatinase-associated lipocalin	102	Single center	Adults	auroc, sensitivity, specificity

Xu Z, et al.[74]	Logistic Regression (LR), L2 norm regularized Logistic Regression (Ridge), Random Forest (RF), and Gradient Boosting Decision Tree (GBDT)	Demographics, Medications, Comorbidities, Chart-events, Lab-events	58,976	Single center, MIMIC III	Adults	AUC, recall and precision
Trongtrakul K, et al.[75]	logistic regression	age, SOFA non-renal score, sepsis, emergency surgery, perioperative blood loss, perioperative urine output	3474	Single center	Adults	auroc, C-statistic, sensitivity, specificity, positive predictive value (PPV), and negative predictive value(NPV)
Bernal W, et al. [76]	Cox proportional hazards model	Age, Sex, Hepatic encephalopathy grade, Glasgow coma scale score, Cardiovascular failure, Mean arterial pressure, INR, Bilirubin, AST, Creatinine, Arterial pH, Arterial lactate	derivation set (n=350) and an validation set (n=150) and external validation dataset (n=412)	Multi center	Adults	area under receiver operating characteristic curve (AUROC), root mean square error (RMSE)
Lindenmeyer CC, et al.[77]	logistic regression analysis	Age, gender, co-morbidities, etiology of chronic liver disease, vital sign, platelet count, prothrombin time (PT), International normalized ratio, lactate, arterial blood gas, pH, 24-hour urine output, need for mechanical ventilation, etc.	436	Single center	Adults	AUROC
Balekian AA, et al. [78]	multivariable logistic regression	Male, Age in years, Race, APACHEII, MELD, MV, Dialysis, Sepsis, GI Bleed, Alcohol use, Direct ICU Admit, ICU LOS in days, Home	653	Multi center	Adults	AUROC

		discharge, Hospital transfe, SNF discharge, Left AMA, Hospice, Expired				
Santos HGD, et al.[79]	logistic regression, penalized logistic regression, artificial neural networks, basic decision trees, random forests, gradient boosted trees	Age, sex, BMI, Chronic renal failure, Chronic pulmonary failure, Chronic heart failure, Diabetes, Alcoholism, Use of steroids, Smoking, Estimated Glasgow Coma score, Total bilirubin, Body temperature, Creatinine, Heart rate, Leukocytes, pH, Platelets, Noradrenaline use, Average pressure, ECOG performance status, Delirium, Type of admission, Nosocomial infection, Respiratory infection, Invasive mechanical ventilation, health history related to cancer disease, current cancerrelated complications	777	Multi center	Adults	auroc, confusion matrix
Vincent F, et al. [80]	Logistic regression analyses	Systemic extension of the disease, Underlying tumor, Renal replacement therapy during ICU, Vasopressors, Mechanical ventilation	1, 053	Multi center	Adults	sensitivity, specificity, ROC curve
Lee S, et al.[81]	random forest classifiers	Age, Sex, Race, Hispanic, In-hospital cardiac arrest location, Witnessed cardiac arrest, Bystander CPR for out-of-hospital cardiac arrest, CPR duration, Initial rhythm, Asystole, Pulseless electrical activity, Bradycardia, Ventricular fibrillation or tachycardia, other/unknown, Cardiac arrest cause, Sudden infant death syndrome, Drowning, Shock, Respiratory failure, Trauma, Initial lactate, Lowest pH initial 24 h after cardiac arrest, Intubated, Induced hypothermia, Benzodiazepine infusion, Length of stay: ICU, Length of stay: hospital, Early EEG, Late EEG	87	Single center	Children	ROC/AUC, Sn/Sp, PPV/NPV
Murtuza B, et al.	Conditional	Weight, Ascending aorta size,	221	Single center	Infants	P value



[82]	inference tree modelling	Morphologic type, TR>mild, Impaired RV function pre-stage I, Restrictive IAS, Antenatal diagnosis, blood lactate clearance				
Gracia Arnillas MP, et al.[83]	the recursive partitioning and regression tree (RPART) method	age, sex, Hypertension, Diabetes mellitus, Headache, GCS, Hydrocephalia, Brain edema, Vasospasm, Fisher, Hunt-Hess, APACHE, Endovascular coiling, Neurosurgical clipping, Non treatment. MR-proADM	90	Single center	Adults	sensitivity, specificity, ROC curve and AUC
Haveman ME, et al.[84]	Random Forest classifier	Gender, Age in years, Injury Severity Score, ICU stay in days since trauma, EEG start in hours after trauma, EEG recording time in hours, ICP, Decompressive craniectomy, Medication administration, Propofol, Midazolam, Fentanyl, Noradrenaline	57	Single center	Adults	AUC
Wildman MJ, et al.[85]	multivariate logistic regression	FEV1, Respiratory rate, Weight loss in last 6 months, Katz Activity of Daily Living (ADL)score, BMI, Charlson co-morbidity score, Long term domiciliary oxygen treatment, Previous endotracheal intubation, Admitted to hospital in last 6 months, Ankle oedema, Abnormal shadow on chest X-ray, Reported prior quality of life, Congestive cardiac failure	832	Multi center	Adults	Hosmer-Lemeshow chi-sq, Slope CI, c (area under ROC curve), P (different to clinicians)
Daly K, et al. [86]	logistic regression model	acute physiology points, length of stay in intensive care, therapeutic intervention score, duration (days) on mechanical ventilation, dialysis, age, presence of chronic ill health, number of failing organs, whether or not the patient had had cardiothoracic surgery	13924	Single center	Adults	AUROC, sensitivity, specificity
Hernández-Tejedor A, et al. [87]	multi-variate logistic regression analysis	sex, Age, Dependency for basic activities of daily living, APACHE II at ICU admission, SOFA at ICU admission, SOFA the day before the	13, 456	Multi center	Adults	Receiver operating characteristic (ROC) curve,

		complication(day -1), SOFA the day of the complication (day 0), ICU mortality, Hospital mortality, ICU length of stay , Hospital length of stay, etc.				sensitivity, specificity, positive predictive values, negative predictive values
Ji SY, et al.[88]	Logistic, AdaBoost, C4.5, CART, SVM, RBF NN	age, gender, blood pressure, cheifcomp, airway, prefluids, GCS, heart rate, respiration rate, ISSHead&Neck, ISS, EDEYE, ED Verbal, EDRT, Head AIS, Thorax AIS, Abdomen AIS, Intubation, Prexcomor, Complications, Safety, Pluse, Position, ChiefComp, Blunt	2086	Multi center	Adults	accuracy, auroc
Che Z, et al.[89]	Linear Support Vector Machine (SVM), Logistic Regression (LR), Decision Trees (DT), Gradient Boosting Trees (GBT), DNN, GRU, GRU+DNN interpretable mimic learning method	It contains a set of 27 static features such as demographic information and admission diagnoses, and another set of 21 temporal features (recorded daily) PaO2, MAP, BE, FiO2, PF, $\delta$ PF, PH, PRISM12, PIM2S, VE, VI, etc.	398	Single center	Children	auroc, auprc
Ebadollahi S,et al.[90]	Similar Patients Metric, Locally Supervised Metric Learning (LSML )	mean ABP measure, systolic ABP, diastolic ABP, SpO2 and heart rate	1500	Single center, MIMIC II	Adults	Classification and Retrieval Accuracy, Patient Prognosis Accuracy
Castiñeira D, et al.[91]	logistic regressions, random forests, support vector machine approaches, and	heart rate, breathing frequency, pulse, SpO2, sex, age, pre-ICU admission location, elective admission, recovery after the procedure, cardiac bypass, diagnosis risk, lack of pupillary response,	284	Single center	Children	accuracy, auroc

	gradient boosted trees	mechanical ventilation, first systolic blood pressure, base excess, FIO2, PaO2				
Mueller M, et al. [92]	artificial neural network (ANN) and a multivariate logistic regression model (MLR).	AB(arterial blood gas), AB(cap. blood gas), Balanced pattern(no), Balanced pattern(yes), Extubation failureExtubation success Mode(AC), Mode(SIMV), Overventilated(no), Overventilated(yes), Ethnicity(black), Ethnicity (Other), Ethnicity(white), Sex(female), Sex(male), Age_D, APGAR1, APGAR5_1, BE, BP, CurrWeight, dBE, dBP, dFIO2, dHCO3, dIErat, dINSP, dMAP, dPaCO2dPaO, dPEEP, dPH, dPIP, dPulse, dRATE, dRRatio, dSaO2, dTIME, dVr, FiO2, Gst_age, HCO3, IEratio, INSP, Lag, MAP, Paco2, Pao2, PEEP, pH, PIP, Pulse, Rratio, Rate, Saline, SaO2, Theoph, Vr, TXBETAME	183	Multi center	Infants	AUC, ROC
Mueller M, et al. [93]	artificial neural network	AB(arterial blood gas), AB(cap. blood gas), Balanced pattern(no), Balanced pattern(yes), Extubation failureExtubation success Mode(AC), Mode(SIMV), Overventilated(no), Overventilated(yes), Ethnicity(black), Ethnicity (Other), Ethnicity(white), Sex(female), Sex(male), Age_D, APGAR1, APGAR5_1, BE, BP, CurrWeight, dBE, dBP, dFIO2, dHCO3, dIErat, dINSP, dMAP, dPaCO2dPaO, dPEEP, dPH, dPIP, dPulse, dRATE, dRRatio, dSaO2, dTIME, dVr, FiO2, Gst_age, HCO3, IEratio, INSP, Lag, MAP, Paco2, Pao2, PEEP, pH, PIP, Pulse, Rratio, Rate, Saline, SaO2,	183	Multi center	Infants	area under the ROC curve

		Theoph, Vr, TXBETAME				
Dunning J, et al. [94]	logistic regression, Recursive partitioning	Parsonnet score, LVEF, age, PA systolic pressure, Emergency re-operation, Current diuretic use for LVF, ejection fraction, IV nitrates, Parsonnet increment, creatinine, Redo operation	6991	Multi center	Adults	auroc, Sensitivity , Specificity, negative predictive value
Manji RA et al. [95]	Logistic regression	Age, Sex, Peripheral vascular disease, Renal insufficiency(creatinine >1.8mg/dL), Renal failure(dialysis), Cerebrovascular disease, Preoperative infection, Operative variables, Procedure, Isolated CABG, Single non-CABG procedure, Nonelective procedure, Selected ICU variables, Postoperative cardiac arrest, ECMO/VAD after cardiectomy, Cerebrovascular accident, Adult respiratory distress syndrome, Number of ventilation d(within first 10 d), Septic shock, Central line infection, Upper gastrointestinal bleeding, Acute renal failure(dialysis needed), ICULOS(d), Categorical variables, Preoperative renal failure(dialysis), ECMO/VAD after cardiectomy, Preoperative infection, Preoperative renal insufficiency (creatinine>1.8mg/dL), Cerebrovascular disease, Peripheral vascular disease, Female sex, Continuous variables, ICULOS beyond 5 d, Mechanical ventilation, Cardiopulmonary bypass time(per 30 min increase in bypass time), Ejection fraction grade(increase of 1 grader	9, 545 admissions	Multi center	Adults	Odds Ratio, 95% Confidence Interval, p Value
Brandi S, et al. [96]	equations of generalized	age, sex, indication for admission (elective, urgency, emergency), type	1, 815 consecutive	Single center	Children	AUROC

	estimation with binomial distribution, logistic function linking and structure of autoregressive correlation, multiple logistic model	of admission, outcome (transference, hospital discharge, discharge with homecare, or death), the use of mechanical ventilation, origin (pediatric unit, emergency unit, surgical center, pediatric outpatientunit, bone marrow transplantation or external), readmission within 48 hours, reason for admission (respiratory failure, sepsis, shock, post-operative, liver failure, neurology, hemodynamic monitoring, post-event monitoring, other), Paediatric Logistic Organ Dysfunction (PELOD) score, presence of venous access	admissions			
McWilliams CJ, et al.[97]	random forest, Logistic regression	Gender, Age, BMI, Length of stay, Discharge delay, In-hospital mortality, Readmission to ICU, Negative outcomes, airway, fio2, spo2, hco3, resp, bp, hr, pain, gcs, temp, haemoglobin, k, na, creatinine, bun	7592+1870	Multi center	Adults	AUROC, Accuracy, F1, Specificity, pAUROC, Brier, Sensitivity
Lin YW, et al. [98]	LSTM	Glasgow coma scale eye opening, Glasgow coma scale verbal response, Glasgow coma scale motor response, Glasgow coma scale total, Capillary refill rate, Diastolic blood pressure, Systolic blood pressure, Mean blood pressure, Heart Rate, Glucose, Fraction inspired oxygen, Oxygen saturation, Respiratory rate, Body Temperature, pH, Weight, Height, Gender, Age, Insurance Type, Race, Chronic diseases	35334	Single center, MIMIC-III	Adults	Accuracy, Precision, Recall, Sensitivity, AUROC, AUPRC
Czeiter E, et al.[99]	Univariable and multivariable analysis	S100B, neuron-specific enolase (NSE), GFAP, UCH-L1, neurofilament protein-light (NFL), and total tau (t-tau)	2867	Multi center	Adults	AUROC
Yin W, et al.	bivariate logistic	Gender, Age, APACHE II, Heart	451	Single center	Adults	

[100]	regression model	rate, Systolic blood pressure, Diastolic blood pressure, Mean blood pressure, Urine output per hour, Respiratory rate, PaO2/FiO2, Ventilation/Non-ventilation, PEEP, Length of mechanical ventilation, ICU length of stay, Hospital length of stay, ICU mortality, Hospital mortality, Respiratory disease, Severe pneumonia, AECOPD, ARDS, Others, Shock, Cardiac arrest, Heart failure, Renal failure, Liver failure, Acute obstructive suppurative cholangitis, Severe acute pancreatitis, Acute peritonitis, Bowel obstruction, Multiple trauma, Tumor, Stroke, CNS infection, Postoperative patients, Organ Transplantation, Burn				
Shickel B, et al. [101]	recurrent neural network (RNN)	MAP, Dopamine, Dobutamine, Epinephrine, Norepinephrine, FiO2, PaO2, SpO2, Ventilation, Creatinine, Urine, GCS, Bilirubin, Platelets	27660/35, 993	Multi center	Adults	AUC
McRae MP, et al.[102]	lasso logistic regression model	Age, Sex, cTnI, CK-MB, MYO, CRP, PCT	160	Multi center	Adults	AUC

#### Appendix IV: Treatment Decisions

Article Refs	Learning Models	Variables	Cohort Size	Single center/ Multi center	Infants/ Children/Adults	Evaluation Methods
Srinivasan S, et al.[3]	Reinforcement Learning	age, weight, SOFA, OASIS and SAPS scores, gender, ethnicity, emergency, admission urgency and hours from admit to the ICU. bicarbonate, bun, creatinine, fio2, glucose, hct, heart rate, lactate, magnesium, meanbp, platelets, potassium, sodium, spo2, spontaneousrr, temp, urine, wbc.	16502	Single center, MIMIC III	Adults	action matching, confusion matrices

		normalized vasopressor dosages and fluid boluses.				
Yu C, et al.[4]	Reinforcement Learning	respiration rate, heart rate, arterial pH, positive end-expiratory pressure (PEEP) set, oxygen saturation pulse oxymetry (SpO2), inspired oxygen fraction (FiO2), arterial oxygen partial pressure, plateau pressure, average airway pressure, mean non-invasive blood pressure, body weight (kg), age, and ventilation.	707	Single center, MIMIC III	Adults	convergence, learning efficiency, consistency with the true policies of the doctors
Nemati S, et al. [5]	Reinforcement Learning	aPTT, arterial carbon dioxide level (CO2), heart rate (HR), heparin dose, albumin, SBP and DBP, bilirubin, creatinine, Glasgow Coma Score (GCS), hematocrit, hemoglobin, International normalized ratio of prothrombin (INR), blood PH, platelet count, prothrombin time, respiration rate, oxygen saturation of arterial blood (SAO2), SOFA scores, temperature, troponin, urea, white blood cell count (WBC), ethnicity, ICU service type, gender, transfer from another hospital, pulmonary embolism, obesity, age, weight.	4470	Single center, MIMIC II	Adults	accumulated reward, time taken to enter the therapeutic range, long-term performance
Yu C, et al.[6]	Reinforcement Learning	respiration rate, heart rate, arterial pH, positive end-expiratory pressure (PEEP) set, oxygen saturation pulse oxymetry (SpO2), inspired oxygen fraction (FiO2), arterial oxygen partial pressure, plateau pressure, average airway pressure, mean non-invasive blood pressure, body weight (kg), age, and ventilation.	8860	Single center, MIMIC III	Adults	Accuracy rate, mean square error
Komorowski M, et al.[7]	Reinforcement Learning	Age, Gender, Weight, Readmission to intensive care, Elixhauser score, Modified SOFA*, SIRS, Glasgow coma scale, Heart rate, systolic, mean and diastolic, blood pressure, shock	96156	Multi center	Adults	Good model calibration was confirmed by plotting the relationship

		index, Respiratory rate, SpO2, Temperature, Potassium, sodium, chloride, Glucose, BUN, creatinine, Magnesium, calcium, ionized calcium, carbon dioxide, SGOT, SGPT, total bilirubin, albumin, Hemoglobin, White blood cells count, platelets count, PTT, PT, INR, pH, PaO2, PaCO2, base excess, bicarbonate, lactate, PaO2/FiO2 ratio, Mechanical ventilation, FiO2, Current IV fluid intake over 4h, Maximum dose of vasopressor over 4h, Urine output over 4h, Cumulated fluid balance since admission, Hospital mortality, 90-day mortality				between the return of the clinicians' policy and patients' 90-day mortality.
Lopez-Martinez D, et al. [8]	Reinforcement Learning	Pain scores, Morphine interventions, Non-morphine analgesic interventions, Physiological signals	38600	Single center, MIMIC III	Adults	physician actions against model actions