

Example Clinical Questions Answered Using ML in MIMIC-III

Cohort	Predicting	Features	Classifier or analysis used
sepsis patients	30-day survival	<u>General info</u> (eg. age, gender, ethnicity, weight, length of stay); <u>vital signs</u> in first 24 h of ICU stay- heart rate, blood pressure, temperature (TEMP), respiratory rate (RR) and oxyhemoglobin saturation (SpO2); <u>lab values</u> including blood routine examination, liver and kidney function, blood glucose, and arterial blood gas (ABG); <u>advanced cardiac life support</u> (eg. ventilation); <u>accompanied diseases</u> (diabetes, malignant tumor, etc.)	conventional logistic regression model, SAPS-II score model and XGBoost algorithm model (Hou et al, 2020)
sepsis patients	28-day mortality	TTE usage	multivariate regression, propensity score analysis, doubly robust estimation, the gradient boosted model, and an inverse probability-weighting model (Feng et al, 2018)
heart failure patients	In-hospital mortality	demographic characteristics, vital signs and laboratory values data	extreme gradient boosting (XGBoost) and the least absolute shrinkage and selection operator (LASSO) regression models (Li et al, 2021)
	Cardiosurgical care complications (eg. mortality)	Need subscription access	RNN https://pubmed.ncbi.nlm.nih.gov/30274956/ ; Real-time predictions; better than clinical reference tools
Adults in ICU	Prolonged length of stay	<u>General variables</u> like age, chronic diseases (metastatic cancer, acquired immunodeficiency syndrome, and hematologic malignancy), type of admission (scheduled surgical, unscheduled surgical, or medical); <u>physiological measurements</u> during first 24 hours in ICU include body temperature, heart rate, Pao2/Fio2 ratio, systolic blood pressure, urinary output, white blood cell count, serum urea nitrogen level, serum sodium level, serum potassium level, bilirubin level, serum bicarbonate level, and Glasgow Coma Score	random forest, support vector machine, deep learning, and gradient boosting decision tree (GBDT) (Wu et al, 2021)

Possible Future Projects Related to Sepsis Using MIMIC-IV

- Note that the criteria for “sepsis” is often unclear and many different identifications of sepsis can be used
- IDs of features (vitals, other data collected in ICU) are in [d_items](#) and their corresponding values for patients are in [chartevents](#) (see ppt)

Cohort	Predicting	Features	Clinical Relevance
Adults in the hospital (core → patients)	Development of sepsis in the ICU (d_icd_diagnosis 99591 and 99592 among potentially other sepsis ids, not sure how to get only sepsis that developed during hospital stay)	Fever, tachycardia, confusion; SOFA score (>2 of the following): altered mental status, tachypnea (> 22 breaths/min), systolic hypotension (< 100 mm Hg)	<ul style="list-style-type: none"> • Disease with highest mortality rate (48.9%) in the MIMIC-III dataset (Dai et al., 2020) • Patient outcomes depend on early detection and treatment • Sepsis is a leading cause of mortality among hospitalized patients and is the most expensive condition affecting the US healthcare system • Physionet 2019 Challenge (winner’s paper here)
Adults in the ICU with non-ventilator acquired pneumonia (exclude d_icd 9973 , include d_icd A403 among potentially other pneumonia ids)		Various features (demographics like age and BMI, labs, past medical history)	Pneumonia is associated with about half of sepsis cases, yet limited research has described risk factors for sepsis in the context of nonventilator hospital-acquired pneumonia (NV-HAP) (Guiliano and Baker, 2020)
Adults in the ICU who had microbiology cultures (hosp → microbiology) and diagnosis of sepsis	In-hospital mortality (core → patients → dod)	Antibiotic prescribed (hosp → prescriptions → start time) before causative organism is known (hosp → microbiology → storetime)	Microbiology cultures take time and sepsis is an acute condition where early detection and treatment is vital → find which medications result in mortality benefit when causative organism is unknown but sepsis is suspected

Adults in the ICU with sepsis	In-hospital mortality	Clustering by vitals and lab values in first 24 hours (eg. serum lactate)	<ul style="list-style-type: none"> Similar to (Hou et al, 2020) but more dimensionality-reduction and visualization-based; Sepsis with normal serum lactate may be distinct class of sepsis (Sauer et al, 2021)
Adults in the ICU with sepsis and within a cluster from row above	In-hospital mortality	Medications given - see source	Outcomes and therapeutic responses to ICU care can be predicted for septic patients; medications may act differently in different groups of patients with sepsis (Marini et al., 2017)

Acute Kidney Injury and Dialysis

Cohort	Predicting	Features	Clinical Relevance
Adults patients with acute kidney injury (drg_code 469) who underwent hemodialysis in the ICU (d_item 225441)	In-hospital mortality (core → patients → dod); Multiclass classification: CVD complications after hemodialysis (item_id 224800-224804)	Age, BMI, chronic medical conditions (eg. DM), previous CVD; Labs like CRP (higher versus lower), BNP, hemoglobin, albumin , TIBC, iron, ApoA2, and ApoA3	No consensus exists regarding the factors influencing mortality in patients undergoing hemodialysis (HD) but some features are identified in this paper by Ma and Zhao, 2017 .
Adults in ICU with acute kidney injury (AKI) (drg_code 469) who received a certain type of continuous renal replacement therapy (RRT) d_item 225802- CRRT dialysis d_item 225803- CVVHD dialysis	In-hospital mortality (core → patients → dod)	Hemodynamic stability (blood pressure), vitals, age, coexisting conditions, previous medications, dialysis volume	<ul style="list-style-type: none"> Increased mortality w/ diagnosis of AKI compared to patient w/o diagnosis; 50% of AKI develops in the hospital Controversy on the superiority of one RRT modality over another. Although there is increasing acceptance that CRRT should be used in hemodynamic unstable patients, its survival advantages

d_item 225805 - peritoneal dialysis d_item 225809 - CCHDF dialysis d_item 225955 - SCUF dialysis			over IHD remains unproven... CRRT does not show superiority to intermittent renal replacement therapy (IRRT) in hemodynamic stable patients (Wang and Bellomo, 2018)
Adults in ICU with acute kidney injury (AKI) (drg_code 469)	In-hospital mortality (core → patients → dod)	Type of continuous renal replacement therapy (RRT) received d_item 225802- CRRT dialysis d_item 225803- CVVHD dialysis d_item 225805 - peritoneal dialysis d_item 225809 - CCHDF dialysis d_item 225955 - SCUF dialysis	

Predicting prognosis of procedures based on patient information (identifying risk factors/contraindications for procedures)

Cohort	Predicting	Features	Clinical Relevance
Adults in the ICU who underwent PEG insertion (d_item 225446)	In-hospital mortality	Anemia, other conditions (eg. dementia), age, labs	<ul style="list-style-type: none"> • Percutaneous endoscopic gastrostomy (PEG) is the main accepted method for long-term tube feeding but may come with increased early mortality risk (Lima et al., 2021) • May not help for patients with dementia (Ayman et al. 2017)
Patients in the ICU who underwent LVAD (d_item 229252 or d_item 220125)	In-hospital mortality	hypertension, preoperative platelet count, preoperative white cell count, inotropic support before LVAD implantation, mechanical ventilation before LVAD implantation, meds given post-op	<ul style="list-style-type: none"> • Left ventricular assist devices (LVADs) are used as an alternative therapy for heart transplantation in patients with advanced heart failure • High mortality, especially in the ICU setting. 90-day mortality rate

			was 25.7%. The importance of weaning patients off respiratory support before the operation (Piffard et al., 2019)
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Predicting Patient Response to Medications

Cohort	Predicting	Features	Clinical Relevance
Adults in the ICU able to receive melatonin (contraindications here)	In-hospital mortality	Melatonin administration (eg. frequency, proportion of days in ICU where melatonin is used, dosage) (emar)	<ul style="list-style-type: none"> Less well appreciated by ICU practitioners is evidence that melatonin may play an important role in serious illness recovery unrelated to sleep (antioxidant properties, antimicrobial activity, immunomodulation, etc). https://ccforum.biomedcentral.com/articles/10.1186/s13054-017-1904-x Virtually free of deleterious side effects, melatonin is inexpensive to administer and offers a variety of potentially beneficial actions.
Adults in the ICU with sepsis	In-hospital mortality	Medications administered (vitamin C), timing of administration (emar)	Vitamin C seems to have pleiotropic effects in sepsis. Vitamin C has been shown to increase arterial pressure in septic patients, and this effect may be mediated by an increase in tetrahydrobiopterin availability, promoting catecholamine and vasopressin synthesis (Marini et al, 2019)

Predicting disease state given features

- The difficulty with these types of questions is that there's no reliable method of identifying when suspected diagnoses were made, and it is difficult to identify which diagnoses are complications and which are the chief complaint

Cohort	Predicting	Features	Clinical Relevance
Adult females in the ICU (core patients)	Myocardial infarction (drg_code 190)	Labs in first 24 hours	MI in females often includes many non-cardiac symptoms; increased detection would be helpful