# Clinical Decision Support System for Outcome Prediction in Intensive Care Units

**Presenting Author:** Ali Jalali PhD[1]

**Co-Authors:** Ali Jalali PhD[2]; Vinay M. Nadkarni MD[1]; C. Nataraj[2]; Mohamed A. Rehman MD[1]

**Background:** Patients in the intensive care units (ICU) are among the most critically ill patients in any hospital. Those at higher risk (of cardiac arrest, for example) would be in immediate need for extensive monitoring and direct attention from healthcare providers. Most of the clinically based studies on outcome prediction have focused on providing simplistic scores that focus on the severity of disease or illness. There are two fundamental problems with these acuity scoring methods. Firstly, they are population based and are not patient-specific. Secondly, the scores are not developed for real-time evaluation of the patients but rather for estimating risk in the first 24 hours after ICU admission. Hence they fail to provide real-time predictive power

**Objective:** The objective of this paper is to address the problem of data driven outcome prediction in the ICU, and proposes the development of a machine learning based clinical decision support system for patient-specific prediction of in-hospital mortality of ICU patients.

**Methods**: The data used in this paper is gathered from the publicly available Physionet database, and consists of 4,000 patients. All patients were adults who were admitted for a wide variety of reasons to ICUs. ICU stays of less than 48 hours have been excluded from the dataset. Patients with directives of Do Not Resuscitate (DNR) or Comfort Measures Only (CMO) were not excluded, hence making the prediction task much more complex. 512 patients among the collected data died during their stay at ICU. For each patient, up to 42 variables were recorded at least once during the first 48 hours after admission to the ICU. The outcome of this study is "In-hospital-mortality" so the outcome is 1 if the patient dies in the hospital even if outside ICU, and it is 0, if patient survives during the hospitalization.

**Clinical Decision Support System:** Based on expert medical knowledge and opinion, we have hence divided the collected data into different groups based on their relationship to a particular organ. The grouping of the variables into these different organ-groups helps the algorithm to better understand the physiological state of each organ and hence guarantees improved decision support. We then extract various mathematical features from the data including statistical, physiological and mathematical based features. Some of these features include: (i) minimum, maximum, mean, variance of the variable, (ii) out of range value, number of alarms, daily trend, (iii) sample entropy (iv) demographic features. The out of range index (ORI) is a measure of both the amplitude differences of a measurement within its normal range and the time that the measurement goes out of normal physiological range. Sample Entropy, is defined as a measure of signal complexity and irregularity

[1] Department of Anesthesiology & Critical Care Medicine, The Children's Hospital of Philadelphia;

[2] Villanova University

We then ranked the extracted features for each organ based on their mutual information with the outcome. Finally we designed a neural network classifier to predict the probability of the death for each patient.

**Results:** The evaluation metric used in this paper is the F-score, which is a measure of a classifier's accuracy. It is the harmonic mean of the positive predictive value and sensitivity of the predictor. We use eight-fold validation for testing the accuracy of the algorithm. The F-score result of the algorithm is 42% accuracy while this score for the widely used acuity scoring systems Sequential Organ Failure (SOFA) and Simplified Acute Physiology Score (SAPS) III are 27% and 29% respectively. The comparison of our results with SOFA and SAPS scoring systems shows approximately 55% and 45% of improvement in the outcome prediction accuracy.

**Conclusion:** In this work we addressed the problem of ICU outcome prediction. One of the main objectives of this study is to increase ICU outcome prediction accuracy in order to help clinicians identify patients at high risk of mortality and morbidity and hence enable them to plan possible treatments in a timely manner to avoid losing the patient. The algorithm that we presented in this paper is able to outperform standard acuity scoring systems in the ICU such as SOFA and SAPS-III by more than 45%. Although this algorithm has similarities with the acuity scoring systems, which makes it acceptable for clinical use, it is capable of analyzing the data at deeper levels to extract the hidden information that exists in the data.