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Research Article

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# Mortality Rate Prediction for Patients Admitted to Intensive Care Unit Based on APACHE IV

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**Abstract**

*One of the important units of the hospital is the intensive care unit, which provides specialized services to patients with acute conditions. In this paper, we introduce an instrument that can improve ICU services to patients, differentiate critical patients, optimize ICU beds, and examine the severity of their disease. To predict the mortality rate, Physiont's database for computing in cardiology challenge (CinC) was used. The survival rate of patients hospitalized in the ICU was 85.33% out of 300. Among the patients, the acute physiology and chronic health evaluation (APACHE) IV scores ranged from 18 to 90, averaging 57.43±18.6. Using the APACHE IV tool, the predicted mortality rate was 24.19%, and the observed mortality rate was 35.67%. Calculations indicated that the average score of APACHE IV for the survivors was 46.84, and for the non-survivors, it was 69.35. As a result, APACHE IV proved to be a valuable tool for nurses and doctors to predict the future conditions of patients and how they will respond to the treatment process.*

**Keywords:** APACHE IV, Intensive Care Unit, Prediction, Mortality Rate, Length of Stay

## Introduction

Patients who are very sick and in critical condition, unable to take care of themselves, and their vital systems are disturbed, are admitted to the intensive care unit (ICU) [1]. Health-therapeutic methods for maintaining patients' health have made undeniable progress, but evaluating the level of improvement and the health expected from these methods is still determined by basic criteria such as mental estimation and the approximation of doctors. Accurate risk assessment for important clinical events in evaluating new treatments, controlling resource consumption, and improving the quality control of the intensive care unit is very valuable [2].

Using new evaluation methods makes it possible to evaluate the care needs in medical departments. The severity of the patients' illness was determined much more precisely than in the past, and those patients who need hospitalization are in care units, separated from other patients. During the past three decades, different tools have been created to predict the mortality rate of admitted patients in the hospital and evaluate and classify the disease's severity [3]. All these indicators aim to create better clinical conditions and continue treating patients. These indicators also compare the results of the improvement process of patients with the same diagnosis and treatment method in hospitals. It is used in different ways. The basis of using these methods is collecting patients' demographic, physiological and clinical information. A variety of software tools are commonly used to predict mortality rates. The software can predict the mortality rate and length of stay for ICU patients. Scoring systems are used to evaluate all or almost all of the different units [4].

The classification systems proposed to predict patient outcomes, and evaluate the efficiency of ICUs and therapeutic trials. Despite the accuracy of the classification systems for estimating the probability of mortality in the defined population of patients in developed countries, the special system health care and characteristics of patients in developing countries may affect the relationship between a known grading tool and the probability of mortality [5]. In 1981, the first patient severity classification system, APACHE, was developed at George Washington University. Newer versions of this tool, such as APACHE II in 1985 and SAPS in 1993, were created and are still commonly used. With the introduction of APACHE IV in 2006, it is suggested that old models should not be used for a long time because their results can increase [6].

Finally, after doing many studies on the validity of these tools. The application of a new chapter started with these tools such as mortality probability model (MPM) and APACHE IV. The results of Soleimani et al.'s research [7], which was carried out using the process of treating patients, showed that the APACHE II index has been able to predict the mortality rate to a certain extent. In this study Using APACHE II, the predicted mortality rate, based on 204 hospitalized patients, was 30.26%, and the observed mortality rate was 27.9%, and the correlation is statistically significant. Similarly, Schein's study [8] found a mortality rate of 11.7%, while Kulkarni's study [9] found a mortality rate of 16%. Compared to other studies [8-9], the difference in mortality in the Soleimani study is possible because the ICU can be equipped with medical equipment, the manpower can be adjusted, and shift types can be adjusted according to the hospital's standards. Also, there is a relationship between the obtained result and hospital policies.

According to the studies mentioned above, this paper tries to provide a more accurate prediction of the mortality of patients admitted to the intensive care unit using the APACHE IV tool. Conducting such a study in each intensive care unit can be a criterion for determining the standard of that unit and comparing the quality of services with other hospital units and the global standard.

The rest of this paper is organized as follows. In Section 2, we present the data and proposed method. The simulation result is introduced in Section 3. In this section, our results based on different approaches are reported. Finally, we stated the conclusion in Section 4.

## Material and Method

The data used in this paper includes the data provided by Physiont for computing in the cardiology challenge (CinC) [10]. The patients under study include 300, 44.2% of them are women, and 57.8% are men. 6 common variables in all patients include height, gender, age, weight, type of ICU, and research ID, which were recorded at the beginning of hospitalization. The patients' average age, height, and weight are 67.4 years, 168.2 cm, and 79.3 kg, respectively. Also, during the hospitalization of the patients and at different time intervals, the physiological parameters of the patients were recorded according to Table 1. Patients whose hospitalization resulted in death are also labeled. The values of the best and worst tests recorded in the first 24 hours of admission to the ICU are recorded and used by the scoring system.

As part of the APACHE 4 software, information such as the patient's age, medical condition, including diseases such as cancer, HIV, etc., as well as physiological parameters, such as blood pressure, heart rate, blood sugar, creatinine, etc., must be entered. Furthermore, some information is given on the patient's level of consciousness, length of hospitalization, and surgeries performed.

**Table 1: Characteristics of data recorded from patients during hospitalization in the intensive care unit**

| | |
|---|---|
| Albumin (g/dL) | MAP [Invasive mean arterial blood pressure (mmHg)] |
| ALP [Alkaline phosphatase (IU/L)] | MechVent [Mechanical ventilation respiration (0:false, or 1:true)] |
| ALT [Alanine transaminase (IU/L)] | Na [Serum sodium (mEq/L)] |
| AST [Aspartate transaminase (IU/L)] | NIDiasABP [Non-invasive diastolic arterial blood pressure (mmHg)] |
| Bilirubin (mg/dL) | NIMAP [Non-invasive mean arterial blood pressure (mmHg)] |
| BUN [Blood urea nitrogen (mg/dL)] | NISysABP [Non-invasive systolic arterial blood pressure (mmHg)] |
| Cholesterol (mg/dL) | PaCO2 [partial pressure of arterial CO2 (mmHg)] |
| Creatinine [Serum creatinine (mg/dL)] | PaO2 [Partial pressure of arterial O2 (mmHg)] |
| DiasABP [Invasive diastolic arterial blood pressure (mmHg)] | pH [Arterial pH (0-14)] |
| FiO2 [Fractional inspired O2 (0-1)] | Platelets (cells/nL) |
| GCS [Glasgow Coma Score (3-15)] | RespRate [Respiration rate (bpm)] |
| Glucose [Serum glucose (mg/dL)] | SaO2 [O2 saturation in hemoglobin (%)] |
| HCO3 [Serum bicarbonate (mmol/L)] | SysABP [Invasive systolic arterial blood pressure (mmHg)] |
| HCT [Hematocrit (%)] | Temp [Temperature (°C)] |
| HR [Heart rate (bpm)] | TropI [Troponin-I (μg/L)] |
| K [Serum potassium (mEq/L)] | TropT [Troponin-T (μg/L)] |
| Lactate (mmol/L) | Urine [Urine output (mL)] |
| Mg [Serum magnesium (mmol/L)] | WBC [White blood cell count (cells/nL)] |

Figure 1 shows APACHE software in version IV. As you can see in this figure, the age of the patient and the physiological parameters recorded from the patients in the first 24 hours of hospitalization, the parameters determining the level of consciousness of the patient, the information related to the patient's health conditions and admission to the ICU and finally showing the estimated mortality rate and estimated length of stay can be seen in this software.

Different indices such as Glasgow coma score (GCS), Patient's age, pupillary light reflex, bleeding in the brain, blood pressure, and arterial oxygen pressure, computerized tomography (CT) scan findings and various scoring systems are also used to predict the mortality of patients [11].

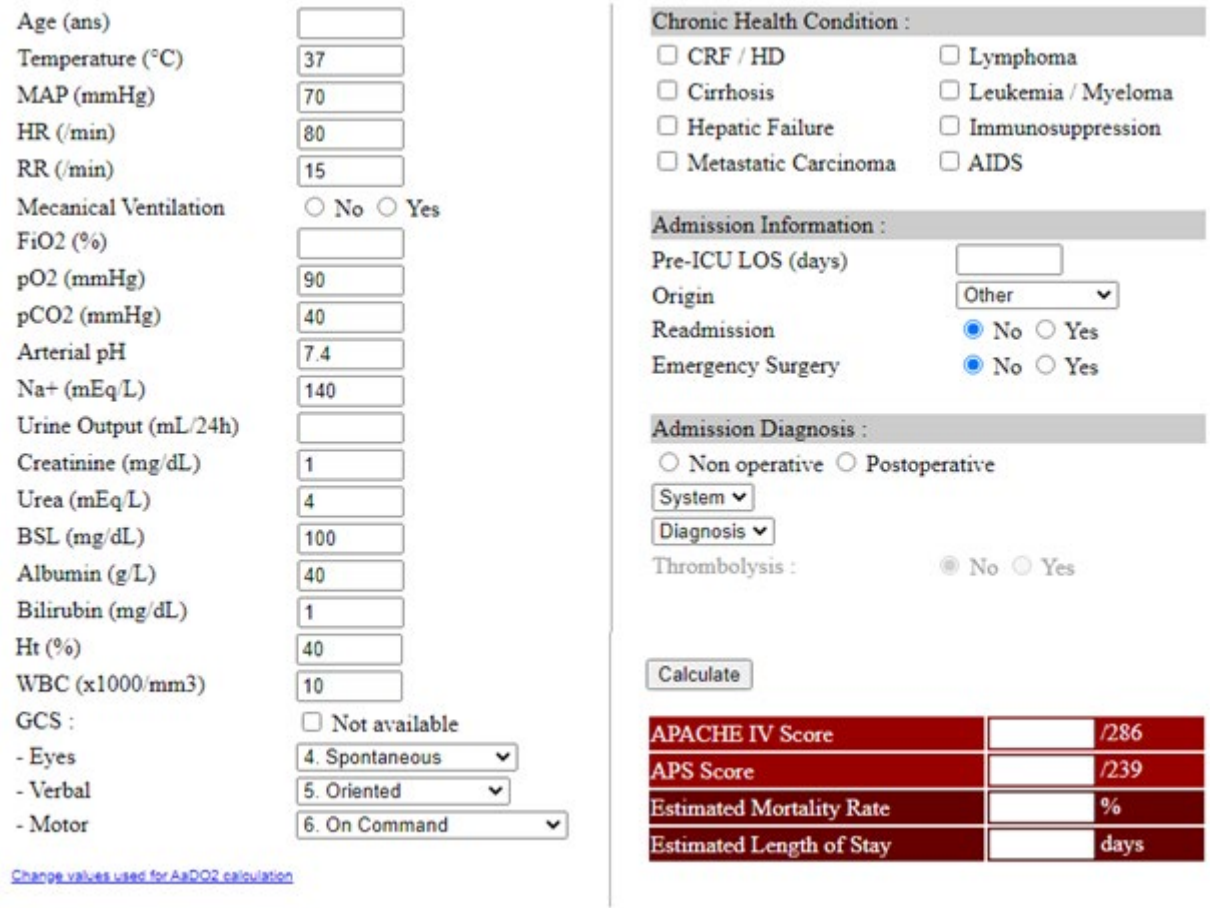


**Figure 1:** Different parts of APACHE IV software

## Result

In this paper, 300 patients were analyzed, including 175 men and 125 women. There were 256 survivors (85.33%) and 44 deaths (14.67%). The patients' minimum and maximum APACHE IV scores were 18 and 90, averaging 67.43±18.6. The predicted mortality rate using APACHE IV tool was 24.19%, and the observed mortality rate was 35.67%. The average APACHE IV score for survivors was 46.84, while the average score for non-survivors was 69.35. Table 2 shows the analysis results of the APACHE IV tool and its comparison with the sequential organ failure assessment (SOFA) tool.

In comparing the average scores between the surviving and deceased patients with the statistical analysis of the t-test with independent samples for each of the tools, it was determined that the average score of APACHE IV in the two groups of patients has a significant difference. The average values in the two groups using the SOFA method did not significantly differ. Table 3 also shows the distribution of the frequency of hospitalized patients and the observed mortality rate.

**Table 2: Comparison of predicted mortality results using APACHE IV and SOFA tools**

| Method | Patient Status | | Mean ± Standard Deviation | P-Value |
|---|---|---|---|---|
| | Survivor | Non-Survivor | | |
| APACHE IV | | | 21.52±9.3 | 0.001 |
| | | | 57.43±18.6 | |
| SOFA | | | 14.34±6.4 | 0.09 |
| | | | 11.87±5.5 | |

**Table 3: Frequency distribution of hospitalized patients and observed mortality rate**

| ICU type | Percentage of patients | Observed mortality percentage |
|---|---|---|
| Coronary Care Unit | 33.5% | 43.6% |
| Cardiac Surgery Resuscitation Unit | 30.4% | 33.2% |
| Medical ICU | 23.7% | 29.1% |
| Surgical ICU | 17.7% | 19.4% |

## Conclusion

Prediction of mortality rate using scoring tools has been used for a long time. In this paper, APACHE IV and SOFA tools as well as computing in the cardiology challenge data, have been used to predict the mortality rate of patients in the intensive care unit. The results show the APACHE IV system's superiority over SOFA in predicting patients' mortality rates. Comparing the predicted mortality difference with the actual amount indicates the services provided to the patients with a standard rate. If these two values are close enough, then the medical staff and equipment of the desired unit will be of better quality. Since there are a limited number of ICU beds, this tool can play a crucial role in determining which patients receive priority for ICU placement. Patients at risk of mortality have a high APACHE IV score. Classification of the severity of diseases in terms of determining the level of service that is necessary for a patient in the departments especially receiving it, it can prevent the occurrence of many unfortunate incidents and increase their survival rate. The use of new methods of patient evaluation is also important from the management point of view because it is possible to prioritize patients in terms of receiving special services and adjust human resources. The occupancy level of hospital beds, etc., had more accurate judgments. APACHE software, one of the successful software in this topic, is designed using methods based on artificial intelligence. This software uses the physiological information available in the patients' medical records to diagnose the severity of the disease. Also, this software can estimate the duration of hospitalization in the ICU and help doctors choose the appropriate treatment method.

Factors such as patient transfer, admission of dying patients, hospital management systems (open or close), and quick and timely visits by the doctor are also effective in the mortality rate in the intensive care unit. According to the problems in the field of medicine, including disease diagnosis, diagnosis and choosing the appropriate treatment method, etc., researchers are looking for new ways to solve them. As mentioned, diagnosing the severity of the disease was and remained one of doctors' concerns. On the other hand, this diagnosis for ICU patients has received more attention from researchers due to the lack of equipment in this unit, its high cost, and the high number of referrals in this department. Research on predicting the mortality rate based on vital signal processing (such as Electrocardiogram (ECG) and blood pressure, etc.) and with the help of artificial intelligence-based methods mentioned in [12-18], reduces the dependence on software.

## Abbreviations

APACHE: Acute Physiology and Chronic Health Evaluation
CinC: Computing in Cardiology Challenge
CT: Computerized Tomography
ECG: Electrocardiogram
GCS: Glasgow Coma Score
ICU: Intensive Care Unit
MPM: Mortality Probability Model
SOFA: Sequential Organ Failure Assessment

## Conflict of Interest Statement

None

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