

Use of the APACHE IV score as a predictor of mortality and length of stay in an intensive care unit

Uso do escore APACHE IV como preditor de mortalidade e tempo de permanência em uma unidade de terapia intensiva

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RESUMO | INTRODUÇÃO: A avaliação do risco de morte e o tempo estimado de permanência em Unidade de Terapia Intensiva (UTI) é uma prática clínica relevante para prever a gravidade da doença e traçar estratégias eficazes para a melhora do paciente e dos indicadores de qualidade do hospital. **OBJETIVO:** Avaliar a confiabilidade do escore APACHE IV como preditor de mortalidade e tempo de permanência em uma UTI do sul do estado do Tocantins. **MATERIAL E MÉTODO:** Pesquisa de caráter descritivo e quali-quantitativo realizada nos prontuários dos pacientes internados em uma UTI do sul do estado do Tocantins. Foram colhidas informações nos prontuários e aplicado o escore APACHE IV nos pacientes internados na UTI do sul do estado do Tocantins, no período de 24 de Outubro a 26 de Novembro de 2018. Foram excluídos os pacientes com período de internação inferior a 24 horas, que não realizaram todos os exames necessários para o APACHE IV, que foram transferidos do setor ou que não tiveram alta ou óbito ao final dessa pesquisa. Foi utilizado o coeficiente de correlação de Spearman para examinar a relação entre o escore APACHE-IV e o tempo de internação na UTI e para verificar a acurácia do APACHE-IV para mortalidade, à curva Receiver Operator Characteristic (ROC) com uma atribuição de 'bom' > 0,80. **RESULTADOS:** O escore APACHE IV foi aplicado em dez pacientes, sendo que este superestimou o período de permanência dos pacientes internados na UTI em estudo, com $p < 0,001$ e a mortalidade geral, com diferença absoluta de 20% ($p = 0,447$). **CONCLUSÃO:** Baseada neste estudo, o APACHE IV não demonstrou confiabilidade para predição de mortalidade e tempo de permanência, porém a amostra insuficiente pode ter contribuído com esta conclusão.

PALAVRAS-CHAVE: Unidade de terapia intensiva. APACHE. Mortalidade.

ABSTRACT | INTRODUCTION: The assessment of the risk of death and the estimated length of stay in the intensive care unit (ICU) is a relevant clinical practice to predict the severity of the disease and to outline effective strategies for patient improvement and hospital quality indicators. **OBJECTIVE:** To evaluate the reliability of the APACHE IV score as a predictor of mortality and length of stay in a ICU in the southern state of Tocantins. **MATERIAL AND METHOD:** This is a descriptive and qualitative research conducted in the medical records of patients hospitalized in a suppressed ICU. Information was collected from the medical records and the APACHE IV score was applied to patients hospitalized in the ICU of the SUPRIMIDO from October 24 to November 26, 2018. Patients with hospitalization less than 24 hours who did not undergo all necessary examinations were excluded. for APACHE IV, who were transferred from the sector or who were not discharged or died at the end of this survey. Spearman's correlation coefficient was used to examine the relationship between the APACHE-IV score and ICU length of stay and to verify the accuracy of APACHE-IV for mortality, to the Receiver Operator Characteristic (ROC) curve with an assignment of 'good' > 0.80. **RESULTS:** The APACHE IV score was applied to ten patients, which overestimated the length of stay of ICU patients, with $p < 0.001$ and overall mortality, with an absolute difference of 20%. ($p = 0.447$). **CONCLUSION:** Based on this study, APACHE IV did not show reliability for predicting mortality and length of stay, but the insufficient sample may have contributed to this conclusion.

KEYWORDS: Intensive care unit. APACHE. Mortality.

Introduction

Clinical evaluation is an important part of medical practice in which it predicts the prognosis of patients admitted to Intensive Care Units (ICUs). Information on the characteristics of the clinical condition can help in the definition of strategies, outlining plans for improving care, helping to prevent complications and achieving better quality indicators. Knowledge of these characteristics allows health professionals to plan this care regardless of the condition that motivated hospitalization¹.

The technologies used in the ICU increase the survival of critically ill patients, while increasing the predisposing risk factors that lead them to acquire Health Care-Related Infections (HAIs), especially mechanical ventilator associated pneumonia (VAP). Among the risk factors is the indiscriminate use of previous antimicrobials, the severity of the underlying disease, length of stay in the ICU and the invasive procedures to which they are subjected².

All patients admitted to the ICU are exposed to a series of events that can often result in prolonged length of stay or, due to the severity of their prognosis, may end up evolving to death. Hospitalizations for cardiovascular and respiratory impairments have a high length of stay and mortality rates. These indexes are evaluated by highly qualified methods that can predict the length of stay and survival of these patients³.

One of the best known models is the Acute Physiology And Chronic Health Evaluation score system (APACHE - Acute and Chronic Health Status Assessment) which assesses length of stay and mortality in ICU patients⁴. The APACHE score had its first version developed in 1981 in a study that considered several parameters including vital signs, physiological variables, neurological score, urine production, age and morbid conditions. Its last version was introduced in 2006, with 129 variables collected in the first 24 hours of admission. Among all the evaluation methods, APACHE IV is perhaps the most used due to its easy application and because it is based on data available in most hospitals⁵.

In clinical practice, a reliable system for categorizing patients is important, identifying the severity of the disease and the effectiveness of therapy, in order to contribute to decision-making and improve the hospital's quality indicators. Therefore, this study

aimed to assess the reliability of the APACHE IV score as a predictor of mortality and length of stay in an ICU in the from the south of the state of Tocantins.

Materials and methods

This is a descriptive, qualitative and quantitative research carried out in the medical records of patients admitted to the general ICU that has ten beds in the south of the state of Tocantins. hospital between October 24 and November 26, 2018, after approval by the Research Ethics Committee (REC) University of Gurupi- UNIRG under the protocol 2.930 (CAAE 97880918.4.0000.5518) and signature of the Free and Informed Consent Form performed by the guardians of the patients admitted to the ICU. The choice of the period of data collection was due to the greater possibility of admitting new patients, since the sector had discharged 80% of the occupation capacity.

All patients hospitalized in the aforementioned period who met the inclusion and exclusion criteria were part of the sample. The inclusion criteria adopted were adult individuals of both sexes and in different specialties. Patients with a hospital stay of less than 24 hours, who did not perform all the necessary exams for APACHE IV, who were transferred from the sector or who were not discharged or died by the end of this research were excluded.

Some data were extracted from the analysis of the medical records of patients hospitalized in the established period. The following information was taken into account: bed, medical record number, date and time of hospitalization, sex, age, origin unit, diagnosis of hospitalization, associated diseases, date and time of discharge, death or transfer, and destination in the case of transfer, level of sedation-RASS (Richamond Agitation-Sedation Scale) and average days of hospitalization⁶.

APACHE IV was calculated in the first 24 hours of hospitalization by the physiotherapy coordinator responsible for the sector. The variables used to calculate the APACHE-IV score were: age, sex, admission dates, discharge or death, systolic and diastolic blood pressure, body temperature, heart rate, respiratory rate, blood glucose, urea, serum creatinine, hematocrit, blood white cells, serum albumin and bilirubin, urine output during the first

24 hours of ICU stay, pH, inspired oxygen fraction (FiO₂), partial pressure of carbon dioxide (PaCO₂), partial pressure of oxygen (PaO₂), bicarbonate (HCO₃), Glasgow coma scale, mechanical ventilation (MV) and diagnosis of admission⁷. The mean arterial pressure was given by two measurements performed on the same limb with an interval of two minutes. The temperature, heart rate and respiratory rate were performed manually and compared with the values recorded on the monitor. In case of divergence of values, another manual evaluation was carried out and the average of the manual measurements was made. The worst values of vital and laboratory parameters were used and their scores were calculated from the online calculator⁸.

The information obtained from each patient was individually entered into a database organized from an electronic spreadsheet and these were compared with the information collected in the medical records regarding the length of stay and mortality rate.

Data analysis

The sample was given by the number of patients admitted to the ICU of the present study, considering the inclusion and exclusion criteria. Qualitative variables were expressed as absolute frequency and percentage and quantitative variables as mean and standard deviation. Student's t-tests and the Mann Whitney test were used to compare the differences between the groups of survivors and non-survivors, in terms of age and sex. For the gender variable, the chi-square test with $p \leq 0.05$ was used to verify the level of significance. In addition, Spearman's correlation coefficient was used to examine the relationship between the APACHE-IV score and length of stay in the ICU. To check the accuracy of APACHE-IV for mortality, the Receiver Operator Characteristic (ROC) curve was used with an assignment of 'good' > 0.80. The Mann Whitney test was used to compare the difference between the surviving and non-surviving groups. For the gender variable, the chi-square test was used with $p \leq 0.05$ for statistically significant. Data analysis was performed using the Stata® program.

Results

In the period proposed for the research, twenty (20) patients were admitted to the ICU under study, however, only ten (10) patients comprised the sample, as three (3) patients did not present all the tests necessary to assess the APACHE IV score and the other seven remained hospitalized in the ICU after the end of this research (Figure 1).

The average age of the patients found in the investigated ICU was 44.80 ± 22.59 years, with 70% of the patients being male. The average length of stay in the ICU was 7.4 days, with a standard deviation of ± 0.521 (Table 1). Of the patients investigated, six presented the following diagnoses: neurological, endocrine, metabolic, respiratory, cardiovascular and renal, and four patients presented cardiovascular and respiratory diagnoses.

The results verified that there was a nonsignificant difference between the two groups (survivors and non-survivors) regarding sex ($p = 0.081$). However, the two groups were significantly different in relation to the variables: age, length of stay in the ICU, RASS and APACHE IV, since for all these variables the p was <0.001 (Table 1). The length of stay in the ICU predicted by APACHE IV was 14 days (± 7.4). For general mortality, the observed values were 30%, while the mortality predicted by APACHE was 50% (Table 2).

The ROC curve for the APACHE IV score and observed mortality was described in Figure 2. The values found were statistically significant and may be a predictor for the observed mortality. However, Spearman's correlation coefficient showed a weak correlation between the APACHE IV score and the length of stay in the ICU observed ($r = 0.025$; $p < 0.0001$).

Figure 1. Sample flowchart

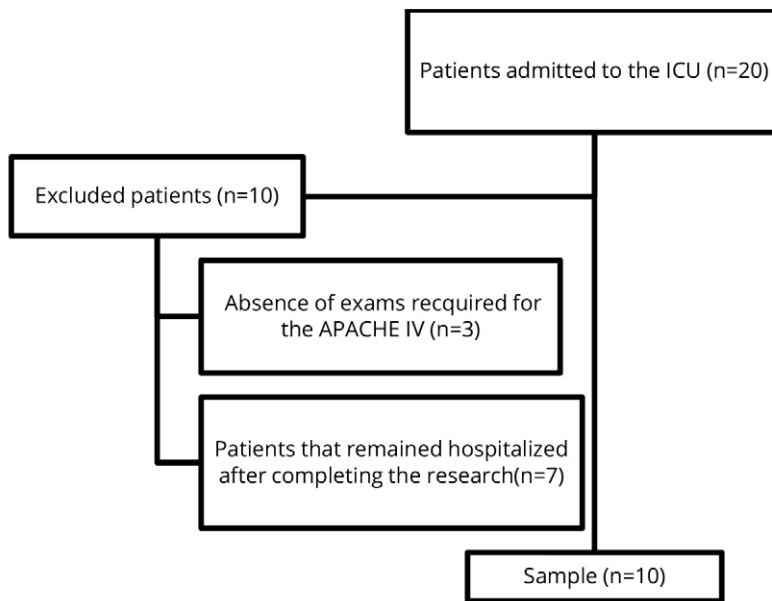


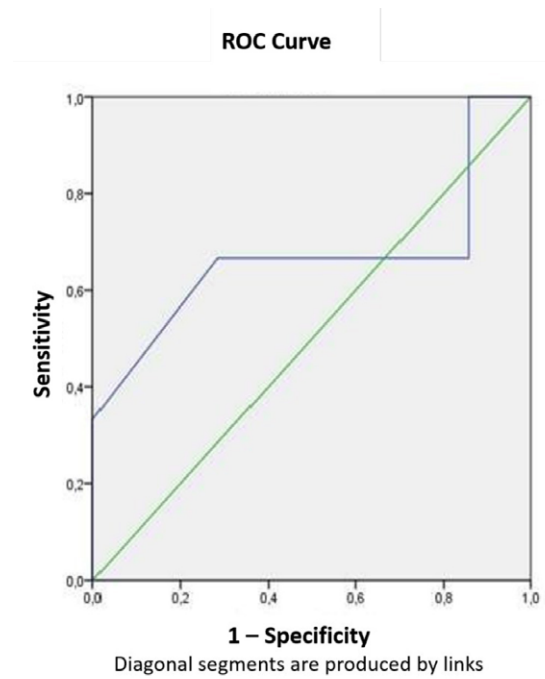
Table 1. Demographic and clinical characteristics of patients admitted to the ICU of the Regional Hospital of Gurupi in 2018

Characteristics	Total (n=10)	Survivors (n=7)	Non survivors (n=3)	p-value
Idade (mean and sd)	44.80 (±22.59)	37.71 (±8.97)	61.33 (±2.72)	0,000
Sex (mean and %)				0,081
Male	7 (70.00%)	5 (71.43%)	2 (66.67%)	
Female	3 (30.00%)	2 (28.57%)	1 (33.33%)	
ICU (mean and sd)	7.4 (±0.52)	7.71 (±0.52)	6.67 (±1.33)	0,000
RASS (mean and sd)	-4.7 (± 0.21)	-4.71(±0.28)	-4,67 (±0.33)	0,000
APACHE IV (mean and sd)	75.70 (±6.67)	70.0 (±3.34)	89.0 (±21.54)	0,000

Table 2. Length of stay and mortality rate found and estimated by the APACHE IV score in the ICU of the Regional Hospital of Gurupi in 2018

Characteristics	Observed	Predicted	p-value
Length of ICU stay (mean and ± SD)	7.4 (±0.52)	14.21 (±7.4)	0,000
Mortality rate (n and %)	3 (30%)	5 (50%)	0,447

Figure 2. The area under the APACHE IV score curve was 0.67, with a 95% confidence interval (0.212; 1,000). These values were statistically significant and can be a predictor for observed mortality



Discussion

The results of the present study showed that APACHE IV overestimated the length of stay found in the ICU under study, with ($p < 0.001$). In addition, overall mortality was also overestimated with an absolute difference of 20% ($p = 0.447$).

The research in question with ten patients did not identify the APACHE IV score as a good predictor of length of stay and mortality in patients admitted to the ICU. These scoring systems generally work well for the population in which they were tested. Experts recommend external validation at national, regional or institutional level. Similar results were also found in a study conducted in Iran with 839 patients, where the mortality rate was higher than that predicted by the APACHE IV score⁷.

The use of these predictors of mortality in the ICU is becoming more and more frequent, because in addition to estimating the length of hospital stay, they assess the severity of the disease, helping the professionals' conduct. The shorter the time that these patients remain in the ICU, the lower the chances of other complications or even the worsening of the underlying disease⁹.

The estimated average length of stay of patients in Brazilian ICUs is six days, however, some factors can prolong this hospitalization, such as the need for ventilatory assistance¹⁰. Patients who need an extension of this assistance are exposed to a series of complications, including (VAP)¹¹. Similar data found in our survey, with a stay time of 7.4 ± 0.52 days.

Sedation is another factor that interferes with the length of stay in the ICU, because the higher the level of sedation, the greater the need for ventilatory assistance. Daily interruption of sedation is a strategy to avoid excessive sedation, in order to assess the need for sedation and decrease the accumulation, the time of mechanical ventilation and the ICU stay¹².

In the present study, all patients were under the effect of sedatives due to severity during the hospital stay. The mean found for sedation assessed by the RASS scale in the first 24 hours was -4.7 ± 0.21 . However, daily interruption of sedation was routine in the ICU, which may have favored a reduction in the length of stay compared to that predicted by APACHE IV. Most patients admitted to the ICU are subjected to high doses of sedatives, resulting in increased length of hospital stay, prolonged use of ventilatory support and risk of death due to other possible complications¹³.

The mean age of the patients found in our study was 44.80 ± 22.59 years. Some studies claim that advanced age is associated with prolonged hospital stay and high mortality rates¹⁴. Data that corroborate this research showed that the survivors had a low average age (37.71 ± 8.97) when compared to non-survivors (61.33 ± 2.72).

The reliability of APACHE IV has been questioned and compared with other predictors of mortality and length of stay. Some studies have verified the ineffectiveness of the APACHE IV score to estimate the length of stay, due to the lack of good calibration. In contrast, they observed a good prediction for the time of mortality. Other authors disagree with this opinion and characterized APACHE IV as a good predictor of mortality and permanence¹⁵.

A study carried out in the Czech Republic evaluated 1,000 patients, with a mean age of 69.9 years, the highest percentage being male ($n = 560$), affected by cardiopulmonary, respiratory and/or gastrointestinal diseases. This compared the reliability of the APACHE II, APACHE IV, SAPS 3 and MPMo III scores, and one can observe that APACHE IV obtained an estimated result closer to that found for the length of stay of the evaluated patients¹⁶.

Two other studies that compared the scores: APACHE II, APACHE IV and SAPS 3 found that APACHE IV revealed good discrimination, but a low calibration regarding the length of stay of patients in the ICU. In the first study, from January to June 2014, 1,003 patients were evaluated, 65% of whom were male and 70% admitted for cardiac, respiratory and metabolic disorders and the other 30% for surgical problems. In the second study, 1,314 patients with a mean age of 57.8 years, 57% of whom were male, comprised the sample. Of these 516 patients underwent neurosurgery. In both studies, they used the worst values during the first 24 hours of hospitalization to calculate the APACHE IV score [17-18]. However, in the present study, a weak correlation was observed between the APACHE IV score and the length of stay in the investigated ICU ($r = 0.025$; $p < 0.0001$).

Although the study brings important contributions, it presented limitations in the sample size due to the reduced number of beds, low turnover and insufficient follow-up time for patients admitted to the ICU.

Conclusion

The APACHE IV score did not demonstrate reliability for predicting mortality and length of stay in the investigated ICU. Studies with a larger population are recommended, with demographic characteristics similar to the Brazilian population and during a longer follow-up period.

Author contributions

Carvalho GA participated in the design, collection of research data, interpretation of results, writing of the scientific article. Rezende AAB participated in the conception, design, search and statistical analysis of the research data, data interpretation and writing of the scientific article. Reis GR participated in the design, collection of research data and interpretation of results. Gardenghi G participated in the interpretation of the results and in the writing of the scientific article.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

References

1. Roque KE, Tonini T, Melo ECP. Eventos adversos na unidade de terapia intensiva: impacto na mortalidade e no tempo de internação em um estudo prospectivo. *Cad. Saúde Pública*. 2016;32(10). doi: [10.1590/0102-311X00081815](https://doi.org/10.1590/0102-311X00081815)
2. Mota EC, Oliveira SP, Silveira BRM, Silva PLN, Oliveira AC. Incidência da pneumonia associada à ventilação mecânica em unidade de terapia intensiva. *Medicina (Ribeirão Preto, Online)*. 2017;50(1):39-46. doi: [10.11606/issn.2176-7262.v50i1p39-46](https://doi.org/10.11606/issn.2176-7262.v50i1p39-46)
3. Feijó CAR, Leite Júnior FO, Martins ACS, Furtado Júnior AH, Cruz LLS, Meneses FA. Gravidade dos pacientes à unidade de terapia intensiva de um hospital universitário Brasileiro. *Rev Bras Ter Intensiva*. 2006;18(1):18-21. doi: [10.1590/S0103-507X2006000100004](https://doi.org/10.1590/S0103-507X2006000100004)
4. Keegan MT, Gajic O, Afessa B. Comparison of APACHE IV Resuscitation Status on Model Performance. *Chest*. 2012;142(4):851-8. doi: [10.1378/chest.11-2164](https://doi.org/10.1378/chest.11-2164)

5. Brinkman S, Bakhshi-Raiez F, Abu-Hanna A, Jonge E, Bosman RJ, Peelen L et al. External validation of Acute Physiology and Chronic Health Evaluation IV in Dutch intensive care units and comparison with Acute Physiology and Chronic Health Evaluation II and Simplified Physiology Score II. *J Crit Care*. 2011;26(1):105e11-8. doi: [10.1016/j.jcrc.2010.07.007](https://doi.org/10.1016/j.jcrc.2010.07.007)
6. Rodriguez AH, Bub MBC, Perão OF, Zandonadi G, Rodriguez MJH. Características epidemiológicas e causas de óbitos em pacientes internados em terapia intensiva. *Rev Bras Enferm*. 2016;69(2):229-34. doi: [10.1590/0034-7167.2016690204i](https://doi.org/10.1590/0034-7167.2016690204i)
7. Ghorbani M, Ghaem H, Rezaianzadeh A, Shayan Z, Zand F, Nikandish R. A study on the efficacy of APACHE- IV for predicting mortality and length of stay in an intensive care unit in Iran. *F1000 Res*. 2017;6:2032. doi: [10.12688/f1000research.12290.1](https://doi.org/10.12688/f1000research.12290.1)
8. Calculadoras ICU- RNSH. APACHE IV pontuação. [Internet]. [Acesso em 2018 out. 05]. Disponível em: <https://intensivecarenetwork.com/Calculators/Files/Apache4.html>
9. Keegan MT, Soares M. O que todo intensivista deveria saber sobre os sistemas de escore prognósticos de mortalidade ajustada ao risco. *Rev Bras Ter Intensiva*. 2016;28(3):264-9. doi: [10.5935/0103-507X.20160052](https://doi.org/10.5935/0103-507X.20160052)
10. Orlando JMC, Milani CJ. 2º Anuário Brasileiro de UTIs – 2º Censo Brasileiro de UTIs. São Paulo: Associação de Medicina Intensiva Brasileira (AMIB); Edição 2002-2003.
11. Mota EC, Oliveira SP, Silveira BRM, Silva PLN, Oliveira AC. Incidência da pneumonia associada à ventilação mecânica em unidade de terapia intensiva. *Medicina (Ribeirão Preto, online)*. 2017;50(1):39-46. doi: [10.11606/issn.2176-7262.v50i1p39-46](https://doi.org/10.11606/issn.2176-7262.v50i1p39-46)
12. Carvalho CRR, Toufen Junior C, Franca SA. III Consenso Brasileiro de Ventilação Mecânica. *J Bras Pneumol*. 2007;33(supl 2):54-70.
13. Shinotsuka CR, Salluh JIF. Percepções e práticas sobre delirium, sedação e analgesia em pacientes críticos: uma revisão narrativa. *Rev Bras Ter Intensiva*. 2013;25(2):155-61. doi: [10.5935/0103-507X.20130027](https://doi.org/10.5935/0103-507X.20130027)
14. Williams TA, Ho KM, Dobb GJ, Finn JC, Knuiman M, Webb SA et al. Effect of length of stay in intensive care unit on hospital and long-term mortality of critically ill adult patients. *Br J Anaesth*. 2010;104(4):459-64. doi: [10.1093/bja/aeq025](https://doi.org/10.1093/bja/aeq025)
15. Choi JW, Park YS, Lee YS, Park YH, Chung C, Park DI et al. The Ability of the Acute Physiology and Chronic Health Evaluation (APACHE) IV Score to Predict Mortality in a Single Tertiary Hospital. *Korean J Crit Care Med*. 2017;32(3):275-83. doi: [10.4266/kjccm.2016.00990](https://doi.org/10.4266/kjccm.2016.00990)
16. Sedlon P, Kameník L, Skvarill J, Malý M, Táborský M, Zavoral M. Comparison of the accuracy and correctness of mortality estimates for Intensive Care Unit patients in internal clinics of the Czech Republic using APACHE II, APACHE IV, Saps 3 and MPMo III models. *Med Glas*. 2016;13(2):82-9. doi: [10.17392/860-16](https://doi.org/10.17392/860-16)
17. Varghese YE, Kalaiselva MS, Renuka MK, Arunkumar AS. Comparison of acute physiology and chronic health evaluation II (APACHE II) and acute physiology and chronic health evaluation IV (APACHE IV) severity of illness scoring systems, in a multidisciplinary ICU. *J Anaesthesiol Clin Pharmacol*. 2017;33(2):248-53. doi: [10.4103/0970-9185.209741](https://doi.org/10.4103/0970-9185.209741)
18. Lee H, Shon YJ, Kim H, Paik H, Park HP. Validation of the APACHE IV model and its comparison with the APACHE II, SAPS 3, and Korean SAPS 3 models for the prediction of hospital mortality in a Korean surgical intensive care unit. *Korean J Anesthesiol*. 2014;67(2):115-22. doi: [10.4097/kjae.2014.67.2.115](https://doi.org/10.4097/kjae.2014.67.2.115)