# Predictors of mortality in the intensive care unit for adult patients admitted on mechanical ventilation: admission profile

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## Abstract

*Evaluating risk factors for mortality in local populations such as adult patients admitted on mechanical ventilation in intensive care units (ICU) may provide support for the management and improvement of outcomes in these units. The inclusion of the workload of professionals in these models has offered a different view of predictors. The aim of this study was to evaluate whether Nursing workload assessed by the Nursing Activities Score (NAS), predictors of mortality (APACHEII and SAPS3) and some additional admission variables for patients admitted on mechanical ventilation in an ICU are predictors of death. We evaluated 194 patients who remained on mechanical ventilation for 48 hours before or after admission in one ICU, in a university hospital of high complexity. The clinical and socio-demographic profile, the NAS of admission and some admission variables were evaluated. The outcome discharge or death in the ICU was evaluated for all patients, and from simple or multiple logistic regression models, risk or protective factors for death in the ICU were obtained. Individually, only SAPS3 was significant for prediction of death (OR = 1.03; 95%CI: 1.01; 1.05), while the APACHEII and the NAS of admission was not able to predict ICU mortality. In the multiple model, the only risk factors for ICU mortality were the presence of chronic obstructive pulmonary disease (OR = 8.82; 95%CI: 1.82; 42.70), having thyroid diseases (OR = 5.98; 95%CI: 1.15; 31.22) and the increase in the level of urea in the blood (OR = 1.01; 95%CI: 1,002; 1.02). The admission variables of this population were more effective in predicting ICU mortality than the predictors of mortality evaluated here.*

**Keywords:** Nursing workload; risk factor; Nursing Activities Score; blood urea, chronic obstructive pulmonary disease; thyrodopathies.

## 1. Introduction

The analysis of risk factors and the use of risk indicators for mortality have been widely used in the health literature in different scenarios (HISSA et al., 2013; RISSO & NASCIMENTO, 2010; GULINI et al., 2018; HEYARD et al., 2020). Critical patients or patients at imminent risk of death have been commonly admitted and assisted in intensive care units (ICU), and have high morbidity and mortality (SENTURK et al., 2011). In addition, these patients demand a high workload of health professionals, highlighting among them nurses, with the highest fraction of this time (CASTELLAN et al., 2016).

It is essential to know the risk or protective factors for different clinical outcomes in ICUs. Brazilian ICUs legislation requires units that know and evaluate their risk factors and indicators of patient mortality and health workers workload (ANVISA, 2010). The most widely used predictors of mortality in ICUs are Acute Physiology and Chronic Health Evaluation II (APACHEII) (KNAUS et al., 1985) and Simplified Acute Physiology Score 3 (SAPS3) (GALL et al., 1984; GALL, LEMESHOW, SAULNIER, 1993). Despite the low applicability of APACHEII, its use is still indicated in clinical trials and remains an index used to describe the severity of critically ill patients in clinical studies, but may prove obsolete in some situations (MORENO & NASSAR JR, 2017). Knowing other risk factors not covered by scores, local factors or factors related to specific groups of patients or units becomes essential. The inclusion of new variables in these models is able to improve the predictive capacity of various indicators (WANG et al., 2012; GUTHC et al., 2018; KATO et al., 2020; MOHAMMED et al., 2020).

A group of patients in ICUs who have called attention are the patients using invasive mechanical ventilation, considered here the use of artificial airway route concomitant to the use of mechanical ventilator. The fact that undergoing mechanical ventilation and time on mechanical ventilation have been routinely reported as risk factors for mortality or worse clinical outcomes (SENTURK et al., 2011; OLIVEIRA et al., 2010; GULINI et al., 2018; GOMES et al., 2019), although models for predicting clinical outcomes to specific populations in the ICU are poorly addressed for admission itself.

Patients on mechanical ventilation in ICUs may represent up to 41.5%, and those on mechanical ventilation for more than 21 days up to 10% of these patients (LOSS et al., 2015). These patients are subject to a high risk of ventilator-associated pneumonia (VAP), which is the most common health care-related infection in ICUs with a prevalence of 9 to 68% and also strongly associated with mortality, which can reach up to 13% (CAMARGO et al., 2004, ROCHA et al., 2008; MOTA et al., 2019). Moreover, the non-provision of the healthcare workload demanded by patients independent of the professional may lead to non-execution of health care, and if associated with other risk factors may increase the incidence of VAP, the use of tracheostomy and reintubation rates (HUGONNET et al., 2007; JANSSON et al., 2019), which may trigger higher morbidity and mortality in this group.

In this scenario, it is essential to measure the Nursing workload. Its measurement is recommended and required by the legislation of Brazilian ICUs for all patients (ANVISA, 2010). The most used Nursing workload measurement instrument currently used in ICUs is the Nursing Activities Score (NAS) (MIRANDA et al., 2003), translated and validated in Brazil by Queijo e Padilha (QUEIJO & PADILHA 2009). NAS has also been listed as a predictor of clinical or health outcomes (eg. GOMES et al. 2019), which reinforces its potential role as a predictor of risk or protection.

The objective of this work is to evaluate the admission variables and mortality scores of patients admitted on mechanical ventilation in an adult ICU as predictors of mortality in the ICU, in addition to evaluating whether SAPS3, APACHEII and Nursing workload of admission measured by NAS singly are predictors for ICU mortality.

## 2. Material and Methods

### *2.1 Type and Place of Study*

The study is retrospective, documental (patient's health records), descriptive, analytical and cross-sectional cohort. The data analyzed here were collected in the study of ventilator-associated pneumonia performed by GOMES (2018), and had part of the data and results published in GOMES et al. (2019) and GOMES et al. (2020). See full detail from profile and their discussion on previous papers.

Data were collected inside the ICU for adult patients of the Clinic Hospital of Uberlândia (Hospital de Clínicas de Uberlândia in Portuguese) the Federal University of Uberlândia (Universidade Federal de Uberlândia in Portuguese). The hospital is located in the city of Uberlândia, Minas Gerais state, Brazil. It is a public hospital, teaching (university type), tertiary care (high complexity), with 525 beds and linked exclusively to the Unified Health System (SUS- Sistema Único de Saúde in Portuguese). The Adult ICU is classified by the criteria of the Brazilian Ministry of Health as complexity level III (BRASIL 1998), a higher level of complexity. The ICU was structured at the time of data collection as a general ICU with no defined specialty, with thirty beds for hospitalization of clinical, neurological, traumatic and surgical patients. The unit treats patients from 13 years of age, although patients from 18 years predominate.

### *2.2 Study and Sample Population*

The study population consists of all patients admitted to the Adult ICU from January to June, 2014, admitted to invasive mechanical ventilation as defined by Gomes (GOMES, 2018). The inclusion criteria in Gomes' study were the medical records of patients over 18 years of age, admitted on mechanical ventilation for more than 48 hours before ICU admission. The author also considered patients who remain on mechanical ventilation for more than 48 hours immediately after admission to the ICU, because it represents the criterion of minimum mechanical ventilation time for the diagnosis of VAP (primary outcome of the original study, GOMES, 2018). Exclusion criteria were medical records that did not contain the variables necessary for the study. For our study, we included as an additional exclusion criterion, the patients without NAS measurements during ICU stay.

Data were collected from 198 patients by GOMES (2018). Four patients were excluded due to the absence of data or NAS evaluations. A total of 194 patients were included in the current study, of which 71 died in the ICU and 123 were discharged from the ICU.

### *2.3. Clinical and Demographic Profile*

Data were collected directly from patients' healthcare records. Initially an individual form was filled out for each patient, containing the following data of patient admission: age (in years), gender (male and female), body mass (Kg), height (cm), diagnosis of admission (characterized in clinical, trauma and surgical; observing that the patient may present more than one diagnosis at admission and with this may belong to more than one group), $C0_2$ partial pressure (mmHg), axillar temperature (°C), time of mechanical ventilation before admission in ICU (day), mean blood pressure (mmHg), blood urea level (mg/dL), PIRO score (points), and the predictors of mortality APACHEII and SAPS3. The presence of comorbidities, chronic obstructive pulmonary disease, congestive heart failure, thyroid alteration (or thyroid diseases) was also evaluated. The Nursing workload was also evaluated at admission by the Nursing Activities Score (NAS), the first 24 hours of ICU stay. The original study includes other variables, which were not described here due to high data loss, see GOMES (2018), GOMES et al. (2019) and GOMES et al. (2020).

### *2.4. Ethical and Legal Considerations*

The study was conducted in accordance with Resolution 466 of 2012 of the National Health Council (BRASIL, 2012) and in accordance with the ethical principles of the Declaration of Helsinki for research involving humans (WORLD MEDICAL ASSOCIATION DECLARATION OF HELSINKI, 1997). The study was submitted to the Ethics and Research Committee of the Federal University of Uberlândia, and approved under the number CAAE: 43409414.8.0000.5152. As the study involved the evaluation of patients' health records and not the direct approach to the patient, their families and the health professional, the Ethics and Research Committee was waived the application of the Free and Informed

Consent Form.

### *2.5. Statistical Analysis*

The patients were divided into two groups for analysis, the patients who died in the ICU and the patients who discharged from the ICU. Qualitative data were described with point estimate of percentage and their exact 95% confidence interval (*95%CI*) based on the *F* distribution (LEEMIS & TRIVEDI, 1996). Quantitative data were described with mean and their *95%CI* based on *Z* distribution (data with Gaussian distribution), or described with median and their *95%CI* based on the interpolation method (HETTMANSPERGER-SHEATHER, 1986), for data that did not follow Gaussian distribution. The data of each group were tested for normality by the Shapiro-Wilk test (SHAPIRO & WILK, 1965). All confidence intervals were proposed as a descriptive approach, the groups were compared by the tests described below.

The independence between the groups and the qualitative variables was tested with the Chi-Square Test of Independence (when the expected frequencies were greater than five) or Fisher's Exact test (when at least one of the expected frequencies were less than five) (PEARSON 1900; FISHER 1922; FISHER 1924). The Chi-Square test had continuity correction (YATES, 1934). For the comparison of data of quantitative variables between the two groups, when the two groups separately presented normality, the differences between the means were tested with Student's *t*-test for homogeneous or heterogeneous variances (STUDENT 1908). The homogeneity of variances was tested between groups with the Levene test (LEVENE, 1960). When at least one of the groups did not present normality, the groups were compared by the Mann-Whitney test (Wilcoxon rank-sum test, unpaired) (MANN & WHITNEY, 1947).

To evaluate the linear relationship between the predictor variables, a simple linear correlation of the Spearman type (SPEARMAN 1904) was performed between all predictor variables of the death event. The significance of the correlation was tested with Student's *t*-test for correlation. The dichotomous qualitative variables were also included assuming the values zero (if not) or one (if yes) for the variable levels, as dummy variables. This analysis was proposed to support the choice of variables included in the complete multiple logistic regression model avoiding collinearity. Some mathematical, theoretical and practical relationships were also used to exclude variables from the complete model.

For the prediction of the occurrence of death in ICU (considered the event of interest) the data of predictor variables were adjusted to simple and multiple logistic regression models (HOSMER & LEMESHOW, 1989) with dependent variable response to death in the ICU (0: success or discharge from the ICU, 1: failure or death in the ICU). In all cases, the Odds-Ratio and their *95%CI* were also calculated. The backward criteria of selection were used from the multiple model, adopting the probability of Wald greater than 0.05 for variable exclusion.

All models constructed were used from a descriptive and non-predictive perspective. The complete models were not presented due to the complexity and difficulty of implementation in the clinical practice of the ICU, always opting for the most parsimonious models. The adequacy and accuracy of the logistic regression models were tested by the Hosmer and Lemeshow Test and the Likelihood Ratio Test (HOSMER & LEMESHOW; 1989) and the Nagelkerke coefficient of determination (NAGELKERKE, 1991). The probabilities of success, failure and total were also reported.

For all analyses, the data were analyzed in the R environment (R CORE TEAM 2020). A significance of 5% was adopted for all analyses, except as described above.

## 3. Results

### *3.1. Comparison of the profile of the two groups*

The ICU mortality rate for patients admitted on mechanical ventilation at least by 48 hours was 36.60% (71 deaths in 194 patients evaluated). Of the 123 patients discharged from the ICU, 11 died in the ward with a mortality rate after discharge from the ICU of 8.94% (11 deaths in 123 patients evaluated). The hospital mortality rate was 42.27% (82 deaths in 194 patients evaluated). We did not use deaths in the ward (11 deaths) in the prediction models, since the risk factors for this phase (ward) were not evaluated, and the intention was to predict death in the ICU and its related factors.

The two groups of patients, discharge or died in the ICU, showed significant differences in some of the variables evaluated in the profile. There is a predominance of male patients in both groups, with no differences between them ($p$ = 0.586). Patients discharged from the ICU have a lower prevalence of clinical admission (32.52% versus 50.7%, $p$ = 0.019), higher prevalence of admission for trauma (30.08% versus 2.82%, $p$ < 0.001), lower prevalence of chronic obstructive pulmonary disease (1.63% versus 14.08%, $p$ = 0.001), and lower prevalence of congestive heart failure (4.88% versus 16.9%, $p$ = 0.012). The two groups showing the same prevalence of surgical admission and presence of thyroid disease ($p$ > 0.05). (Tables 1)

**Table 1.** Admission categorical variables of patients admitted on mechanical ventilation in an adult intensive care unit (ICU) at least 48 hours, stratified into death or discharge from the ICU.

| Trait | Level | % (n) [LL *95%CI*, UL *95%CI*] | | Statistic; *p* |
|---|---|---|---|---|
| | | ICU Discharge | ICU Death | |
| Gender | Male | 65.85 (81) [56.76; 74.16] | 61.97 (44) [49.67; 73.24] | $X^2$ = 0.15; 0.586 |
| | Female | 34.15 (42) [25.84; 43.24] | 38.03 (27) [26.76; 50.33] | |
| Clinical admission | No | 67.48 (83) [58.45; 75.65] | 49.30 (35) [37.22; 61.44] | $X^2$ = 5.51; 0.019 |
| | Yes | 32.52 (40) [24.35; 41.55] | 50.70 (36) [38.56; 62.78] | |
| Trauma admission | No | 69.92 (86) [61.00; 77.86] | 97.18 (69) [90.19; 99.66] | $X^2$ = 19.17; < 0.001 |
| | Yes | 30.08 (37) [22.14; 39.00] | 2.82 (2) [0.34; 9.81] | |
| Surgical admission | No | 43.09 (53) [34.20; 52.32] | 54.93 (39) [42.66; 66.77] | $X^2$ = 2.08; 0.149 |
| | Yes | 56.91 (70) [47.68; 65.8] | 45.07 (32) [33.23; 57.34] | |
| Thyroid Change | No | 98.37 (121) [94.25; 99.80] | 91.55 (65) [82.51; 96.84] | FET; 0.054 |
| | Yes | 1.63 (2) [0.20; 5.75] | 8.45 (6) [3.16; 17.49] | |
| COPD presence | No | 98.37 (121) [94.25; 99.80] | 85.92 (61) [75.62; 93.03] | FET; 0.001 |
| | Yes | 1.63 (2) [0.20; 5.75] | 14.08 (10) [6.97; 24.38] | |
| CHF presence | No | 95.12 (117) [89.68; 98.19] | 83.10 (59) [72.34; 90.95] | $X^2$ = 6.37; 0.012 |
| | Yes | 4.88 (6) [1.81; 10.32] | 16.9 (12) [9.05; 27.66] | |

Legend: COPD: chronic obstructive pulmonary disease, CHF: congestive heart failure, $X^2$:Chi-square test with continuity correction; *p*: probability; FET: Fisher's Exact Test; LL *95%CI*: closed lower limit of the 95% confidence interval; UL *95%CI*: closed upper limit of the 95% confidence interval.

Patients discharged from the ICU had a lower mean for SAPS3 than patients who died in the ICU (60.56 points versus 67.14 points, $p = 0.002$). The means for APACHEII and mean blood pressure were the same between the two groups. When comparing the medians, patients discharged from the ICU had lower medians for age (48 years versus 64 years, $p < 0.001$), lower median for urea concentration in the blood (41 mg/dL versus 54 mg/dL, $p = 0.005$) and higher median for axillary temperature (36.3 ºC versus 36.0 ºC, $p = 0.021$). The other quantitative variables of the profile did not show differences between the two groups, and the two groups did not differ statistically in terms of median for NAS-ad, body mass index, PIRO, weight and height. (Table 2).

**Table 2.** Admission quantitative variables of patients admitted on mechanical ventilation in an adult intensive care unit (ICU) at least 48 hours, stratified into death or discharge from the ICU.

| **Trait (unit)** | **ICU Discharge** | **ICU Death** | **Statistic; *p*** |
|---|---|---|---|
| | **Median (*95%CI*)** | | ***Z; p*** |
| Height (cm) | 165 (165; 170) | 165 (161; 167) | -1.89; 0.058 |
| Age (year) | 48 (39; 54) | 64 (57; 69) | -4.9; <0.001 |
| Body mass index (Kg/m$^2$) | 24.61 (24.09; 24.84) | 24.82 (24.34; 25.39) | -0.86; 0.390 |
| NAS-ad (point) | 52.8 (52.7; 55.0) | 54.0 (52.7; 56.2) | -0.23; 0.821 |
| PIRO (point) | 2 (2; 2) | 2 (2; 2) | -0.8; 0.422 |
| $C0_2$ partial pressure (mmHg) | 36.7 (34.0; 38.6) | 34.5 (33.0; 37.5) | -1.33; 0.183 |
| Axillar temperature (ºC) | 36.3 (36.0; 36.6) | 36.0 (35.8; 36.4) | -2.30; 0.021 |
| Time of mechanical ventilation before admission in ICU (day) | 0 (0; 1) | 1 (0; 3) | -0.82; 0.411 |
| Urea in blood (mg/dL) | 41 (36; 45) | 54 (45; 70) | -2.78; 0.005 |
| **Trait (unit)** | **Mean [*95%CI*]** | | ***t; p*** |
| APACHEII (point) | 18.41 [16.95; 19.86] | 18.89 [16.88; 20.89] | -0.38; 0.701 |
| Body mass (Kg) | 69.44 [67.77; 71.11] | 67.17 [64.91; 69.43] | -1.62; 0.107 |
| Mean arterial pressure (mmHg) | 84.11 [81.48; 86.74] | 85.20 [80.72; 89.67] | -0.41; 0.682 |
| SAPS3 (point) | 60.56 [58.13; 62.99] | 67.14 [64.60; 70.68] | 3.09; 0.002 |

Legend: *95%CI*: confidence interval (lower limit and upper limit being adopted ( ) for open interval and [ ] for closed interval), obtained by *Z* distribution for the mean when the data follow Gaussian distribution; or by the interpolation method for the median; *p*: probability; *t*: Student *t*-test statistic; *Z*: *Z* statistic approximate for the Mann-Whitney test.

### *3.2. Selection of variables for logistic regression models*

As SAPS3 was the unique predictor of mortality that differed between the two groups, it was selected as a predictor of mortality for the multiple model and for the patients admitted on mechanical ventilation, and the variables that are used in its calculation were not included in the multiple regression model for predicting mortality, to avoid redundancy. With this, the variables of age, presence of congestive heart failure, axillary temperature, $CO_2$ partial pressure ($PaCO_2$), mean blood pressure, types of admission (clinical, surgical and trauma admission) were not included in the multiple regression model. We did not have access to all the variables necessary to compute the SAPS3 or APACHEII calculation, since these scores are often calculated by the ICU team, and they do not record these variables in the patient's health records. With this, it was not possible to evaluate the variables that make up these indexes singly or in the multiple model. Despite this we assume that SAPS3 is a validated and more informative predictor than the isolated use of the variables that compose it.

It is observed that most correlations between predictor variables are weak and with values below 0.750, the criteria adopted her for exclusion (regardless of whether positive or negative, full results are not showed here). This criterion not was allowed the additional exclusion of variables for the full multiple model. So, for the M4 model, the full multiple prediction model that evaluated the admission variables adopted the following variables - gender, presence of chronic obstructive pulmonary disease, presence of thyroid disease, blood urea level, PIRO scale, NAS-ad and SAPS3. The anthropometry variables were not included, since there were indications of not differing between groups and were maintained in the study, only descriptive of the population studied.

### *3.3. ICU Mortality prediction models*

In the simple regression models, the model M1 (Table 1), which assesses the predictive capacity of the NAS-ad (NAS of admission), singly, showed that this is not able to predict ICU mortality ($B_1 = 0.003$; $p = 0.853$; Model M1; Table 3). When were tested the predictors of mortality, only the SAPS3 was capable of predicting ICU mortality ($B_1 = 0.03$; $p = 0.003$; Model M2; Table 3) and that the increase in one unit of the SAPS3 indicator increases the chances of death in the ICU in 3% (*OR* = 1.03; *95%CI*: 1.01; 1.05). The APACHEII was not able to predict ICU mortality in the group of patients studied here ($B_1 = 0.01$; $p = 0.699$; Model M3; Table 3). The SAPS3 was the ICU mortality predictor selected for use in the multiple logistic regression model. (Table 3).

When the ICU admission variables were evaluated together with SAPS3 in the model M4 (Table 3), only three variables were maintained in the reduced model, and neither the NAS-ad nor SAPS3 remained in the final model. Patients with chronic obstructive pulmonary disease were 8.82 more likely to die in the ICU than those without COPD (*OR* = 8.82; *95%CI*: 1.82; 42.70), and patients with thyroid diseases were 5.98 more likely to die in the ICU than those who did not (*OR* = 5.98; *95%CI*: 1.15; 31.22), and patients who had increased urea levels have a higher risk of mortality ($B_3$= 0.01; $p = 0.012$), and the increase in one unit in urea blood levels, a continuous variable, increases the chances of death by 1% (*OR* = 1.01; *95%CI*: 1,002; 1.02). (Table 3)

**Table 3.** Simple or multiple logistic regression models and respective Odds-Ratio for prediction of death in the intensive care unit (ICU) in patients admitted in mechanical ventilation at least 48 hours in one ICU.

| *Mi* | Trait or constant | | *Bi* | *SE* $B_i$ | *Wald* | *p* | OR | LL | UL |
|---|---|---|---|---|---|---|---|---|---|
| M1 | Constant | $B_0$ | -0.73 | 0.99 | 0.54 | 0.462 | 0.48 | | |
| | NAS-ad | $B_1$ | 0.003 | 0.02 | 0.03 | 0.853 | 1.00 | 0.97 | 1.04 |
| M2 | Constant | $B_0$ | -2.58 | 0.71 | 13.13 | <0.001 | 0.08 | | |
| | SAPS3 | $B_1$ | 0.03 | 0.01 | 8.70 | 0.003 | 1.03 | 1.01 | 1.05 |
| M3 | Constant | $B_0$ | -0.68 | 0.37 | 3.44 | 0.064 | 0.51 | | |
| | APACHEII | $B_1$ | 0.01 | 0.02 | 0.15 | 0.699 | 1.01 | 0.97 | 1.04 |
| M4 | Constant | $B_0$ | -1.34 | 0.28 | 22.08 | <0.001 | 0.26 | | |
| | COPD presence | $B_1$ | 2.18 | 0.80 | 7.31 | 0.007 | 8.82 | 1.82 | 42.70 |
| | Thyroid problem presence | $B_2$ | 1.79 | 0.84 | 4.50 | 0.034 | 5.98 | 1.15 | 31.22 |
| | Urea blood level | $B_3$ | 0.01 | 0.00 | 6.25 | 0.012 | 1.01 | 1.002 | 1.02 |

Legend: *Mi*: *i-th* model; M1: Admission Nursing workload; M2: Mortality predictor 1, SAPS3; M3: Mortality predictor 2, APACHEII; M4: SAPS3 plus some additional admission variables; COPD: Chronic obstructive pulmonary disease; NAS-ad: NAS of admission; *Bi*: *i-th* estimate of model parameters, *SE Bi*: standard error of *Bi* estimate, *OR* = Odds-Ratio; Wald: Wald Test Chi-Square Statistic; *p*: probability based on the Wald test, LL and UL: lower and upper limit, respectively, of the Odds-Ratio 95% confidence interval. In all models, n failure = 123 discharges and n success = 71 deaths in ICU.

The predictive capacity of the models was tested by likelihood ratio test. For the APACHEII and NAS-ad in the simple logistic regression models the hypothesis that all logistic regression coefficients are null was not rejected ($p > 0.05$). While for SAPS3 and model M4, the null hypothesis was, and then these models were able to predict mortality in the ICU, that is, they contribute to improve the quality of predictions for the estimated model (Table 4). The Hosmer and Lemeshow Test show that all models no show significant differences between the results predicted by the model and those observed indicated that the predicted values and could be used ($p > 0.05$; Table 5). Despite this, the $R^2$ were lower than 0.17 for model 1 to 4, showing low fit in most tested models, which indicates that they should be used with caution for future prediction. All proposed models were more efficient in identifying patients who discharged from the ICU, with a percentage of hit to discharge between 0.919 and 1.000. When we evaluated the probability of hit to death, the models showed low probability of hit, ranging from < 0.001 to 0.296. The multiple model, M4 was the best for predicting patients who died in the ICU (Table 4).

In all situations evaluated in model 4, the presence of chronic obstructive pulmonary disease associated with the presence of thyrodopathies is the worst-case scenario for the patient. And regardless of these, the increased concentration of urea in the blood worsens the prognosis of the patient in ICU. (Figure 1).

**Table 4.** Quality and adjustment measurements of some logistic regression models for the prediction of death in the intensive care unit (ICU) patients admitted on mechanical ventilation at least 48 hours.

| Model | $R^2$ | Likelihood Ratio Test | | | Hosmer and Lemeshow Test | | | Probability of hit | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $X^2$ | *d.f.* | *P* | $X^2$ | *d.f.* | *P* | Discharge | Death | Both |
| M1 | <0.001 | 0.03 | 1 | 0.853 | 2.370 | 7 | 0.937 | 1.000 | <0.001 | 0.634 |
| M2 | 0.064 | 9.26 | 1 | 0.002 | 6.990 | 8 | 0.538 | 0.919 | 0.141 | 0.634 |
| M3 | 0.001 | 0.15 | 1 | 0.699 | 4.610 | 8 | 0.798 | 1.000 | <0.001 | 0.634 |
| M4 | 0.162 | 24.52 | 3 | <0.001 | 1.99 | 8 | 0.981 | 0.951 | 0.296 | 0.711 |

Legend: M1: Model 1 for admission workload measured by NAS (Nursing Activities Score), *d.f.*: degrees of freedom; M2: Model 2 for SAPS3; M3: Model 3 for APACHEII; M4: Model 4 for SAPS3 plus additional admission variables; $X^2$: Chi-square statistics; *p*: probability; $R^2$: Nagelkerke coefficient of determination.

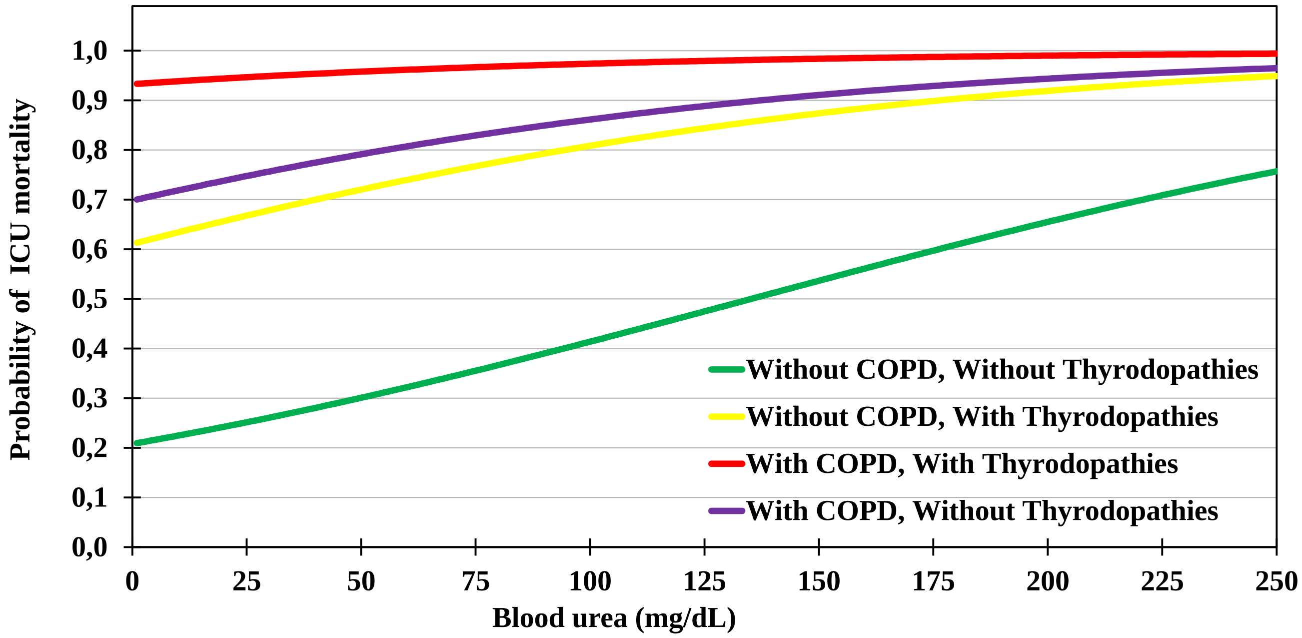


**Figure 1**. Expected probability of mortality in the Intensive Care Unit (ICU) in patients admitted in mechanical ventilation at least 48 hours, obtained by multiple logistic regression model for the four fixed possible scenarios of presence and absence of obstructive pulmonary disease and thyroid diseases, and oscillating blood urea levels.

## 4. Discussion

There is a predominance of middle-aged men with a significant percentage of admissions for trauma resulting from accidents. The profile of the patients was similar to other ICUs, and a discussion of the profile of the patients can be seen in detail in GOMES et al. (2019, 2020).

Although we did not observe an effect of NAS alone on ICU mortality, a higher workload measured by NAS has been associated with a higher incidence of VAP and other infections related to health care

(NOGUEIRA et al., 2017; GOMES et al., 2019) and even associated with a higher risk or mortality rate (MARGADANT et al., 2019). Regarding mortality, the NAS has also shown a positive correlation with APACHEII (NOGUEIRA et al., 2007), a correlation not observed here between the NAS and the two predictors of mortality. GOMES et al. (2019) describes that NAS-ad was a predictor for the occurrence of VAP in this same population, with higher risk of VAP in patients with higher NAS-ad, and who did not have adequately offered the workload during hospitalization. The Nursing workload during hospitalization is probably a better predictor for outcomes than only the value observed at admission, and further studies are still needed.

There are not many options available for the direct measurement of the workload dispensed to a patient for other health professionals than Nursing, which hinders its inclusion in studies that assess its impact on the patient. Nevertheless, its impact is noticeable in the results of care, as perceived by physicians (MICHTALIK et al., 2013). Most of the time, this workload is measured by the ratio of the number of professionals in each category by the number of beds in the unit or number of patients attended, which allows only unit-level analyses and ecological studies.

APACHEII did not show predictive capacity for ICU mortality, as observed in other studies (OLIVEIRA et al., 2010; LENTSCK et al., 2020). In neurological ICU patients, it has been associated with the ability to predict healthcare associated infections and the time of devices use (LI et al., 2014), which is indirectly associated with higher mortality and increased hospital costs. APACHEII's low predictive capacity may be related to its validation exclusively in the U.S. population, which may restrict its applicability in other populations (MORENO & NASSAR JR, 2017), or even subpopulations as observed in ours. While this, SAPS3 is valid in the Brazilian population of surgical patients (SILVA JUNIOR et al., 2010) or even in adult ICUs (ARÊA LEÃO et al., 2018), being useful to indicate severe patients and determine greater care in this group. Predictors of mortality may be dependent on the studied group, for example, neurological patients in the same unit evaluated here had good predictive capacity of SAPS3 for mortality (COSTA, 2020).

The use of these indicators can also be influenced by the administrative choice of the unit and have no relation to a group or to the profile of the unit. The choice between the two indicators is more due to the ease of use of one or the other or even the familiarity of the doctor with their use (SOARES & DONGELMANS 2017). Such situations make it difficult to compare them, since most units only calculate one, and not always the information for calculating both is available in the medical records.

Although we observed that the admission variables are more important than predictors of mortality, these results have not been constant in the literature. COSTA (2020) observed that the variables NAS-ad, SAPS3 and the presence of diabetes mellitus are admission variables that were associated with higher risk of mortality in neurological patients in the same unit evaluated by us. The presence of COPD has also been observed as a risk factor for death in elderly ICU patients, along with the concomitant use of SAPS3 and APACHEII. In this study, the mean blood pressure was also a predictor of mortality (LUCENA et al., 2019). PERES et al., (2015) also found urea levels as a predictor for ICU death in patients and the APACHEII predictor did not remain in the significant multiple model. Acute kidney injury is also common after major traumas, and is associated with increased mortality in critically ill patients (HAINES et al. 2019). Patients with acute kidney injury diagnosed by increased serum creatinine had a higher risk of hospital mortality after non-cardiac surgery, accompanied by several aggravated short-term outcomes and higher total medical costs (XIE et al. 2020). Thyroid hormone dysfunctions and or levels associated with the APACHEII mortality predictor have also been associated with increased probability of predicting the mortality of ICU patients (WANG et al., 2012; GUTHC et al., 2018; MOHAMMED et al., 2020).

It is evident that each patient population may present different predictor variables and indicators for mortality and health care requirements even within the same unit or between different services. It is important to note that, in the literature, we observed several proposals for the inclusion of variables and or approaches for predicting mortality, reinforcing the need to improve existing predictors. Even these variables can be better predictors than the indicators already validated, as we observed. We can highlight, for example, the inclusion of variables related to nutritional status (KATO et al., 2020), not evaluated by us. For the population of patients admitted to mechanical ventilation, there is still a need to evaluate other possibilities of predictors, especially those related to hospitalization. Here, we will not explore the causal relationships of the presence of COPD, thyrodopathies and level of urea in the blood have with mortality, since the design and objective of the study were not to show these causes, but to look for new risk factors for mortality in this population. Other studies need to explore how these risk factors act in these patients and demonstrate their causal relationship or not. Eventually, the inclusion of other variables in the models could change the efficiency of the two predictors evaluated here, like the axillary temperature that differed in both groups. One study suggests that increased body temperature in patients seen in the Emergency Services and ICU is associated with lower mortality in patients with sepsis and fever was associated with a better quality of care (INGHAMMAR & SUNDEN-CULLBERG 2020), perhaps because it serves as a warning sign. Note that this variable was not included in our model by its use in SAPS3.

Our models obtained low ability to determine ICU death, with intermediate determination coefficients. GOMES (2018) obtained Nagelkerke coefficient of determination values higher than 0.700 for the prediction of VAP in this same population. While studies for mortality prediction have observed lower values, and for trauma victims, values of 0.253 (OLIVEIRA, 2020) and models applied to critically ill patients with acute renal failure obtained 0.585 (SOUZA et al., 2014). These low values may reflect the greater difficulty of knowing all predictors of mortality, but reference values are not stipulated or are not yet available by all studies, making generalizations on the quality of adjustments difficult. Another possibility is the need to evaluate other independent variables that are more efficient in discriminating patients who die in the ICU.

As a limitation of the study, we have the data from a single ICU, with restricted number of patients and large losses of variables, which did not allow the inclusion of a large quantity of predictor variables and generalizations of the results obtained for other scenarios. More recent studies have used extensive databases with large samples to construct these relationships and models. NEEDLEMAN et al. (2020) evaluated 78303 admissions to evaluate the association of Nursing dimensioning and patient mortality. NOGUEIRA et al. (2017) included 1,717 subjects to evaluate the impact of Nursing workload on care and on some outcomes in Brazilian ICUs. KÜNG et al. (2019), working in a much more restrictive scenario that is Neonatology, included 908 research subjects. BRUYNEEL et al. (2019) included 3,377 subjects to evaluate the NAS and the patient nurse ratio in hospitals in Belgium. It is evident the need to expand the database for greater generalizations and proposition of a predictive model that can be applied in other realities. Another limitation is the high loss of data and variables from data collection, although the low quality healthcare records, for example of Nursing, are common even in ICUs (ANTUNES et al. 2018).

## 5. Conclusion.

We conclude that nursing workload measured by NAS at admission and APACHEII predictor are not predictors for ICU mortality for patients admitted on mechanical ventilation for at least 48 hours. Only the SAPS3 predictor alone is significant. And from the multiple logistic model we demonstrated that the presence of COPD, the presence of thyroid diseases and the increase in the blood urea level are the only risk factors for ICU mortality identified. In addition, these risk factors observed in the multiple model were more effective in predicting than SAPS3, reinforcing the need to assess predictors of mortality in specific patient populations.

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