# Predictive accuracy of COVID-19 WHO severity classification and comparison with a Bayesian-method-based severity score (EPI-SCORE)

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## 1. Introduction

Coronavirus Disease 2019 (COVID-19) present a wide range of clinical scenarios ranging from asymptomatic carriers to critically ill patients. Patients with mild disease can present with symptoms of fever, cough, and fatigue and some patients deteriorate quickly after a short period of mild symptoms. Sepsis, respiratory failure, acute respiratory distress syndrome (ARDS), heart failure, and septic shock are commonly observed in critically ill patients.
Early detection of patients at risk to develop critical illness may aid in delivering proper care and reduce disease related mortality. The World Healthcare Organization (WHO) has proposed a classification, which separates patients affected by COVID-19 according to the gravity of their clinical scenario. It is of great importance to ensure validation of severity scores which can help to direct the choice of the best therapeutic options, and which can help us to predict the prognosis of each patient presenting with a clinical diagnosis of COVID-19.

## 2. Aims

We sought to assess the predictive accuracy of the World Health Organization (WHO) severity classification on a group of patients hospitalized with a diagnosis of COVID-19 in our healthcare facility located in the south of Belgium. We also sought to compare its predictive power with a new prediction model based on a Bayesian network analysis obtained on the same population (COVID EPI-SCORE).

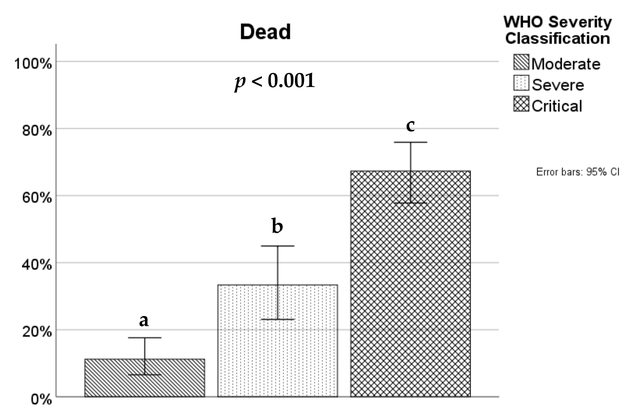
## 3. Methods

We analyzed retrospectively a population of 295 patients hospitalized at Epicura Hospital Center (Province of Hainaut, Belgium), admitted between March 1st and April 30th, 2020, who tested positive for COVID-19.

## 4. Results

Our cohort's median age was 73 (62-83) years, and the female proportion was 43%. All patients were classified following WHO severity classification at admission. 125 (42.4%) had *Moderate* illness, 69 (23.4%) had *Severe* illness, and 101 (34.2%) suffered from *Critical* illness. Death proportions through these three classes were 11.2%, 33.3%, and 67.3%, respectively, and the proportions of patients suffering from *Critical Illness* (dead or IMV) were 11.2%, 34.8%, and 83.2%, respectively.
A Bayesian network analysis was used to create a model to analyze predictive accuracy of the WHO severity classification and to create the EPI-score. The 6 variables that have been automatically selected by our machine learning algorithm were the WHO severity classification, acute kidney injury (AKI), age, LDH, lymphocytes and aPTT. ROC curve indexes hereby obtained were 83.8% and 91% for the models based on WHO classification only and our EPI-score, respectively.

1

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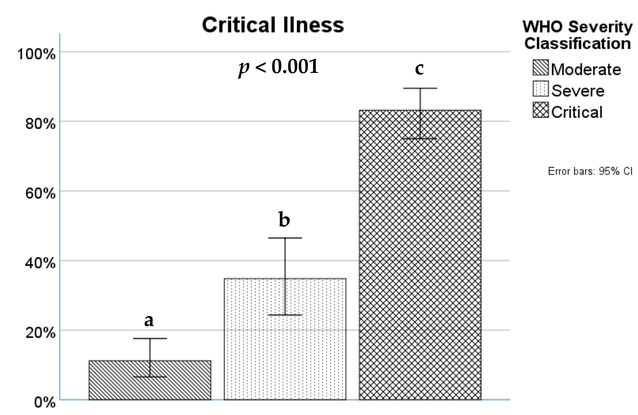



**Figure 1.** Frequency of patients dead in function of WHO severity classes (1). Frequency of patients suffering from critical illness (dead or admitted to ICU) in function of WHO severity classification (2). Each letter denotes a subset of WHO severity classification whose proportion is significantly different at the 0.05 level after Bonferroni's correction.

## 5. Discussion

The present study offers a thorough analysis of the COVID-19 severity classification proposed by the WHO. We used data describing laboratory-confirmed patients at hospital admission to help clinicians in early recognition of pejorative evolution of COVID-19-related pneumonia. The WHO classification did show good prognostic power for severity prediction throughout our cohort, confirmed by both conventional statistics and Bayesian network modeling.
Moreover, this study proposes a new and original severity predictive analysis through Bayesian network modeling. With the herein designed model, WHO severity classification could be strengthened by adding five other variables to help predict Critical Illness in SARS-COV-2 induced pneumonia patients to propose our COVID-19 EPI-SCORE. This method proposes a powerful associative model that yielded a simple score based on the well-known WHO classification and was internally validated by 10-fold randomization. Besides being useful in clinical practice, this score could be valuable in the classification of severity of patients in clinical trials.
The use of a nonparametric Bayesian network has several advantages over classical regression: variables can be categorical or numerical, relationships can be linear or non-linear, missing values are automatically processed when learning the network. Moreover, as it is a Bayesian model, we can use the score without having all the information on the model's variables; the Bayes theorem allows us to update the output incrementally upon reception of pieces of evidence describing the patient.

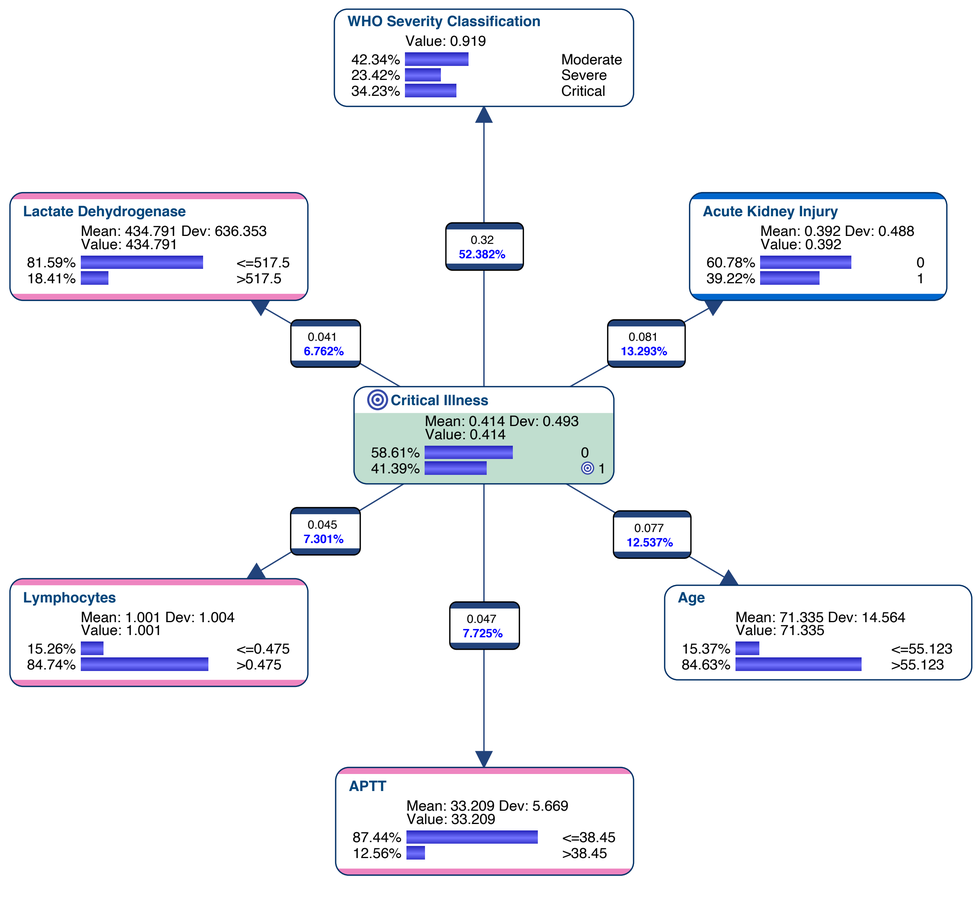
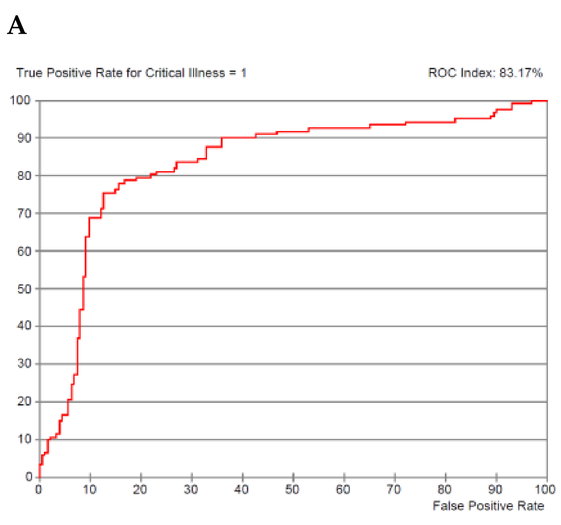



**Figure 2.** Graphical presentation of variables that have been automatically selected by our machine learning algorithm following the Target Node Critical Illness, giving the EPI-SCORE.

A

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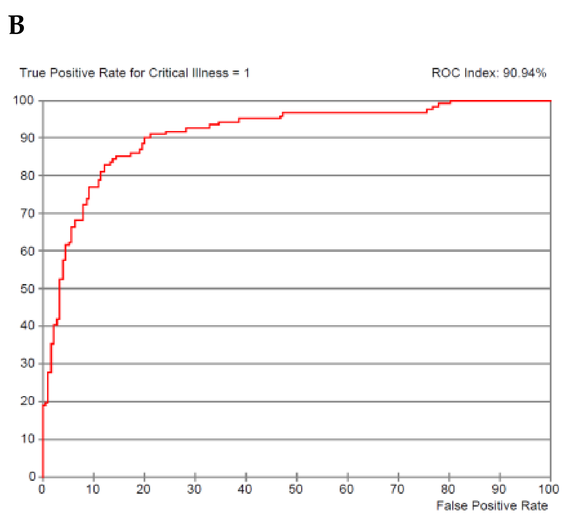


**Figure 3.** ROC Curves of the Bayesian Network Model. ROC curve of WHO severity classification (A) and COVID-19 score (EPI-SCORE) (B)

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## 5. Conclusion

Our study shows that the WHO severity classification is reliable in predicting a severe outcome among COVID-19 patients. The addition to this classification of a few clinical and laboratory variables as per our COVID-19 EPI-SCORE has demonstrated to significantly increase its accuracy and can thus be useful in clinical practice or for classification of patients in clinical trials.