The Classification Algorithms Applied to the Inpatient Stay for Lower Limb Surgery

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Abstract. The revolutions of recent years in health care have involved several areas ranging from patient treatment to resource management. Therefore, several strategies have been put in place to increase patient value while trying to reduce spending. Several indicators have arisen to evaluate the performance of healthcare processes. The main one is Length of Stay (LOS). In this study, classification algorithms were used to predict the LOS of patients undergoing lower extremity surgery, an increasingly common condition given the progressive aging of the population. The context is the Evangelical Hospital “Betania” in Naples (Italy) in 2019-2020, which augments a multicenter study conducted by the same research team on several hospitals in southern Italy. All selected algorithms show an Accuracy above 90% but among them, the best is Logistic Regression with a value reaching 94%.

Keywords. Lower Limb Surgery, Length of Stay, Classification Algorithms.

1. Introduction

Throughout the world, a process of evolution is being observed that is increasingly focused on two fundamental aspects: value to the patient and cost of care [1]. Among the metrics widely adopted to assess cost and quality is length of stay (LOS). A significant impetus to the process of evolution in health care has come from innovations achieved in both technology [2-4] and materials used [5-7]. A significant impetus has come from data analysis techniques that have revolutionized not only the doctor-patient relationship but also the management of hospital resources. Fuzzy logic [8,9], statistical analysis [10-12], mathematical models [13-15] or management approaches such as Lean Six Sigma [16-18] are just a few examples. LOS, which is recognized as a parameter of effectiveness, also lends itself well to the use of these techniques in both orthopedic [19] and other settings [20] with excellent results in Italy. In fact, in this study, we want to use Machine Learning algorithms to predict the LOS of patients undergoing lower limb surgery. Lower limb fractures are a common condition among the elderly population.

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being 70% of fractures caused by osteoporosis [21]. Therefore, in the face of increasing demand, the challenge of healthcare cost containment becomes even more important. This aspect justifies our study conducted using data from 162 patients undergoing lower limb surgery in 2019-2020 at the Evangelical Hospital "Betania" in Naples, Italy. Through the use of predictive models, it is possible to know the LOS a priori and optimize bed management by aiding planning. This study continues a line of research begun in 2021 that involved two hospitals in Southern Italy [22,23].

2. Methods

The information for this study was extracted from the information system of the Evangelical Hospital "Betania" in Naples, Italy. Using hospital discharge records, through the procedure code reported in the literature [19] and the year of discharge, medical records of interest were filtered. From the extracted variables, after the pre-processing stage, the independent variables used in the study (Age, Gender (M/F), Comorbidities (1/0), Complication during surgery (1/0), Pre-Op LOS) were obtained, in agreement with previous studies [22,23]. Figure 1 shows the distribution of the variables.

2.1. Classification Algorithms

To proceed with the use of the classification algorithms, it is necessary to partition the LOS, a continuous variable, into two homogeneous groups. The Decision Tree, Random Forest, Gradient Boosted Tree, Support Vector Machine, Logistic Regression and Naïve Bayes algorithms were selected based on other studies [22,23]. DT, RF and GBT are all algorithms based on decision trees, which are optimized in RF and GBT through multiple implementation. Different discourse for the others. SVM aims to search for the best separation hyperplane between classes, NB is based on a simplified version of Bayes’ theorem while LR uses a logistic function to estimate the probability of occurrence. For the implementation, an 80% split was made for the training set and 20% split for the test set. The software chosen is KNIME Analytics Platform.

3. Results

This section will present the results of machine learning algorithms. First, the selected algorithms were implemented. Table 1 shows the results in terms of Accuracy and Error.
Table 1. Results of classification algorithms.

<table>
<thead>
<tr>
<th>Algorithms</th>
<th>Accuracy</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT</td>
<td>90.9</td>
<td>9.1</td>
</tr>
<tr>
<td>RF</td>
<td>87.9</td>
<td>12.1</td>
</tr>
<tr>
<td>SVM</td>
<td>90.9</td>
<td>9.1</td>
</tr>
<tr>
<td>GBT</td>
<td>87.9</td>
<td>12.1</td>
</tr>
<tr>
<td>LR</td>
<td>93.9</td>
<td>6.1</td>
</tr>
<tr>
<td>NB</td>
<td>87.9</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Looking at the values obtained, it can be seen that with all algorithms excellent results are obtained with values ranging from 87% to 94%. The best is LR with an accuracy close to 94%. It was therefore decided to select this algorithm and investigate the performance detail.

Table 2. Class statistics (%) and Confusion matrix of LR.

<table>
<thead>
<tr>
<th>Class</th>
<th>Recall</th>
<th>Precision</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>F-Measure</th>
<th>Confusion Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>94.44</td>
<td>94.44</td>
<td>93.33</td>
<td>94.44</td>
<td>1 17</td>
</tr>
<tr>
<td>2</td>
<td>93.33</td>
<td>93.33</td>
<td>93.33</td>
<td>94.44</td>
<td>93.33</td>
<td>1 14</td>
</tr>
</tbody>
</table>

4. Discussion and Conclusion

In this work, following what already in the literature [22,23], data from 162 patients who underwent lower limb surgery in 2019-2020 at the Evangelical Hospital "Betania" in Naples (Italy) were analyzed.

The objective is to construct a predictor of LOS using 5 independent variables through machine learning algorithms replicating what has already been published by the same research group for two other hospitals in the same area [27, 28]. All algorithms showed excellent results, but among them the best was LR with an accuracy close to 94%. When the results were analyzed by class, it was found that the LR classifier performed best in the first class (patients with low to medium hospital stay). This consideration is marginal when looking at the confusion matrix is due to the predominance of class 1 in the test set. Looking at the accuracy obtained in other publications, the best results were recorded for the A.O.R.N. "A. Cardarelli" in Naples [23] on a dataset of more than 200 patients. Compared with the University Hospital "San Giovanni di Dio e Ruggi d'Aragona" of Salerno [22] similar as sample size, the results are slightly better. Finally, there is no homogeneity in the best algorithm (LR for this study compared to RF [22] and NB [23]). The work has several limitations, such as a small number of variables and patients. In addition, the other works are used only as a comparison; integration of the datasets will lead to generalizable conclusions.

References


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