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Modeling Cholecystectomy Hospital Stay Through a Linear Approach

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Abstract. Cholecystectomy is among the most frequent procedures in general surgery. In the healthcare facility organization, it is important to evaluate all interventions and procedures that have a great impact on health management and that have a clear effect on the Length of Stay (LOS). The LOS represents, in fact, an indicator of performance and measure the goodness of a health process. This study was conducted with the aim of providing LOS for all patients undergoing cholecystectomy at the "A.O.R.N. A. Cardarelli" of Naples. Data were collected in the two years 2019 and 2020 and included 650 patients. A MLR model is created in the work to predict the value of LOS as a function of the following variables: gender, age, pre-operative LOS, presence of comorbidities and complication during surgery. The results obtained are as follows: R= 0.941 and R2= 0.885.

Keywords. Cholecystectomy, Length of Stay, Multiple Regression Model

1. Introduction

Cholecystectomy is a frequent procedure in surgery and is performed for the treatment of acute cholecystitis presenting with a complication of cholelithiasis [1]. Inflammation can be caused by gallstones, that can be treated with laparoscopic cholecystectomy (LC) and open cholecystectomy (OC) [2]. LC has been widely adopted as a treatment for gallstone disease [3], as it represents a more reliable technique with significantly reduced mortality rate for all patients not at high risk. The LC technique is more frequent, and it guarantees a low invasiveness that minimizes complications and, as required by the provisions of the Italian Government in the New Guarantee System [4], limits post-operative hospitalization to 3 days. Comparing the two procedures, the benefits of the LC procedure in terms of quality of life and total mortality are evident with a reduction in post-operative pain and therefore less use of painkillers. The benefits of LC technique are also evident on hospital spending with obvious savings on interventions in both men and women and these differences increase substantially with age [5]. Many works show that the more days spent in hospital before surgery, the higher the costs sustained by the facility [6]. All the information derived from the LOS study can be a valuable aid in the planning of departments and in the proper management of resources to achieve a good

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quality of the services offered [7]. Several studies have evaluated this parameter using analytical techniques of data analysis [8 -10], regression [11, 12], artificial intelligence [13, 14] and statistical analysis [15,16]. This work analyzed LOS and the factors that determine its variation for all patients of "A.O.R.N. A. Cardarelli" of Naples (Italy) undergoing cholecystectomy. In the study were considered the interventions of cholecystectomy both in laparoscopy and open, and the dataset of 650 patients included all admitted to hospital in the two years 2019 and 2020 who underwent this specific surgery. The variable LOS was modeled with Multiple Linear Regression to analyze and demonstrate how it is affected by other hospital and patient-related variables.

2. Methods

The data used in this work were provided by the "A.O.R.N. A. Cardarelli", with the aim of analyzing the LOS for patients undergoing cholecystectomy. The dataset included 650 cases in the years 2019 and 2020. The information collected for patients is as follows: gender (male/female), age, complications during surgery, presence of comorbidities (hypertension, diabetes, obesity, tumor, date of admission, intervention, and discharge.

Multiple Linear Regression is a statistical technique used to predict the result of a variable based on the value of two or more variables. The variable to be predicted is the dependent variable. The MLR model was constructed using the overall LOS as an independent variable while dependent variables are sociodemographic data, pre-operative LOS and the presence of intraoperative complications. Before creating the model, the following six hypotheses must be verified:

1. The linear relationship between the independent and dependent variable.
2. Absence of multicollinearity.
3. The independence of the residuals.
4. The residuals have constant variance.
5. The residuals are normally distributed.
6. Presence of outliers.

IBM SPSS (Statistical Package for Social Science) ver.28 was used for the analysis.

3. Results

To be implemented the model have been verified before the 6 hypotheses. The Durbin-Watson test must have a value between 1,5 and 2,5; in this case it was 1,642. The absence of abnormal values in the dataset was demonstrated, actually the Cook distance for each observation was less than 1. Then, the collinearity was assessed through Tolerance parameters and Variance Inflation Factors (VIF) with permissible Tolerance values > 0,2 and VIF <10, as shown in Table 1.

Table 1. Collinearity diagnostics.

Input variables	Tolerance	VIF
Gender	0.974	1.027
Age	0.902	1.109
Complications during surgery	0.783	1.277

Presence of comorbidities	0.768	1.302
Pre-operative LOS	0.924	1.082

After the hypotheses were verified, the MLR model was implemented and in Table 2 the R2, Adjusted-R2 and Standard Error of the Estimate are shown.

Table 2. Model summary.

	R	R^2	Adjusted- R^2	Std. Error of Estimate
MLR Model	0.941	0.885	0.884	3.432

As shown in Table 2, the MLR model has obtained acceptable values for the determination coefficients, in fact the R2 values are higher than 0,5 and therefore are able to provide a rough estimate of the LOS that could be useful for the management. Table 3 shows the regression coefficients of the model and the results of the t-test, with a significance level of 0,05.

Table 3. Regression coefficients of the model

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sign.
	B	Std. Error	Beta		
Intercept	1.824	0.673	-	2.712	0.007
Gender	- 0.527	0.273	-0.026	-1.931	0.054
Age	0.028	0.009	0.045	3.224	0.001
Complications during surgery	3.311	0.393	0.127	8.418	< 0.001
Pre-operative LOS	0.994	0.018	0.859	56.242	< 0.001
Presence of comorbidities	0.508	0.455	0.016	1.117	0.264

As can be seen from the table above, the statistically significant variables are age, complication during surgery and pre-operative LOS, which resulted in a p-value of less than 0.05.

4. Discussion and Conclusion

In this study the analysis was conducted with a dataset of 650 patients who have undergone cholecystectomy in the "A.O.R.N. A. Cardarelli" applying a MLR model. MLR analysis carried out in the work obtained a regression coefficient R2 value of 0.885 and an Adjusted-R2 value of 0.884, and this prove to be good and it's able to represent well the problem under consideration. The t-test results reported the following significant variables: age, complication during surgery and pre-operative LOS. This information is of strategic importance for the creation of pathways for specific age groups, for the management of complications or for the standardization of the pre-operative phase. This work demonstrated that the MLR represents a valid preliminary support to characterize the demand and to be able to estimate the occupation of the beds and the use of other hospital resources.

The future development of this work is multiple, as it could be an extension of the years of observation and other variables of the model could be considered to intensify and solidify the forecasting model [17-19].

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