Healthcare Transformation with Informatics and Artificial Intelligence
J. Mantas et al. (Eds.)

© 2023 The authors and IOS Press.
This article is published online with Open Access by IOS Press and distributed under the terms of the Creative Commons Attribution Non-Commercial License 4.0 (CC BY-NC 4.0).
doi:10.3233/SHTI230478

Prediction of Hospital Length Stay for Patients Undergoing Mastectomy

Gaetano D'ONOFRIO[a], Antonio D'AMORE[a], Filippina ONOFARO[a], Emanuele CAPUTI[a], Annalisa NAPOLI[a] , Maria TRIASSI[b,c] and Marta Rosaria MARINO[b,1]
[a] *A.O.R.N. "Antonio Cardarelli", Naples, Italy*
[b] *Department of Public Health, University of Naples "Federico II", Naples, Italy*
[c] *Interdepartmental Center for Research in Healthcare Management and Innovation in Healthcare (CIRMIS), University of Naples "Federico II", Naples, Italy*

Abstract. The prolonged length of stay is an important aspect to be considered for the healthcare management since this affect both the health-related expenditure of the hospital and the quality of the offered service. In the light of these consideration is important for hospitals to be able to predict the LOS of patients and to work on the principal aspect affecting it in order to reduce LOS as much as possible. In this work we focus on patients undergoing mastectomy. The data were collected form 989 patients who underwent mastectomy surgery in the Surgery Department of the AORN "A. Cardarelli" of Naples. Different models have been tested and characterized and the one with the best performance was identified.

Keywords. Length of stay, Mastectomy, Breast Cancer, Machine Learning

1. Introduction

Breast cancer is today the most important cause of female mortality in the world, treated with mastectomy. It is estimated that about 50% of the total cost of a mastectomy is related to hospitalization costs and the length of stay in the hospital ward. At the same time, several studies claim that a well-considered reduction in hospital admissions has no effect on the health of patients, but rather has beneficial effects on their psychological health, allowing them to return earlier to a family environment [1]. In addition, the number of days of each patient, also known as Length of Stay (LOS) is a useful measure to assess service levels, in particular, prolonged LOS can be caused by inefficiencies or waste during hospitalization, mainly due to patient and organizational factors [2]. Predicting the LOS for patients undergoing mastectomy is a powerful way to maximize service level quality and minimize resource waste utilization [3]. Moreover, LOS monitoring is one of the crucial factors for identifying economic features of care used by private and public organizations for estimating costs according to expected LOS [4]. Researchers and practitioners are focused on developing models and methodologies for estimating LOS [5, 6], and models have been proposed to decrease LOS for other surgeries [7-12]. The implementations presented actually adopt all those data analysis strategies already successfully used in the health sector for the analysis of biomedical

[1] Corresponding Author: Marta Rosaria Marino. Department of Public Health, University of Naples "Federico II", Naples, Italy. Email: martarmarino@gmail.com.

data [13-15] but also from a management point of view for the analysis of hospital resources [16-18] and pathways [19, 20]. The main aim of the proposed work is to design and develop the most suitable ML model able to estimate the LOS for patients undergoing mastectomy in order to optimize the healthcare management process.

2. Methods

The proposed study relies on a dataset collected by 989 subjects underwent mastectomy between 2019 and 2021 in the Department of the "A.O.R.N. A. Cardarelli" of Naples. In particular, this dataset is composed of personal information (i.e., Gender (male/female) or age) Presence of comorbidities (Hypertension, diabetes, obesity, tumor stage) and hospitalization dates. The proposed study relies on the analysis and advancement of artificial intelligence models, that have achieved highest outcomes to deal with several task in different domains [21-26]. Furthermore, LOS has been computed as the difference between admission and discharge dates and was divided into two classes for data analysis. The entire dataset has been split into two subsets for statistical validation of the proposed analysis: training (80%) and test (80%). Finally, several ML models have been developed through KNIME analytics platform: the Decision Tree (DT), the Random Forest (RF), the Gradient Boosting-based Tree (GBT) and the Logistic Regression (LR).

3. Result and Discussion

Based on the data collected from the patients who underwent mastectomy in the Surgery Department of the "A.O.R.N. A. Cardarelli" of Naples, the LOS was calculated for each patient considering their hospitalization date. The parameters Age and Presence of comorbidities such as hypertension, diabetes, obesity and tumor stage were considered as factors affecting the LOS. These data were used to train and test several MLs to predict LOS with the DT, RF, GBT and RL algorithms and Table 1 reports the result based on the percentage of accuracy and error.

Table 1. Effectiveness performance of each ML model

Models	Accuracy (%)	Error (%)
DT	68.69	31.31
RF	77.79	22.21
GBT	65.15	34.85
LR	69.19	30.01

Data show the algorithm with the best accuracy is the RF, showing an accuracy of about 78%. Moreover, Table 2 details the main performance of each model according to several effectiveness measures (Precision, Recall, Sensitivity, Specificity and F-measure) to investigate their performance from different points of view.

Table 2. Key indicators of models effectiveness

Models	Class	Precision (%)	Recall (%)	Sensitivity (%)	Specificity (%)	F- measure
DT	1	69.2	96.2	96.2	12.3	0.805
	2	61.5	12.3	12.3	96.2	0.205
RF	1	76.6	96.2	96.2	40.0	0.853

Models	Class	Precision (%)	Recall (%)	Sensitivity (%)	Specificity (%)	F- measure
GBT	2	83.9	40.0	40.0	96.2	0.542
	1	71.1	81.2	81.2	32.3	0.758
	2	45.7	32.3	32.3	81.2	0.378
LR	1	68.6	100	100	6.2	0.813
	2	100	6.2	6.2	100	0.116

Also in this case, the algorithm showing the best performance is the RF one for both classes. Since that, we calculated the confusion matrix for this algorithm, reported in Table 3. Data show 128 true positive and 26 true negative, 5 false negative and 39 false positive. So, the algorithm is able to correctly classify 153 samples up to 197, that is the 78% of the entire sample, in accordance with the accuracy results.

Table 3. Confusion matrix of RF algorithm

Real/Predicted	1	2
1	128	5
2	39	26

4. Conclusions and future developments

In the proposed study, we investigated how ML models can be used for predicting, and consequently reducing, the LOS for patients undergoing mastectomy. Data show that the best algorithm, among the ones tested, was the RF, So, these results, even if preliminary, demonstrate the feasibility of ML models in daily routine hospital management to optimize the reduction of the LOS for patients undergoing mastectomy. Future developments will include the both the extension of the dataset and the number of patients involved in the study. In this context it could be of particular interest to make a comparison among various parameter that can affect the LOS in patients undergoing mastectomy in order to find the most relevant one and implement corrective actions aimed at LOS reduction. Moreover, different departments and surgical procedures could be considered, and numerous processes could be optimized in the same way.

References

[1] Gümüş M, Satıcı Ö, Ülger BV, Oğuz A, Taşkesen F, Girgin S. Factors Affecting the Postsurgical Length of Hospital Stay in Patients with Breast Cancer. J Breast Health. 2015 Jul 1;11(3):128-131. doi: 10.5152/tjbh.2015.2546. PMID: 28331707; PMCID: PMC5351451.

[2] Shojania KG, Showstack J, Wachter R M 2001 Assessing hospital quality: a review for clinicians Eff. Clin. Pract. ECP 4 82–90.

[3] Detsky AS, Stricker SC, Mulley AG, Thibault G E. Prognosis, survival, and the expenditure of hospital resources for patients in an intensive-care unit N. Engl. J. Med. 1981;305:667–72.

[4] Molloy IB, Martin BI, Moschetti WE, Jevsevar DS. Effects of the Length of Stay on the Cost of Total Knee and Total Hip Arthroplasty from 2002 to 2013 J. Bone Joint Surg. Am. 2017;99:402–7.

[5] Trunfio TA et al. "Multiple regression model to analyze the total LOS for patients undergoing laparoscopic appendectomy." BMC Medical Informatics and Decision Making. 22.1.2022;1-8.

[6] Trunfio, Teresa Angela, Anna Borrelli, and Giovanni Improta. "Is It Possible to Predict the Length of Stay of Patients Undergoing Hip-Replacement Surgery?." International Journal of Environmental Research and Public Health 19.10.2022;6219.

[7] Majolo, M., et al. "Studying length of stay in the Emergency Department of AORN "Antonio Cardarelli" of Naples." 2021 10th International Conference on Bioinformatics and Biomedical Science. 2021.
[8] Converso, Giuseppe, et al. "A simulation approach for agile production logic implementation in a hospital emergency unit." International conference on intelligent software methodologies, tools, and techniques. Springer, Cham, 2015.
[9] Pearson S D, Kleefield S F, Soukop J R, Cook E F and Lee T H 2001 Critical pathways intervention to reduce length of hospital stay Am. J. Med. 110 175–80
[10] Majolo, Massimo, et al. "Studying length of stay in the Emergency Department of AORN "Antonio Cardarelli" of Naples." 2021 10th International Conference on Bioinformatics and Biomedical Science. 2021.
[11] Latessa I, Fiorillo A, Picone I, Balato G, Trunfio T A, Scala A and Triassi M 2021 Implementing fast track surgery in hip and knee arthroplasty using the lean Six Sigma methodology TQM J. 33 131–47
[12] Di Laura, Danilo, et al. "Efficiency measures of emergency departments: An Italian systematic literature review." BMJ open quality 10.3 (2021): e001058.
[13] Colella, Ylenia, et al. "Overcrowding analysis in emergency department through indexes: a single center study." BMC Emergency Medicine 22.1 (2022): 1-11.
[14] Bonavolontà, Paola, et al. "Evaluation of sarcopenia and sarcopenic obesity in patients affected by oral squamous cell carcinoma: A retrospective single-center study." Journal of Cranio-Maxillofacial Surgery (2023).
[15] Orabona, Giovanni Dell'Aversana, et al. "A comparison of a SARS-CoV-2 rapid-test and serological-test in a Public Health Hospital." The Journal of Infection in Developing Countries 16.02 (2022): 258-264.
[16] Improta, G., T. Simone, and M. Bracale. "HTA (Health Technology Assessment): a means to reach governance goals and to guide health politics on the topic of clinical Risk management." World Congress on Medical Physics and Biomedical Engineering, September 7-12, 2009, Munich, Germany. Springer, Berlin, Heidelberg, 2009.
[17] Cortesi, Paolo Angelo, et al. "Cost-effectiveness and budget impact of emicizumab prophylaxis in haemophilia A patients with inhibitors." Thrombosis and Haemostasis 120.02 (2020): 216-228.
[18] Arpaia, Pasquale, et al. "An Augmented Reality-Based Solution for Monitoring Patients Vitals in Surgical Procedures." Augmented Reality, Virtual Reality, and Computer Graphics: 8th International Conference, AVR 2021, Virtual Event, September 7–10, 2021, Proceedings 8. Springer International Publishing, 2021.
[19] Bonavolontà, Paola, et al. "Postoperative complications after removal of pleomorphic adenoma from the parotid gland: A long-term follow up of 297 patients from 2002 to 2016 and a review of publications." British Journal of Oral and Maxillofacial Surgery 57.10 (2019): 998-1002.
[20] Ferraro, Anna, et al. "Implementation of lean practices to reduce healthcare associated infections." International Journal of Healthcare Technology and Management 18.1-2 (2020): 51-72.
[21] Amato, F., Moscato, V., Picariello, A., Piccialli, F., and Sperlí, G. (2018). Centrality in heterogeneous social networks for lurkers detection: An approach based on hypergraphs. Concurrency and Computation: Practice and Experience, 30(3), e4188, doi: https://doi.org/10.1002/cpe.4188
[22] Amato, F., Moscato, V., Picariello, A., & Sperlí, G. (2017, July). Diffusion algorithms in multimedia social networks: A preliminary model. In Proceedings of the 2017 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining 2017 (pp. 844-851), doi: https://doi.org/10.1145/3110025.3116207
[23] Sperlí, G. (2020, March). A deep learning based chatbot for cultural heritage. In Pro-ceedings of the 35th Annual ACM Symposium on Applied Computing (pp. 935-937), doi: https://doi.org/10.1145/3341105.3374129
[24] M. Ianni, E. Masciari, G. Sperlì, A survey of big data dimensions vs social networks analysis, Journal of Intelligent Information Systems 57 (1) (2021) 73–100. doi:https://doi.org/10.1007/s10844-020-00629-2
[25] Moscato, V., & Sperlì, G. (2021). A survey about community detection over On-line Social and Heterogeneous Information Networks. Knowledge-Based Systems, 224, 107112. doi: https://doi.org/10.1016/j.knosys.2021.107112
[26] Montella, E., Ferraro, A., Sperlì, G., Triassi, M., Santini, S., & Improta, G. (2022). Predictive analysis of healthcare-associated blood stream infections in the neonatal intensive care unit using artificial intelligence: A single center study. International Journal of Environmental Research and Public Health, 19(5), 2498.