Comparison of Statistical Models of Predict the Factors Affecting the Length of Stay (LOS) in the Intensive Care Unit (ICU) of a Teaching Hospital

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ABSTRACT

Introduction: Modeling can be a useful tool to find out how the distributions of hospital length of stay (LOS) and the factors affecting the length of stay. The present study aims to determine factors affecting the length of stay and selecting suitable statistical models. Material and Method: This is a cross-sectional study of 565 patients who were treated in the intensive care unit of Imam Khomeini hospital in Ahvaz. Preliminary data were collected retrospectively through the medical records of all patients admitted on intensive care units of Ahvaz Imam Khomeini Hospital in 2015. Statistical analysis and multivariate modeling were done using SPSS 21 and STATA 7 software. Results: Average length of stay in ICU was 8.16±0.75 days. The Mean and Median age of patients were 58.6±20 and 61 respectively. The Mean LOS for females (16.44±9.37 days) was more than the men (11.5±3.5 days) (p<0.01). The maximum and minimum lengths of stay belonged to patients with endocrine disorders (14.7±3.1 days) and patients with gastrointestinal disorders (5.53±1.1 days) respectively (p<0.01). The goodness of fit for Gamma model showed that this model was more suitable and powerful than Log-normal model to predict the factors affecting the patient’s length of stay in intensive care units of hospital. Conclusion: Gamma regression model was more robust to predict factors regarding the hospital length of stay. According to Gamma model the key factor in predicting the length of stay in ICU was the type of disease diagnosis. The result of statistical modeling can help managers and policy makers to estimate hospital resources and allocate them for different hospital services.

Keywords: length of stay, statistical modeling, ICU, teaching hospital.

1. INTRODUCTION

Intensive care unit (ICU) is one of the critical parts of a hospital which can reduce the rate of mortality and side effects of hospitalization (1, 2). An increase in the length of stay and the hospital costs are the main problems of admitted patients in intensive care units (3). The LOS is the key indicators that use to plan for hospital resources in making plans for patients (4-6). Clinical, demographic, and managerial factors are impact on the hospital length of stay in ICU (7-14). Since the optimum use of resources plays an important role in enhancing the efficiency of hospitals, reducing the length of stay can led to increase hospital resources efficiency and effectiveness (15-16). To manage hospital beds and patients LOS in ICU we need to model hospital data (17).

Modeling is one of the basic tools used in explaining the medical and health phenomena. These tools determine the distribution of specific variables and their relations with other variables by means of regression statistic methods. Modeling the length of stay is a valuable way to know about the status of distribution of LOS (18). The effecting factors in the length of stay cannot be predicted by using common statistic methods like linear regression method since the useful variable because the distribution of LOS data is normal. Hospital length of stay data have a right skewness (19-20). LOS is a numerical discrete variable; therefore, numerical data distribution should be used to analyze them (17). To model the numerical discrete variable should be used the model which has been a suitable prediction power (18). Statistical models with different distribution can predict the length of stay, as well as the factors influencing it (21). Identifying a robust
2. MATERIAL AND METHODS

This is a cross-sectional study of 565 patients treated in the intensive care unit of Imam Khomeini hospital in Ahwaz. Preliminary data were collected retrospectively from medical records of all patients admitted to the intensive care unit from 1 January 2015 to 31 December 2015. To confirm the content validity of data form, we used the expert’s views about questions and variables. In this study According to Kolmogorov-Smirnov test, distribution of the dependent variable data was abnormal and had a right skewness. In this study six percent of the patients an intensive care unit died on the first day (LOS=0), so zero data have not been included in modeling. First, data were analyzed by univariate tests. Including Mann-Whitney, Kruskal-Wallis, and Spearman coefficient. Then we selected the significant variables to model by using multi-variate regression analysis and stepwise modeling method. In this study significant level was determined 0.01. In this study Log-normal model was used base on formula: In (y) = o+1x, in which X variable data are made from even distribution (0, 1), ~N (0, σ^2), in which, σ^2 = 0.5, 1.0, 1.5. 1=1 was used, o was estimated in this way:

E(y|x) =exp o+1x+0.5^2

Also Y variable skewness is as follows:

(Exp (1)+2)/(Exp (1)-1)^3/5

And also some data are produced by log-normal distribution with variances of 0.5, 1, 1.5 and 2. Also, GAMMA model was used based on following formula: Variable data from standard GAMMA with density function

In which scale parameter is b = exp (β0 + β1x). and are chosen in such a way that result will be and they are produced by parameters of 5,0,1,2,4. We used SPSS 21 and STATA 7 to analyze the data modeling.

3. RESULTS

Table 1 shows the demographic and clinical characteristics which influence the patients’ length of stay in intensive care unit. Average length of stay in ICU was 8.16±0.75 days. The Mean and Median age of patients were 58.61±20 and 61 respectively. The Mean LOS for females (16.44±9.37 days) was respectively, The Mean LOS for females (16.44±9.37 days) was respectively, 12.3% (70) 495 (87.7%) no

| Diagnosis      | P.value | Mean±SD | Variables |
|----------------|---------|---------|-----------|
| Sex            | 0.01    | 5.35±11.5 | 339 (60%)  |
|                |         | 9.37±16.44 | 226 (40%)  |
| Diagnosis      | 0.01    | 9.15±12.41 | 276 (48.8%) |
|                |         | 5.53±11.44 | 211 (37.3%) |
|                |         | 11.26±17.75 | 60 (10.6%)  |
|                |         | 14.75±31.54 | 16 (2.8%)   |
| Bed sore       | 0.01    | 11.18±14   | 180 (35.9%) |
|                |         | 7.68±13.61 | 385 (64.1%) |
| Diagnosis      | 0.01    | 11.50±18.69 | 93 (21.2%)  |
|                |         | 7.70±12.51 | 472 (78.8%) |
| Diagnosis      | 0.01    | 11.05±15.69 | 97 (21.1%)  |
|                |         | 7.77±13.28 | 468 (78.9%) |
| Diagnosis      | 0.01    | 8.12±12.41  | 70 (12.3%)  |
|                |         | 8.16±13.93 | 495 (87.7%) |
| Diagnosis      | 0.01    | 10.67±13.48 | 184 (38.6%) |
|                |         | 7.43±13.81 | 381 (61.4%) |
| Diagnosis      | 0.01    | 11.66±16.89 | 68 (15.7%)  |
|                |         | 7.82±13.23 | 497 (84.3%) |
| Diagnosis      | 0.01    | 11.66±5.69  | 63 (19.6%)  |
|                |         | 7.82±12.8 | 205 (80.4%) |

Table 1. Findings related to clinical and demographic variables affecting the length of stay in ICU

The distribution of the patients’ length of stay was from 0 to 122 days. Most patients (%16.6) stayed in intensive care unit 1 day and 6 percent of patients stayed zero (0) day. Acc-
According to Table 2, comparison between log-normal regression model and Gamma model showed that in Gamma model type of diagnosis ($\beta= -0.5493982; CI= [-0.9413864, -0.15741]$) variable was significant. Factors to predict length of stay in ICU in Log – normal model:

a) Age ($\beta=0.0200913; CI= [0.0121126, 0.047]3))

b) Sex ($\beta=0.5652086; CI= [0.3062281, 0.472476])

c) Type of diagnosis ($\beta= -0.7543791; CI= [-1.298991, -0.2097672])$ were significant factors affecting the length of stay.

Gamma model showed that patient with dyspepsia had a significant shorter length of stay than other patients. According to AIC and BIC test, Gamma model was better than Log-normal model to predict factor affecting the LOS in ICU patients.

4. DISCUSSION

The present study aims to determine factors affecting the length of stay and selecting suitable statistical models. LOS data are right skewness to model skewed data; we use Gamma and Log-normal regression to model skewed data (21). In this study, affecting factors LOS were assessed, the result of univariate regression analysis showed that increase of age of patients led to increase in LOS. Some study also showed that increase of patient age led to increase in LOS (22-28). Therefore hospital managers and clinicians can use the managerial and clinical methods to manage LOS patients with infection and Bedsores.

Most patients hospitalized in intensive care unit were elderly people, so managers and policy makers are recommended to make suitable plans and programs which can better provide necessary services for aging people.

The result of study showed that 35.9% of patient had a bedsore and the patient with Bedsores had longer LOS than other patients. Also some study showed that Bedsores led to increase LOS in ICU (22-28).

So due to the meaningful relation between bedsore and LOS by making suitable plans to control and prevent bedsore we can shorten the patients’ length of stay and speed up their recovery. Considering the following points can help prevent and lessen bed sore in patients: Planning and implementing protocol in order to identify the patients in danger before admission to ICU. Paying special attention by nurses and hospital staff to elderly patients, women, patients with long periods of stay, those referred from other hospitals or centers, patients with physical disorders and patients with low consciousness, diabetes, fever, infection, hypertension and respiratory diseases.

Forming and activating a committee or community attended by nurses, doctors, units officials and high ranking hospital managers in order to hold regular meetings in which the bottom cause and the solution of this problem (bed sore) are discussed and units with more problems are identified.

Identifying patients in danger of bedsore before admission along with a particular attention to the factors creating it can be effective in preventing this problem. It seems that designing and using special forms for examining the risk of bedsore before admission is necessary. Other studies show that bed sore has a meaningful relation with an increase in length of stay in ICU (22-24). According to the result, 38.6% of patients had hospital infections. Univariate analysis showed that patient with hospital infection had significantly longer LOS than other patients. Some study showed that hospital infection led to increase LOS in ICU (25-27).

So because of the high rate of hospital infections and the significance of controlling them to reduce medical loss and the length of stay in ICU it is necessary to identify the factors which cause these hospital infections in order to take efficient steps that consequently lead to a decrease in LOS.

5. CONCLUSION

The results of this study showed that in comparison to other statistic models Gamma model had stronger ability in predicting the factors affecting the length of stay in ICU.

### Table 2. Relation between LOS and demographic and clinical variables by using log-normal and Gamma regression.

| Variable | log-normal | Gamma |
|----------|-------------|--------|
| P-Value  | SE          | P-Value| SE "        |
| Age      | 0.0200913   | 0.0121126 | 0.0121126     |
| Sex      | 0.5652086   | 0.3062281 | 0.472476     |
| Type of diagnosis | 0.7543791 | [-1.298991, -0.2097672] |

- Fast blood sugar, 2. Blood Sodium, 3. Reference Category 4. Bayesian information criterion 5. Akaike information criterion, *P<0.05, **P<0.01
predicting the length of study. Choosing a suitable statistic model will enhance managers and policy makers’ ability to organize hospital resources in an optimum way, furthermore comprehensive and exact information about the average length of stay can be useful for managers better physical, financial and strategic hospital planning.

- Acknowledgments: This study is part of M.Sc. thesis for Laleh Gharacheh. This work was financially supported by grant: U-95083 from the Vice-Chancellor for Research Affairs of Ahvaz Jundishapur University of Medical Sciences. The authors would like to thank all participants in this research.
- Conflict of interest: none declared.

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