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SOCIO-DEMOGRAPHIC AND HEALTH FACTORS INFLUENCING THE HOSPITAL LENGTH OF STAY FOR ELDERLY PATIENTS RESIDENT OF THREE GEOGRAPHICAL AREAS OF PELOPONNESE-GREECE

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ABSTRACT

The length of stay (LOS) at a hospital of a patient contains important information in health statistics. A longer stay may result in resource restrictions with regard to the availability of beds at hospitals. Some of the determinants of LOS are the socio-demographic characteristics and hospital characteristics. This study try to explain the variation in LOS for elderly patients who hospitalized from 2008 to 2011 with respect to socio-demographic variables as age, gender, social security contract, living in rural or urban area, distance of place of abode from hospital, medical departments, clinical related characteristics. Computerized inpatient hospital discharge data, over a 4-year period, 2008–2011, was provided by the Administrations of Kalamata, Pyrgos, Amaliada and Sparta Hospitals. A total of 110606 hospitalizations were analyzed. The distribution of the outcome measure (LOS) was skewed and so the relationship between the independent variables and LOS was examined using parametric with log transformed LOS and non-parametric tests. Generalized linear regression models were fit to test the association between the LOS and patient demographic and clinical characteristics.

Keywords: Hospitalization, length of stay, predicting models.
JEL Classification:

1. Introduction

Hospitals consume a significant proportion of recurrent expenditure by the Government of Greece. Funding of hospitals is also currently at the center of discussions on the Greek Government's health care reform agenda to improve the efficiency and safety of the health care system.

Analysis of cost data is important in providing reliable information about the overall cost to health system of a particular medical condition. Since the most financial expenditures made by hospital are fixed in a short run, decision-makers need a new cost variable. Length of stay (LoS) is an important metric for assessing the quality of care and planning capacity within a hospital. The length of time patients spend in hospital beds will not release much cash, but is known to be a good representation of the amount of resource utilised.

Department of Health in Greece use average LoS as a key performance indicator for the efficancy of the hospital and Hellenic Statistical Authority publish the LoS by sick category on the website. The length of stay at hospital by patients contains important information, which can be used for policy making and future projections on resource requirements by government as well as hospitals. This is also an important ingredient for insurance companies from the point of view of severity of claims. The disease elasticity of LOS will be of help to hospital management in estimating the release of beds. Insurers can use such studies in calculating the likely losses in the case of hospitalization given the probability of a disease.

However, certain features of LoS, as many other cost variables, make it difficult to analyse.

Length of stay in Hospital distribution is typicaly found to be positively (right) skewed, as most patients undergo routine treatments and have roughly similar days in the hospital, but a small proportion of patients with complication or severe disease need to stay more days in the hospital.

As efficancy evaluation need to provide arithmetic mean of the LoS, but the typically non-normal nature of LoS data may lead to violations of assumptions required for the calculation of the arithmetic mean using methods based on the normal distribution (Barber & Thompson, 2000).

For the analysis of LoS primary interest is usually whether the LoS of a particular group is greater (or less) than those associated with an alternative group (a second or a prototype hospital). Non parametric methods or transformation of skewed data to achieve approximate normality are widely used in practice. Usualy a log, shifted log, square root and reciprocal transformations are used. The weakness of this is that log-LoS is not useful for policy making, log-models are about geometric, not arithmetic, means, and retransformation is complicated by heteroscedasticity (Faddy, Graves, & Pettitt, 2009). A generalization linear model using gamma error distribution and a log-link function avoids the problem of retransformation and is recommended by Dodd et al. (Dodd S Bodger K, 2006). Five different approaches was compare to modeling cost data, OLS regression on untransformed and log transformed outcomes, OLS with bootstrapping and robust standards errors, median regression and gamma regression using log-link function. The best residuals were obtained from the gamma regression but not method can predict extreme values.

Manning and Mullahy assessed the performance of OLS regression with log –tranformation and gamma regression with log –link function on nonzero and right skewed data. They identified problems with both methods, the garden variety distributional problems – skewness, kurtosis and heteroscedasticity – can lead to an appreciable bias for some estimators or appreciable losses in precision for others (Manning & Mullahy, 2001).

Older Greek people have lengthy hospital stays, the reasons for delay discharges are medical issues, hospital factors (delayed diagnostic services etc) , patient and carer needs, as well as problems in accessing alternative or social care.

This study try to explain the variation in LOS for elderly patients who hospitalized from 2008 to 2011 with respect to socio-demographic variables as age, gender, social security contract, living in rural or urban area, distance of place of abode from hospital, medical departments, clinical related characteristics. Also, the purpose of this paper is to compare different approaches to model LoS data from older patients, a poisson loglinear model, a gamma regression with log-link function model and a negative binomial log link function.

2. Methods

Data

Data used in this study were obtained as primary data from discharge records of all elderly admissions at the four hospital of the Peloponnese, General Hospital of Pirgos, General Hospital of Amaliada, General Hospital of Kalamata and General Hospital of Sparti, from 1/1/2008 to 31/12/2011. Inclusion criteria were ≥65 years of age and a minimum inpatient stay of one night. The registers included the following collected determinants for individual patients: age, gender, date of admission and discharge, residence area, reasons for admission,

treatment outcome, hospital clinic, number of admission per week day and type of social security. Reasons for admission was recode to ICD-10 classification and residential area to municipality classification.

From other official registers the database was filled with geographical attributes like elevation, distance for closer health services provider etc.

The final database contains 72412 cases.

Models

The purpose of this paper is to compare different approaches to model LoS data, a poisson loglinear model, a gamma regression with log-link function model and a negative binomial log link function were used.

The number of days each patient stay at the hospital is record as count. As a consequence, the Poisson regression model is particularly appropriate for this type of response (Faddy et al., 2009). Poisson regression assumes the response variable Y has a Poisson distribution, and assumes the logarithm of its expected value can be modeled by a linear combination of unknown parameters.

The distribution of the number of days using Poisson model is of the form (McCullagh & Nelder, 1989:

$$Prob(Y = y) = \frac{e^{-\lambda T}(\lambda T)^{y}}{y!}, \text{ with } \lambda = e^{\beta' x} > 0.$$

The conditional mean is:

$$E[Y\backslash x] = \lambda = e^{\beta' x}.$$

The variance of the random variable is constrained to be equal to the mean $Var[Y\backslash x] = \lambda$.

If a Poisson regression model doesn't fit the data and it appears that the variance of y is increasing faster than the Poisson model allows, then a simple scale-factor adjustment is not appropriate. One way to handle this situation is to fit a parametric model that is more dispersed than the Poisson. A natural choice is the negative binomial.

Suppose that y ~ Poisson (λ), but λ itself is a random variable with a gamma distribution. That is, suppose y | λ ~ Poisson (λ), λ ~ Gamma(α, β), where Gamma(α, β) is the gamma distribution with mean αβ and variance $\alpha\beta^2$, whose density is :

$$P(\lambda) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)}\lambda^{\alpha-1}e^{-(\frac{\lambda}{\beta})}$$

for λ > 0 and zero otherwise.

The unconditional distribution of y is negative binomial, this distribution has mean E(y) = αβ and variance Var(y) = $\alpha\beta + \alpha\beta^2$. For building a regression model, it is natural to express the negative binomial distribution in terms of the parameters μ = αβ and κ = 1/α, so that E(y) = μ and Var(y) = $\mu + \kappa\mu^2$. The variance function is quadratic(Jong & Heller, 2008).

For regression purposes, we typically assume $y_i \sim Negbin(\mu_i, \kappa)$ and apply a log link, so that

$$\log \mu_i = \eta_i = xT_i\,\beta.$$

Or we can use $\log \mu_i = \eta_i = o_i + xT_i\,\beta$ if an offset is needed.

Good of fit can be tested by the ratio (deviance)/(degree of freedom), value close to 1 indicate good of fit. Large or small values of the ratio may indicate an over-dispersion response. Additional measures of goodness of fit include the Bayesian Information Criterion (BIC).

Covariates

Martin and Smith (1996) showed that demographic characteristics of patients and some hospital characteristics are two important determinants of LOS. The important demographic characteristics are age, gender, type of disease etc. Hospital size, location of the region, the type of hospital etc. are some of the hospital characteristics which have impact on LOS.

The covariates to our models are presented to Table 1.

3. Results

Figure 1 displays the distribution of LoS in the group of all patients. The LoS is highly positive skewed, with a mean 4.83 days and median value 3 days. The mean value is different by Hospital.

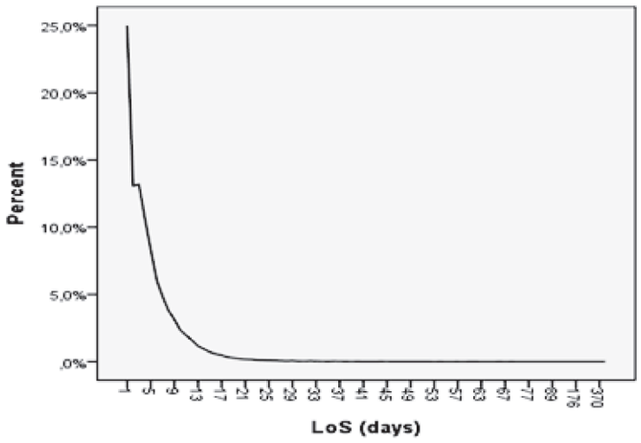
Table 1. Covariates for the model

Covariate	Summary Statistics
Sex	Men 50,1% , Women 49,9%
Age Category	64-74 32% , 75-84 48% , 85+ 20 %
Urbanization	Urban 46% , Suburban 50% , Rural 4%
Elevation	Mean 149 m (SD 146 m)
Social Security	Agriculturalist 59% , Employees 36%

Figure 1. Distribution of LoS

Average LoS to General Hospital of Kalamata is 3.97 (SD 4.87) while the ALoS to General Hospital of Pirgos is 5.6 (SD 5.6), to General Hospital of Amaliada 5.7 (SD 9.8) and to General Hospital of Sparti 6.0 (SD 5.3).

Taking into account variables as sex, age group etc, the difference of LoS between the groups was examined.



The results are presented at Table 2.

Table 2. Difference of LoS between independent groups

Variable	ELIA (2 hospitals)	LAKONIA	MESSINIA
Sex	** M<W	-	-
Age category	** (64-74)<(75-84)<85+	**(64-74)<(75-84)<85+	** (64-74)<(75-84)<85+
Urbanization	** Urban < Rural < Suburban	** Urban< Rural < Suburban	** Urban> Suburban >Rural
Distance	**	**	**
Elevation	** (Pir): 0-100<100+	** 500+>0-500	-
Social Security	** (Am) Agriculturalist >Employee	** Agriculturalist >Employee	** Agriculturalist < Employee
Health services	** (Am) 1,2<3		** 3<1,2
Admission day	** Tuesday, Thursday <...< Saturday, Sunday	** Tuesday, Thursday <...< Saturday, Sunday	** Tuesday <...< Saturday, Sunday
Clinical	** Orthopedics >....> Surgery	** Pathological >...> Surgery	** Orthopedics >....> Surgery
Number of Admission	** 1-15>16-20> 21+	** 1-10>11-15> 16+	** 1-20,21-30> 31+

** indicates statistical significant difference

Taking into account the sex, the LoS for the men is smaller than the women but this difference is significant only for patients to the two hospitals in Prefecture of Elis. According age categories statistical significant differences appeared, smaller ages have smaller LoS, older people are "bed blockers", as they don't have alternative care.

For a group of variables like social security form, urbanization, residential area health services the differences are significant but also have different direction between the Prefectures.

Table 3. Models comparison

Model	df	Deviance/df	Pearson Chi-Square/ df	Bayesian Information Criterion (BIC)
Poisson loglinear	42981	1,92	2,23	205233,68
Gamma (log link)	42981	0,57	,68	182324,55
Negative binomial (log link)	42981	0,43	,51	202697,05

Table 3 displays evidence of goodness of fit for the three models. The best fitting model is the gamma log link model. Included covariates to the gamma model

Table 4. Significance level of included covariates

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	1029,556	1	,000
Sex	9,338	1	,002
Age category	395,015	2	,000
Urbanization	4,851	2	,088
Health services	14,193	2	,001
Distance	31,620	4	,000
Elevation	6,205	3	,102
Number of Admissions	22,503	6	,001
Admission Day	45,979	6	,000
Admission reason	2548,437	18	,000
Number of admission reasons	14,412	2	,001
Social security	177,605	10	,000
Hospital Clinic	1313,418	13	,000

4. Conclusions

This paper aimed first to examine factors that affect to the LoS in to a hospital for elderly patients to Peloponnesus and secondly to compare methods of multivariable regression analysis of the LoS. Age, social security scheme, admission day, clinical, urbanization, elevation affecting to LoS, some of them with different direction accordingly the hospital.

The three models that were compared were Poisson loglinear, Gamma (log link) and Negative binomial. The gamma model with log-link seemed to be the fitting model for the highly skewed LoS data presented in this paper.

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