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HIV AIDS length of stay outliers

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Abstract

Costs with HIV/AIDS hospitalizations are one of the major financial burdens on healthcare systems worldwide. In Portugal, hospitalizations related to HIV infection are some of the most expensive and the second major diagnosis category, and also accounts for the greatest average length of stay. As a result, it is crucial to understand and identify HIV/AIDS hospital length of stay outliers. The objective of this study is to analyse HIV/AIDS length of stay high outliers during five consecutive years (2009-2013) and to identify its determinants for a specific HIV/AIDS diagnosis related group. To attain these objectives we will use a logistic regression model with random effects.

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Keywords: Hospital length of stay; outliers; random effects; HIV/AIDS.

1. Introduction

The quest of cost reduction in the Portuguese National Health Service (NHS) is an important policy objective for the current government, as a consequence of the public debt crisis after 2011. For the year 2012, a cut of €710 million is expected in health spending [1] meaning that hospitals must drastically reduce their spending, namely by constraining the resources devoted to patients.

In the absence of cost data, one of the principal benchmarks for inpatient efficiency has been the length of stay

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(LOS) required for a particular episode of care [2]. Hospitalizations are an important component of the costs of providing health care in governments; specifically the study of LOS is essential for the management, budgeting and funding hospitals.

There is some interest in studying LOS and its determinants [2, 3] but very little is known about the causes of variation in LOS in Portugal, namely regarding HIV/AIDS and cancer which represent the greatest financial burdens. This paper focuses in HIV/AIDS hospitalizations and its outliers, as core hospital indicators. In Portugal, is possible to obtain LOS data from the diagnosis related groups (DRG) classification since their implementation in 1989. DRGs provide a classification system of hospitalized patients with clinically recognized definitions. The DRG determines the payment allocated to the hospital, and is based on the characteristics of patients consuming similar quantities of resources, as a result of a process of similar hospital care. In Portugal the hospitalizations related to HIV infection are some of the most expensive and the second major diagnosis category, and also accounts for the greatest average length of stay.

The study of LOS outliers is essential for the management and financing of hospitals. LOS can in part explain hospital costs as there is a strong correlation between LOS and hospital costs[4-6]. For example, in a Spanish study, two public hospitals revealed that 4.8% of total patient discharges represent 15.4% of total LOS and 17.9% of total hospital costs.[7] In Portugal, Bentes et al. [8] verified that between 1989 and 1990 the number of long-stay patients (high LOS outliers) increased 2.59%.

The aims of this study are to analyse HIV/AIDS LOS outliers during five consecutive years and to identify factors that explain HIV/AIDS LOS high outliers for a specific DRG.

This paper consists of six sections. The first section addresses the problem presented. In the following section are addressed some aspects related to the issue studied, as also the concepts and the technology used. Then in chapter three it is presented the methodology used: data, variables and statistical procedures. Fourth chapter presents the results and fifth chapter discusses the most important aspects identified throughout the development process component of practice. Finally, the last chapter presents the most relevant conclusions.

2. Background

2.1. DRG data

DRG is the most commonly used case mix system for hospital reimbursement adopted in many countries. This classification proposed by Fetter et al.[9] determines the payment allocated to the hospital, and is based on the characteristics of patients consuming similar quantities of resources, as a result of a process of similar hospital care. The DRGs require the collection of a minimum set of data that includes the variables: principal diagnosis, secondary diagnosis, procedures, age, sex, discharge status, and birth weight (in the case of new-borns) to group the episode in one of 25 major diagnoses categories. There are medical and surgical DRGs according to the presence or absence of procedures occurred in the operating room. The DRG hospitalization episodes are converted to discharge equivalent taking into account the length of hospitalization occurred in each of them and the normal range defined for each DRG. A unique price is predetermined for all inpatient discharge (discharge equivalent).

The main problem of this classification is that it assumes the costs associated with a particular DRG are usually the same and so on, the activities associated with patients in a particular group are also the same.

2.2. Length of stay outliers

Outlier is a very different or inconsistent observation with the remaining data. It can be a human (or other) error, or it can be from the nature of the variability of the data, and in this case should reveal important information that must be analysed. There is no universal technique to find an outlier, although the most used method is Tukey's [10] method that is resistant to extreme values and is based in the interquartile range (IQR):

$$\text{Trimpoint}=75^{\text{th}}\text{percentile}+a.\text{IQR} \quad (1)$$

Tukey defined 25th percentile–1.5IQR and 75th percentile+1.5IQR as "inner fences", 25th percentile–3IQR and 75th percentile+3IQR as "outer fences", the observations between an inner fence and its nearby outer fence as "outside", and anything beyond outer fences as "far out".

3. Methods

3.1. Data source

The data were provided by the Central Health System Administration (ACSS) and refer to the Portuguese national database of the diagnosis related groups (APR – DRG v21.0). The data are anonymous and available from the ACSS for scientific research. In the DRG database each record corresponds to a discharge episode (hospitalization) and contains information collected while the patient was hospitalized. Hospital characteristics were obtained from data provided by ACSS and the Portuguese National Institute of Statistics.

3.2. Study population

Between 1st January 2009 and 31st December 2013 there were 33,005 discharges registered in Portuguese National Health Service (NHS) hospitals with HIV/AIDS. For this study we considered only those that met the following criteria: hospitalizations classified under the MDC 24 created for HIV infections patients, which incorporates the DRG 700-716; inpatients aged 18 years or older; all hospitalizations were included except those for transfers to another hospital (to avoid including the inpatient episode twice, given that often the cause of the transfer was lack of procedure facilities).

With these criteria, we selected 17,895 hospitalizations, 3,873 in 2009; 3,740 in 2010; 3,596 in 2011, 3,547 in 2012 and 3,149 in 2013.

3.3. Outcome variable

The outcome variable of the study is if the Length of stay (LOS) is a high outlier or not. In this way we have two possibilities for the outcome: Yes (it is a high outlier) and No (it is not a high outlier). Within each DRG and for every year, each LOS was classified as outlier or not using Tukey's method. We are only interested to study high outliers and this is the outcome variable.

The covariates examined were the following: gender, age of the patient at date of admission, type of admission (urgent or planned), status at the end of hospitalization (death or discharge), presence of pneumonia as HIV-related complications, whether or not HIV/AIDS was the principal diagnosis, the number of secondary diagnosis and the number of procedures undertaken. The last two variables were obtained as a sum of the total diagnoses and procedures in 20 possible cases, as done in similar analyses [11-13]. A variable reflecting the economic Portuguese crisis was also considered, the variable has the value one for the crisis' years (2012 and 2013).

3.4. Statistical analysis

We used logistic regression with random effects to examine the association of each variable with HIV/AIDS LOS high outliers. In DRG data, patients are nested within hospitals on the basis of their own choices (place of residence, trust in a particular doctor, the hospital's reputation, etc.), thus violating the independence assumptions of classical regression analysis. As a result, hierarchical modelling is strongly advocated as a more appropriate statistical method for dealing with multilevel structured data, such as patients clustered within hospitals[14-17]. Moreover, the hospital random effects, which acknowledge unmeasured factors that are nonetheless important, should be interpreted as differences in hospital quality/performance. The model takes the form:

$$P(Y_i = 1 \mid \eta_i) = \frac{\exp(\eta_i)}{1+\exp(\eta_i)}, \quad \eta_i = \mathbf{x}_i \beta + \mathbf{z}_i u \tag{2}$$

Where $\boldsymbol{\beta}$ is the fixed effects parameters, $\mathbf{x_i}$ is the ith row of Nxp design matrix $\mathbf{X}$ for the fixed effects, $\mathbf{u}$ contains the random effects that are normally distributed with mean $\mathbf{0}$ and variance matrix $\boldsymbol{\Sigma}$, $\mathbf{z_i}$ is the ith row of the Nxr design matrix $\mathbf{Z}$ for the random effects.

4. Results

In 17,895 cases we found 6.3% of outliers. The mean and median LOS for outliers were 71.35 and 59 days; and 14.19 and 10 days for non outliers. Table 1 presents HIV/AIDS hospitalizations between 2009 and 2013 and table 2 presents the number and percentage of outliers for each year and DRG.

Table 1. HIV/AIDS hospitalizations between 2009 and 2013.

DRG	2009 n (%)	2010 n (%)	2011 n (%)	2012 n (%)	2013 n (%)	Total n (%)
700 - Tracheostomy infection by the human immunodeficiency virus	16 (0.4%)	7 (0.2%)	9 (0.3%)	14 (0.4%)	9 (0.3%)	55 (0.3%)
701 - Infection with human immunodeficiency virus with procedure in the operating room and ventilation and nutritional support	30 (0.8%)	21 (0.6%)	35 (1%)	24 (0.7%)	27 (0.9%)	137 (0.8%)
702 - Infection with human immunodeficiency virus with operating room procedure and multiple infections related major	15 (0.4%)	18 (0.5%)	14 (0.4%)	6 (0.2%)	5 (0.2%)	58 (0.3%)
703 - Infection with the human immunodeficiency virus, with procedure in the operating room and diagnostic related major	102 (2.6%)	98 (2.6%)	96 (2.7%)	93 (2.6%)	82 (2.6%)	471 (2.6%)
704 - Infection with the human immunodeficiency virus, with procedure in the operating room without diagnosis related major	142 (3.7%)	170 (4.5%)	164 (4.6%)	167 (4.7%)	192 (6.1%)	835 (4.7%)
705 - Infection with human immunodeficiency virus with multiple infections related major, tuberculosis	110 (2.8%)	106 (2.8%)	87 (2.4%)	77 (2.2%)	68 (2.2%)	448 (2.5%)
706 - Infection with human immunodeficiency virus with multiple infections related major, without tuberculosis	122 (3.2%)	130 (3.5%)	117 (3.3%)	131 (3.7%)	112 (3.6%)	612 (3.4%)
707 - Infection with human immunodeficiency virus with nutritional support and ventilator	172 (4.4%)	149 (4.0%)	156 (4.4%)	153 (4.3%)	152 (4.8%)	782 (4.4%)
708 - Infection with the human immunodeficiency diagnosed related major, exit against medical opinion	67 (1.7%)	48 (1.3%)	62 (1.7%)	48 (1.4%)	35 (1.1%)	260 (1.5%)
709 - Infection with the human immunodeficiency virus, with multiple diagnoses related major or significant diagnoses, with tuberculosis	228 (5.9%)	192 (5.1%)	180 (5.0%)	155 (4.4%)	144 (4.6%)	899 (5.0%)
710 - Infection with the human immunodeficiency virus, with multiple diagnoses related major or significant diagnoses, without tuberculosis	628 (16.2%)	616 (16.5%)	586 (16.3%)	568 (16,0%)	519 (16.5%)	2,917 (16.3%)
711 - Infection with the human immunodeficiency diagnosed related major, without multiple diagnoses related major or significant diagnoses, with tuberculosis	171 (4.4%)	134 (3.6%)	115 (3.2%)	97 (2.7%)	64 (2.0%)	581 (3.2%)

712 - Infection with the human immunodeficiency diagnosed related major, without multiple diagnoses related major or significant diagnoses, without tuberculosis	306 (7.9%)	277 (7.4%)	237 (6.6%)	243 (6.9%)	213 (6.8%)	1,276 (7.1%)
713 - Infection with the human immunodeficiency virus, with significant related diagnosis, exit against medical opinion	69 (1.8%)	59 (1.6%)	39 (1.1%)	48 (1.4%)	50 (1.6%)	265 (1.5%)
714 - Infection with the human immunodeficiency virus, with significant related diagnosis	1,108 (28.6%)	1,124 (30.1%)	1,118 (31.2%)	1,162 (32.8%)	1,096 (34.8%)	5,608 (31.3%)
715 - Infection with human immunodeficiency virus with other related diagnosis	233 (6.0%)	269 (7.2%)	261 (7.3%)	252 (7.1%)	212 (6.7%)	1,227 (6.9%)
716 - Infection with human immunodeficiency virus without other related diagnosis	354 (9.1%)	322 (8.6%)	310 (8.6%)	309 (8.7%)	169 (5.4%)	1,464 (8.2%)
Total	3,873 (100.0%)	3,740 (100.0%)	3,586 (100.0%)	3,547 (100.0%)	3,149 (100.0%)	17,895 (100.0%)

Table 2. HIV/AIDS LOS outliers between 2009 and 2013.

DRG	2009 n (%)	2010 n (%)	2011 n (%)	2012 n (%)	2013 n (%)	Total n (%)
700 - Tracheostomy infection by the human immunodeficiency virus	1 (6.25%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (22.2%)	3 (5.5%)
701 - Infection with human immunodeficiency virus with procedure in the operating room and ventilation and nutritional support	0 (0.0%)	1 (4.76%)	1 (2.9%)	2 (8.3%)	3 (11.1%)	7 (5.1%)
702 - Infection with human immunodeficiency virus with operating room procedure and multiple infections related major	2 (13.3%)	0 (0.0%)	1 (7.1%)	0 (0.0%)	1 (20%)	4 (6.9%)
703 - Infection with the human immunodeficiency virus, with procedure in the operating room and diagnostic related major	6 (5.9%)	9 (9.2%)	4 (4.2%)	2 (2.2%)	5 (6.1%)	26 (5.5%)
704 - Infection with the human immunodeficiency virus, with procedure in the operating room without diagnosis related major	8 (5.6%)	12 (7.1%)	12 (7.3%)	15 (9.0%)	19 (9.9%)	66 (10.8%)
705 - Infection with human immunodeficiency virus with multiple infections related major, tuberculosis	8 (7.3%)	6 (5.7%)	5 (5.7%)	5 (6.5%)	6 (8.8%)	30 (6.7%)
706 - Infection with human immunodeficiency virus with multiple infections related major, without tuberculosis	4 (3.3%)	5 (3.8%)	7 (6.0%)	8 (6.1%)	5 (4.5%)	29 (4.7%)
707 - Infection with human immunodeficiency virus with nutritional support and ventilator	5 (2.9%)	7 (4.7%)	14 (9.0%)	8 (5.3%)	11 (7.2%)	45 (5.8%)
708 - Infection with the human immunodeficiency diagnosed related major, exit against medical opinion	5 (7.5%)	1 (2.1%)	3 (4.8%)	4 (8.3%)	2 (5.7%)	15 (5.8%)

709 - Infection with the human immunodeficiency virus, with multiple diagnoses related major or significant diagnoses, with tuberculosis	10 (4.4%)	17 (8.9%)	8 (4.4%)	12 (7.7%)	5 (3.5%)	52 (5.8%)
710 - Infection with the human immunodeficiency virus, with multiple diagnoses related major or significant diagnoses, without tuberculosis	32 (5.1%)	41 (6.7%)	41 (7.0%)	30 (5.3%)	43 (8.3%)	187 (6.4%)
711 - Infection with the human immunodeficiency diagnosed related major, without multiple diagnoses related major or significant diagnoses, with tuberculosis	15 (8.8%)	14 (10.4%)	7 (6.1%)	7 (7.2%)	1 (1.2%)	44 (7.6%)
712 - Infection with the human immunodeficiency diagnosed related major, without multiple diagnoses related major or significant diagnoses, without tuberculosis	13 (4.2%)	15 (5.4%)	12 (5.1%)	19 (7.8%)	19 (8.9%)	78 (6.1%)
713 - Infection with the human immunodeficiency virus, with significant related diagnosis, exit against medical opinion	6 (8.7%)	4 (6.8%)	2 (5.1%)	0 (0.0%)	1 (2.0%)	13 (4.9%)
714 - Infection with the human immunodeficiency virus, with significant related diagnosis	86 (7.8%)	73 (6.5%)	72 (6.4%)	71 (6.1%)	91 (8.3%)	393 (7.0%)
715 - Infection with human immunodeficiency virus with other related diagnosis	10 (4.3%)	17 (3.6%)	12 (4.6%)	16 (6.3%)	5 (2.4%)	60 (4.9%)
716 - Infection with human immunodeficiency virus without other related diagnosis	19 (5.4%)	17 (5.3%)	17 (5.5%)	13 (4.2%)	7 (4.1%)	73 (5.0%)
Total	230 (5.9%)	239 (6.4%)	218 (6.1%)	212 (6.0%)	226 (7.2%)	1,125 (6.3%)

As we can see, the percentage of discharges and outliers is more a less stabilized for each DRG and year.

In this work we will only present the results for the logistic regression with random effects to identify factors that explain HIV/AIDS LOS high outliers for DRG 714. We choose this DRG because represents the largest DRG among the 17 DRGs created for HIV infection patients. For DRG 714 there were 5,608 hospitalizations in 54 hospitals, although to apply the logistic regression with random effects model, we will only analyse hospitalizations from hospitals with more than ten discharges episodes, so we will analyse 5,548 discharges occurred in 40 hospitals. Table 3 shows the results for the logistic regression with random effects, presenting the Odds Ratio (OR), the 95% Confidence Interval (CI) and the associated p-value.

Table 3. Factors related to HIV/AIDS LOS outliers between 2009 and 2013.

	OR	95% CI	p-value
Gender (male)	0.999	0.784-1.272	0.991
Age/10	1.002	0.918-1.093	0.966
Status (death)	1.976	1.462-2.670	<0.001
Type of admission (urgent)	1.160	0.837-1.608	0.374
Number of secondary diagnoses	1.106	1.067-1.145	<0.001
Number of procedures	1.240	1.204-1.275	<0.001
Pneumonia	0.494	0.375-0.649	<0.001

AIDS as principal diagnosis	1.534	1.160-2.028	0.003
Crisis	0.863	0.678-1.098	0.231

Gender, age, type of admission and crisis are not statistically significant at the 5% level. All the other variables behaved has expected. In-hospital mortality contributes to increase approximately two times the risk of a discharge being an outlier. Number of secondary diagnoses and number of procedures are positively associated with HIV/AIDS LOS outliers, reflecting co-morbidities and complications that patients experienced during hospitalization. Pneumonia is a protector factor for the discharge being an outlier. When AIDS is the principal reason of hospitalization it indicates that the patient is in an acute situation of health and, as expected, it contributes to a longer stay in hospital.

We also plot the hospital random effects in order to capture unobserved factors specific to each hospitals (for example, discrepancies in medical expertise, health care). Figure 1 shows these effects and their respective 95% confidence interval (CI) for both components, for the 40 hospitals.

The first eleven hospitals have a statistically random effect below one, being considered as the more efficient hospitals (with less risk of outliers), the last 18 hospitals exhibit large positive effects prolonging hospitalizations, contributing to have more risk of outliers (random effects are statistically significant greater than one).

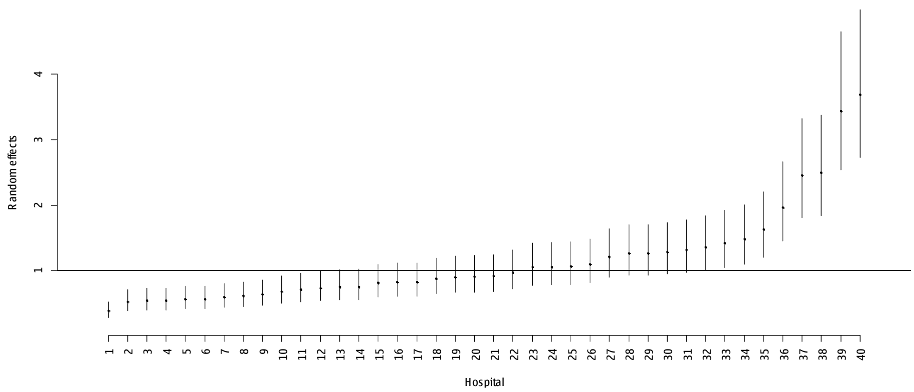

Fig. 1. Random effects and their 95% CI for each hospital.

5. Discussion

The growth of public expenditure on health increases the need for cost reduction by gains in efficiency and the elimination of waste. For this reason the Portuguese Court of Auditors published a report audit about the financing system of the public hospitals belonging to the Portuguese National Health Service. They concluded that the methodology used to analyse DRG LOS, is insufficiently grounded and is not the most appropriate [18]. The detailed analysis of outliers can be a solution. This study presents an analysis of HIV/AIDS outliers and in the last five years the number and percentage of outliers are more a less stabilized, rounding the 6% value. This value is higher compared to another Portuguese study that involved all DRGs, but is approximately of DRGs with higher percentage of LOS outliers.[6]

Logistic regression model with random effects is the approach used to analyse factors that are associated with HIV/AIDS outliers; the framework presented here suggests differences among hospitals that emphasize the need for further research. In DRG data, patients are nested within hospitals on the basis of their own choices (place of residence, trust in a particular doctor, the hospital's reputation, etc.), thus violating the independence assumptions of classical logistic regression analysis. As a result, hierarchical modelling is strongly advocated as a more appropriate statistical method for dealing with multilevel structured data, such as patients clustered within hospitals. Moreover, the hospital random effects, which acknowledge unmeasured factors that are nonetheless important, should be interpreted as differences in hospital quality/performance.

We confirmed that death, number of secondary diagnoses, number of procedures, pneumonia and AIDS as principal diagnoses, contribute to increase the risk of having outliers. Gender and age are not statistically significant, although they are retained in the model in order to control for possible confounding. The discharges that ends on death contributes more for a discharge being considered as an outlier. In Portugal, urgent admissions do not necessarily reflect emergency situations, as it is common that patients seek attendance at a hospital emergency room due to difficulties in making an appointment elsewhere. In this study, this type of admission does not contributed to explain LOS outliers.

A great number of diagnoses or procedures usually indicates a more severe condition of the patient and consequently, a delayed discharge [12, 19]. In this analysis both variables have an odds ratio greater than one and a statistically significant value indicating a long-duration hospitalization, contributing to the discharge being an outlier, as presumed. Pneumonia is associated with the early days of the hospitalization. When AIDS is identified as the principal diagnosis, the hospitalizations tend to be prolonged as these patients are in more acute situations and more likely to need a longer in-hospital treatment. The variable related to economic crisis is not statistically significant, although we were expected that the years of crisis (2012 and 2013) would contribute to prolong the hospitalizations.

There is a set of hospitals more efficient in terms of risk-adjusted; nine of these eleven hospitals are small hospitals located in small areas, but two of them are large hospitals in a metropolitan area that offers more differentiated services. The set of hospitals that exhibit large positive effects extending hospitalizations have very different characteristics.

This study allowed the identification of associated factors HIV/AIDS LOS high outliers considering that the patients are nested within hospitals. As do most studies, the current one has limitations. The DRG data and information on hospital characteristics were gathered for purposes other than this study and some vital features of HIV/AIDS patients are not available, such as cluster of differentiation 4 (CD4) cell counts and viral load [20, 21].

6. Conclusions

The present study analyses the HIV/AIDS LOS high outliers, which reveals elevated figures for costs and bed-days when compared to worldwide data; these expenditures will have great impact on the budgeting and funding of public hospitals. The analysis of DRG data is imperative in comparing different hospitals, patients, and places in terms of costs, hospital activity, and efficiency.

Our findings are of great interest for clinical practice, discharge planning, and the efficient management of LOS. For healthcare policy purposes, our identification of “atypical” hospitals should caution policymakers not to regard all hospitals equally. Clinicians can derive benefits from this study as it provides a better understand of the factors influencing HIV/AIDS LOS outliers, which allow them to modify their clinical practice. Appropriate policies can be developed to manage the hospital care and its resources, as well as promote the early prediction of HIV/AIDS patients requiring a longer period of hospitalization, and the higher costs thus incurred. Costs and funding formulae may also be adjusted according to the relevant factors influencing HIV/AIDS. The results obtained also allow for a better planning of hospital bed requirements.

As a whole, our findings confirm the multifactor nature of influence of health on LOS outliers, and provide advice to the policymaker who is looking for easy ways to reduce NHS hospital use. For example, if we are able to reduce by 7 (via primary cares) the mean number of procedures, the probability of not being an outlier (reduce the use of NHS hospital use) reduce in 5%, in terms of LOS.

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