Public-Private Partnerships and Public Hospitals in Portugal: Evidence from delivery data

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Public Hospitals account for a large part of the Portuguese National Health Service. Public-Private Partnerships (PPP) have provided a new approach to public management, making it interesting to understand the differences between the two models, namely in what concerns efficiency. In this article, the hospitals analyzed are divided into three groups (according to Central Administration of Health Systems (ACSS) Benchmarking). Each group has a PPP associated, as well as several Public Hospitals. A statistical analysis is carried out, and a model is estimated to assess the impact of PPPs. Inpatient days are one of the most used variables when it comes to evaluating hospitals performance. The National Diagnostic Related Groups (DRG) Database allows retrieve the information regarding deliveries, from 2009 to 2014. The type of delivery influences greatly the number of days the parturient is committed to the hospital but is not the only relevant variable. The number of days associated with a type of delivery depends on several variables. Estimated models show that age has limited relevance as an explanatory variable, but the same does not happen with the type of delivery and other variables included. PPP evidence obtained is mixed: in some cases the PPP performs better than Public Hospitals regarding inpatient days, *ceteris paribus* showing more efficiency, but in other cases the reverse happens.

Key-words: Public-Private Partnerships; Public Hospitals; Deliveries; Caesareans; Inpatient days.

I. Introduction

The health sector is expanding throughout the world and Portugal is no exception. Although in the last decade the economic recession affected several countries, particularly in the European Union (EU), this did not distress the will of countries to bet on health, but rather how resources are allocated and how they are managed.

Hospitals are in the center of health. However due to their specificities it is very difficult to evaluate performance. One important measure to assess hospitals performance is the number of inpatient days. Inpatient days correspond to the number of days that the patient is committed to the hospital. Each patient is different; however, through Diagnostic Related Group (DRG) codes it is possible to group patients with similar characteristics. Inpatient days then become a strong indicator to compare patients with the same pathologies.

New management mechanisms were introduced in Public Hospitals, for instance, the status *Empresa Pública Empresarial* (EPE) in 2002. Another example of reforms is Public-Private Partnerships (PPP). The popularity of PPP has been rising in numerous countries and economies. However, empirical evidence of its benefits is mixed [15]. Making a critical analysis regarding Public Hospitals and Public-Private Partnerships would be useful to understand the differences between them and their performances. Therefore, the goal of this article is to compare Public-Private Partnerships and Public Hospitals regarding hospitals performance, in the case of deliveries.

In the last decade, in Portugal, new PPPs have emerged in four major hospitals. The study of these cases is imperative and may be useful for the future decisions. Compare hospitals is very difficult, they are very heterogeneous. However, ACSS managed to group hospitals according to their features. There are three groups of interest and in each group there is at least one PPP, thus allowing the analysis. To protect the hospitals identities, code numbers and letters were assigned.

Due to its importance, deliveries are the subject of this analysis to compare Public Hospitals and Public-Private Partnerships. To achieve this, one needs to understand the indicators that affect this specialty. The number of days the patient is committed to the hospital is one of the most important indicators of performance.

Descriptive statistics are computed to obtain an overview of the hospitals behavior, regarding deliveries. Mean difference tests, comparisons of proportions and multiple linear regression modelling are also applied for each group. The results obtained show that age has limited relevance as explanatory variable for inpatient days, but the same does not happen, for instance, with the type of delivery. PPP evidence obtained is mixed: in some cases the PPP performs better than Public Hospitals regarding

inpatient days, *ceteris paribus* showing more efficiency, but in other cases the reverse happens.

II. Economic Framework and Portuguese National Health System

II.1 Economic Framework

The health sector is one of the most important sectors in any country since it generates numerous jobs and is responsible for the population's health.

Portugal spends around 9% of its Gross Domestic Product (GDP) in healthcare, which is a significant percentage when compared with other Organization for Economic Co-operation and Development (OECD) countries [10].

II.2 Portuguese National Health System

The Portuguese healthcare system is characterized by three coexisting and overlapping systems: the National Health Service (NHS), a universal, tax-financed system; public and private insurance schemes for certain professions and voluntary health insurance. So, the Portuguese health system has a mix of public and private funding.

The planning and regulation of the NHS takes place, in its majority, at the central level in the Ministry of Health and its institutions. The management takes place at the regional level. In Portugal, the hospital systems are organized in five administrative health regions [7].

Regarding the healthcare financing system in Portugal, there are four main types of sources: taxes, social contributions, co-payments and private insurance [6].

The way in which Public Hospitals are financed may influence their behavior as providers. There are two methods to subsidize Public Hospitals [5] [7]:

- Retrospective payments are based in the previous years, the expenses are verified and the inflation is added.
- Prospective payments are directly related with the activity developed and with predetermined prices. This type of payment may have in account: capitation, expenditure targets/budget, case-based payments and prospective case-mix (DRG).

Although there is no perfect system, the prospective payments are better suited for funding hospitals than retrospective payments. Retrospective payments do not encourage an efficient management of resources.

In Portugal, the first legal regime about PPP, created in 2002, defines the principles and instruments for the establishment of health partnerships, private management and funding arrangements between the Ministry of Health or institutions and services integrated with the National Health Service and other entities [8] [10].

III. Public-Private Partnerships

A PPP is a long-term contract between a private company and a public body. The contract has lasts for 30 years for the infrastructure and 10 years for the clinical part (healthcare providing) [7].

Some benefits and drawbacks will be briefly explained:

- Benefits (the quality of services should be higher when compared to other entirely public services; the State shares expenses and the risk [9] [17] and there is a greater flexibility of funding, triggering a higher number of built infrastructures [17]).
- Drawbacks (the contests and/or contracts should be very clearly defined [17]; in Portugal, objections towards the long-term consequences about PPPs have been raised [7] and they may be considered as a threat to the freedom of access to healthcare [18]; the lack of accountability by independent viewers [9] and deficiency of existence of literature as guide of how to proceed [18].

The Portuguese Model of PPP depends heavily on the Private Finance Initiative (PFI) developed by the United Kingdom [7].

In the Portuguese NHS, PPPs are seen as a new provision mechanism and contracting of public healthcare, including both differentiated and specialized care in hospital and primary care and continuum care in the legal system.

IV. Benchmarking

The existence of comparability between hospitals concerning differences in access, quality and economic and financial performance is fundamental in order to assess and plan strategically. Each hospital can be evaluated on the basis of several components and therefore compared with other hospitals with similar characteristics. Hospitals are aggregated by ACSS in five different Groups [4].

Currently, there are four major hospitals under the regiment of PPP in Portugal: Hospital de Cascais; Hospital São Marcos - Braga; Hospital Reynaldo dos Santos – Vila Franca de Xira and Hospital Beatriz Ângelo – Loures [4].

For the porpuses of this analysis Hospital Beatriz Ângelo – Loures will not be included. The three hospitals under the regime of PPP selected for this analysis will be briefly presented:

- *Hospital Reynaldo dos Santos – Vila Franca de Xira*
  Hospital Vila Franca de Xira is a public hospital that since the first of June of 2011 is managed through a partnership model between the State and a private entity (Grupo José de Mello Saúde). This new managing project started in the former infrastructure and in parallel, the new hospital infrastructure was built. According to the ACSS hierarchical clustering, this hospital belongs to group B [3] [15]. The years evaluated in DRG database will be those subsequent to the contract, which means 2012, 2013 and 2014.
- *Hospital de Cascais*
  Since January 2009, Lusiadas Saúde is responsible for the management of Hospital de

Cascais under the regiment of PPP. The new hospital started functioning in February of 2010. [2] [11].

Hospital de Cascais belongs to group C. The years relevant are from 2009 to 2014.

- *Hospital de São Marcos - Braga*

  The new Hospital de Braga came to replace the old Hospital de São Marcos, in May of 2011. However, the management started to be private in September of 2009 [1]. The years relevant for the study will be 2010 to 2014. The group, in which this hospital is inserted, according to the ACSS benchmarking, is group D.

V. Facts about deliveries in Portugal

Portugal has a home birth tradition that until the 1970's was part of the Portuguese culture. When childbirths were brought to the hospitals, the rates of perinatal death started decreasing [19]. Maternal age has been increasing, both in Portugal and throughout Europe. In Portugal, the percentage of women over 35 years old giving birth increased 4% from 2004 to 2010 [12].

Regarding deliveries, two classifications are used in healthcare services: Eutocia delivery (*Parto Eutócico*) and Dystocia delivery (*Parto Distócico*). Eutocia delivery is commonly called Normal Birth. Dystocia delivery covers labor induction, forceps, suction cups, general anesthesia and Caesarean [17]. The number of days a patient is hospitalized differs according to the type of delivery.

Caesareans commonly have the higher numbers for inpatient days. Caesarean rate is an important indicator of performance. Their increased numbers are a problem in all European Countries.

Hospital production is rarely measured with precision. The most obvious and important reason for that is the complexity involved.

There are several indicators that may affect the number of hospitalization days the goal is to understand whether these can be related with the nature of the hospital (PPP or Public Hospital).

Some correlations between the variables were tested for each group. Age does not seem to be highly correlated with the variable inpatient days: either the correlation is non-significant, or it is very close to zero. In the three groups, both caesareans and eutocia exhibit a significant correlation with inpatient days, always with the expected sign. The fact that the hospital is a PPP is not correlated with inpatient days in one of the groups and is correlated in the other two, but with different signs. Caesarean and eutocia are negatively correlated in all groups.

VI. Methodology

The analysis conducted in this article is based on the National DRG database for the years 2009 to 2014. The DRG database allows the collection of data from hospitalizations, ambulatory surgery and medical ambulatory services from the hospitals of the Portuguese National Health System that contains several variables [5].

Data was supplied in excel sheets and to process it the software IBM SPSS Statistics 20.0 was used.

This database contains information about the patients but secures their anonymity. Personal information about the patient includes gender, birth date, age and region of residence. Other variables included in the database are: year, hospital code, inpatient days, dsp (patient destiny after leaving the hospital), birth weight, interv_cir (date of the first surgical intervention), adm_tip (type of administration– schedule or urgency), SNS (if the patient belongs to the NHS), mot_transf (motif of transfer), risk of severity and mortality (for the years 2012 to 2014), DRG code, GDC (*Grande Categorias de Diagnóstico*) code and type of DRG.

This database has numerous entries and it is proper to assume that it encounters several errors. Some errors that were found and eliminated, will briefly described:

- Some lines exhibit, the hour registered of entry in the hospital equal to the hour of exit, since the time was in seconds the likelihood that these timings were correct was virtually zero;
- Inpatient days cannot be negative nor have values over 366 days;
- The cases where the gender was equal to 3 would deflect averages.

Delivery cases were selected as stated before. The key variable in this analysis are the inpatient days. This variable is a well-known variable to assess hospital performance and quality. According to *Relatório de Acompanhamento (Execução dos Contratos-Programa 2010),* this variable was considered one of the national goals to achieve hospital quality.

Descriptive statistics such as the mean of the days of hospitalization, mode, standard deviation, the number of deliveries and the average age of parturient were computed for each hospital.

The percentage of caesareans was calculated, just like the percentage of caesareans per year; for every hospital in each group.

Once these statistics were made, it was noticed that there were various outliers who compromised the results. Outliers in the universe were removed accordingly to the rule mean ± 2 standard deviation [13] or alternatively, a dummy variable was introduced to take them into account. These outliers are not necessarily a typing error; they may be due to exceptions. However, common errors could also be the reason for these outliers, (for instance, entering data into the database or error in the encoder (DRG)).

To better understand the previous results, plots of the histograms and the quartiles were as well computed for the whole group and for the hospitals in the group, with the same scale in order to allow comparisons. The boxplots present quartiles with and without the outliers. The difference is remarkable.

Subsequently an assessment of the normality of the universes was necessary to determine whether

parametric tests can be run. The conclusion was that the three groups did not follow a normal distribution. Therefore, the next tests had to be non-parametric.
Kruskal-Wallis test was made to compare universes for all the hospitals in each group regarding Public Hospitals and the PPP whereas Mann-Whitney test was used to compare the hospitals pairwise.
The difference between caesareans and non-caesareans in each group is tested with a chi-square test. To compare proportions for each pair of hospitals the comparisons of columns proportions test was used.
A multiple linear regression is used to understand how several independent variables impact the dependent variable (in this case inpatient days).
To increase the explanatory value of the multiple regression, several binary (or dummy) variables were constructed: simple dummies; ordinal dummies and interactive dummies [20].

VII. Results

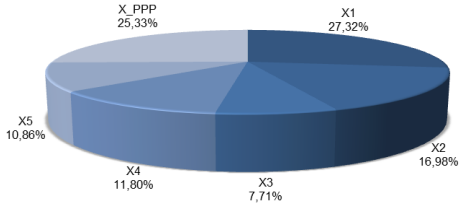
Although the hospitals in each Group (X, Y and Z) were already defined by the ACSS, throughout the analysis some changes had to be made. Some hospitals were removed. The population served by each hospital is important to relate with the number of deliveries and it will be presented between parentheses alongside the hospital code.
Thus, Group X is formed by the following hospitals: X1 (244000), X2 (143000), X3 (108200), X4 (155000), X5 (143600) and X_PPP (215000). The period of analysis for Group X is 2012-2014.
The hospitals in Group Y for the purpose of this analysis: Y1 (336000), Y2 (214000), Y3 (91200), Y4 (350000), Y5 (233500), Y6 (255200), Y7 (519800), Y8 (191200) and Y_PPP (170000). The years for which Group Y will be assessed are 2009 to 2014.
The hospitals in Group Z are Z1 (381800), Z2 (650000), Z3 (700000), Z4 (452000), Z5 (509500) and Z_PPP (1200000). Group Z was considered for the years 2010 to 2014.

VII.1 *Group X*

VII.1.1 *Number of deliveries*

X1 and X_PPP are the hospitals with the highest number of deliveries; together they represent over 50% of deliveries in the group.

Figure 1: Percentage of deliveries in Group X



Regarding the number of deliveries per year one can observe a general reduction trend; X_PPP is an exception, increasing steadily the number of childbirths.

VII.1.2 *Outliers*

The percentage of outliers removed for the whole group is 3.64%. The hospital with the highest number of outliers is X4 (5.83%).

VII.1.3 *Inpatient days*

The hospitals X3 and X4, two of the three hospitals with the lowest number of deliveries present the highest averages, regarding inpatient days. X_PPP stands in the middle of the group.
The histograms for each hospital allow considering their different dimensions. X4 and X3 have considerably less number of deliveries.
Quartiles without outliers are imperceptible. This shows that removing the outliers gives a better insight. X_PPP quartiles vary between zero and seven (regarding inpatient days). The median is three.
Age of the parturient may stand as a possible explanation for inpatient days. The overall effect, however, seems to be unclear. On one hand, an increased age may mean an increased risk of complications and therefore, more days committed in the hospital. On the other hand, an advanced age may mean that this is not the mother's first delivery and so she is less prone to complications. In this case, the variable was not significant.
Therefore, there is not an obvious relation between age and inpatient days (Spearman's correlation between inpatient days and age corresponds to 0,006).

VII.1.4 *Testing for differences in average inpatient days*

Normality tests run on the distribution on inpatient days yield the results that inpatient days do not follow a normal distribution. This result which was considered for all the hospitals forces the use of non-parametric tests from now on.
Kruskal-Wallis non-parametric test was used to investigate whether the PPP average inpatient days is globally different from the other Public Hospitals. The significance was smaller than 0.05, so the average days of hospitalization can be considered different. Mann-Whitney test allows the comparison between each pair of hospitals of group X. According to the results, only X1-X5 can be considered to statistically have the same inpatient days average.

VII.1.5 *Caesareans*

The percentage of caesareans throughout the years shows the evolution of the hospitals in the group. Although not all the years, X_PPP has been decreasing the percentage of caesareans. X_PPP exhibits the smallest percentage of caesareans by almost 10 percentage points, with a decreasing trend. However, it is noticeable that both X1 and X5 have also been decreasing their percentages.

Using a chi-square test one is able to compare proportions of caesareans and non-caesareans, for the entire group. The null hypothesis is rejected and the proportions can be considered different. The column proportions test compares the hospital universes pairwise, regarding caesareans and non-caesareans. X_PPP has a higher non-caesareans proportion than X1, X2, X4 and X5 and is statistically above no other hospital in terms of caesareans.

VII.1.6 *Multiple Linear Regression*

Multiple linear regression implied the use of several dummy variables. Table 1 shows the selected linear regression.

Table 1: Multiple Linear Regression

Independent Variables	β	t-ratio	p-value
(Constant)	3.228	68,164	0.000
d_2012	-0.083	-4.669	0.000
d_X1	-0.237	-10.110	0.000
d_X2	-0.516	-19.589	0.000
d_X3	0.269	6.700	0.000
d_X4	0.313	8.865	0.000
d_X5	-0.248	-8.148	0.000
d_dsp7	-1.018	-15.328	0.000
AGE	-0.009	-6.253	0.000
d_admtip	0.456	10.508	0.000
caesarean	0.846	41,904	0.000
d_mort4	2.803	2.856	0.004
d_sev2	0.927	2.833	0.005
d_sev3	2.531	2.580	0.010
caesarean_X3	1.012	14.855	0.000
caesarean_X4	0.596	11.019	0.000

Variables year, hospital, dsp, severity and mortality are ordinal variables. A base group variable was used for each case.

For the years, the base group was 2014. For dsp, the base group used was dsp equivalent to one. For hospitals, the base group variable was the PPP hospital, in this case, X_PPP. Lastly, for the severity and mortality, both were compared with the variable where the values assumed numbers equal to one.

The dummy d_admtip and caesarean were simple dummies. In d_admtip, the value one was attributed when the type commitment was programmed and zero to urgencies. Caesarean had value one and non-caesarean value zero.

Two hospitals exhibit positive coefficients associated with the respective dummy variable (X3 and X4). This means that, all the other conditions equal, these hospitals would have more days of hospitalization than the reference hospital (the PPP). Two hospitals exhibit positive coefficients associated with the respective dummy variable (X3 and X4). This means that, all the other conditions equal, these hospitals would have more days of hospitalization than the reference hospital (the PPP). In particular, parturients would stay on average 0.269 days more in X3 and 0.313 days more in X4. All the remaining hospitals present negative β's for the dummy variables, meaning that they tend to retain recent mothers for less time than the PPP.

Although significant, the coefficient associated with age is so small that this variable has almost no influence on inpatient days. The result is consistent with the already explained mixed effect of age: older parturients may be subject to a more difficult delivery in case it is their first one, but being older may also signal that they have already given birth to other children, therefore reducing the expected days of hospitalization.

Although low, the coefficient associated with the year 2012 (the first year X_PPP is PPP) is negative, signaling that the existence of a PPP hospital in this group tended to decrease (or, at least, not to increase) deliveries inpatient days.

The dummy associated with leaving the hospital against the medical decision is negative, as expected.

Scheduled deliveries imply on average half a day more of hospitalization than urgency admissions.

Mortality risk increases hospitalization days by almost three days, ceteris paribus, whereas low severity increases by approximately one and high severity by approximately 2.5 days.

On average, caesareans imply about one extra hospitalization day and reinforce the positive effect of hospitals X3 and X4 (multiplicative dummies) when compared with other dystocic deliveries.

The estimated regression exhibits a determination coefficient (R^2) equal to 0.285 meaning that the independent variables explain 28.5% of the inpatient days variance. Recall that this regression was obtained after excluding outliers. In the case of group X, these observations account for 3.64% of the universe. If we include them in the regression and add a dummy to take them into account (this dummy is equal to 1 when the observation is an outlier), results do not change qualitatively, but the figure for R^2 increases substantially, to 0.469. The magnitude of the parameters only changes slightly their robustness is preserved, so all the interpretations above remain valid. The dummy outliers add on average more than 8 days to hospitalization.

The regression described in Table 1 seems to be able to answer the crucial question of this research, the impact of being PPP on inpatient days, which, all the rest equal are a measure of hospital efficiency. In the case of group X, the evidence is mixed: the PPP hospital performs better than some of the other hospital in the group, but not better than all.

Although with robust parameters, the described regressions for group X (without outliers and with a dummy for them) present a relatively low value for R^2. A possible explanation for this may be the fact that inpatient days after a delivery are more or less pre-defined, and only vary in case there is some problem associated. Therefore, explanatory variables contribute to a limited extent to justify the duration of hospitalization.

The value of the Durbin-Watson statistic indicates (1.988) that there is no autocorrelation in the residuals since it is very close to two. Also value VIF (Variance

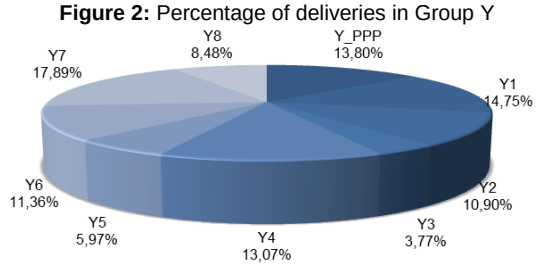
Inflation Factor) is lower than ten for all variables, which means that there is no multicollinearity. This consolidates the robustness of the regression.

VII.2 *Group Y*

VII.2.1 *Number of deliveries*

The percentage of deliveries per hospital is presented in the next Figure.

Figure 2: Percentage of deliveries in Group Y



Y7 has the highest number of deliveries and Y3, Y5 and Y8 are the hospitals with fewer deliveries. Y7 covers a higher number of inhabitants than all the other hospitals in the group; consequently a higher number of deliveries are expected. On the other hand, Y3 is the hospital with the smallest number of deliveries, but also the hospital that covers less population.

Both Y5 and Y8 show low numbers when compared to the other hospitals in the group. These two hospitals are located near Lisbon, where there are several other hospitals. Parturients may opt for another hospital.

As it happened in group X, but less significant, Y_PPP registers a large increase in the first few years of the analysis, contradicting the trend exhibited by the others hospitals in the group; in the rest of the period, the number of deliveries remained fairly constant.

VII.2.2 *Outliers*

The total percentage of outliers removed in Group Y corresponds to 3.15%. The hospital with the highest percentage of outliers is Y2, with 6.75%.

VII.2.3 *Inpatient days*

Y_PPP and Y4 have the highest averages in the group, regarding inpatient days; the other hospitals have similar averages.

The histograms show the frequency for each hospital, providing an overview of the hospitals behavior regarding childbirth. Frequency in Y3 is much smaller than in the other hospitals. Y8 is the only hospital with mode equal to two.

As mentioned before, quartiles were computed with and without outliers. Y_PPP quartiles vary from 2 to 5 inpatient days (without outliers). The median is equal to 3.

Y_PPP presents both a high average of inpatient days and an elevated average age of the parturition. However, in the other hospitals there is not a visible relationship between average age of delivery and average inpatient days after giving birth.

The correlation between age and inpatient days is not very significant.

VII.2.4 *Testing for differences in average inpatient days*

Normality tests on the variable inpatient days provide information whether the next tests executed have to be parametric or non-parametric. The normality test features a significance smaller than 0,05 for all the hospitals, therefore the distribution is not normal.

Kruskal-Wallis concludes that the average of inpatient days regarding Y_PPP and the other hospitals is not equal.

Mann-Whitney's test allows comparing each pair of hospitals. Y7-Y3, Y_PPP-Y4, Y1-Y6 and Y8-Y5, can be considered to statistically have the same averages, regarding inpatient days.

VII.2.5 *Caesareans*

Several hospitals tend to decrease the percentage of caesareans across the years. Among these hospitals is Y_PPP. In five years, Y_PPP has gone from the hospital with the highest percentage to stand in the middle of the group.

Chi-Square tests if caesarean and non-caesarean proportions are statistically equal, regarding inpatient days. The null hypothesis is rejected; the proportions are not equal regarding inpatient days.

The comparisons of column proportions allow comparing hospitals pairwise in the case of caesareans and non-caesareans. For caesareans, the proportion of Y_PPP is higher than the proportion for Y4, Y7 and Y8. The proportion of hospital Y_PPP in non-caesarean is greater than Y1 and Y2.

VII.2.6 *Multiple Linear Regression*

In order to use multiple regression, dummy variables were created.

Table 2: Multiple Linear Regression

Independent Variables	β	t-ratio	p-value
(Constant)	3.363	123.016	0.000
d_2009	-0.048	-5.291	0.000
d_2010	-0.077	-8.659	0.000
d_2011	-0.056	-6.315	0.000
d_Y1	-0.516	-42.632	0.000
d_Y2	-0.292	-22.474	0.000
d_Y3	-0.214	-9.956	0.000
d_Y4	0.211	15.390	0.000
d_Y5	-0.466	-25,884	0.000
d_Y6	-0.335	-22,754	0.000
d_Y8	-0.505	-36.090	0.000
d_Y7	-0.326	-28.315	0.000
age	-0.007	-12.653	0.000
caesarean	0.866	82,284	0.000
d_admtip	0.082	4.703	0.000
caesarian_Y3	-0.316	-8.537	0.000
caesarian_Y4	-0.276	-12.709	0.000
caesarian_Y5	-0.272	-9.062	0.000
caesarian_Y6	-0.264	-11.580	0.000
d_dsp7	-0.429	-14.260	0.000
Eutocia	-0.282	-32.489	0.000

The simple dummies in the model are Caesarian, d_admtip and Eutocia.

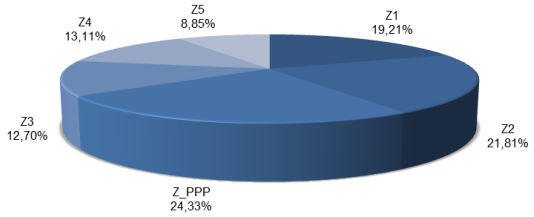
The ordinal variables in this group are year, hospital and dsp. The ordinal variables always have a base group. For years, the base group was 2014. For the hospitals, it was Y_PPP. Dsp base group corresponds to dsp equal one; this means that the hospital sends the patient home by medical discharge.
The interactive variables correspond to the product of dummy variables. In this model, they multiply the hospital and the caesarean dummy.
Y4 is the only hospital that exhibits a positive dummy coefficient. Keeping all the other variables constant, this means that Y_PPP performs better than Y4. A patient in Y4 stays on average 0.211 days more in the hospital than a patient from Y_PPP. All the other hospitals display positive values, thus the parturient stays on average an inferior number of days in the other hospitals than in the PPP. Therefore, this group does not present evidence that a PPP performs better than Public Hospitals in terms of the efficiency measure hospitalization days.
The first years, although significant, present small negative β's. This means that the first years of the Y_PPP had an impact (although very small) in reducing inpatient days.
As expected, the variable age, despite its clear significance, has a marginal influence on inpatient days.
Caesareans make on average the parturient stays 0.866 days more in the hospital when compared with other dystocic deliveries.
Deliveries with a schedule date may be associated with higher risk deliveries. It is expected that variable d_admtip increases the number of inpatient days when compared with urgency admissions.
Leaving the hospital against a medical decision (dummy d_dsp7) presents a negative coefficient. When compared to normal discharges, these cases make the number of inpatient days decrease on average 0.429 days.
Eutocia deliveries correspond to normal deliveries, therefore, less prone to complications. Keeping the other variables constant, this dummy impacts the number of inpatient days negatively compared with other non-caesarean dystocic deliveries.
If hospital dummy presents a positive coefficient and the interactive variable a negative coefficient (caesarean_Y4), this means that caesareans counteract the negative efficiency of the hospital when compared with the reference. On the other hand, when the hospital dummy has a negative coefficient, by adding a negative interactive dummy the effect is amplified: this is the case for hospital Y3, Y5 and Y6.
The determination coefficient (R^2) in this regression is 0.225. The independent variables explain 22.5% of inpatient days variance.
This regression did not include the outliers, they were removed. The outliers corresponded to 3.15% of cases in group Y. An attempt to include the outliers in the multiple linear regression was made. This new attempt consisted in including the outliers with a new dummy (d_outliers) that presented value one when the observation was an outlier and zero otherwise. The new regression presents similar values for the variables β's, so all interpretations remain valid qualitatively. The determination coefficient (R^2), however, increases from 0.225 to 0.539. The outlier dummy is significant and presents a β equal to 13.280. This means that outliers make the average number of inpatient days increase by approximately 13 days.
The Durbin-Watson test is 1.934; close enough to 2 to admit that there is no autocorrelation in the residuals.
VIF values are all under 10, so there is no multicollinearity.

VII.3 *Group Z*

VII.3.1 *Number of deliveries*

The number of deliveries can be related with the number of inhabitants the hospital serves and age of the population in that region.
Z_PPP has the highest number of deliveries, followed by Z2 and Z1. Z_PPP is expected to have a high number of deliveries since it serves the greatest amount of residents. Z2 and Z1 are located near the capital in highly populated areas. Z5 is located in Alentejo. This region is well known for the desertification and a high number of elderly people.

Figure 3: Percentage of deliveries in Group Z



All the hospitals in the group have been decreasing the numbers of deliveries throughout the years of analysis. However, Z_PPP appears with an abnormal high number of deliveries in 2011 almost the double of the other years. The number of deliveries in 2011 for Z_PPP is almost the double of the other years. This is probably related with the change that happened in this year; the new facilities for the hospital were inaugurated.

VII.3.2 *Outliers*

The total amount of outliers removed in the group is 2.22%. The hospital that presents the highest percentage is Z1 (with 4.01%).

VII.3.3 *Inpatient days*

Z2 has the highest average number of inpatient days in the group.
Histograms demonstrate the differences in frequencies for the different hospitals in the Group. Z5 is the hospital with the lowest frequency.

Quartiles without outliers have more information. Z_PPP quartiles vary from 0 to 5.
Z2 is the hospital with the highest number of inpatient days and has the lowest average regarding the mother's age. The correlation between age and inpatient days is not very significant.

VII.3.4 *Testing for differences in average inpatient days*

Normality tests give information on whether the universe follows a normal distribution, regarding inpatient days. The hypothesis is rejected and the following tests had to be non-parametric tests.
To test whether the PPP average was statistically equal to the other hospitals average the Kruskal-Wallis test was used. The null hypothesis were the averages are statistically equal was declined.
Mann-Whitney's test allows the comparison between each pair of hospitals. The null hypothesis is rejected for all the cases.

VII.3.5 *Caesareans*

Group Z demonstrates that almost every hospital has been decreasing the percentage of caesareans. Z1 has the lowest figure in the group.
The chi-square test allows testing the proportion between caesarean and non-caesareans. With no surprise, the hypothesis that they are statistically equal is rejected.
Comparisons of column proportions test for each pair of hospitals regarding non-caesareans and caesareans. Concerning non-caesareans, the proportion of hospital Z_PPP is significantly larger than the proportions from hospitals Z2, Z4 and Z5. The proportion of hospital Z_PPP, in caesareans, is greater than that of hospital Z1.

VII.3.6 *Multiple Linear Regression*

Multiple Regression implied the construction of several dummy variables.

Table 3: Multiple Linear Regression

Independent Variables	β	t-ratio	p-value
(Constant)	2.322	76.736	0.000
d_Z1	0.329	20.280	0.000
d_Z2	0.551	34.845	0.000
d_Z3	0.317	14.721	0.000
d_Z4	-0.100	-4.440	0.000
d_Z5	0.235	8.981	0.000
caesarean	1.319	80.877	0.000
Eutocia	-0.355	-25.919	0.000
d_dsp7	-0.800	-12.839	0.000
d_admtip	0.629	22,020	0.000
caesarean_Z3	-0.374	-10.787	0.000
caesarean_Z4	-1.051	-31.372	0.000
caesarean_Z5	-1.081	-27.028	0.000

Ordinal variables in this model are hospitals and dsp. The base group for the hospitals is Z_PPP. For dsp, the base group is dsp equals to one.
This model includes three simple variables: Caesarean, Eutocia and d_admtip.
The interactive variables multiply the hospitals dummy with the caesarean dummy.
In this group, variable age proved not to be significant. Recall that in the other groups, age, although significant, did not have a noticeable impact on inpatient days.
Four hospitals (of the five included) present positive coefficients while the dummy for hospital Z4 exhibits a negative coefficient. This means that holding the other variables constant, a parturient in the PPP (Z_PPP) would stay 0.100 days more committed to the hospital than a parturient in Z4. On one hand, a patient in the PPP tends to have smaller average inpatient days than in the other four hospitals.
A parturient that undergoes a caesarean stays, on average, 1.319 days more committed to the hospital than a parturient with a different type of dystocic delivery Eutocia deliveries are typically less prone to complications. Eutocia deliveries contribute to an earlier discharge of 0.374 days as compared with non-caesarean dystocic patients.
A scheduled delivery is usually associated with high risk deliveries and therefore, makes the inpatient days average increase by 0.629 days. As for the other groups, when a patient decides to go home without medical consent the average inpatient days decrease. In this group, they decrease almost one whole day (0.800 days).
The hospital dummy with a negative coefficient means that this hospital is more efficient regarding inpatient days than the PPP: joining with a negative interactive dummy (caesarean_Z4) means that caesareans amplify the effect.
When the hospital dummy presents a positive coefficient and the interactive variable a negative coefficient (caesarean and hospitals Z3 and Z5), this means that caesareans counteract the inefficiency effect of the hospital.
This regression presents a determination coefficient (R^2) of 0.203. Therefore, the independent variables explain 20.3% of the inpatient days variance.
As for the other groups, another linear regression was attempted. The goal was to perceive what difference the outliers' presence would bring. A new dummy was built, with value one if the observation is an outlier and zero otherwise. The determination coefficient changes significantly. The new value of R^2 is 0.530. The magnitude (β) of the parameters changes slightly, but the previous interpretations remain valid. The dummy outlier is very significant and increases the average inpatient days by 16.701 days.
The Durbin-Watson test for the regression without outliers has a value of 1.898, which is close to two. Therefore, there is almost no presence of autocorrelation. The presence of multicollinearity is encountered when VIF is higher than ten. Since this does not happen is this case, there is no multicollinearity.

VIII. CONCLUSION

Public-Private Partnerships in the health sector are emerging in Portugal. There is yet not much

information about PPPs in Portugal and not many assessments regarding their performance or what they improved when compared to Public Hospitals.

The existence of comparability between hospitals was determinant for this analysis. The hospitals divided into three groups (X, Y and Z) had similar characteristics and, with at least one PPP in each group, the comparison between PPP and Public Hospitals was possible.

First, for each group the number of deliveries and their evolution across the years per hospital were computed. The percentage of outliers removed allowed inferring the hospitals with the highest percentages and the DRG codes predominant in the outliers.

Kruskal-Wallis and Mann-Whitney tests both were employed to test for differences in average inpatient days. Kruskal-Wallis tested if the average of inpatient days was equal between Public Hospitals and PPP; in every group the null hypothesis was rejected, they are not equal. Mann-Whitney tested whether the average of inpatient days was equal between hospitals, pairwise.

Caesareans percentage throughout the years displays the hospitals behavior and whether they are committed to reducing the number of caesareans. A chi-square test compares the proportions between caesareans and non-caesareans and through the column proportion test it is possible to infer which hospital has a statistically larger percentage of caesareans. Finally, a multiple linear regression model was estimated to identify the impact of several independent variables on the dependent variable inpatient days.

A summary of the results for each group is presented below.

- Group X

The PPP corresponds to a quarter of the number of deliveries in the whole group. Regarding the number of deliveries per year, the PPP contradicts the declining tendency, since it is the only one in the group where deliveries have been increasing.

The outliers for each hospital and for the whole group were calculated, for this group the percentage of outliers is 3.64%. Inpatient days average in each hospital of the group ranges from 2.70 to 3.74 days.

The percentage of caesareans in the PPP has decreased, ensuring a smaller percentage than all the other hospitals, by almost 10 percentage points. In this group, testing proportions between hospitals allow to conclude that statistically the PPP performs better than almost all the other hospitals, regarding non-caesareans.

However, through the multiple linear regression analysis it is not clear that the PPP is overall more efficient in terms of inpatient days. Looking at the hospital dummies, some hospitals exhibit a smaller average number of inpatient days than the PPP, ceteris paribus, while other hospitals tend to perform worse.

Age, although significant, has almost no influence on inpatient days. As expressed throughout this article, age exhibits a contradictory effect: an older parturient can be associated with a higher risk delivery, but it can also imply that she has already given birth to other children, therefore reducing the expected inpatient days.

The year 2012 expresses a significant small negative coefficient, which means that the first year X_PPP started as a PPP contributed to a slight decrease on the average number of inpatient days.

Scheduled deliveries contribute to an increase on the average inpatient days, while leaving the hospital without medical discharge reduces them, as expected.

On average, caesareans imply about one extra hospitalization day when compared with other dystocic deliveries and reinforce the hospital effect with positive coefficients (multiplicative dummies).

High mortality risk increases the number of inpatient days by almost three days, *ceteris paribus*, whereas low severity increases by approximately one and high severity by approximately 2.5 days. All these results seem coherent, low severity increases the number of hospitalization days less than high severity.

Adding the outliers with a dummy variable in a new multiple linear regression did not change substantially the magnitude of the parameters, but the coefficient of determination increased considerably. The introduction of this new variable indicates that the outliers increase the average inpatient days by almost nine days.

- Group Y

The PPP presents an increasing number of deliveries, opposed to the other hospitals trend. The outliers' percentage in this group is 3.15%. Average inpatient days for the hospitals vary between 2.74 and 3.42.

Regarding caesareans, in a five year period the PPP has moved from being the hospital with the highest percentage, to the middle of the group. However, in this group the hospitals behavior is not very clear, some tend to increase this percentage and others to decrease, and there is not a clear path.

Y_PPP performs better than a few hospitals regarding non-caesareans but also performs better than some other hospitals regarding caesareans. This hospital does not present clear results to allow making an assessment regarding caesareans proportions.

The results of the multiple linear regression show that, *ceteris paribus*, Y_PPP only performs better than one Public Hospital, regarding inpatient days. All the other hospitals display a negative coefficient which means that a parturient stays a higher number of days committed to the hospital in the PPP, on average.

In this group, the three first years of analysis were significant, although displaying a small coefficient. Once again, age, although significant, has a marginal influence on reducing inpatient days.

Deliveries with a schedule date contribute to an increase on average inpatient days compared to urgency deliveries. Leaving the hospital without

medical discharge diminishes the number of inpatient days.

Eutocia deliveries are associated with less complicated deliveries; therefore the negative coefficient indicates the inpatient days tend to be smaller, on average, when compared to other dystocic deliveries. In this group, caesareans tend to increase the number of hospitalization days by almost one day versus other dystocic deliveries.

Multiplicative variables present two effects in this group: if the hospital variable has a positive coefficient and a negative coefficient for the interactive variable, caesareans counteract the negative efficiency effect of the hospital; on the other hand if the hospital presents a negative coefficient and the interactive variable also does, the efficiency effect is amplified. Both situations happen for group Y.

To include the outliers, a new multiple linear regression was computed; the determination coefficient increases significantly and the β's present similar figures. The presence of outliers contributes to an increase on average inpatient days by approximately thirteen days.

- Group Z

Group Z encounters the hospitals that cover the highest numbers of inhabitants, compared to the other groups. The hospital with the highest number of deliveries is the PPP. The numbers of deliveries throughout the years remain steady, with the exception of 2011. The outliers' removal in this group corresponds to 2.22%.

The percentage of caesareans has been slowly decreasing throughout the years. The proportions tests reveal that regarding non-caesareans the PPP has statically greater proportions than a few hospitals in the group.

According to the results of the multiple linear regression, the PPP is the hospital with the best performance in terms of inpatient days, with the exception of one Public Hospital.

Eutocia and caesarean variables exhibit opposite effects when compared with other dystocic deliveries: on the one hand, eutocia deliveries tend to decrease the number of hospitalization days by 0.374; on the other hand, caesareans contribute to an increase on the average days of hospitalization by more than one day. Age was not a significant variable for this model.

A scheduled delivery tends to increase the average days of hospitalization and an early discharge influences negatively the average inpatient days.

Interactive dummies show that the inefficiency of two Public Hospitals as compared with the PPP is amplified in the case of caesareans; in turn, the efficiency of one Public Hospital is mitigated by caesareans.

Introducing outliers with a new dummy led to a new multiple linear regression model; the β's did not change significantly, but the determination coefficient increased considerably. In the case of group Z, the outliers increase the length of hospitalization by more than sixteen days.

Throughout the analysis some conclusions common to all groups were reached: it was confirmed that caesareans increase the average number of inpatient days, whereas eutocia deliveries make them decrease. Age does not have a relevant impact on inpatient days. Leaving the hospital without medical consent decreases the number of inpatient days. A scheduled delivery makes the number of inpatient day increase against an urgency delivery, probably due to the complexity associated with a scheduled delivery.

Public-Private Partnerships do perform better in some cases (but not always) when compared to Public Hospitals. Public-Private Partnerships involve resources, time and money, so it is worth assessing their eventual superiority.

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