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Title: Analysis of the resource consumption variation within DRGs.

1 - INTRODUCTION

In this paper we analyze the resource consumption variation within Diagnosis Related Groups (DRGs) based on data from Portuguese hospitals. The main objective is to evaluate the resource consumption variation on DRGs and identify the main reasons for such variation.

If the resource consumption by patients with similar problems can be described exactly, the work of the physicians can be compared across, as can the results of one hospital be compared with another, for the actual resource consumption pattern (1).

The purpose of this study is to analyze the resource consumption variation, and then to identify some aspects that can influence this variation.

Based on the literature survey, two variables can be selected to measure the resource utilization: Length of Stay (2; 3; 4; 5) and Cost per Patient (6; 7). According to Costa, C. (8) the more reliable variable to measure resource consumption should be the Cost per Patient, if the same procedures were applied across the different hospitals. Length of Stay – even if it does not reflect the intensity of medical care and does not imply that all patients with identical Length of Stay have the same resource consumption levels – is easy to compile, reliable and generally available in most of the studies, making it a natural proxy of resource consumption.

Assuming that, there are factors that, according to the literature, influence the Length of Stay. According to Hornbrook (9) a criterion for the classification of hospital cases is the homogeneity of service rendered, being implicit that the constant efficiency of hospital and doctor drives that “any variation on inputs represents a substantial

difference on outputs". Moreover, Schwartz (10) presents some of the factors (inputs) that may influence the variation on resource consumption (outputs):

- Patient characteristics - Sex, Age, Principal Disease Severity, Total Patient Severity, Co-morbidities, Social-Economic Factors and Education. We can also include in this group other uncontrolled factors like adverse patient reactions to a certain treatment or the contraction of a nosocomial infection leading to the existence of acquired complications during the hospital stay;
- The characteristics of professionals – experience and training;
  The doctor's responsibility is to carry out a correct diagnosis and prescribe adequate treatment, so that the patient is cured or is symptoms are relieved (9). However, it is exactly on the type of treatment that the medical practices diverge. According to a study of the U.S. General Accounting Office (11) medical practices in seventeen hospitals diverged significantly, resulting on different costs between doctors executing the same procedure.
- The characteristics of the care institutions – qualitative and quantitative dimension, type and ownership;
  On a study from Link (7), variations between hospitals were due essentially to institutional differences like hospital size, type of hospital (university or not) and the associated costs to employee salaries, but also patient condition.
- The characteristics of the Health System – degree of public financing and intervention;
- Other characteristics such as type of admission, type of episode (surgical or medical), time to hospitalisation or codification mistakes on discharge summaries.

2 - DATA/METHODOLOGY

The data is from the public Portuguese hospitals in the year 2002 with a total of 950,443 inpatient discharges and 498 DRGs. From these DRGs we analyzed a sample of 72 DRGs and a total of 246,749 inpatient discharges.

Disease Staging was used, in its computerized version, from the discharge abstracts database as input for recoding of episodes for the following attributes: Principal disease, Secondary diseases, stage and sub-stage of secondary diseases, Body

System Index, Total Severity recalibrated for Portugal, based on the Expected Mortality Index.

The selection of DRGs for this analysis was based on the five factors, that according to the literature, can influence more significantly the resource consumption variation (Production Volume, Complexity, Length of Stay, Severity and Co-morbidities), as well as a measure of variation (Coefficient of Variation).

The variables used in the analysis of the resource consumption variation were: DRG Type (medical, surgical); Production Volume; Average Length of Stay Index (LOSI = ALOS by DRG / Total ALOS); Total Severity (TS); Co-morbidities (COM); Sex; Average Age (AA); Admission Type (TA); Principal Disease (PD); Number of hospitals with more than 30 discharges in each DRG (N_HOSP).

The Total Severity is calculated by the *Disease Staging* and corresponds to the expected mortality rate which can only be used as a *proxy* of patient Total Severity if discrimination exists (12) and includes in its calculation formula the variables: Principal Disease, Principal Disease Severity, number and severity of Co-morbidities, Age, Sex, Admission Source and Type of Admission.

To assess the validity of using the expected mortality as a proxy of Total Severity, we computed its discrimination using c-statistic, which equals the area under the ROC curve (12).

We considered this measure valid for the 72 DRGs surgical and medical under analysis as a whole, with a c-statistic value of 0,942 and 0,842, respectively. Individually we considered as a one the DRGs with its adjacent, and we have found that 20 DRGs (DRGs - 39, 75, 161, 162, 163, 231, 256, 265, 266, 269, 270, 323, 324, 341, 358, 359, 360, 410, 430 e 467) showed low number of deaths(< 30), being these DRGs removed from the analysis for presenting low phenomenon prevalence (13). All the others showed a good c-statistic value. Then we are analyzing 52 DRGs, which represented a total of 172,065 discharges.

The impact of the variables under analysis on the resource consumption variation, measured by the Coefficient of Variation of the Length of Stay (CV), was analyzed throughout a linear regression.

Furthermore, the Total Severity was also considered on 3 levels of severity relating the resource consumption variation in a similar way to *Disease Staging* – level 1 corresponding to lower severity and level 3 to higher severity. The values of Total Severity up to percentile 33.3 were associated to the first level; the ones between 33.4 and 66.6 to the second level, the last one referring to the upper third.

Then, the DRGs with higher and lower variation were identified, in order to study its relation with the number of different principal diseases, the presence and severity of the co-morbidities and case complexity. The selection was made as follows (see Tables 1 and 2):

- The 52 DRGs were sorted by decreasing order of Coefficient of Variation (CV1, CV2, CV3) for each one of the Severity Levels (SL1, SL2, SL3);
- The first 13 DRGs were selected as well as the respective CVs up to the first quartile (DRGs with higher CVs) and the last 13 with respective CVs beyond the 3rd quartile (DRGs with lower CVs) of each one of the Severity Levels (SL1, SL2, SL3);
- From each DRG group with higher and lower CVs, those that were common to two or three Severity Levels were selected.

Table 1 – DRGs with the higher CV

DRG	DRGType	CV1	DRG	DRGType	CV2	DRG	DRGType	CV3
81	Med.	88.9121	3	Sur.	85.4288	2	Sur.	82.1856
82	Med.	92.1836	82	Med.	84.4214	3	Sur.	76.7294
104	Sur.	82.6563	123	Med.	91.3003	82	Med.	78.2144
172	Med.	97.0759	124	Med.	81.2145	123	Med.	78.2969
173	Med.	95.8444	182	Med.	72.7650	124	Med.	94.7394
203	Med.	98.8091	183	Med.	77.6059	127	Med.	75.7016
205	Med.	92.1289	203	Med.	74.9290	172	Med.	76.0914
206	Med.	116.3719	205	Med.	81.6043	173	Med.	76.6078
236	Med.	91.9252	206	Med.	115.2005	182	Med.	80.0407
403	Med.	79.0566	212	Sur.	79.3320	183	Med.	81.9373
404	Med.	84.4758	236	Med.	79.4101	206	Med.	78.7110
489	Med.	80.5262	403	Med.	74.2518	403	Med.	75.9995
490	Med.	101.3609	404	Med.	87.3496	404	Med.	79.0931

Common DRG's in two levels
Common DRG's in three levels

Table 2 – DRGs with the lowest CV

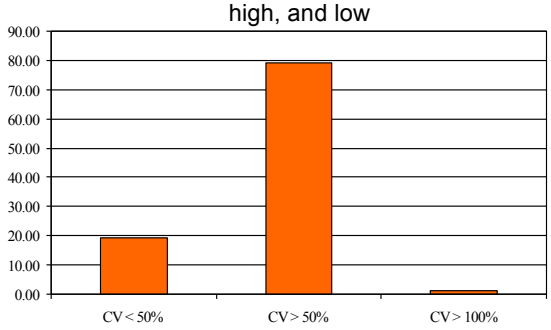
DRG	DRGType	CV1	DRG	DRGType	CV2	DRG	DRGType	CV3
105	Sur.	32.1397	105	Sur.	37.63886	91	Med.	50.3268
107	Sur.	42.5483	107	Sur.	39.69515	105	Sur.	41.4447
109	Sur.	27.5384	109	Sur.	23.5536	107	Sur.	32.1585
121	Med.	34.1461	121	Med.	37.36505	109	Sur.	25.0963
122	Med.	31.7226	122	Med.	35.1944	121	Med.	50.1189
123	Med.	52.84699	125	Med.	36.27246	122	Med.	43.7624
125	Med.	33.4568	149	Sur.	0.0000	125	Med.	40.8008
154	Sur.	50.36813	154	Sur.	31.5323	149	Sur.	39.9530
155	Sur.	9.3936	155	Sur.	0.0000	154	Sur.	31.6526
156	Sur.	0.0000	156	Sur.	0.0000	155	Sur.	40.4256
209	Sur.	38.1365	209	Sur.	38.40481	209	Sur.	40.2759
211	Sur.	51.91476	211	Sur.	42.13731	211	Sur.	44.0921
322	Med.	43.5259	322	Med.	45.89322	322	Med.	45.9816

Common DRG's in two levels
Common DRG's in three levels

3 - RESULTS

For the resource consumption of the 72 DRGs it was concluded that: i) 79% of the DRGs show high variation, ii) 19,5% show low variation e iii) only one DRG, representing 1,5% shows very high variation (see Table 3).

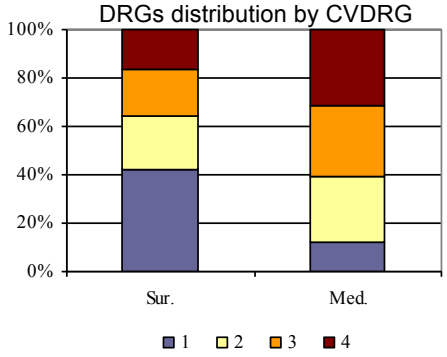
Table 3 - % of DRGs with CV very high, high, and low



It can be observed (in Table 4) that aproximately 60% of surgical DRGs are situated below the 2nd quartile – lower CV – unlike medical DRGs where aproximately 60% show above the 2nd quartile.

The conclusion therefore is that the type of DRG influences the CV, with the medical DRGs showing persistently higher CV values than the surgical ones.

Table 4 – Medical and Surgical DRGs distribution by CVDRG



For the remaining attributes: Output Volume, Average Length of Stay, Total Severity, Co-morbidities, Sex, Average Age, Type of Admission and Principal Disease Severity, it was not possible, through descriptive analysis, to find any pattern on Resource Consumption Variation. This absence of a pattern led to the use of **multiple linear regression** aiming to identify which factors influence the dependent variable: the Coefficient of Variation.

Two regressions were carried out differing by the fact that Regression I considers Total Severity and Regression II considers Main Disease Severity. As a result Regression I explains 27% of the variation with a significance level of 0.001, clearly lower than 0.05, thus validating the model as adequate to describe the above mentioned relations.

For the independent variables it was observed that **Total Severity and type of DRG were influencing the CV**. These variables also showed significance levels below

0.05 (TS 0,009 and DRG type 0,008) as well as a high positive coefficient, confirming the direct correlation between quantity of medical DRGs and CV level.
For Regression II, where Patient Total Severity was replaced by Principal Disease Severity, the model explained 18.3% of the variation for a significance level of 0.011, still under 0.05, again validating the model as adequate to describe the relations under analysis, although the explanation was weaker than Regression I.

The results for the independent variables of Regression I were maintained in Regression II, with the exception of Main Disease Severity that shows no correlation to the variation, with levels of significance above 0.05 (0.847) and the number of Hospitals with levels of significance close to 0.05 (0.042) and a negative coefficient.

3.1. TOTAL SEVERITY DETAILED ANALYSIS

Total Severity was split into 3 levels (NG1, NG2 e NG3) and for each level and DRG, the Average Length of Stay and CV were calculated.

Moreover, a statistical analysis was done between the CVs on each of the three levels and the global CV, seeking also to compare the ranking of the CVs on the 3 levels and the global variation, in order to verify if the DRGs were ranked identically.

Table 5 shows the Spearman correlation between the CV across SL through ranking of CV. We can see that the correlation between CVs of levels 1 and 2, between CVs of levels 2 and 3 and between these and the global is high, being moderate for the remaining ones. For agreement, all Kappa values were lower than 0.40, exhibiting weak accordance between the ranking on the 3 severity levels. Nevertheless a higher accordance level (0,078) is observed between severity levels 1 and 2 and between

Table 5 – Correlation and accordance analysis of VC from the three levels of severity

Groups in analysis	Spearman Corr		Kappa	
	Value	Sig.	Value	Sig.
Rank_Grav1 vs Rank_Grav2	0.768	0.00 *	0.078	0.000
Rank_Grav1 vs Rank_Grav3	0.582	0.00 *	-0.020	0.313
Rank_Grav2 vs Rank_Grav3	0.778	0.00 *	0.020	0.313
Rank_Grav1 vs Rank_Global	0.805	0.00 *	0.059	0.003
Rank_Grav2 vs Rank_Global	0.878	0.00 *	0.078	0.000
Rank_Grav3 vs Rank_Global	0.847	0.00 *	0.042	0.000

* Approached to the normal distribution

the level 2 and the global one, thus indicating the existence of DRGs with identical variations between distinct severity levels.

Although the agreement between the rankings was very low, a search per quartile was performed to look for common DRGs, comparing CV rankings. A pattern was found for DRGs in the 1st quartile and beyond the 3rd quartile on the 3 tables that showed higher number of DRGs, revealing DRGs with high and low CVs influenced by Total Severity.

This analysis lead to the existence of 2 DRG groups: one with higher CVs and another with lower CVs. These were then identified and are presented hereunder:

Table 6 – DRGs with higher CV

DRG		Severity Levels	DRG Type	Global CV	Total Severity	Principal Disease	COM	COMPL
3	Craniotomy, age 0-17	2,3	sur	78.8173	0.0664	18	1.24	3.60
82	Respiratory neoplasm	1,2,3	med	84.9222	0.3238	37	1.60	1.52
123	Circulatory disorders with AMI, expired	2,3	med	90.7860	0.5869	8	2.20	1.18
124	Circulatory disorders except AMI, with card cath and complex diagnostic	2,3	med	80.0579	0.0469	28	1.79	1.39
172	Digestive malignancy, with CC	1,3	med	79.5615	0.3052	26	1.90	1.56
173	Digestive malignancy, w/o CC	1,3	med	83.2308	0.1924	15	0.83	0.92
182	Esophagitis, gastroent, and misc digest disorders, age > 17, with CC	2,3	med	72.8065	0.0402	26	2.51	0.82
183	Esophagitis, gastroent, and misc digest disorders, age > 17, w/o CC	2,3	med	74.6329	0.0161	29	0.84	0.53
203	Malignancy of hepatobiliary system or pancreas	1,2	med	83.5059	0.2996	29	1.70	1.47
205	Disorders of liver except malig., cirr., alc hepa, with CC	1,2	med	80.3749	0.1221	15	2.21	1.31
206	Disorders of liver except malig., cirr., alc hepa, w/o CC	1,2,3	med	107.6842	0.0156	11	0.48	0.62
236	Fractures of hip and pelvis	1,2	med	84.2623	0.1455	4	1.39	1.30
403	Lymphoma and non-acute leukemia, with CC	1,2,3	med	76.7687	0.2569	24	2.65	2.73
404	Lymphoma and non-acute leukemia, w/o CC	1,2,3	med	84.3638	0.1520	29	0.96	1.32

Table 7 – DRGs with lower CV

DRG	Severity Levels	DRG Type	Global CV	Total Severity	Principal Disease	COM	COMPL
105 Cardiac valve and other major cardiothoracic proc w/o card cath	1,2,3	sur	37.3195	0.0323	15	1.69	6.06
107 Coronary bypass with cardiac cath	1,2,3	sur	41.3792	0.0420	4	2.52	5.73
109 Coronary bypass w/o cardiac cath	1,2,3	sur	26.7004	0.0238	3	2.26	3.92
121 Circulatory disorders with AMI and major complications, discharged alive	1,2,3	med	42.3780	0.1476	7	2.41	2.10
122 Circulatory disorders with AMI w/o major complications, discharged alive	1,2,3	med	39.5376	0.0762	10	1.93	1.24
125 Circulatory disorders except AMI, with card cath w/o complex diagnostic	1,2,3	med	37.2806	0.0314	28	0.85	1.04
149 Major small and large bowel procedures, w/o CC	2,3	sur	39.9861	0.0226	26	0.83	1.96
154 Stomach, esophageal, and duodenal procedures, age >17, with CC	1,2,3	sur	61.2241	0.1597	26	2.69	4.48
155 Stomach, esophageal, and duodenal procedures, age >17, w/o CC	1,2,3	sur	48.2928	0.0172	26	0.66	1.94
156 Stomach, esophageal, and duodenal procedures, age 0-17	1,2	sur	69.4869	0.0000	13	0.54	2.01
209 Major joint and limb reattachment procedures of lower extremity	1,3	sur	39.8300	0.0134	32	0.93	3.93
211 Hip and femur procedures except major joint, age > 17, w/o CC	1,2,3	sur	46.2506	0.011745	36.00	0.71	1.97
322 Kidney and urinary tract infections, age 0-17	1,3	med	48.1449	0.0082	6	0.51	0.70

Table 8 – Results summary

	Lower CV	Higher CV
Average Co-morbidities (COM)	1.20	1.57
% Co-morbidities levels 2 and 3	16.21	23.51
Complexity (COMP)	2.85	1.45
Average Total Severity (TS)	0.0377	0.1802

From the analysis of the Table 8 the main results are the following:

- The DRGs that show higher variation on resource consumption have episodes with more associated Co-morbidities as well as more patients on severity stages 2 and 3 (to the DRGs with lower variation correspond 4.5% when considering stage 3 alone and to those with higher variation this value reaches 9.1%). **To summarize, more complex patients have closer Average Length of Stay and**

are associated with a larger number of surgical cases (these having higher relative weights associated, leading to higher complexity overall);

- Total Severity was analyzed in average terms through the Mean Total Severity. The value found for the group of DRGs with higher CV was 0.1802 and for the one with lower CV the value was 0.0377, allowing us to state that **the higher the Total Severity the higher the variation on resource consumption**. As for the DRGs, TS should be made part of patient classification, differentiated by stage, since it was observed, from the SL analysis, that these in fact influence the variation of resource consumption. Some authors confirm this theory, namely Hornbrook (15) who says "more severe patients are expected to have higher costs as a reflection of the higher intensity of necessary resources;
- For type of DRG, the medical DRGs justify the highest variation, with 13 medical DRGs having been found in the higher CV group, against a single surgical one. On the DRGs with lower variation, the surgical ones standout with 9 against only 4 medical. It is therefore possible to state that **the higher the number of medical DRGs, the higher the variation on resource consumption.**

4 - DISCUSSION AND CONCLUSIONS

The first methodological option was the choice of DRGs to include in this study. Since the objective was to analyse the variation on resource consumption, a literature survey was carried out looking for factors that might influence this variation the most and are available in the inpatient discharge database that served as the main source for this analysis. There are other important factors capable of influencing the variation of resource consumption, like different medical practices associated with each doctor/ patient. However, this investigation would require lengthy field work, outside of the scope of this project.

Patient Total Severity (TS) was used instead of Main Disease Severity (MDS) because, on one hand, the first one deals with a series of factors related with the global condition of the patient whereas the second one focuses on the data from the main disease. On the other hand it was possible to demonstrate statistically that TS

directly influence the variation on resource consumption, unlike MDS where this proof was not obtained.

We chose to analyze TS on 3 severity levels, defined through the percentiles, based on the premise of direct correlation between TS and variation on resource consumption (15) and identically to the 3 severity stages of *Disease Staging* (16;17):

- Stage 1 – Disease without complications;
- Stage 2 – Disease with local complications;
- Stage 3 – Disease involving multiple locations or systemic complications.

The main findings show that:

- From the global analysis of the resource consumption variation on 72 DRGs, it was concluded that the highest variations correspond to 80% of DRGs and the lowest variations correspond to 20% of DRGs. The rule is created: in fact there is a pattern in resource consumption variation associated to the 80% of DRGs, the 20% being the exception;
- From the final group of 27 DRGs evaluated we concluded that 14 show high variation on resource consumption and 1 very high;
- From the analysis of the factors that could influence these variations we could conclude the following:
  - The medical DRGs and patient Total Severity are the factors that seem to influence the variation the most. In parallel it was observed that the medical DRGs come associated with more severe patients and also with higher variations on resource consumption. The finding associated with the medical DRG suggests one analysis of the professional characteristics, in this case the physicians;
  - To more severe patients and higher variations also correspond higher numbers of Co-morbidities, even more clear on patients on higher severity stages;
  - On the surgical DRGs a low variation on resource consumption was observed. In fact these cases show fair to good homogeneity on resource consumption and appear associated with a low number of Co-morbidities;

- For the case complexity, lower variations emerge as associated with patients of higher complexity, like the surgical ones. Certainly due to a spread standardization of procedures, availability of protocols or higher results evidence.

There is no such objective defined nor is desirable that all patients inside the same DRG consume resources identically. It is in fact to be expected, according to Averill (18), that some variation on resource intensity is likely to exist between patients of each DRG. The definition of DRG is based on the concept of average resource consumption and therefore it is not necessary that every patient is identical although, in resource consumption terms, the degree of variation among patients should be known and predictable.

From the implications and recommendations of this analysis we highlight the following:

- Implications on the level of financing. We are financing in the same way patients that are clinically different, meaning we are creating DRGs winners and losers. This way, and depending on the case-mix of the hospital, it can become over or under financed.

  Given the high variation on resource consumption inside each diagnosis category, one question emerges: “Is the financing model based on DRGs adequate?”
- Implication on the different clinical practices both between hospitals and between direct providers. As mentioned before, different clinical practices among providers generate large differences on resource consumption within each DRG. One way to compensate for the large variations on resource consumption due to clinical practice is to implement *Clinical Governance* effectively and/or implement a system for patient classification that takes into account patient severity;
- Implications on DRG construction and maintenance in Portugal. DRG must be followed and updated along time, namely in what concerns product classification (group and sub-group construction), given the fact that there is a rapid evolution in the “state of the art” of medicine as a consequence of technological progress and clinical practice, as well as the emergence of new community diseases; “in medicine what is true today, tomorrow may cease to be”.

This analysis could probably find different results if it would have been possible to access to the patients clinical data, because it would allow the analysis of resource consumption by patient and DRG. A future study should focus on the analysis of variation of resource consumption throughout the use of clinical databases.

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