Does innovation influence the performance of medical care organizations?

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Biographical Note

Mãdãlina Gherman was born in 1990 in the town of Roman, Romania, where she graduated from the "Roman-Voda" local high-school, after which she went on to study at the biggest economics university in Romania, the Academy of Economic Studies from Bucharest. During the bachelor studies, she beneficiated of an Erasmus Exchange Scholarship for studying a semester at the Faculty of Economics of University of Porto, which made her fall in love with the city of Porto and the quality of the education provided by this university. This is why, after getting her bachelor degree in Marketing in Bucharest in 2012, she came to Porto to study the Master in Management programme offered by FEP Porto.

At the conclusion of this step in her education, Mãdãlina feels that the knowledge she has accumulated here has helped her form a strategic and thorough thinking, with attention to detail and to inspecting all aspects of the problems, which she hopes will lead her to successfully manage her own business in the near future. The realization of a paper version of the dissertation, to submit to the *International Competitiveness Management Conference – COMPETICON* (Annex 7), also allowed her to develop scientific-related skills. Furthermore, she met here people she admires and formed friendships that will last a lifetime.

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Abstract

Innovation is a widely studied field nowadays, given its importance for any organization who wishes to achieve and maintain a competitive advantage in the market. Numerous studies have explored the relation between innovation and performance and to which extent the first determines the latter.

The research question this study revolves around is: does innovation in medical care influence its performance? The present paper is looking to answer to that, as well as analysing the correlations between service, process and organizational innovation - between themselves and with the performance of the health care units.

From a theoretical point of view, this research contributes to the existing literature in this field, giving further insight into whether there is a binding relation between the acquisition of innovative technology, reorganization of processes and organizational practices – and performance (measured in a financial, market and operational way). From a practical point of view, having information like this might help hospitals make better decisions into their innovation policy design.

The study is performed through a quantitative analysis (survey to health care literature and reports data) on 34 Portuguese hospitals. As a parallel investigation, the hospitals are divided by type of property and geographical region they belong to and comparative tests are performed to test the existence of differences. The study finds that organizational innovation is correlated to process innovation, and the measure of organizational innovation "*Diffusion of knowledge*" is correlated with the measure of service innovation "*Introduction of new procedures or treatments*". Furthermore, service and process innovation both have a unit of measure which influences operational performance; operational performance, has, in turn, its impact on financial performance, but the correlation is not found significant at the level of the same operational measures as before, so we cannot conclude that innovation in medical care units has overall an impact in their financial performance.

Key words: innovation, performance, performance measures, health care, hospitals

Jel-Codes: I19; O31

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1. Introduction

The relation between the implementation of innovation and performance, and the amount in which the first determines the latter has been subject to several studies during past years (Irwin *et al*, 1998; Naranjo-Gil, 2009; Dias and Escoval, 2013; Caiado and Neto, 2013). The services field is an area of special interest due to the particularities of the introduction of innovations and the way they are embedded in the organization (Länsisalmi *et al*, 2006).

The research question this study revolves around is: is innovation in medical care correlated with better performance? Several studies' results (Dias and Escoval, 2013; Irwin *et al*, 1998) are bound to show a connection between medical innovation and an increase in performance, but is it a significant one and does it depend on the type of property or location of the hospital? This study is looking to answer to that, as well as analysing the dimensions of influence that service, process and organizational innovation have on the performance of the health care units.

This study has a theoretical as well as a practical pertinence: from the theoretical point of view, it contributes to the existing literature in this field and to similar studies like Gunday *et al.* (2011) and Irwin *et al.* (1998)'s one, giving further insight into whether there is a binding relation between the acquisition of innovative technology, reorganization of processes and organizational practices – and performance (measured in a financial and operational way). From a practical point of view, on the other side, having information like this might help hospitals make better decisions into their innovation policy design. This study is aiming to go further than just state the existence of a correlation between innovation and higher operational performance in hospitals – and goes in the depths of correlating different innovational measures between them and then connecting them with performance measures, looking to form a structural model of correlations.

This report will be organized as follows: firstly, we review the relevant literature, which explores the topics of innovation and performance in general, but as well encapsulating their particularities in the health care sector (partially overlapped with their particularities in the public sector) – here we formulate the hypotheses of the

study that will be tested later; in the same chapter we are covering the similar studies that were made, the methodologies used and the main results and observations.

After this theoretical framework, we discuss the methodological aspects used in the similar studies, as well as for our investigation. Then, we explore the findings of the study, structured into 2 parts: descriptive statistics and hypotheses testing.

In the descriptive statistics, we detail our findings in terms of global measures for innovation (service, process and organizational) as well as for each measure of each type of innovation; comparisons are made between the type of property and the geographical regions the hospitals belong to.

The hypothesis testing confirms or rejects the premises formulated in the second chapter, leading to the main conclusions of the study. These conclusions are then grouped in the last chapter, alongside with the recommendations for future similar studies.

2. Literature Review

In this chapter the two main concepts of the study – innovation and performance – will be explained and explored in more detail, and then adapted to the health care sector. This is followed by a short description of the Portuguese health care system and a review of similar studies.

2.1. The concept of innovation

Innovation is the creation and adoption of new ideas, or, generally, of something new – (Gopalakrishnan and Damanpour, 1997). The authors distinguish between innovation generators and innovation adopters organizations, and add that the decision to adopt the innovation marks the beginning of its implementation. The adoption of innovation can be the direct result of managerial choice or can be imposed by external conditions.

> "*Regardless of the internal or external origin of the impetus for change, innovation adoption is a means of creating change in the organization to ensure adaptive behaviour and is intended to change the organization so that it maintains or improves its level of performance or effectiveness.*" (Damanpour and Schneider, 2006, p. 218).

There are primary and secondary attributes of innovation: while the primary ones relate to the innovation type (e.g. technical or administrative), the secondary attributes have to do with its complexity or costs. Innovation distinguishes between product/service and process innovation (in this study both will be present), radical or incremental and technical or administrative (Gopalakrishnan and Damanpour, 1997).

Research at the organizational level offers insights into the role innovation plays in managing organization-wide concerns, such as adaptability to the environment, capacity to allocate resources to innovative (*vs* operative) programs or activities, and overall organizational outcomes and effectiveness (Gopalakrishnan and Damanpour, 1997). Access and ability for contact and information exchange with external organizational systems are also essential for innovation (Kimberly, 1978, Fennel, 1984). As a tested hypothesis, Gopalakrishnan's article states that organizations with

greater economic health invest more in innovation, partly because they can afford to take more risk and can more easily absorb the cost of failure.

Table 1 – Types of innovation, adapted from Gunday *et al.* (2011)

Type of innovation	Brief description
Product/ service innovation	Introduction of a new product/service or changes to existing products/services in terms of characteristics, specifications, uses, etc. Tends to be rather incremental than radical, as a response to a customer need, rather than anticipating an unformulated need Support activities innovations are developed around the product Service innovations are commonly implemented but are easier to imitate and less noticeable by customers
Process innovation	Implementation of new or improved production or delivery methods, for the purpose of cost reduction or higher quality
Organizational innovation	Implementation of a new organizational method in the firm's business practice, administrative organization or external relations e.g. a new way of organizing the databases
Marketing innovation	Implementation of a new or significantly changed marketing method

Having the characteristics of the types of innovation and ways to measure innovation thoroughly explained (Table 1), the Oslo Manual (2005) states that it is important – for data collection purposes – to have the innovations be clearly enclosed in one innovation type, though it might prove difficult at times, as some innovations have characteristics spanning more than one type. As far as the impact of innovations on firm performance, the effects range from sales growth to increase in productivity and efficiency. It is important to know which are the innovations (and type of innovations) that succeed in improving the firm performance as they are of central importance for future company policy making (Oslo Manual, 2005). Although incremental innovations are more often than radical ones, radical innovations are more positively associated

with performance – by bringing something completely new, they send the right signals about the company's innovative capability on the market (Oke, 2007).

Without going into very much depth in the subject, we should mention some key determinants and influencers of innovation, that play an essential role in the decision making for pursuing a certain type of innovation: the management/ the leadership of the entity, the staff, the dimension and performance of the entity, intrinsic characteristics of the field they operate in - how fast paced it is in terms of technology, how competitive, etc.

Innovation in healthcare is subject to particularities that derive from its unique nature as well as from its status as a public organization (public health care units only). It is a more complicated process, due to the fact that innovative practices have to be tested before being permanently introduced, as well as to their adoption being regulated by laws, making changes more laborious. The pressure is on both the hospitals' side and on the governments', as public authorities are constantly trying to reduce healthcare costs while improving quality (Länsisalmi *et al.*, 2006).

Halvorsen *et al.* (2005) makes an in-depth analysis of the innovation in the public sector, hindered by the existence of a lot political decision centers and policy issues (innovation is said to be often "pushed from the outside" rather than being inherent to the organization). Putting public and private innovation side by side "*a factor that seriously complicates any study of the dynamics of innovation in the public institutions considered in this project is the lack of simple and clear cut relations between the private objectives of the organisation and its owners and incentives for and rewards from innovation*" (Halvorsen *et al.*, 2005). Simply put, the profit motivation that the private sector stand for, while the public one not-so-entirely, has a big impact in their decisions of whether to invest or not in innovation. The customer's perception is brought into attention too in this report, arguing that in the private sector the correlation between price and quality is, of course, found important by people, while in the public sector, they have to make complex decisions when it comes to choosing their social services or health care provider. A phrase from the article that perfectly sums the public - private sector contrast is "For the private sector, the creation of new demands is a welcome market opportunity; for public services it is a political challenge".

Innovations in healthcare organizations are typically new services/ treatments, new ways of working or new technologies (Länsisalmi *et al.*, 2006). From the patient's point of view, the intended benefits are either better health or less suffering due to illness. From an organizational point of view, the desired benefits are often enhanced efficiency of internal operations and/or the quality of patient care (Faulkner and Kent, 2001). Thankur *et al.* (2012) summarize innovation in healthcare as "*those changes that help healthcare practitioners focus on the patient by helping healthcare professionals work smarter, faster, better and more cost effectively*" (p. 564).

Analyzing the differences in healthcare innovation between public and private hospitals (as we have analyzed the core differences between innovation in the two sectors), but also between regions of the same country, Bonastre *et al.*'s (2014) research studies the case of the acquisition of expensive anti-cancer drugs in French hospitals (a service/ treatment innovation), grouping them by region and property type (of the hospital). Results reveal there is a difference in expenditure for expensive innovation between private and public hospitals at first, but then, when adjusted to the Case-Mix of the hospitals, it is not significant; there is no difference in the expenditure between regions. This led to the conclusion that equal access is provided (in France) to innovative solutions.

But such differences in access to healthcare exist in countries with social inequalities, like Brasil, as Noronha and Andrade's (2002) study reveals. Here, privileged social categories get access to better health care than lower income groups. Glied and Lleras-Muney (2003) offer further insight into this issue, by correlating social inequalities (in the case of their study, in the U.S.) with educational level, arguing that educated people are likely to better take advantage of technological innovations in healthcare than their less educated counterparts.

Technology is a key driver of innovation in healthcare (Omachonu and Einspruch, 2010). Leider's (2010) examination of technological-informational innovation in hospitals enumerates seven information-based innovations in health care and the operational benefits they bring; however, not all units are too keen and quick in adopting these organizational changes, fact explained by a "misalignment of costs and benefits - many systems intended for healthcare providers offer benefits to patients and insurance companies, but not necessarily the providers themselves." (Shekelle *et. al.*

2006, as quoted in Leider, 2010). The human factor is, as always, a strong determinant of implementing organizational innovations - the strategic leadership, the staff attitude and the hospital's climate being associated with informational innovations. The article (Leider, 2010) studies also the contribution of organizational IT innovation in the overall IT impact of the hospitals, the latter which has a positive association with the performance of the health care unit.

For healthcare, innovation is therefore crucial. "*However, there is a need for solid performance measurement and impact assessment to depict its contribution to the efficiency of health care delivery, patient- and other stakeholder satisfaction and the overall performance of the health care system*" (Cucciniello and Nasi, 2013).

Based in the information presented, which explores the types of innovation and the role of organizational innovation as a driving factor in healthcare, we can elaborate 2 hypotheses related to innovation in healthcare:

H1: The higher the level of organizational innovation, the higher the level of service innovation.

H2: The higher the level of organizational innovation, the higher the level of process innovation.

Based in the information presented that explores the differences in innovation between the public and the private sector and between the different regions of a country, we can elaborate 2 more hypotheses:

H3: There is a difference between the level of innovation in public hospitals and the level of innovation in private hospitals.

H4: There is a difference between the hospitals' level of innovation depending on their geographical localization.

2.2. Performance and performance measurement

As opposed to the innovation concept, the term of performance is not so easily defined in literature. As widely as it is used, most authors take its significance for granted and skip directly to methods or ratios for performance measurement.

Although it is widely used with meanings varying from robustness to return on investment, Lebas (1995) argues in his study that performance is not only a measure of

past achievements, but foremost for "the potential for future successful implementation of actions in order to reach objectives and targets" (Lebas, 1995, p. 23-24). It is the key concept that makes the link between the questions: 'Where have we been?' 'Where are we now?' 'Where do we want to go?' 'How are we going to get there?', from one side and 'How will we know we got there?', on the other. Summarizing all these in one question only: 'What do we measure?' – introducing the concept of performance measurement. Although in general lines, the objectives of performance measurement are setting targets, time frames and concrete ways to achieve them, translating these steps differs for every industry, type of organization, etc.

Gunday *et al.* (2011) summarizes a very extensive model of corporate performance measures, given in the Table 2.

Table 2 – Performance measures, from Gunday *et al.* (2011)

Type of performance measures	**Measures**
Innovative performance	Composite construct based on indicators like no. of new patents, new products, new processes, new projects, R&D etc.
Production performance	Production cost Production speed Volume flexibility Conformance quality
Market performance	Market share Sales Customer satisfaction
Financial performance	General profitability Return on assets Return on sales Cash flow (excluding investments)

Financial ratios can be used to examine the profit-generating ability of an organization based on sales, equity and assets - asset utilization or turnover ratios measure how successfully the company generates revenues through utilizing assets,

collecting receivables and selling its inventories (Delen *et al.*, 2013). It is, as seen in Table 2, an output of innovative, production and market performances. Relative performance of different sized companies can be compared through the use of financial ratios. Depending on the public or private nature of the organization, overall (organizational) performance can mean more than financial ratios, though.

Compared to traditional enterprise performance measurement, public sectors not only have economic, profit-bearing attributes, but also "non-economic obligations of environmental benefits and social benefits, which needs to set performance targets to balance multiple objectives, multi-agent interests" (Zhongua and Ye, 2012, p.795). Markets, market shares and scales, organizational goals and strategies, organizational types, structures and systems, organizational management level, culture, commitment and decision-making autonomy are factors which impact the public sector performance (Zhongua and Ye, 2012). Therefore, adequate methods for assessing performance are required. Benchmarking (imitating then exceeding) is a method used in several relevant studies, followed by systematic assessment, data envelopment analysis (return on investment as key ratio) and balanced scorecards (due to the multiple interests and targets, social and economic).

Studies use the most suitable method for their need to correlate performance with its determinant factors, which they are looking to test. In the healthcare area, though, key points should be pinpointed as being factors of core differentiation from business/profit orientated companies – performance, although defined in explicit goals that must be met, must include a quality study, as it is not just an objective assessment of numbers, but includes judgments of value and quality from the part of the end users of the service – the patients (Oslo Manual, 2005).

Referring to health care measures of performance, Berg *et al*. (2005) distinguish between internal and external measures, depending on who they are important to: the health care unit (internal measures – reflecting financial performance, efficiency etc.) or the external public and authorities (external measures, related to the quality of the services provides, an essential aspect of performance in health care). For this, they conducted a study to form measures of performance which led in the end to the elaboration of a standard set of measures based on operability in different contexts (emergency room, controls, operability with different conditions etc). Several other

studies look for the measuring of performance in healthcare use similar measures – data by hospital sectors (care units) in terms of quality: efficiency in treatment, satisfied patients, speed in responding to emergency situations etc. Caiado and Neto's article proposes for example as suitable measures, the numbers of readmissions 5 days after the end of treatment as proxy for quality of service, the access to services (area covered and number of first consults), assistance performance and financial performance. Amado and Santos (2009) use similar measures in their study, which they categorize under the names of equity of access, efficiency, service effectiveness and cost effectiveness. To do so, they explain the need to use different models to correctly measure different dimensions of performance. Additionally, as Halverson (2005) points out in terms of measuring public services' performance, "*Benefits of innovations are often hard to quantify, or those achievements that are apparent are hard to value in strictly financial and budgetary terms*".

On what concerns the practical way to measure the hospital performance outcomes, as seen in most studies and summarized by the Oslo manual (2005), the most common ways to do so are by patients' satisfaction survey, statistical data, regulatory inspections and third-party assessment.

Having now completed the theoretical basis about the concepts of innovation and performance, 2 more hypotheses can be defined:

H5: The higher the level of organizational innovation (H3a), service innovation (H3b) and process innovation (H3c), the higher the level of service (operational) performance.

H6: The higher the level of service (operational) performance, the higher the financial performance.

2.3. The Portuguese health care system

The Portuguese health care system is characterized by three coexisting systems: the National Health Service (NHS), special social health insurance schemes for certain professions (health subsystems) and voluntary private health insurance. Despite the public/ private mix, primary care is mainly delivered in the NHS health centers (Simões, 2012). Recently, in order to ensure the sustainability of this service, some user fees at the end of the treatments were implemented (Frayer, 2012).

The health units can be divided into 3 types: hospitals, serving major areas and offering access to all types of treatments, surgeries etc. (and the type of health units we are going to look at in this study, due to their higher complexity); local health care units - offering different specialty consultations, treatments, and small scale surgeries; and medical posts, located mainly in the parishes, offering family medicine access.

In 2009, Portugal had 186 hospitals, with 35.593 beds, of which only 17% were private providers of care. The sites and portals of health in Portugal show that the number is around 200 in recent years (2012-2013), although this could be due to separation of big hospital units into 2 or more units, as, decades ago, the contrary happened – many smaller health facilities merged into big hospitals. The number of the main (bigger) providers in the country is around 90 hospitals though (Simões, 2012).

Recently, from 2010 onwards, several public hospitals (belonging to the NHS) have suffered organizational changes, transitioning from autonomous entities into health care centers grouping 2 or more hospitals in the same region, serving a population located in the same close geographical areas. While hospitals are still known under their previous names, the health care centers have a unique denomination as "Hospital Center .... [names of the cities served by the health center]" and the same central management. Transparency of information is a value of the NHS, most of the big hospital centers publishing annual reports on their websites, with respect to the activities performed during the year and operational and financial numbers; more information can be found on the Ministry of Health's website as well as the Health Portal one - from the National Health Plan for the upcoming years to joint reports that present assistance activity results per regions of the country and the percentage of compliance with the measures imposed as target by the Portuguese DGS (General Direction of Health).

While public hospitals are still major suppliers of health care in Portugal, the private sector is constantly growing, accounting nowadays for almost 40% of the health care delivered in the country, according to APHP statistics (the Portuguese Association of Private Hospitals).

2.4. Similar studies

Several studies have been conducted to assess the impact of innovation on performance, some less and some more closely related to the research question of this study. A resume of them, in terms of types of innovation studied and performance measures used, can be seen in Table 3:

Table 3 – Similar studies

Type of innovation	**Activity/ Industry**	**Country**	**Performance measures**	**Authors**
Product, process, organizational, marketing	Manufacturing	Turkey	Market Financial Production Innovation	Gunday *et al.* (2011)
Service, process, organizational	Services	Australia	Financial (sales, profit) Market (market share)	Prajogo *et al.* (2013)
Organizational	Health Care	U.S.	Financial (Equity and assets ratios)	Leidner *et al.* (2010)
Service, process	Health care	Portugal	Operational	Dias and Escoval (2013)
Product/Service, process	Health care	U.S.	Financial (Equity ratios)	Irwin *et al.* (1998)
Service, processes	Health care	Spain	Operational (efficiency)	Naranjo- Gil (2009)
Service	Health care	Spain, Italy	Financial Operational	Cucciniello and Nasi (2013)
Service	Health care	France		Bonastre *et. al.* (2014)

By the field or sector in study, these researches span from product concerned industries (manufacturing - Gunday *et al*, 2011) and service ones (profit orientated enterprises - Prajogo *et al*, 2013) to health care units (Leidner, Preston and Chen, 2010; Dias and Escoval, 2013; etc. – see Table 3). While for broader industries a more general model is used in the assessment of the innovation impact on performance, allowing for all types of correlations and links between the two sides (Gunday *et al*, 2011), for health care units in study the range of measures is narrowed by the

specificity of the hospital, the type of innovation or the type of innovation in study (specific radical innovations and their immediate impact has been studied in Cuccieniello's study, for example).

By type of innovation under study, the service innovation prevails (Prajogo *et al,* 2013, and all the health care sector studies) with the variant of product innovation for product-focused companies (in Gunday *et al,* 2011), but process, organizational or marketing innovation are also the object of some of these studies.

Concerning the performance measures used, either operational or performance measures are used (or both), and only Gunday's study explores the full range of measures of performance (and does it as well for innovations) in order to create a complete image of an interconnected innovation – performance model for a production industry.

The diversity of the environments studied is high, with different countries hosting every study, including a Portuguese study in the health care area.

As far as hypotheses and results of these studies - Naranjo-Gil (2009) and Cucciniello and Nasi (2013) explore the specific impact of one new practice in the health care area on performance, while Irwin *et al.* (1998) and Dias and Escoval (2013) construct clusters of hospitals based on innovativeness and efficiency. Gunday's study, with its numerous hypotheses and results, creates a complex model, as specified above. Closely related to some of the hypotheses previously defined are Leidner, Preston and Chen's (2010) study, which studies (between other hypotheses) the impact of organizational IT innovation in the financial performance of U.S. hospitals (and finds there is a weak possitive association between the two), and Bonastre *et. al.*'s (2014) study, which is looking to find if there are regional and property type differences between French hospital in the distribution of an innovative medicine.

3. Methodological Considerations

This chapter explores the methodology of the similar studies presented, as well as the framework, collection of data and other methodological considerations of the present research.

3.1. Methodological aspects employed in similar studies

The studies previously explored are similar in the aspect of employing a quantitative analysis in order to establish the desired links between innovation and performance, but differ with regard to the measures and statistical methods used (Table 4).

Table 4 – Methodological considerations of similar studies

Authors	Country of study	Sample size	Industry sector	Data collection	Resp rate	Key informant	Unit of analysis	Statistical analysis
Gunday *et al.* (2011)	Turkey	1674	Manufacturing	Survey, interviews	11%	Firm top or middle manager	Firm/ company	Structural equation modelling
Prajogo *et al.* (2013)	Australia	1500	Services	Survey	12%	Operational or strategic manager	Firm/ company	Multivariate analysis
Leidner *et al.* (2010)	U.S.	149	Health	Survey, interviews	47	Hospital executives	Hospital	Partial least squares
Dias and Escoval (2013)	Portugal	134	Health	Survey, interviews	70%	Hospital board administrator	Hospital	Cluster analysis
Cucciniello and Nasi (2013)	Spain, Italy	5	Health	Survey, interviews	100%	Clinician, nurses, patients	Hospital section	Factor analysis
Naranjo-Gil (2009)	Spain	218	Health	Survey, archival data	51.37 %	CEOs of public hospitals	Public Hospital	Partial least squares
Irwin *et al.* (1998)	U.S.	220	Health	Survey, financial reports analysis	85%	Doctors, practicioners	Hospital	Regression
Bonastre *et. al.* (2014)	France	448	Health	Statistics and health databases	100%	Statistics and health French databases	Hospital	Multilevel model with random intercept

The sample size for most studies (with the exception of Cucciniello's one) is big, with more than 130 units, which, adjusted to the response rate, leaves each study with at least 90 valid answers for a pertinent statistical analysis - it is notable, though, the big difference in the sample size between the non-health care related studies (1500 companies) and the health-care related ones (5 to 220 ones); this goes to show the increased difficulty in making a statistical analysis in the health care area, due to the limited number of study units (compared to the number of commercial companies). The

answer rate of the surveys is higher in the health-care studies though. The key informers are usually middle managers in non-health related studies and hospital administrators or doctors/ practitioners in the healthcare area studies.

The data collection is performed through survey in all studies, completed by interviews and/ or documental analysis in some of them (Irwin *et al*, 1998; Naranjo-Gil. 2009).

The type of statistical analysis used is different from study to study and is related to the measures used (innovation measures and performance measures) and purpose of the study (as well as being adequate to the sample size). Cluster analysis, partial least squares and multivariate analysis are present in 2 studies each, which employ a number of 5 to 15 variables (Dias and Escoval, 2013; Prajogo *et al*, 2013, Irwin *et al*, 1998), while for a very high number of variables (Gunday *et al*, 2011), structural equation modelling was the best solution, also leading to interesting results.

3.2. Phases of the study and methodology

This study is performed on 34 Portuguese hospitals. For classifying the hospitals we divide them in terms of geographical region, type of property and dimension. Given the degree of complexity of the data that is the subject of the research, concerning both types of innovations implemented in the hospitals as well as operational, financial and marketing performance, the method employed for collecting it was a survey to the literature. The years in analysis were 2008-2012 in terms of innovations implemented (due to the tedious nature of innovations it can take up to several years for the change to propagate and start having effects) and 2012 in terms of performance (or the latest data available about operational and market performance measures).

Based on the similar studies and the key aspects they measured, the variables that were studied are:

Innovation variables

a) Service innovation: introduction of new treatments, introduction of new (innovative) equipment and machinery, improvement of quality of treatments/ services, increasing the safety of the patients;
b) Process innovation: improving the quality of processes, increasing the speed of patient processing, decreasing the variable costs of patient processing;

c) Organizational innovation: improving/ reorganizing the informational system of the hospital, diffusing the knowledge amongst staff, other organizational innovations (usually related to reorganization of departments of roles of staff in the administrative scheme).

Performance variables

a) Operational performance: number of readmissions after the end of treatment (adjusted to risk), beds occupation rate, average admission duration;
b) Financial performance: net income, assets, profits and return on assets (ROA);
c) Market performance: overall patient satisfaction.

The innovation information was found either on the sites of the Hospitals / Health care units or in their reports. Their classification into either Service, Process of Organizational innovation has been made according to their purpose and scope. Some of these innovations were explicitly mentioned in the reports or on the sites, others not, being mentioned in reports in categories like: Activity of the year..., Assistencial activity... etc. As defined at the beginning of this study, innovation is the generation of something new, therefore innovation has been recognized in the reports or site where not being explicitly denominated.

The classification of the degree of innovation has been made on a scale from 1 to 5, with the following meanings: 1 = innovation not implemented (information about it not found in the sources); 2 = improvement of current (previous) services/ processes/ organizational structures; 3 = implementation of new services/ processes/ etc. imitated from the national health system; 4 = implementation of new services/processes/etc imitated from the international health system; 5 = implementation of totally new services/ processes/ etc. This is therefore a gradual differentiation between incremental (2) and disruptive (5) innovation. As disruptive innovations are, at their purest, complete novelties in the world, they are very rare to find (but not impossible) between the units from our sample. A grade of 4 marks already a disruptive innovation in the territory of Portugal.

The operational performance measures were taken from the hospitals' activity reports, as well as patients' overall satisfaction, representing the measure for market performance, was extracted from a report issued by the Ministry of Health for the public hospitals, and from health care groups' reports for the private ones.

As far as the financial performance measures are concerned, they were extracted directly from the financial reports (balance sheets and cash flows statements) or extracted from the Sabi Bureau van Dijk database (https://sabi.bvdinfo.com), which provides financial information about Portuguese hospitals, considering them as Companies.

As controlling variables for the dimension of the hospitals were used: the number of beds, number of staff (including doctors, nurses, administrative personnel and other staff), and number of persons in the covered area (the district/ town).

The data collected was organized in a database, presented in Annexes 1 and 2, that is a summary of the information currently existent in Portugal about innovation in hospitals and data about hospital performance.

4. Results and Interpretation

This chapter shows the results obtained after processing the data, as well as exploring into details the statistical methods employed in order to reach those results.

Firstly, we present a detailed descriptive analysis of the results in terms of innovation and performance in the studied hospitals; afterwards, we test the hypotheses formulated in the Literature Review chapter and explain the confirmation or information of the results obtained based on identical hypotheses in similar studies.

For the purpose of studying if the level of innovation and of performance is affected by location of the hospital or type of property, we have grouped them. By the type of property, they are public (EPE entities), private or Private-Public Partnership (PPP). By region, the hospitals belong to one of the 4 regions: North, Center, Lisbon and Valley of Tejo and South. From the sample of 34 entities, 24 are public hospitals, 8 are private and 2 are Private-Public Partnerships; 13 of the hospitals studied belong to the North region, 8 to the Center one, 9 are localized in the Lisbon and Valley of Tejo area and 4 are in the South region of Portugal.

Obviously some hospitals are very innovative in one or two points (for example: introduction of new treatments and quality of processes) while lacking in the others; the existence of many values of 1, where no proof has been found on the implementation of those types of innovation in the studied years, has led overall to lower averages than they could deserve (if averages were calculated only taking into account values different of 1 results would be very different).

4.1. Descriptive analysis

Following the completion of the database, the first results calculated were the average values for the main categories of innovation and performance. The hospitals were grouped by localization and by type and the averages were calculated for each group.

Table 5 shows the findings in terms of service innovation, taking each of its 4 elements: introducing new procedures of treatment, introducing new technical equipment, safer conditions of treatment and improving the quality of services.

Table 5 - Service Innovation (Average value per Region and Property) (N=34)

	Introducing new procedures of treatment	Introducing new technical equipment	Safer conditions of treatment	Quality, continuous improvement of services
Region				
North	3,115	2,058	1,481	1,808
Center	2,171	1,938	1,375	1,796
Lisbon and Valley of Tejo	2,500	2,139	1,278	1,667
South	2,500	1,000	1,250	2,000
Property Type				
Private	3,000	2,125	1,000	1,000
Public	2,432	1,938	1,427	2,120
PPP	4,000	1,000	2,250	1,000

In terms of introduction of new treatments, the hospitals in the north of the country are the most innovative (score 3,115 out of 5), followed by the ones in the Lisbon and South region (with equal averages of 2,5) and lastly the Center region (2,171).

As concerns the distinction between types of hospitals, the public ones have mostly average scores, between 1,5 and 2,5, the private ones score higher in new procedures/ treatments, average in new equipment and machinery and no innovations belonging to safety of procedures and continuous quality improvement. The Public-Private entities score the highest in new procedures and safer procedures, while new technical equipment and continuous improvement of quality services have not been undergone.

We should point out the mean values of the innovation in procedures and treatments as standing out compared to the other types of service innovation; with a mean of 3,115 in the North region, and 2,5 in the Lisbon and South region, it is safe to say Portuguese hospitals are innovative on overall when it comes to keeping constantly up to date with the latest procedures and treatments in the national and international scene (as a value of 3 corresponds to innovation in a regional-national frame and a value of 4 to innovation in a national-international frame). Significant are also the values of treatments/ procedures innovation in the public-private hospitals (a very high average of 4) and the private ones (average of 3).

As far as process innovations are concerned, the overall values in Table 6 are lower than the ones in service innovations.

Table 6 - Process Innovation (Average value per Region and Property) (N=34)

	Quality, continuous improvement of processes	Increasing the speed of patient processing and care	Decreasing the variable costs of patient processing and care
Region			
North	2,885	1,538	1,346
Center	2,438	1,000	1,375
Lisbon and Valley of Tejo	2,308	1,308	1,192
South	2,063	1,250	1,000
Property Type			
Private	1,955	1,364	1,227
Public	2,719	1,333	1,313
PPP	2,833	1,000	1,000

The improvement of the quality of processes is the most sough-after innovation by hospitals, with average values between 2,063 and 2,885, decreasing from north to south of the country. Public and PPP hospitals are more worried about increasing the quality of their processes than the private ones. The most common ways of innovating in quality of processes are the accreditations hospitals get which recognize and differentiate their outstanding quality of processes from other hospitals'.

The other two notes process innovations, increasing the speed of patient processing and care and decreasing the costs of patient processing and care, were less pursued by the hospitals, with average values between 1,000 and 1,538, with slightly more elevated values in the North region.

Finally, on what concerns the last type of innovation, the organizational one, it can be noticed from Table 7 that renewing the informational systems represents the main innovation effort of the hospitals, especially in the North region. It is a more significant effort for the PPP hospitals and the least for the private ones.

Table 7 - Organizational Innovation (Average value per Region and Property) (N=34)

	Renewing the information system of the hospital	Increasing the diffusion of knowledge among the hospital personnel	Structural / Other organizational innovations
Region			
North	2,538	1,846	1,500
Center	1,531	1,000	1,719
Lisbon and Valley of Tejo	1,808	1,000	1,500
South	1,688	1,000	1,625
Property Type			
Private	1,364	1,000	1,364
Public	2,146	1,458	1,719
PPP	3,000	1,000	1,000

Other organizational innovations have been observed in a low rate on hospitals throughout the country, without differentiation of types; this innovation has to do with restructuration of areas/ departments inside the hospital or of staff roles in the departments. Increasing the diffusion of knowledge among the hospital personnel, the third type of organizational innovation, was undertaken only by public hospitals in the North region, in a low amount.

Besides the description of each measure of innovation inside each type (Tables 5, 6 and 7), it is important to obtain a composite (global) measure representative of each type of innovation. We employed the Principal Component Analysis (PCA) to obtain a representative measure for each type of innovation. In the case of Service innovation, we collected, from the reports surveyed, 4 different ways of innovating; for Process and Organizational innovation, 3 measures for each. By using the PCA, we can find appropriate weights for each measure to construct a composite (global) measure.

Principal Component Analysis is, usually, a method of variable reduction. In this research, we employed it to compute a composite variable for each type of innovation.

PCA allows the quantification of the contribution of each variable to explain the variance of data. Therefore, we can employ this method to obtain the weights of measures when they are to be aggregated into a single composite variable. The PCA has been remarkably used to build variables and composite indexes (e.g. Greyling, 2013). By contrast to these applications of PCA, our method innovates in the sense that it does not remove components, in order to favour accuracy over simplicity of the composite variable.

The procedure employed was as follows:

1. Obtain, using the software IBM SPSS Statistics (version 22.0), the same number of components as the number of measures inside each innovation type (i.e., without removing any component). The respective Rotated Component Matrix (employing the Varimax with Kaiser Normalization rotation method) for each innovation type is in the Annex 3.

2. For each component, use the factor loadings in the rotated component matrix as weights to obtain an intermediate composite variable for each component. A table with the composite measure for each observation (hospital) and for each innovation type is found in Annex 4.

3. Weight each intermediate composite variable by its percentage of variance explained. The tables with the Total Variance Explained for each principal component analysis done is in Annex 3.

After employing this method, the following composite global measures for innovation have been obtained, as presented in Table 8.

Table 8 - Global composite measures for innovation (means) (N=34)

	Service Innovation	Process Innovation	Organizational Innovation
Region			
North	1,624	1,665	2,307
Center	1,491	1,429	1,631
Lisbon and Valley of Tejo	1,534	1,384	1,687
South	1,169	1,248	1,681
Property Type			
Private	1,379	1,325	1,297
Public	1,568	1,557	2,072
PPP	1,426	1,281	2,419

We can see that the composite global measures for all three types of innovations are not very high, most of them having a global score lower than 2, with the exception of organizational innovation in northern hospitals and in public and PPP hospitals. The composite global averages are lower than the simple averages for each section, meaning several hospitals have scored higher degrees in subsections with a lower weight in the total measure than in the ones with a heavier weight.

It would be interesting to have a look at the maximum and minimum global composite measures grouped by regions and type of hospital property.

Table 9 - Minimum and maximum global composite measures of innovations in hospitals, by region and type of property (N=34)

	Service Innovation		Process Innovation		Organizational Innovation	
	Max	Min	Max	Min	Max	Min
Region						
North	2,413	0,981	2,593	0,935	3,544	1,116
Center	2,851	0,981	2,262	0,935	2,854	1,116
Lisbon and Valley of Tejo	2,519	1,011	1,708	0,935	2,228	1,116
South	1,408	0,981	1,667	0,935	2,524	1,116
Property Type						
Private	2,102	1,011	1,708	0,935	2,228	1,116
Public	2,851	0,981	2,593	0,935	3,544	1,116
PPP	1,871	0,981	1,627	0,935	3,201	1,637

The Center region is the one where the most service innovative hospital is found, while the North region hosts the most process innovative as well as the most organizational innovative hospital. In terms of type of property of the hospital, the public sector holds the most innovative hospital in all three categories.

As far as minimums are concerned, there are overall hospitals with the same minimum values in all regions of the country, both public, private, or PPP. To be noted that, for service and process innovations, the minimum global composite measures are lower than 1 (the minimum grading value) - this is due to having low grades in most sections, and the fact that the PAC model has given some negative weights to 1 or 2 of the components built based on the chosen measures to explain innovation.

The organizational innovation holds higher numbers in terms of maximum and minimum global composite values than the other two types of innovation, being reflected in a similar way as is was in terms of mean global composite values.

What about the other side of the balance, performance?

Table 10 - Average performance measures (average per Region and Property), Data referring to year 2012, source Sabi database and hospital reports (N=34)

	Operational			Market	Financial			
	Readmission rate adjusted to risk (%)	Occupation rate (%)	Average duration of hospitalization (days)	Satisfaction (%)	EBITDA (000 EUR)	Assets (000 EUR)	Net income (000 EUR)	ROA
Region								
North	1,31	84,98	6,95	85,1	-1714,2	125529,2	-1516,4	-0,061
Center	1,44	77,85	7,21	85,2	-5968,4	85730,6	-6550,3	-0,062
Lisbon and Valley of Tejo	1,17	81,56	6,93	85,1	-3123,9	140067,4	-5115,4	0,018
South	1,06	79,73	7,73	84,1	-2112,7	150446,4	-5267,4	-0,066
Property Type								
Private	0,64	---	5,107	81,00	4334,3	45002,6	3094,0	0,048
Public	1,38	81,86	7,380	85,87	-5891,2	154584,3	-6627,1	-0,069
PPP	0,99	78,40	6,950	81,30	58,7	55036,6	-157,9	-0,006

Data referring to year 2012, source Sabi database and hospital reports (N=34)

As far as performance is concerned, the averages displayed in Table 10 show some significant differences, especially when it comes to differentiating by type of hospital. Financially, the public hospitals are quite under performant, with an average loss per hospital of almost 6 million EUR in 2012. Almost all public hospitals have negative values, the average being raised by the few that have positive values. As a mention here, while fluctuations on the financial performance of public hospitals exist from on year to another, the reported losses from the previous year affect the current year's financial statements. The 2012 values are therefore an aggregate measure of the current and previous years' profits/losses. On the other hand, the private hospitals present on average positive gains, while the public-private partnerships are approximately breakeven on average. The public hospitals weigh more on the value of assets, though, whose value is approximately triple the value of private or PPP hospitals' assets (not surprising, given the bigger size of public units).

The same ranking in terms of performance (Private > PPP > Public) is observed when it comes to operational performances as well. Private hospitals have both a lower rate of readmission adjusted to risk and a lower average duration of hospitalization compared to the public and PPP ones.

It is interesting to notice that patients' satisfaction (market performance) is higher in the case of public hospitals than the private or PPP ones. It happened probably

because their scoring decision was affected by the cost of the service, which shaped their expectations differently - a similar overall experience in a private and public hospital leading to a lower scoring for the first. This would come in accordance with Halvorsen's (2005) affirmation that people associate price with quality when it comes to private services, while, assumingly, perceiving this connection more loosely in the case of public services.

Analyzing these measures from the perspective of the region they belong to, the North region differentiates itself as being the one with the least financial losses (of aprox. 1,7 millions of EUR per unit on average), as opposed to the Center region, which has the highest losses registered (almost 6 million EUR on average per unit of analysis). The South region has the lowest rate of readmissions, followed by the Lisbon region, the North one and lastly the Center. The North and Lisbon region have a lower duration of hospitalization on average than the Center and South regions, while, as far as satisfaction of patients, there are not big differences between the regions.

Table 11 summarizes the profile of the hospitals in the sample group that was studied, in terms of size, characterized by number of beds number of employees/ staff and the population in the influenced area.

Table 11 - Sample profile (Average value per Region and Property) (N=34)

	Nr. beds	Nr. employees	Influence area - population
Region			
North	475	2023	679113
Center	643	2234	220022
Lisbon and Valley of Tejo	584	2799	707161
South	367	1798	227398
Property Type			
Private	142	768	751500
Public	576	2444	470908
PPP	518	1860	274450

Public hospitals and public-private venture ones are significantly larger in size, as they often are the grouping of 2 or more hospitals in the same area (neighbourhood of a city or a group of 2 neighbour smaller cities) into one health care center EPE (“Entidade Publica Empresarial”).

4.2. Hypotheses testing

In Sections 2.1 and 2.2 we stated the research hypotheses grounded in the literature review. Each hypothesis was tested and analysed considering the global composite measure for each innovation type and the several measures inside each. All the outputs of each research hypothesis are in Annex 4.

H1: The higher the level of organizational innovation, the higher the level of service innovation.

To analyse and test this result we employed the Spearman's rank correlation coefficient (or Spearman's rho)[1], a nonparametric measure of statistical dependence between two variables. It assesses how well the relationship between two variables can be described. We want to analyse the dependence (correlation) between the organizational innovation and the service innovation. According to Maroco (2010), the suitable test is the correlation, using the Spearman rho. Moreover, we test the correlation among the several measures of each innovation type.

The general form of the null hypothesis (H0) is: "There is no association between the organizational innovation and service innovation" (i.é, Spearman's rho = 0) against the hypothesis that "There is a correlation between the two variables" (i.é, rho ≠ 0). The following table presents the correlations between the variables:

Table 12 – Correlations between Service and Organizational innovation (Spearman's rho)

		Service innov.: global composite measure	Organizational innov.: global composite measure
Service innovation: global composite measure	Correlation Coefficient	1,000	0,254
	Sig. (1-tailed)		0,074*
	N	34	34
Organizational innov.: global composite measure	Correlation Coefficient		1,000
	Sig. (1-tailed)		
	N		34

*correlation is not significant at the 0,05 level (2 tailed)

[1] The Spearman correlation coefficient can take values from +1 to -1. A rho of +1 indicates a perfect association of ranks, a rho of zero indicates no association between ranks and a rho of -1 indicates a perfect negative association of ranks. The closer rho is to zero, the weaker the association between the ranks.

Considering a significance level of 5% (or 1%), the null hypothesis is retained. We can not conclude, in the case of the analysed Portuguese hospitals, that an organizational innovation implies a service innovation. However, if we consider a significance level of 10%, we can reject the hypothesis that there is no association between the organizational innovation and service innovation in Portuguese hospitals, and conclude that these two types of innovation are, in fact, correlated. Nevertheless, following the standard, more rigorous, analysis, we will consider a significance of 5% or less.

This result is in accordance with the study of Gunday (2011), which reveals there is not a significant association between the level of organizational innovation and product/ service innovation, in the case of production/ manufacturing firms. This can be due to the existence of other variables that determine the service innovation that render the effect of the organizational innovation on it to a minimum.

We want to test not only is the composite global measure of organizational innovation is correlated to the global service innovation measure, but also its components. Therefore we formulate hypothesis H1a, as follows:

H1a: The higher the level of organizational innovation measured by i, the higher the level of service innovation measured by j, i= Renewing the information system of the hospital; Increasing the diffusion of knowledge among the hospital personnel; Structural organizational innovations and j= Introducing new procedures of treatment; Introducing new technical equipment; Safer conditions of treatment; Quality continuous improvement of services.

The Spearman rho coefficient is the adequate test to assess the relation between the several measures of the two kinds of innovations. The following table (Table 13) contains the correlations among all of them.

Table 13 - Correlations between Service and Organizational innovation (1-tailed Spearman's rho)

		Service: Introducing new procedures of treatment	Service: Introducing new technical equipment	Service: Safer conditions of treatment	Service: Quality continuous improvement of services	Organizational: Renewing the information system of the hospital	Organizational: Increasing the diffusion of knowledge	Organizational: Structural organizational innovations
Service: Introducing new procedures of treatment	Correlation Coefficient	1,000	-0,177	-0,009	-0,341	0,231	**0,343***	-0,205
	Sig. (1-tailed)		0,158	0,479	0,024	0,094	**0,024**	0,122
Service: Introducing new technical equipment	Correlation Coefficient		1,000	0,138	-0,013	0,064	-0,053	0,073
	Sig. (1-tailed)			0,218	0,471	0,359	0,382	0,342
Service: Safer conditions of treatment	Correlation Coefficient			1,000	-0,166	**0,337***	0,068	-0,039
	Sig. (1-tailed)				0,175	**0,026**	0,351	0,414
Service: Quality continuous improvement of services	Correlation Coefficient				1,000	0,206	0,194	0,133
	Sig. (1-tailed)					0,121	0,136	0,227
Organizational: Renewing the information system of the hospital	Correlation Coefficient					1,000	0,557	-0,029
	Sig. (1-tailed)						0,000	0,435
Organizational: Increasing the diffusion of knowledge	Correlation Coefficient						1,000	-0,114
	Sig. (1-tailed)							0,260
Organizational: Structural organizational innovations	Correlation Coefficient							1,000
	Sig. (1-tailed)							

Legend:

The cells in grey represent the relationships that we want to analyse.

Bold numbers represent significant correlations (* significant at 5% level)

We can see from the analysis of Table 13 that the measure of Service innovation "*Introducing new procedures of treatment*" is correlated with the Organizational measure "*Increasing the diffusion of knowledge*". In fact, the rho between the two variables is 0,343, being this correlation significant at the 0,05 level (1 tailed). We can reject the null hypothesis of no association between the two variables. We can explain this by the fact that a higher knowledge amongst the staff in terms of what is new and performant (shortly: innovative) in the medical world leads to a higher determination to make use of those innovations in terms of treatments and procedures. The other pair that is significantly correlated is the Service measure "*Safer conditions of treatment*" and the Organizational measure "*Renewing the information system of the hospital*" (correlation = 0,337, significant at 5%). As technological innovations are mostly electronic softwares and means of help that come to replace the likes of: manual records of patients, intensive care units surveillance, communication between patient and physician, and others, and lead to: reduced errors in prescription; reduced waiting times, reduced hospitalization from improved disease management etc. (all in the view of Leidner *et al*, 2010), we can see how this type of innovation is related with the increase in the safety of patient treatments. We would have expected, nevertheless, to see a positive association between the organizational informational systems innovation and the quality improvement of services. The correlation is not significant though.

All the other associations, in fact, are not significant (at 5%). Concerning the stated hypothesis we can conclude that not all types of organizational innovation imply a service innovation.

Now we are going to analyse the relation between other two types of innovation.

H2: The higher the level of organizational innovation, the higher the level of process innovation.

This hypothesis is similar to the previous one. The Spearman rho coefficient will be used to assess the relation between the two kinds of innovations. Table 14 contains the outputs of SPSS for this hypothesis, 1-tailed test, as in the 2-tailed test the correlation is significant at the 0,01 level. The null hypothesis (H0) is: “There is no association between the organizational innovation and process innovation” (i.é, Spearman’s rho = 0) against the hypothesis that “There is a positive correlation between the two variables” (i.é., rho > 0).

Table 14 – Correlations between Process and Organizational innovation measures (Spearman's rho)

		Process innov.: composite global measure	Organizational innov.: composite global measure
Process innov.: composite global measure	Correlation Coefficient	1,000	0,454
	Sig. (1-tailed)		0,004*
	N	34	34
Organizational innov.: composite global measure	Correlation Coefficient		1,000
	Sig. (1-tailed)		
	N		34

*correlation is significant at the 0,01 level (1 tailed).

Considering a significance level of 1% we can reject the null hypothesis. It means that the correlation between the two types of innovation is positive with a significant level of 1%. With an rho of 0,454, as it is far from 0 (rho = 0 means no correlation) but also not very close to 1 or -1, the variables are correlated, but not very strongly.

We can conclude that when the organizational innovation increases in a hospital, the process innovation also increases in a correlation of about a half (0,454). This result is in line with the study of Gunday (2011), who also finds a correlation between organizational and process innovation, in that case even higher, of 0,698 - a quite strong positive link between the two measures. Organizational innovation is considered by Gunday a "preparatory field" for the other types of innovation, and according to our findings, it does give space for development to process innovation. We can bring into attention here a similar explanation as the one given in the case of the previously seen association between organizational informational innovation and safety of treatments; IT innovations in healthcare - by replacing manual, less precise work, with its electronic performant counterpart - contribute for a better, safer, quicker, less expensive processing of patients - all of which are aspects of process innovation.

As done previously in hypothesis H1a, we can analyse the behaviour of the several measures of innovation in study.

H2a: The higher the level of organizational innovation measured by i, the higher the level of process innovation measured by j, i= Renewing the information system of the hospital; Increasing the diffusion of knowledge among the hospital personnel; Structural organizational innovations and j= Quality, continuous improvement of processes; Increasing the speed of patient processing and care; Decreasing the variable costs of patient processing and care

The Spearman rho coefficient is the adequate test to assess the relation between the several measures of the two kinds of innovations. The following table (Table 15) contains the correlations among all them.

Table 15 – Correlations between Process and Organizational innovation (1-tailed Spearman's rho)

		Process: Quality continuous improvement of processes	Process: Increasing the speed of patient processing and care	Process: Decreasing the variable costs of patient processing	Organizational: Renewing the information system of the hospital	Organizational: Increasing the diffusion of knowledge	Organizational: Structural organizational innovations
Process: Quality - continuous improvement of processes	Correlation Coefficient	1,000	0,294*	-0,247	**0,579****	**0,301***	0,270
	Sig. (1-tailed)		0,046	0,079	**0,000**	**0,042**	0,061
Process: Increasing the speed of patient processing and care	Correlation Coefficient		1,000	-0,212	**0,377***	**0,327***	0,136
	Sig. (1-tailed)			0,114	**0,014**	**0,030**	0,222
Process: Decreasing the variable costs of patient processing	Correlation Coefficient			1,000	-0,127	0,105	-0,188
	Sig. (1-tailed)				0,237	0,278	0,143
Organizational: Renewing the information system of the hospital	Correlation Coefficient				1,000	0,557**	-0,029
	Sig. (1-tailed)					0,000	0,435
Organizational: Increasing the diffusion of knowledge	Correlation Coefficient					1,000	-0,114
	Sig. (1-tailed)						0,260
Organizational: Structural organizational innovations	Correlation Coefficient						1,000
	Sig. (1-tailed)						

Legend:

The cells in grey represent the relationships that we want to analyse.

Bold numbers represent significant correlations (* significant at 5% level, ** significant at 1%)

As it was to be expected, the correlation by components reflects the result of the correlation We can see from the analysis of Table 15 that the measure of Process innovation "*Quality - continuous improvement of processes*" is correlated with the Organizational measure "*Renewing the information system of the hospital*". In fact, the rho between the two variables is 0,579, being this correlation significant at the 0,05 (and 0,01) level (1 tailed). We can reject the null hypothesis of no association between the two variables. This shows that an upgrade in the informational systems of the Portuguese hospitals contributes to the overall improvement in the quality of processes (and to obtaining quality standards certifications and awards). The other pairs that are significantly correlated are the Process innovation "*Quality - continuous improvement of processes*" and Organizational measure "*Increasing the diffusion of knowledge*" (correlation = 0,301, significant at 5%), Process measure "*Increasing the speed of patient processing and care*" and Organizational measure "*Renewing the information system of the hospital*" (correlation = 0,377, significant at 5%) and the pair "*Increasing the speed of patient processing and care*" - "*Increasing the diffusion of knowledge*" (correlation = 0,327). This can be explained by the fact that, in Portuguese hospitals, the organizational aspects are streamlined and reflecting in the functioning of processes; while as always, even in closely correlated measures, the change of one is not as deeply reflected in the change of the other, here the correlation level between an organizational change (innovation) and a change/ innovation in the processes of the health unit is of about a third (~0,33 on average).

Structural organization innovations are not significantly associated with process innovation components, nor are the decreasing variable costs of patient processing and care explained by organizational innovations.

While still remaining in the field of innovation testing, we are now proceeding to test the hypotheses that look for differences in innovation regarding the type of property of the hospitals or their geographical location.

H3: There are differences, concerning the level of innovations of type i, between the hospitals depending on the geographical region (i.é, the region – North, Center, Lisbon and Valley of Tejo and South – has an impact in the level of innovation), i=service, process, organizational.

To analyse and test this result we use the Kruskal-Wallis[2] non-parametric test. This test allows to probe if there are differences with statistical significance between the medians of the degree of hospital innovations in each region.

The regions are classified in: North, Center, Lisbon and Valley of Tejo (LVT) and South. According to Maroco (2010) this is the suitable test for what we want to analyse. The F test employed in ANOVA *one way* could be another option for analysing this hypothesis, but this analysis of variance depends on the hypothesis that all populations are independent and normally distributed. Given that these conditions are not assured in our study, we use the Kruskal-Wallis test, as it does not put any constraint on the comparisons. All tests with a *p-value* $\leq \alpha$=0,05 are considered statistically significant.

The null hypothesis in study is: H0: "the distribution of values of the dependent variable (degree of innovation of type *i*) is identical in the *k* populations (k = hospital in the North region, Center, LVT, South)", against the alternative hypothesis that there is at least one category of region where the distribution of the degree of innovations is different from one other category under study. The following table (Table 16) presents the statistics of the Kruskal-Wallis test (for α=0,05):

Table 16: Kruskal-Wallis test for geographic region (Hypothesis 3)

	N	***p-value* (K-W)**	**Decision**
Service innovation (composite measure)	34	0,472	Retain the null hypothesis
Process innovation (composite measure)	34	0,306	Retain the null hypothesis
Organizational innovation (composite measure)	34	0,339	Retain the null hypothesis

Considering the results presented on the previous table (complete information can be consulted in Annex 5), the null hypothesis is retained for every type of innovation. This means that we cannot reject the hypothesis that there are no differences concerning the degree of innovation between the regions where the hospitals are located

[2] The Kruskal-Wallis test, tests the null hypothesis that the distribution of the dependent variable values are similar in the *k* populations, against the alternative hypothesis that there are least one population where the distribution of the dependent variable is different of one distribution of the other populations under study.

in. Consequently, nothing can be said about the impact of the geographical region on the innovation degree.

It would be interesting to analyse the hypothesis in more depth considering not the global composite measure but each measure of innovation for the 3 types. Table 17 presents a more complete analysis, using the statistics of the Kruskal-Wallis test (for α=0,05):

Table 17 - Kruskal-Wallis test for geographical region (Hypothesis 3)

	Chi-Square	***p-value* (K-W)**	**Decision**
Service: Introducing new procedures of treatment	2,593	0,459	Retain the null hypothesis
Service: Introducing new technical equipment	2,634	0,451	Retain the null hypothesis
Service: Safer conditions of treatment	0,595	0,897	Retain the null hypothesis
Service: Quality, continuous improvement of services	0,343	0,952	Retain the null hypothesis
Process: Quality, continuous improvement of processes	3,333	0,343	Retain the null hypothesis
Process: Increasing the speed of patient processing and care	3,453	0,327	Retain the null hypothesis
Process: Decreasing the variable costs of patient processing and care	1,109	0,775	Retain the null hypothesis
Organizational: Renewing the information system of the hospital	5,422	0,143	Retain the null hypothesis
Organizational: Increasing the diffusion of knowledge among the hospital personnel	7,076	0,069	Retain the null hypothesis
Organizational: Structural/ Other organizational innovations	0,840	0,840	Retain the null hypothesis

In all cases, we retain the null hypothesis. It stresses the previous conclusion that we cannot conclude that the region influences the innovation effort.

This confirms the results of the French study of Bonarte *et al.* (2014), which concluded the geographical localization of the French hospitals did not exert an influence on the implementation of innovative treatments (in our study, we have seen there is not an influence of localization on the other types of innovations either). This can be explained by the similarity of Portugal and France in terms of equal overall economical development of the geographical regions; equal access to information and the desire to keep up the competitiveness for all hospitals, leads to similar levels of innovation throughout the country.

We pass now to the testing of the influence of the type of property of the hospital on its innovativeness.

H4: There are differences, concerning the level of innovations of type i, between the hospitals depending on the type of property (i.é, the property – public, private and PPP – has an impact in the level of innovation), i=service, process, organizational.

This hypothesis is similar to the previous one in terms of analysis. We start by doing the Kruskal-Wallis test, to assess if there are differences with statistical significance between the medians of the degree of hospital innovations in each property type. The types of property are divided in Public, Private and Public-Private Partnership (PPP). The null hypothesis in study is: H0: "the distribution of values of the dependent variable (degree of innovation of type *i*) is identical in the *k* populations (k=public hospital, private hospital, PPP)", against the alternative hypothesis that there is at least one category of property where the distribution of the degree of innovations is different from one other category under study. The following table (Table 18) presents the statistics of the Kruskal-Wallis test (for α=0,05):

Table 18: Kruskal-Wallis test for property type (Hypothesis 6)

	N	***p-value* (K-W)**	**Decision**
Service innovation (composite measure)	34	0,601	Retain the null hypothesis
Process innovation (composite measure)	34	0,402	Retain the null hypothesis
Organizational innovation (composite measure)	34	0,020	**Reject the null hypothesis**

Considering the results presented on the previous table (complete information can be consulted in Annex 6), the organizational innovation is the only one that allows us to reject the null hypothesis. This means that there are differences concerning the degree of organizational innovation between the Public, Private and PPP hospitals. In order to determine the group that has the higher level, we need to do the post hoc tests for the Kruskal-Wallis omnibus test. Through the pairwise comparisons, we can conclude that in the case of the analysed Portuguese hospitals, and concerning the degree of organizational innovation, there are differences between the public and private hospitals (see Annex 5).

Moreover, given the global composite values we have previously got, we can say that the public hospitals are the ones that have a higher degree of organizational innovation. We can explain this difference based on the structural changes that the public hospitals have passed through in the past 5 years - the organization of independent hospitals into EPE health care centers (that was mentioned in the chapter 2.3) leading to major changes in management structures, overall organization and the need to merge different informational systems, patient databases and overall, align different systems into one. Such an alignment could have likely asked for a renewal in IT platforms and structural innovations in the public hospitals. On the other hand, private hospitals are overall newer than the public ones, and beneficiate since their opening of the latest performant informational systems (so these are not considered innovations); the public hospitals often need to "catch up" when it comes to the latest technologies, implementing them over time.

We cannot conclude anything concerning the service and process innovation when it comes to type of property. In fact, we can see the significant level of the null hypothesis concerning the service and process innovation is higher than 5% (60,1% and 40,2%, respectively), therefore we cannot reject the null hypothesis "H0: the medians of the degree of service and process innovation of each type of hospital are identical".

But before moving on, it would be interesting to analyse the hypotheses considering not the composite global measure but each measure of innovation type. Table 19 presents the statistics of the Kruskal-Wallis test (for α=0,05):

Table 19: Kruskal-Wallis test for property type (Hypothesis 6)

	Chi-Square	***p-value* (K-W)**	**Decision**
Service: Introducing new procedures of treatment	2,48	0,289	Retain the null hypothesis
Service: Introducing new technical equipment	1,381	0,501	Retain the null hypothesis
Service: Safer conditions of treatment	3,188	0,203	Retain the null hypothesis
Service: Quality, continuous improvement of services	8,994	0,011	**Reject the null hypothesis**
Process: Quality, continuous improvement of processes	3,669	0,16	Retain the null hypothesis
Process: Increasing the speed of patient processing and care	0,652	0,722	Retain the null hypothesis
Process: Decreasing the variable costs of patient processing and care	0,574	0,751	Retain the null hypothesis

Organizational: Renewing the information system of the hospital	7,131	0,028	**Reject the null hypothesis**
Organizational: Increasing the diffusion of knowledge among the hospital personnel	1,825	0,401	Retain the null hypothesis
Organizational: Structural / Other organizational innovations	2,397	0,302	Retain the null hypothesis

The null hypothesis is rejected in the case of two measures of innovation: the continuous improvement of the quality of services and the renewal of informational systems in the hospitals. We can conclude that in the case of those two types of innovation, there are differences between the hospitals depending on whether they are public, private or PPP. Proceeding, as in the previous case, to do the post hoc tests for the Kruskal-Wallis test, we see (in Annex 6, pairwise comparison) that the same public – private hospitals pair is the one that presents differences in the case of the service (quality...) innovation measure. In the case of the organizational informational innovation, although the Kruskal-Wallis test rejected the hypothesis of no difference between the three groups, the pairwise comparison revealed no significant differences between any two of the groups. Based on the averages shown in the descriptive analysis, for the continuous improvement of the quality of services, public hospital lead in terms of innovation, this being in fact a subtype of service innovation that was not implemented in any of the analysed private hospitals (mean=1).

The null hypothesis is retained in the case of all the other types of innovation, therefore we cannot say the property of the hospital plays a role on their degree of innovation.

We proceed now to testing what is maybe the most important hypothesis of the study, as it tests practically the research question found in the title - the influence of innovation on the performance of the hospitals.

H5: The higher the level of organizational innovation (H3a), service innovation (H3b) and process innovation (H3c), the higher the level of operational performance i; i= Readmission rate adjusted to risk; Occupation rate; Average duration of hospitalization (days).

All the 3 hypothesis are analysed using the same test - Spearman Rho correlation. The general form of the null hypothesis (H0) is: "There is no association between the organizational innovation (H3a), service innovation (H3b), process

innovation (H3c) and the Operational performance. Table 20 contains the correlations among the several types of innovation and the operational performance measures.

The service innovation is correlated with the *Readmission rate adjusted to risk* (rho=0,410, sig=0,005). Strangely, the correlation is positive, meaning an increase in one of the measure is associated with an increase in the other. Is it that a higher innovation in the services offered by the hospitals (treatments, procedures, etc.) leads to a higher rate of readmissions? It could happen in the case of procedures of such novelty that the shorter or longer time effects could not be foreseen. But on the other hand, a higher rate of readmission (therefore a negative operational performance) could in fact lead to a higher innovation in services, in order for the innovative services to provide better care that would lead to a lower number of complications and readmissions. When looking from this perspective on the relation, it makes much more sense.

In the case of the *Occupation rate*, it is correlated with the process innovation composite measure (rho=0,493, sig.=0,005). The level of association is high, meaning that when one increases, the other increases too. On average, when a hospital invests more in process innovation, it results in an increase of their occupation rate. This goes to show people are ready to embrace innovation, but on overall occupation rates should not exceed limits of around 85% as hospitals should always have free spaces for emergency cases.

Table 20 – Correlations between global measures of the 3 types of innovation and operational performance (1-tailed Spearman rho)

		Service composite measure	Process composite measure	Organizational composite measure	Operational Performance: Readmission rate adjusted to risk (2012)	Operational Performance: Occupation rate (2012)	Operational Performance: Average duration of hospitalization (days) (2012)
Service composite measure	Correlation Coefficient	1,000	0,305*	0,254	**0,410***	0,168	0,131
	Sig. (1-tailed)		0,039	0,074	**0,014**	0,206	0,249
	N	34	34	34	**29**	26	29
Process composite measure	Correlation Coefficient		1,000	0,454**	0,337*	**0,493****	-0,091
	Sig. (1-tailed)			0,004	0,037	**0,005**	0,319
	N		34	34	29	**26**	29
Organizational composite measure	Correlation Coefficient			1,000	0,085	0,312	0,051
	Sig. (1-tailed)				0,330	0,061	0,396
	N			34	29	26	29
Operational Performance: Readmission rate adjusted to risk (2012)	Correlation Coefficient				1,000	0,241	0,251
	Sig. (1-tailed)					0,118	0,095
	N				29	26	29
Operational Performance: Occupation rate (2012)	Correlation Coefficient					1,000	-0,041
	Sig. (1-tailed)						0,421
	N					26	26
Operational Performance: Average duration of hospitalization (days) (2012)	Correlation Coefficient						1,000
	Sig. (1-tailed)						
	N						29

Legend:

The cells in grey represent the relationships that we want to analyse.

Bold numbers represent significant correlations (* significant at 5% level, ** significant at 1%)

Finally, if we consider the operational measure *Average duration of hospitalization*, none of the innovation types are associated to this performance. We can also conclude that the organizational innovation (measured by the composite variable) is not correlated with any of the operational performance measures. We retain the null hypothesis stated for H3a.

We proceed finally to test the last hypothesis that probes the connexion between operational and financial performance and looks to determine in an indirect way, the impact of innovation in the financial performance of the health care units.

H6: The higher the level of operational performance, the higher the financial performance.

Similar to the way we have tested the previous hypotheses (and the first 2 hypotheses), we use a 1-tailed Spearman test to correlate the operational performance (divided into its 3 measures) and the financial performance (and its 4 components). Table 20 shows the results of the test.

As we can note in the Table 21, the only statistically significant correlations between operational and financial measures of performance are the correlations between the *Average days of hospitalization* and the *Value of Assets* (correlation = 0,347, significant at 5%) and *the same operational measure* and *value of the net income* (correlation = - 0,318, significant at 5%). The first of these two correlations is quite surprising, as the two measures have no apparent direct connexion. The second correlation though, the negative one, can be explained more easily by the fact that a longer average duration of hospitalization per patient means increased costs for the hospitals, therefore lowering their net income.

Table 21 – Correlations between operational and financial performance component measures (1-tailed Spearman rho)

		Operational Performance: Readmission rate adjusted to risk (2012)	Operational Performance: Occupation rate (2012)	Operational Performance: Average duration of hospitalization (days) (2012)	Financial Performance: EBITDA 000EUR (2012)	Financial Performance: Assets 000EUR (2012)	Financial Performance: Net income 000EUR (2012)	Financial Performance: ROA (2012)
Operational Performance: Readmission rate adjusted to risk (2012)	Correlation Coefficient	1,000	0,241	0,251	-0,147	0,224	-0,129	-0,116
	Sig. (1-tailed)		0,118	0,095	0,223	0,122	0,253	0,275
	N	29	26	29	29	29	29	29
Operational Performance: Occupation rate (2012)	Correlation Coefficient		1,000	-0,041	0,047	0,202	-0,069	0,111
	Sig. (1-tailed)			0,421	0,409	0,161	0,369	0,295
	N		26	26	26	26	26	26
Operational Performance: Average duration of hospitalization (days) (2012)	Correlation Coefficient			1,000	-0,226	**0,347***	**-0,318***	-0,259
	Sig. (1-tailed)				0,120	**0,033**	**0,046**	0,088
	N			29	29	**29**	**29**	29
Financial Performance: EBITDA 000EUR (2012)	Correlation Coefficient				1,000	-0,347*	0,930**	0,760**
	Sig. (1-tailed)					0,022	0,000	0,000
	N				34	34	33	33
Financial Performance: Assets 000EUR (2012)	Correlation Coefficient					1,000	-0,323*	0,051
	Sig. (1-tailed)						0,033	0,388
	N					34	33	33
Financial Performance: Net income 000EUR (2012)	Correlation Coefficient						1,000	0,799**
	Sig. (1-tailed)							0,000
	N						33	33
Financial Performance: ROA (2012)	Correlation Coefficient							1,000
	Sig. (1-tailed)							
	N							33

Legend:

The cells in grey represent the relationships that we want to analyse.

Bold numbers represent significant correlations (* significant at 5% level, ** significant at 1%)

As this analysis is drawing to an end, we can take a moment and resume the findings we have come up with while trying to investigate the relation between innovation and performance in the health care sector in Portugal.

Going through a long stream of connecting variables, we have identified a correlation between organizational innovation and process innovation (not with the service innovation though). At the same time, service innovation and process innovation have somewhat of a connection with 2 of the 3 operational performance measures we have studied. But the only operational measure that has an impact in the financial numbers of the hospitals is the third one (average duration of hospitalization). By association, then, innovation has not been proved to have an impact on the financial performance of the hospitals. Of course the nature of hospitals is not profit making, therefore the financial measures, although important, are not the most relevant when it comes to make a complete description of the situation of a certain hospital (especially dealing with public entities).

5. Conclusion and Recommendations

In this chapter we will present the conclusions of the present study, in the form of a résumé of the results detailed in the previous chapter, as well as accepting the limitations of the study and offering recommendations for future studies that will deal with the same subject in more depth.

5.1. Conclusions

This study reports on the dimensions and types of innovation in Portuguese hospitals, as well as looking into their performance measures and correlating the two areas. The analysis has brought up some interesting findings, confirmed some previous studies and theories while infirmed others and offers a fresh perspective on the subject of health care innovation.

Analyzing the innovation database we have put up altogether, we have found out that in terms of service innovations, hospitals tend to innovate the most in the introduction of new procedures/ treatments (in terms of the other types of innovations we can not note striking differences in their averages).

The North region and the Lisbon and Valley of Tejo are the leading ones in overall innovation, reflecting in fact their leadership in most sectors in Portugal. But the geographical location of the hospitals throughout Portugal does not have an effect on the innovations implemented, as we have checked testing hypothesis H3, which was infirmed (our conclusion was in line with the finding of the somewhat similar Bonarte *et al.*'s 2010 study, given that Portugal is a country with no real different development of its regions).

The tests have proven there are differences between the overall level of innovation between public and private hospitals, and averages show us there are also differences in certain subtypes of innovation.

Big differences are noticed in the financial performance of the hospitals by property types - public hospitals are under performant (negative results), private ones are performant (positive results) and PPP are break even. This is not a striking result, as private hospitals are in fact more profit-oriented than the public ones, charging accordingly for their services, while delivering top care to the patients. In terms of

payment of the health services, situations are becoming somewhat confusing nowadays, are public hospitals charge some tariffs that, while lower than the ones practiced by the private entities, can become more expensive when not compensated by the health insurances. We assume the difference in terms of price is still a differentiating factor in terms of patient satisfaction evaluation (market performance), as they have evaluated public hospitals higher than the private ones.

Operationally, the private hospitals are performing better as well.

The hypotheses testing revealed there is no significant positive correlation between the level of organizational innovation and the level of service innovation - global measures; but there is a correlation, not very strong, between one component of organizational innovation and one component of service innovation. There is, on the other hand, a correlation of almost half between organizational and process innovation, reflected also at the level of their components.

As far as the correlation between innovation itself and performance, service innovation and process innovation are correlated connection with 2 of the 3 operational performance measures (readmission rate adjusted to risk and occupation rate). But the only operational measure that has an impact in the financial numbers of the hospitals is the third one (average duration of hospitalization), leading therefore to the information of the hypothesis that there could be an association between innovation and the financial performance of the hospitals.

5.2. Limitations and recommendations

This study was limited by a number of factors, out of which we can enumerate:

- the lack of more comprehensive data;
- the particular nature of hospitals, particularly the public ones which benefit from public sponsorship and capital subsidizing and are not mainly directed towards profit making; great investments in modern innovative machinery may take years to see itself generating a profit in the financial statements and even so, it is difficult to assess directly the role of the equipment in the generation of cash flows;
- difficulty in quantitating the data and assessing degrees of innovation;

- possibility that innovativeness in one area does not reflect in all the hospital (in the operational, financial and satisfaction results);
- possibility that some hospitals are a 'one wonder' case - they have a big breakthrough after which they do not continuously improve/ innovate;
- possibility that some newer hospitals were innovative since the beginning and did not need to implement a lot of innovations in the years in study, obtaining a low score, while other older hospitals have updated over the years and obtained points for innovation, while only reaching a similar level to the first ones;
- the implementation of innovations can take years to have visible results;
- impossibility of doing a first hand (direct) study through survey due to the very dense nature of information and difficulty in finding the right man-source

For further studies that want to deepen the understanding of the subject, for finding out the specific impact of innovation in a complete system that determines performance, our recommendation is to make a regression model. For accuracy, though, all or at least the major determinants of performance must be inserted in the equation. Such a study would have to look into great depth into performance measurement and gather the data for all measures that influence/ determine performance significantly (including measures that are not as easy to quantify, as the path and strength of the leadership, etc). Such a model may turn out very complex, which is probably why there aren’t such studies performed as of yet (most studies relating innovation in healthcare to performance resorting to correlations or clusters analysis).

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*** Sistema de avaliação da qualidade apercebida e da satisfação do utente dos hospitais EPE e SPA, *Adiministração Central da Sistema de Saude e Universidade Nova Lisboa*

Annexes

Annex 1 – Innovation data collected from hospital reports

				Service Innovation			
				Innovation	Type	Year	Degree
Hospital São Marcos	Braga	PPP	North	Minimum invasive surgery techniques (in neonatal endoscopy and other areas)	Introducing new procedures of treatment	2012	5
				Certification ISO 14001 for ambiental management (2nd in the country)	Safer conditions of treatment	2012	3,5
Hospital Santa Maria Maior	Barcelos	Public	North	Acquisiton of new ocular equipment	Introducing new technical equipment	2011	2,75
Centro Hospitalar Do Alto Ave	Guimaraes	Public	North	International accreditation from Joint Commission International	Quality, continuous improvement of services	2007	3
				Informatics system used in projects in the digestive endoscopy area	Introducing new procedures of treatment	2010	4
Centro Hospitalar Póvoa Do Varzim/Vila Conde	Povoa Varzim	Public	North	Innovative procedures in general surgery (micro-laparoscopic surgery)	Introducing new procedures of treatment	2011	3
Clipovoa Hospital Privado	Povoa De Varzim	Private	North	Acquisition of new machinery and equipment in Otorhinolaringology and Imagiology, Gastroenterology	Introducing new technical equipment	2010 - 2012	3
Centro Hospitalar Do Tâmega E Sousa	Penafiel	Public	North	International accreditation from Joint Commission International	Quality, continuous improvement of services	2007	3
				Broadening of the spectrum of services in the MCDT (complementary means of diagnosis)	Introducing new procedures of treatment	2011-2012	2,5
Unidade Local De Saúde De Matosinhos	Matosinhos	Public	North	Increase in working areas, technological equipments and continuous improvement of the services	Quality, continuous improvement of services	2010; 2011	2,5
				Creating new units of intermediary care (intermediary polivalent care); creating online platforms for supervision of pregnancies	Safer conditions of treatment	2011	3,75
				ESSURE innovative sterilization technique	Introducing new procedures of treatment	2008-2011	3
Hospital São João	Porto	Public	North	Innovative treatments and procedures - Pioneer in Portugal (ex: Via Verde de Sepsis, treatments for insanguine hernias etc)	Introducing new procedures of treatment	2008-2011	5
				ESSURE innovative sterilization technique (1st-2nd in Portugal)	Introducing new procedures of treatment	2006-2010	4
Centro Hospitalar Do Porto	Porto	Public	North	Creation of new areas of treatment, continous improvement of services	Quality, continuous improvement of services	2010	2
				New units of treatment and new adequated machinery	Introducing new technical equipment	2011	3
				Implementation of measures and quality standards for the safety of patients - risk management	Safer conditions of treatment	2010	2

				Service Innovation			
				Innovation	Type	Year	Degree
Ipo Porto	Porto	Public	North	New installments of technology in Braquitherapy and Radiology, most advanced in the country	Introducing new technical equipment	2011	4
				Pioneer methods in the treatment of cancer in Portugal	Introducing new procedures of treatment	2010	4
				Creation of new areas of treatment, continous improvement of services	Quality, continuous improvement of services	2008-2009	3
Hospital Cuf Porto	Porto	Private	North	1st surgery in Portugal for breast cancer with intra-operative radiotherapy; Innovative surgery in Portugal for deafness	Introducing new procedures of treatment	2012	4
Centro Hospitalar Vila Nova De Gaia	Vila Nova De Gaia	Public	North	Acquisition of Nuclear magnetic resonance machinery, telemetry central and extra-corporal circulation machines; confocal microscope (1st in Portugal)	Introducing new technical equipment	2009-2012	4
				Reimplantations; reverse vasectomy; mandibule reconstruction	Introducing new procedures of treatment	2010-2011	4,5
				Continuous improvement in quality of patient care	Quality, continuous improvement of services	2009-2012	3
Hospital Da Arrabida	Vila Nova De Gaia	Private	North	New areas of treatment	Introducing new procedures of treatment	2011	3
				New machinery and equipment, aumentation of disponibilities	Introducing new technical equipment	2010`	3
Centro Hospitalar Entre O Douro E Vouga	Sta Maria Da Feira	Public	Center	International accreditation from Joint Commission International	Quality, continuous improvement of services	2007	3
Centro Hospitalar Tondela Viseu	Viseu	Public	Center	New projects in Oncology and Mental Health	Introducing new procedures of treatment	2011-2013	3
Cliria Hospital Privado	Aveiro	Private	Center	Acquisition of new machinery and equipment in Imagiology and ambulatory	Introducing new technical equipment	2010; 2011	3
Centro Hospitalar Cova Da Beira	Covilha	Public	Center	International accreditation from Joint Commission International	Quality, continuous improvement of services	2007	3
				MedTex textile in the processing and treatment of patients innoation	Quality, continuous improvement of services	2010-2012	3,75
Centro Hospitalar Universitario De Coimbra	Coimbra	Public	Center	Introduction of new procedures in the pediatrics and burns area and pathologic anatomy	Introducing new procedures of treatment	2012	4
Ipo Coimbra	Coimbra	Public	Center	Introduction of new medicines used as treatment for melanoma and other types of cancer	Introducing new procedures of treatment	2011	3,25
				New radioionizing equipment and other eco-friendly machinery	Introducing new technical equipment	2010	3,5
				New method for detecting and classifying all types of human HPV and creating better treatments	Introducing new procedures of treatment	2010	4,5

				Service Innovation			
				Innovation	Type	Year	Degree
Hospital Distrital Da Figueira Da Foz	Figueira Da Foz	Public	Center	Acquisiton of a TAC (axial computerized tomography) innovative machinery	Introducing new technical equipment	2009	4
				Implementation of 6 international standards for patient safety	Safer conditions of treatment	2011	4
Centro Hospitalar Leiria Pombal	Leiria	Public	Center	International accreditation from Joint Commission International	Quality, continuous improvement of services	2011	3
				New cardiology and hemodynamic service	Introducing new procedures of treatment	2009	2,5
Centro Hospitalar Do Médio - Tejo	Torres Novas	Public	Lisbon and Valley of Tejo	International accreditation from Joint Commission International	Quality, continuous improvement of services	2007	3
Hospital Do Mar	Bobadela	Private	Lisbon and Valley of Tejo	New areas of treatment and care: paliative care, vegetative care and brain conditions (for elder groups)	Introducing new procedures of treatment	2011	4
Centro Hospitalar Lisboa Central	Lisbon	Public	Lisbon and Valley of Tejo	Innovative projects and procedures: human milk bank, ADD Colour system for daltonists, early intervention in hearing problems for new borns	Introducing new procedures of treatment	2011-2013	3,5
Centro Hospitalar De Lisboa Ocidental	Lisbon	Public	Lisbon and Valley of Tejo	Safe surgery check-list programme	Safer conditions of treatment	2011	3,5
			Lisbon and Valley of Tejo	New units for endoscopy, extracorporal litotricy	Introducing new technical equipment	2010-2013	3,5
Ipo Lisboa	Lisbon	Public	Lisbon and Valley of Tejo	Acquisition of a new generation sequentiator for genetics diagnosis and a 4D radiology machine	Introducing new technical equipment	2013	4
			Lisbon and Valley of Tejo	ISO 15189 certification for clinical pathology and epidemiology	Quality, continuous improvement of services	2012	4
Hospital Cuf Infante Santo	Lisbon	Private	Lisbon and Valley of Tejo	Introduction of new techonology and procedures in the mamary and dermatology area	Introducing new procedures of treatment	2010	3
			Lisbon and Valley of Tejo	One day diagnose' technique in treating breast conditions; First simultaneous coclear implant surgery in Portugal	Introducing new procedures of treatment	2011	4
Hospital Cuf Descobertas	Lisbon	Private	Lisbon and Valley of Tejo	Innovation in the supply: imuno-alergology section; other new treatments	Introducing new procedures of treatment	2010-2012	3,5
Hospital Da Luz	Lisbon	Private	Lisbon and Valley of Tejo	Robotic surgery technology da Vinci Si HD 1st in Portugal; various new and innovative procedures (Essure sterilization, External Radiotherapy, etc)	Introducing new procedures of treatment	2010-2012	4
			Lisbon and Valley of Tejo	New innovative technological equipment (robotics and others)	Introducing new technical equipment	2010-2012	4

				Service Innovation			
				Innovation	Type	Year	Degree
Hospital Dr. Fernando Da Fonseca	Amadora Sintra	Public	Lisbon and Valley of Tejo	TAC, Magnetic resonance, mamography and radiology equipment	Introducing new technical equipment	2010-2011	2,75
				Conjoint interventions for constant improving conditions of service and safety of patient treatment	Quality, continuous improvement of services	2012-2013	2
Hese Evora - Hospital Da Misericordia (Partnership With Grupo Espirito Santo Saude)	Evora	Public/ Private	South	Introducing new specialties: Reumatology, vascular surgery, infectiology, neurosurgery Introducing new procedures: nuclear medicine, hemodinamics, digital angiogram, magnetic resonance	Introducing new procedures of treatment	2011; 2012	3
Centro Hospitalar Do Baixo Alentejo E.P.E. Beja	Beja	Public	South	International accreditation from Joint Commission International	Quality, continuous improvement of services	2007	3
Hospital De Faro	Faro	Public	South	Iametrics benchmarking system	Quality, continuous improvement of services	2011	3
Centro Hospitalar Barlavento Algarvio	Portimao	Public	South	Proceedings for improvement of patient safety and continuous improvement of quality of services	Safer conditions of treatment, Quality, continuous improvement of services	2010-2011	2
				Innovative treatment for serose otitis	Introducing new procedures of treatment	2011-2014	5

				Process Innovation			
				Innovation	Type	Year	Degree
Hospital São Marcos	Braga	PPP	North	Certification ISO 9001:2008 (CHKS) - Support, cleaning, transport, safety of processes	Quality, continuous improvement of processes	2012	4
Hospital Santa Maria Maior	Barcelos	Public	North	Ambiental practices	Quality, continuous improvement of processes	2011	2
Centro Hospitalar Do Alto Ave	Guimaraes	Public	North	Quality of admission and processing of patients - certification ISO 9000:2000	Quality, continuous improvement of processes	2011	3
Centro Hospitalar Póvoa Do Varzim/Vila Conde	Povoa Varzim	Public	North	Implementing new methods for better management of costs of logistic operations and variable factors of processes	Decreasing the variable costs of patient processing and care	2009-2010	3
Centro Hospitalar Do Tâmega E Sousa	Penafiel	Public	North	Support services for performance improvement in exploration systems (BI indicators system)	Quality, continuous improvement of processes	2011	2,5
Unidade Local De Saúde De Matosinhos	Matosinhos	Public	North	Certification ISO 9001:2008	Quality, continuous improvement of processes	2012	3
				Improving the waiting time	Increasing the speed of patient processing and care	2011-2012	2
Hospital São João	Porto	Public	North	ePatient centric interaction platform with patients - management of queues, results' evaluation	Increasing the speed of patient processing and care	2010	4
				Excellence in Health Care award	Quality, continuous improvement of processes	2012	4
Centro Hospitalar Do Porto	Porto	Public	North	Shortening the delays in the processes and services of treatment	Increasing the speed of patient processing and care	2009	2
				CHKS Accreditation for Quality	Quality, continuous improvement of processes	2009	3,5
Ipo Porto	Porto	Public	North	Qualification of services as Comprehensive Cancer Center (CCC)	Quality, continuous improvement of processes	2011	4
				Development of specific modules to accompany the processes (banks of transplants etc)	Quality, continuous improvement of processes	2009 - 2010	3,5
				Certification HQS and 9001:2008 for continuous improvement of services	Quality, continuous improvement of processes	2008	3
				Innovative method of reorganization of costs - activity based costing	Decreasing the variable costs of patient processing and care	2008	3,5
Hospital Cuf Porto	Porto	Private	North	Certification for Quality ISO 9001:2008	Quality, continuous improvement of processes	2012	3
Centro Hospitalar Vila Nova De Gaia	Vila Nova De Gaia	Public	North	Significant Investments in patient care quality and safety continuous improvement of processes	Quality, continuous improvement of processes	2010	3,5
				New patient processing and attendance software	Increasing the speed of patient processing and care	2010	3
Hospital Da Arrabida	Vila Nova De Gaia	Private	North	Quality Managemeny system in Imagiology, clinical analysis, transfusional medicine and central sterilization	Quality, continuous improvement of processes	2011	3,5
Centro Hospitalar Entre O Douro E Vouga	Sta Maria Da Feira	Public	Center	Medtrix EPR - electronic patient records and integrated data system for all processes	Quality, continuous improvement of processes	2010	4

				Process Innovation			
				Innovation	Type	Year	Degree
Centro Hospitalar Universitario De Coimbra	Coimbra	Public	Center	Fusion between different areas and reorganization of processes	Quality, continuous improvement of processes	2009-2012	2,5
Ipo Coimbra	Coimbra	Public	Center	OECI Accreditation for superior oncological Institute and ISO 9001:2000 for Imunotherapy	Quality, continuous improvement of processes	2011	4
Hospital Distrital Da Figueira Da Foz	Figueira Da Foz	Public	Center	Concentration/ceiling of expenses and reduction of materials costs-prices	Decreasing the variable costs of patient processing and care	2010 - 2011	2
				ISO 9001:2008 certification for different medical and general services	Quality, continuous improvement of processes	2011	3
Centro Hospitalar Leiria Pombal	Leiria	Public	Center	ABC system costing management for cost reduction in processes	Decreasing the variable costs of patient processing and care	2009	2
Centro Hospitalar Do Médio - Tejo	Torres Novas	Public	Lisbon and Valley of Tejo	ISO 9001 certification for quality	Quality, continuous improvement of processes	2011-2012	3
Hospital Do Mar	Bobadela	Private	Lisbon and Valley of Tejo	Reorganization of prices list and a balanced cost-price-profits offer	Decreasing the variable costs of patient processing and care	2010	2
Centro Hospitalar Lisboa Central	Lisbon	Public	Lisbon and Valley of Tejo	ISO 9001:2008 certification for quality in sterilization, central surgery, pathology and imunotherapy	Quality, continuous improvement of processes	2011	3
Hospital Cuf Infante Santo	Lisbon	Private	Lisbon and Valley of Tejo	Quality certification renewal for hospital services	Quality, continuous improvement of processes	2008	2
			Lisbon and Valley of Tejo	Reorganization of processes for the reduction of waiting time	Increasing the speed of patient processing and care	2011-2012	3
Hospital Cuf Descobertas	Lisbon	Private	Lisbon and Valley of Tejo	Quality certification renewal for hospital services	Quality, continuous improvement of processes	2008	2
Hospital Da Luz	Lisbon	Private	Lisbon and Valley of Tejo	Introduction of one-day surgery concept	Decreasing the variable costs of patient processing and care	2010	2,5
Hospital Dr. Fernando Da Fonseca	Amadora Sintra	Public	Lisbon and Valley of Tejo	CHKS Accreditation for Quality and continuous adaptation to changing standards	Quality, continuous improvement of processes	2011	3,5
Hospital De Faro	Faro	Public	South	Rearranging the spaces and processes in Internal medicine and UAVC for a quicker processing and treatment of patients	Increasing the speed of patient processing and care	2012	2
				APCER Qualification for imunotherapy and other services	Quality, continuous improvement of processes	2011	3
Centro Hospitalar Barlavento Algarvio	Portimao	Public	South	CHKS Accreditation for Quality and continuous adaptation to changing standards	Quality, continuous improvement of processes	2012	3,5
				Implementation os ISO 9001:2008 continuous improvement of quality norms and standards	Quality, continuous improvement of processes	2008 - 2011	3

				Organizational Innovation			
				Innovation	Type	Year	Degree
Hospital São Marcos	Braga	PPP	North	New informatics platform (developed by Glintt) - integrating all previous information and offering decision making support	Renewing the information system of the hospital	2011	5
Hospital Santa Maria Maior	Barcelos	Public	North	Multidisciplinary team for risk awareness	Structural / Other organizational innovations	2012	3,5
Centro Hospitalar Do Alto Ave	Guimaraes	Public	North	Restructuration of the informatic services - certification ISO 2000 (article)	Renewing the information system of the hospital	2012	3,5
				Portuguese Quality Indicator Project (measurement of previous performance and highlighting errors)	Increasing the diffusion of knowledge among the hospital personnel	2012	4
Centro Hospitalar Do Tâmega E Sousa	Penafiel	Public	North	New informational systems: Medsoft, Mac Web, Datacenter, Esteris	Renewing the information system of the hospital	2011 - 2012	3
Unidade Local De Saúde De Matosinhos	Matosinhos	Public	North	Informatics system SISU and Business Intelligence Platform	Renewing the information system of the hospital	2009; 2010	3,5
				Integrated contabilistic communication	Increasing the diffusion of knowledge	2011	2
				Aligning organizational systems to an electronic model (including prescriptions, front office and pharmacy communications)	Structural / Other organizational innovations	2011	3
Hospital São João	Porto	Public	North	jOne software users database, Clinical Intelligence national database of patients, syndroms, etc	Increasing the diffusion of knowledge among the hospital personnel	2012	5
				APDIC – Arquivo e Preservação Digital de Informação Clínica	Renewing the information system of the hospital	2011	3,5
Centro Hospitalar Do Porto	Porto	Public	North	Financial ERP Informatical System; passing for an electronical informational system	Renewing the information system of the hospital	2009	3
				Organizational Accreditation for a safe and integrated system	Structural / Other organizational innovations	2011	4
Ipo Porto	Porto	Public	North	Improving the logistic solutions inside the hospital	Structural / Other organizational innovations	2011	2
				Implementation of the RORENO informational system related to cancer rates and evolution	Increasing the diffusion of knowledge	2008 - 2010	4
				Oasis Integrated Informational System for Hospital Management	Renewing the information system of the hospital	2008 - 2009	3,5
Centro Hospitalar Vila Nova De Gaia	Vila Nova De Gaia	Public	North	Critical Care management software	Renewing the information system of the hospital	2009	3
Centro Hospitalar Entre O Douro E Vouga	Sta Maria Da Feira	Public	Center	Organizational reorganization due to fusion of more items in the health care center	Structural / Other organizational innovations	2009	3
				Creation of a central modern data-center with complex functionalities	Renewing the information system of the hospital	2010	2,5
Centro Hospitalar Tondela Viseu	Viseu	Public	Center	Implementation of an internal control system and strict monitorization of financial performance	Structural / Other organizational innovations	2010	2,5

				Organizational Innovation			
				Innovation	Type	Year	Degree
Centro Hospitalar Universitario De Coimbra	Coimbra	Public	Center	Defining new informational structures and assistencial models	Structural / Other organizational innovations	2012	3,5
Ipo Coimbra	Coimbra	Public	Center	Information systems helping dynamize the processes: SIGIC, ALERT PI, etc	Renewing the information system of the hospital	2009	2,75
Hospital Distrital Da Figueira Da Foz	Figueira Da Foz	Public	Center	Uniformization of informatics systems	Renewing the information system of the hospital	2010	2
Centro Hospitalar Do Médio - Tejo	Torres Novas	Public	Lisbon and Valley of Tejo	Reorganization of the administrative structure in the health care center and departments	Structural / Other organizational innovations	2012	2,5
Centro Hospitalar Lisboa Central	Lisbon	Public	Lisbon and Valley of Tejo	Reorganizing the informational system: electronic prescriptions, Pyxis, Docbase electrocardiography, etc.	Renewing the information system of the hospital	2012	2,75
Centro Hospitalar De Lisboa Ocidental	Lisbon	Public	Lisbon and Valley of Tejo	Creating of a datacenter for disaster recovery	Renewing the information system of the hospital	2011-2012	2,75
Ipo Lisboa	Lisbon	Public	Lisbon and Valley of Tejo	Reorganization of spaces, human resources and informatics systems	Structural / Other organizational innovations	2013	2
Hospital Cuf Infante Santo	Lisbon	Private	Lisbon and Valley of Tejo	Creation of new administrative and process monitoring jobs; Reorganization of front office personnel	Structural / Other organizational innovations	2012	2
Hospital Cuf Descobertas	Lisbon	Private	Lisbon and Valley of Tejo	Reorganization of the administrative structure in Front Office	Structural / Other organizational innovations	2012	2
				Project 'Factura na hora' for administrative reorganization and better bookkeeping	Renewing the information system of the hospital	2012-2013	2,5
Hese Evora - Hospital Da Misericordia (Partnership With Grupo Espirito Santo Saude)	Evora	Public/ Private	South	Integral electronic databases	Renewing the information system of the hospital		3
Hospital De Faro	Faro	Public	South	Requalification and reorganization of the administrative structure inside every department	Structural / Other organizational innovations	2012	2,5
				GO-TIC informatics platform	Renewing the information system of the hospital	2011	2,75
Centro Hospitalar Barlavento Algarvio	Portimao	Public	South	Reorganization of different internal services (external consultation, logistics, information policy)	Structural / Other organizational innovations	2011	2

Annex 2 – Performance data collected from hospital reports

							Operational				Financial			
				Nº beds	Nº employees	Influence area - population	Readmission rate adjusted to risk %	Occupation rate %	Average duration of hospitalization (days)	**Satisfaction %**	EBITDA (000 EUR)	Assets (000 EUR)	Net income (000 EUR)	ROA
Hospital São Marcos	Braga	PPP	North	705	2.265	380.000	1,08	87,7	6,1	81,3	1.704	60.618	1.293	0,021
Hospital Santa Maria Maior	Barcelos	Public	North	124	491	154.645	1,7	81,74	7,13	81,7	-524	9.714	-526	-0,054
Centro Hospitalar Do Alto Ave	Guimaraes	Public	North	525	1.735	327.366	1,00	82,75	7,23	85,8	-7.386,0	109.081,0	-4.331,0	-0,040
Centro Hospitalar Póvoa Do Varzim/Vila Conde	Povoa Varzim	Public	North	143	658	142.941	1	83	5,65	-	-1.590,4	9.229,5	-2.254,7	-0,244
Clipovoa Hospital Privado	Povoa Varzim	Private	North	-	-	220.000	-	-	-	-	-373,5	43.227,0	-	-
Centro Hospitalar Do Tâmega E Sousa	Penafiel	Public	North	480	1.651	519.722	1,22	83,5	6,92	84,3	-5.495,9	113.458,6	-5.517,5	-0,049
Unidade Local De Saúde De Matosinhos	Matosinhos	Public	North	380	2.198	184.000	1,9	91,1	7	85,2	-4.954,8	149.449,7	-4.432,5	-0,030
Hospital São João	Porto	Public	North	1.083	5.464	300.000	1,4	84,23	7,96	88,9	1.225,0	330.256,0	1.005,7	0,003
Centro Hospitalar Do Porto	Porto	Public	North	774	2.229	1.623.800	0,84	84,9	6,85	86,9	-272,3	134.680,0	-5.293,8	-0,039
Ipo Porto	Porto	Public	North	319	1.981	1.800.000	2,1	82,9	8,2	90,7	3.720,0	400.600,0	9.283,6	0,023
Hospital Cuf Porto	Porto	Private	North	144	382	1.800.000	0,47	-	5,52	81	-9.076,1	22.923,1	-9.087,2	-0,396
Centro Hospitalar Vila Nova De Gaia	Vila Nova De Gaia	Public	North	550	3.198	688.000	1,25	88	7,9	-	-1.868,9	186.644,9	-3.883,0	-0,021
Hospital Da Arrabida	Vila Nova De Gaia	Private	North	-	-	688.000	-	-	-	-	7.607,6	61.996,6	5.545,5	0,089
Centro Hospitalar Entre Douro E Vouga	Sta Maria Da Feira	Public	Center	384	1.448	145.000	2	78,6	5,3	88,1	-1.950,0	99.508,0	-1.935,0	-0,019
Centro Hospitalar Tondela Viseu	Viseu	Public	Center	636	2.189	282.829	0,75	80,89	8,05	81,2	-1.459,8	97.100,0	-4.210,0	-0,043
Cliria Hospital Privado	Aveiro	Private	Center	-	-	125.000	-	-	-	-	-327,8	2.300,9	322,0	0,014
Centro Hospitalar Cova Da Beira	Covilha	Public	Center	317	1.255	93.549	1,6	83	7,69	86,2	-8.941,0	84.084,8	-9.752,0	-0,116
Centro Hospitalar Universitario De Coimbra	Coimbra	Public	Center	2.279	7.671	319.400	1,7	79,35	8,51	-	-32.875	199.167	-32.909	-0,165

							Operational				Financial			
				Nº beds	Nº employees	Influence area - population	Readmission rate adjusted to risk %	Occupation rate %	Average duration of hospitalization (days)	Satisfaction %	EBITDA (000 EUR)	Assets (000 EUR)	Net income (000 EUR)	ROA
Ipo Coimbra	Coimbra	Public	Center	236	942	319.400	0,7	69	7,3	93,7	3.400,0	90.039,0	1.694,6	0,019
Hospital Distrital Da Figueira Da Foz	Figueira Da Foz	Public	Center	144	647	75.000	2,2	78,2	7,36	83,4	-3.878,3	25.012,3	-3.884,4	-0,155
Centro Hospitalar Leiria Pombal	Leiria	Public	Center	503	1.488	400.000	1,15	75,9	6,24	78,6	-1.715,5	67.633,5	-1.728,2	-0,026
Centro Hospitalar Do Médio - Tejo	Torres Novas	Public	Lisbon/Valley of Tejo	478	1.839	233.463	1,57	83,7	7,73	83,7	-17.794,0	86.400,0	-17.500,0	-0,203
Hospital Do Mar	Bobadela	Private	Lisbon/Valley of Tejo	-	-	200.000	-	-	-	-	291,7	1.366,9	182,8	0,134
Centro Hospitalar Lisboa Central	Lisbon	Public	Lisbon/Valley of Tejo	1.462	7.590	378.986	1,16	80,8	9,1	88,3	-26.484	218.688	-26.517	-0,121
Centro Hospitalar De Lisboa Ocidental	Lisbon	Public	Lisbon/Valley of Tejo	862	3.863	993.000	0,87	78,4	8,8	85,4	-9.728	159.738	-9.747	-0,061
Ipo Lisboa	Lisbon	Public	Lisbon/Valley of Tejo	257	1.808	993.000	1,9	82,8	6,7	91,2	-3.116,0	152.470,0	-9.300,0	-0,061
Hospital Cuf Infante Santo	Lisbon	Private	Lisbon/Valley of Tejo	142	943	993.000	0,81	-	5	82	2.129,4	77.521,8	470,1	0,006
Hospital Cuf Descobertas	Lisbon	Private	Lisbon/Valley of Tejo	141	978	993.000	0,63	-	4,8	80	11.369,8	87.235,4	6.945,6	0,080
Hospital Da Luz	Lisbon	Private	Lisbon/Valley of Tejo	-	-	993.000	-	-	-	-	23.052,9	42.449,0	17.279,2	0,407
Hospital Dr, Fernando Da Fonseca	Amadora Sintra	Public	Lisbon/Valley of Tejo	749	2.570	587.000	1,22	82,1	6,4	-	-7.836,5	434.737,5	-7.852,4	-0,018
Hese Evora - Hospital Da Misericordia	Evora	PPP	South	331	1.455	168.900	0,9	69,1	7,8	-	-1.586,3	49.454,7	-1.609,3	-0,033
Centro Hospitalar Do Baixo Alentejo	Beja	Public	South	229	1.750	126.690	0,89	73,3	7,11	86,6	-3.664,2	86.075,9	-7.706,2	-0,090
Hospital De Faro	Faro	Public	South	583	2.443	450.000	1,19	87,7	7,3	-	-2.016	418.269	-5.523	-0,013
Centro Hospitalar Barlavento Algarvio	Portimao	Public	South	326	1.545	164.000	1,25	88,8	8,7	81,6	-1.184,2	47.986,0	-6.231,0	-0,130

Annex 3 - Outputs for Principal Components Analysis

Service innovation

Rotated Component Matrix[a]

	Component			
	1	2	3	4
ServiceIntroducingnewproceduresoftreatment	-,111	-,024	-,178	,977
ServiceIntroducingnewtechnicalequipment	,992	,074	-,008	-,106
ServiceSaferconditionsoftreatment	,074	,993	-,084	-,022
ServiceQualitycontinuousimprovementofservices	-,008	-,088	,980	-,177

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	1,405	35,125	35,125
2	1,220	30,489	65,614
3	,799	19,965	85,579
4	,577	14,421	100,000

Extraction Method: Principal Component Analysis.

Process innovation

Rotated Component Matrix[a]

	Component		
	1	2	3
ProcessQualitycontinuousimprovementofprocesses	-,089	,143	,986
ProcessIncreasingthespeedofpatientprocessingandcare	-,086	,986	,143
ProcessDecreasingthevariablecostsofpatientprocessingand	,993	-,084	-,088

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	1,443	48,086	48,086
2	,847	28,242	76,328
3	,710	23,672	100,000

Extraction Method: Principal Component Analysis.

Organizational innovation

Rotated Component Matrix[a]

	Component		
	1	2	3
OrganizationalRenewingtheinformationsystemofthehospital	,972	,013	,234
OrganizationalIncreasingthediffusionofknowledgeamongthe	,236	-,062	,970
OrganizationalStructuralOtherorganizationalinnovations	,012	,998	-,057

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	1,467	48,897	48,897
2	1,005	33,514	82,411
3	,528	17,589	100,000

Extraction Method: Principal Component Analysis.

Annex 4 - Composite Measures for each hospital (and innovation type)

Service innovation

% Var. explicada	0.351247986	0.304893851	0.199653134	0.144205029
	Component 1	Component 2	Component 3	Component 4
Service innov 1	-.111	-.024	-.178	.977
Service innov 2	.992	.074	-.008	-.106
Service innov 3	.074	.993	-.084	-.022
Service innov 4	-.008	-.088	.980	-.177
Hospital 1	3.517505927	0.918396034	2.023321611	3.422266271
Hospital 2	0.577541758	1.853960404	-0.087750011	4.559796151
Hospital 3	0.926564026	0.747449175	3.033255915	0.253257154
Hospital 4	0.614585956	0.884290383	0.174873621	3.604721757
Hospital 5	3.609041402	3.624210948	0.480315581	0.351922212
Hospital 6	0.597971142	0.708538907	2.135416356	3.2510163
Hospital 7	0.929637766	0.779963198	2.670555509	0.318692663
Hospital 8	0.929637766	0.779963198	2.670555509	0.318692663
Hospital 9	2.994664887	2.009157837	1.590770302	0.261531484
Hospital 10	0.763804454	0.744251052	2.402985932	1.784854482
Hospital 11	0.929637766	0.779963198	2.670555509	0.318692663
Hospital 12	0.763804454	0.744251052	2.402985932	1.784854482
Hospital 13	0.669863726	0.896194432	0.26406348	3.116001151
Hospital 14	0.725141497	0.90809848	0.353253339	2.627280545
Hospital 15	0.725141497	0.90809848	0.353253339	2.627280545
Hospital 16	2.929460951	1.103555458	0.694742849	0.46075103
Hospital 17	2.929460951	1.103555458	0.694742849	0.46075103
Hospital 18	0.725141497	0.90809848	0.353253339	2.627280545
Hospital 19	0.669863726	0.896194432	0.26406348	3.116001151
Hospital 20	0.669863726	0.896194432	0.26406348	3.116001151
Hospital 21	0.614585956	0.884290383	0.174873621	3.604721757
Hospital 22	2.708349868	1.055939264	0.337983414	2.415633455
Hospital 23	3.589398512	1.106051559	0.151968735	3.287251122
Hospital 24	0.929637766	0.779963198	2.670555509	0.318692663
Hospital 25	4.141599167	4.157910203	0.434376143	0.287827031
Hospital 26	0.614585956	0.884290383	0.174873621	3.604721757
Hospital 27	2.673252498	0.997199622	1.676922957	0.310354188
Hospital 28	2.681559905	1.08507536	0.69665159	0.487206917
Hospital 29	0.559308185	0.872386335	0.085683763	4.093442363
Hospital 30	0.687808773	3.344177581	-0.214115883	4.526245924
Hospital 31	3.107968639	1.072186415	0.178975579	3.213095537
Hospital 32	3.896142915	0.913848635	3.62792199	-0.1756307
Hospital 33	3.572783698	0.930300082	2.11251147	2.933545665
Hospital 34	0.914836581	3.508349697	1.591989625	2.300492702

Process innovation

% Var. explicada	0.480862234	0.282418973	0.236718793
	Component 1	Component 2	Component 3
Process innov 1	-.089	.143	.986
Process innov 2	-.086	.986	.143
Process innov 3	.993	-.084	-.088
Hospital 1	0.422607027	3.374828668	3.790970919
Hospital 2	0.616270977	1.367022482	3.258599418
Hospital 3	0.638629248	1.331241301	3.012185508
Hospital 4	0.683345788	1.259678938	2.519357689
Hospital 5	0.817495411	1.044991851	1.040874232
Hospital 6	0.638629248	1.331241301	3.012185508
Hospital 7	0.817495411	1.044991851	1.040874232
Hospital 8	0.638629248	1.331241301	3.012185508
Hospital 9	0.508259867	2.388816166	3.647992123
Hospital 10	0.683345788	1.259678938	2.519357689
Hospital 11	0.549196166	1.474366026	3.997841146
Hospital 12	1.810076744	0.960846474	0.95311403
Hospital 13	0.638629248	1.331241301	3.012185508
Hospital 14	2.802658077	0.876701097	0.865353828
Hospital 15	0.817495411	1.044991851	1.040874232
Hospital 16	0.817495411	1.044991851	1.040874232
Hospital 17	0.817495411	1.044991851	1.040874232
Hospital 18	0.817495411	1.044991851	1.040874232
Hospital 19	0.728062329	1.188116576	2.02652987
Hospital 20	0.556756649	3.160141581	2.312487462
Hospital 21	0.638629248	1.331241301	3.012185508
Hospital 22	0.593912707	1.402803663	3.505013327
Hospital 23	2.306367411	0.918773785	0.909233929
Hospital 24	0.552976408	2.317253803	3.155164304
Hospital 25	2.623791913	1.162950547	2.836665104
Hospital 26	1.810076744	0.960846474	0.95311403
Hospital 27	0.593912707	1.402803663	3.505013327
Hospital 28	0.728062329	1.188116576	2.02652987
Hospital 29	0.292237646	4.432403533	4.426777534
Hospital 30	0.549196166	1.474366026	3.997841146
Hospital 31	0.549196166	1.474366026	3.997841146
Hospital 32	0.638629248	1.331241301	3.012185508
Hospital 33	3.075366039	1.192440221	3.285612822
Hospital 34	0.552976408	2.317253803	3.155164304

Organizational innovation

% Var. explicada	0.488971837	0.335143133	0.17588503
	Component 1	Component 2	Component 3
Organizat. Innov 1	.972	.013	.234
Organizat. Innov 2	.236	-.062	.970
Organizat. Innov 3	.012	.998	-.057
Hospital 1	3.16368096	0.976758173	1.615622782
Hospital 2	1.231131422	1.948102023	1.090557662
Hospital 3	1.219476652	0.949780251	1.147283375
Hospital 4	1.219476652	0.949780251	1.147283375
Hospital 5	2.920655422	0.973385933	1.557080356
Hospital 6	4.356891222	0.79741121	4.642225783
Hospital 7	1.219476652	0.949780251	1.147283375
Hospital 8	1.236958807	2.447262909	1.062194806
Hospital 9	3.19864527	3.971723488	1.445445645
Hospital 10	3.16368096	0.976758173	1.615622782
Hospital 11	2.698025731	2.717076793	1.399267933
Hospital 12	1.219476652	0.949780251	1.147283375
Hospital 13	2.920655422	0.973385933	1.557080356
Hospital 14	1.219476652	0.949780251	1.147283375
Hospital 15	1.236958807	2.447262909	1.062194806
Hospital 16	1.219476652	0.949780251	1.147283375
Hospital 17	1.219476652	0.949780251	1.147283375
Hospital 18	2.191578806	0.963269212	1.381453078
Hospital 19	2.689284653	1.968335464	1.441812218
Hospital 20	1.231131422	1.948102023	1.090557662
Hospital 21	1.219476652	0.949780251	1.147283375
Hospital 22	1.219476652	0.949780251	1.147283375
Hospital 23	1.219476652	0.949780251	1.147283375
Hospital 24	2.938137577	2.47086859	1.471991787
Hospital 25	2.191578806	0.963269212	1.381453078
Hospital 26	1.219476652	0.949780251	1.147283375
Hospital 27	3.16368096	0.976758173	1.615622782
Hospital 28	1.248613577	3.445584681	1.005469094
Hospital 29	4.59261095	0.735380729	5.612065166
Hospital 30	5.107885268	1.003736095	2.083962189
Hospital 31	2.949792347	3.469190362	1.415266075
Hospital 32	1.231131422	1.948102023	1.090557662
Hospital 33	4.368545992	1.795732982	4.585500071
Hospital 34	3.885451765	0.921472172	2.702547017

Annex 5 – SPSS Outputs for H3 testing

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Serviceglobalmeasure is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,472	Retain the null hypothesis.
2	The distribution of Processglobalmeasure is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,306	Retain the null hypothesis.
3	The distribution of Organizationalglobalmeasure is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,339	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Test Statistics[a,b]

	Serviceglobal measure	Processgloba lmeasure	Organizationa lglobalmeasu re
Chi-Square	2,519	3,619	3,366
df	3	3	3
Asymp. Sig.	,472	,306	,339

a. Kruskal Wallis Test

b. Grouping Variable: Region_Cod

H3 for all measures of innovation

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Service Introducingnewproceduresoftreatment is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,459	Retain the null hypothesis.
2	The distribution of Service Introducingnewtechnicalequipment is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,451	Retain the null hypothesis.
3	The distribution of ServiceSaferconditionsoftreatment is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,897	Retain the null hypothesis.
4	The distribution of Service Qualitycontinuousimprovementofservices is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,952	Retain the null hypothesis.
5	The distribution of Process Qualitycontinuousimprovementofprocesses is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,343	Retain the null hypothesis.
6	The distribution of Process Increasingthespeedofpatientprocessingandcare is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,327	Retain the null hypothesis.
7	The distribution of Process Decreasingthevariablecostsofpatient processingand is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,775	Retain the null hypothesis.
8	The distribution of Organizational Renewingtheinformationsystemofthe hospital is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,143	Retain the null hypothesis.
9	The distribution of Organizational Increasingthediffusionofknowledgeamongthe is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,069	Retain the null hypothesis.
10	The distribution of OrganizationalStructural Otherorganizationalinnovations is the same across categories of Region.	Independent-Samples Kruskal-Wallis Test	,840	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Test Statistics[a,b]

	ServiceIntroducingnewproceduresoftreatment	ServiceIntroducingnewtechnicalequipment	ServiceSaferconditionsoftreatment	ServiceQualitycontinuousimprovementofservices	ProcessQualitycontinuousimprovementofprocesses	ProcessIncreasingthespeedofpatientprocessingandcare	ProcessDecreasingthevariablecostsofpatientprocessingand	OrganizationalRenewingtheinformationsystemofthehospital	OrganizationalIncreasingthediffusionofknowledgeamongthe	OrganizationalStructuralOtherorganizationalinnovations
Chi-Square	2,593	2,634	,595	,343	3,333	3,453	1,109	5,422	7,076	,840
df	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	,459	,451	,897	,952	,343	,327	,775	,143	,069	,840

a. Kruskal Wallis Test

b. Grouping Variable: Region_Cod

Annex 6 – SPSS Outputs for H4 testing

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Serviceglobalmeasure is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,601	Retain the null hypothesis.
2	The distribution of Processglobalmeasure is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,402	Retain the null hypothesis.
3	The distribution of Organizationalglobalmeasure is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,020	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Test Statistics[a,b]

	Serviceglobal measure	Processgloba lmeasure	Organizationa lglobalmeasu re
Chi-Square	1,019	1,823	7,845
df	2	2	2
Asymp. Sig.	,601	,402	,020

a. Kruskal Wallis Test

b. Grouping Variable: Property_Cod

Each node shows the sample average rank of TypeProperty.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
PRIVATE-PUBLIC	-10.438	3.993	-2.614	.009	.027
PRIVATE-PPP	15.000	7.733	1.940	.052	.157
PUBLIC-PPP	4.562	7.199	.634	.526	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

H4 for all measures of innovation

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Service Introducingnewproceduresoftreatment is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,289	Retain the null hypothesis.
2	The distribution of Service Introducingnewtechnicalequipment is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,501	Retain the null hypothesis.
3	The distribution of ServiceSaferconditionsoftreatment is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,203	Retain the null hypothesis.
4	The distribution of Service Qualitycontinuousimprovementofservices is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,011	Reject the null hypothesis.
5	The distribution of Process Qualitycontinuousimprovementofprocesses is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,160	Retain the null hypothesis.
6	The distribution of Process Increasingthespeedofpatientprocessingandcare is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,722	Retain the null hypothesis.
7	The distribution of Process Decreasingthevariablecostsofpatient processingand is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,751	Retain the null hypothesis.
8	The distribution of Organizational Renewingtheinformationsystemofthe hospital is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,028	Reject the null hypothesis.
9	The distribution of Organizational Increasingthediffusionofknowledgeamongthe is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,401	Retain the null hypothesis.
10	The distribution of OrganizationalStructural Otherorganizationalinnovations is the same across categories of TypeProperty.	Independent-Samples Kruskal-Wallis Test	,302	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Test Statistics[a,b]

	ServiceIntroducingnewproceduresoftreatment	ServiceIntroducingnewtechnicalequipment	ServiceSaferconditionsoftreatment	ServiceQualitycontinuousimprovementofservices	ProcessQualitycontinuousimprovementofprocesses	ProcessIncreasingthespeedofpatientprocessingandcare	ProcessDecreasingthevariablecostsofpatientprocessingand	OrganizationalRenewingtheinformationsystemofthehospital	OrganizationalIncreasingthediffusionofknowledgeamongthe	OrganizationalStructuralOtherorganizationalinnovations
Chi-Square	2,480	1,381	3,188	8,994	3,669	,652	,574	7,131	1,825	2,397
df	2	2	2	2	2	2	2	2	2	2
Asymp. Sig.	,289	,501	,203	,011	,160	,722	,751	,028	,401	,302

a. Kruskal Wallis Test

b. Grouping Variable: Property_Cod

Each node shows the sample average rank of TypeProperty.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
PPP-PRIVATE	.000	6.945	.000	1.000	1.000
PPP-PUBLIC	-9.917	6.466	-1.534	.125	.375
PRIVATE-PUBLIC	-9.917	3.587	-2.765	.006	.017

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

ServiceQualitycontinuousimprovementofservices * TypeProperty(Test 4)

Each node shows the sample average rank of TypeProperty.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
PRIVATE-PUBLIC	-8.688	3.793	-2.290	.022	.066
PRIVATE-PPP	15.812	7.345	2.153	.031	.094
PUBLIC-PPP	7.125	6.838	1.042	.297	.892

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

OrganizationalRenewingtheinformationsystemofthehos... * TypeProperty(Test 8)

Each node shows the sample average rank of TypeProperty.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
PRIVATE-PUBLIC	-8.688	3.793	-2.290	.022	.066
PRIVATE-PPP	15.812	7.345	2.153	.031	.094
PUBLIC-PPP	7.125	6.838	1.042	.297	.892

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

OrganizationalRenewingtheinformationsystemofthehos... * TypeProperty(Test 8)

Annex 7 – Paper submitted to the *International Competitiveness Management Conference* – COMPETICON

Does innovation influence the performance of medical care organizations?

Mãdãlina Gherman

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Paulo Sérgio Amaral de Sousa

Abstract

Innovation is a widely studied field, given its importance for any organization who wishes to achieve and maintain a competitive advantage in the market. The research question this study revolves around is: does innovation influence performance in medical care? We are going to answer that, as well as analyze the influence that service, process and organizational innovation have on the performance of the health care units.

The study is performed through a quantitative analysis on 34 Portuguese hospitals. As a parallel investigation, the hospitals are divided by type of property and geographical region they belong to and comparative tests are performed to test the existence of differences. The study finds that organizational innovation is correlated to process innovation, and one measure of organizational innovation is correlated with a measure of service innovation. Furthermore, service and process innovation both have a unit of measure which influences operational performance; however, we cannot conclude that innovation in medical care units has an overall impact in their financial performance.

1. Introduction

The relation between the implementation of innovation and performance, and the amount in which the first determines the latter has been subject to several studies during past years (Irwin *et al*, 1998; Naranjo-Gil, 2009; Dias and Escoval, 2013; Caiado and Neto, 2013). These researches span from product concerned industries (manufacturing - Gunday *et al*, 2011) and service ones (profit orientated enterprises - Prajogo *et al*, 2013) to health care units (Leidner *et al*, 2010). The services field is an area of special interest due to the particularities of the introduction of innovations and the way they are embedded in the organization (Länsisalmi *et al*, 2006). While for broader industries a more general model is used in the assessment of the innovation impact on performance, allowing for all types of correlations and links between the two sides (Gunday *et al*, 2011), for health care units in study the range of measures is narrowed by the specificity of the hospital, the type of innovation or the type of innovation in study.

From a theoretical point of view, this research contributes to the existing literature in this field, giving further insight into whether there is a binding relation between the acquisition of innovative technology, reorganization of processes and organizational practices – and performance (measured in a financial and operational way). From a practical point of view, having information like this might help hospitals make better decisions into their innovation policy design.

2. Research background and hypotheses

2.1. The concept and types of innovation

Innovation is the creation and adoption of new ideas, or, generally, of something new – (Gopalakrishnan and Damanpour, 1997). The adoption of innovation can be the direct result of managerial choice or can be imposed by external conditions.

Research at the organizational level offers insights into the role innovation plays in managing organization-wide concerns, such as adaptability to the environment, capacity to allocate resources to innovative (*vs* operative) programs or activities, and overall organizational outcomes and effectiveness (Gopalakrishnan and Damanpour, 1997). As a tested hypothesis, Gopalakrishnan's article states that organizations with greater economic health invest more in innovation, partly because they can afford to take more risk and can more easily absorb the cost of failure.

Gunday depicts in his study (2011) the groups of innovations and their main characteristics:

Table 1 – Types of innovation, adapted from Gunday *et al.* (2011)

Type of innovation	Brief description
Product/ service innovation	Introduction of a new product/service or changes to existing products/services in terms of characteristics, specifications, uses, etc. Tends to be rather incremental than radical, as a response to a customer need, rather than anticipating an unformulated need Support activities innovations are developed around the product Service innovations are commonly implemented but are easier to imitate and less noticeable by customers
Process innovation	Implementation of new or improved production or delivery methods, for the purpose of cost reduction or higher quality
Organizational innovation	Implementation of a new organizational method in the firm's business practice, administrative organization or external relations e.g. a new way of organizing the databases
Marketing innovation	Implementation of a new or significantly changed marketing method

The Oslo Manual (2005) states that it is important – for data collection purposes – to have the innovations be clearly enclosed in one innovation type, though it might prove difficult at times, as some innovations have characteristics spanning more than one type. As far as the impact of innovations on firm performance, the effects range from sales growth to increase in productivity and efficiency. It is important to know which are the innovations (and type of innovations) that succeed in improving the firm performance as they are of central importance for future company policy making (Oslo Manual, 2005). Although incremental innovations are more often than radical ones, radical innovations are more positively associated with performance – by bringing something completely new, they send the right signals about the company's innovative capability on the market (Oke, 2007).

Innovation in healthcare is subject to particularities that derive from its unique nature as well as from its status as a public organization (public health care units only). It is a more complicated

process, due to the fact that innovative practices have to be tested before being permanently introduced, as well as to their adoption being regulated by laws, making changes more laborious. The pressure is on both the hospitals' side and on the governments', as public authorities are constantly trying to reduce healthcare costs while improving quality (Länsisalmi *et al.*, 2006).

Halvorsen *et al.* (2005) makes an in-depth analysis of the innovation in the public sector. According to him "*a factor that seriously complicates any study of the dynamics of innovation in the public institutions considered in this project is the lack of simple and clear cut relations between the private objectives of the organisation and its owners and incentives for and rewards from innovation*" (Halvorsen *et al.*, 2005). Simply put, the profit motivation that the private sector stand for, while the public one not-so-entirely, has a big impact in their decisions of whether to invest or not in innovation. The customer's perception is brought into attention too, arguing that in the private sector the correlation between price and quality is, of course, found important by people, while in the public sector, they have to make complex decisions when it comes to choosing their social services or health care provider. A phrase from the article that perfectly sums the public - private sector contrast is "For the private sector, the creation of new demands is a welcome market opportunity; for public services it is a political challenge".

Innovations in healthcare organizations are typically new services, new ways of working or new technologies (Länsisalmi *et al.*, 2006). From the patient's point of view, the intended benefits are either better health or less suffering due to illness. From an organizational point of view, the desired benefits are often enhanced efficiency of internal operations and/or the quality of patient care (Faulkner and Kent, 2001). Thankur *et al.* (2012) summarize innovation in healthcare as "*those changes that help healthcare practitioners focus on the patient by helping healthcare professionals work smarter, faster, better and more cost effectively*" (p. 564)

Analyzing the differences in healthcare innovation between public and private hospitals, but also between regions of the same country, Bonastre *et al.*'s (2014) research studies the case of the acquisition of expensive anti-cancer drugs in French hospitals (a service/ treatment innovation), grouping them by region and property type. Results reveal there is a difference in expenditure for expensive innovation between private and public hospitals at first, but then, when adjusted to the Case-Mix of the hospitals, it is not significant; there is no difference in the expenditure between regions. This led to the conclusion that equal access is provided (in France) to innovative solutions. But such differences in access to healthcare exist in countries with social inequalities, like Brasil, as Noronha and Andrade's (2002) study reveals. Here, privileged social categories get access to better health care than lower income groups. Glied and Lleras-Muney (2003) offer further insight into this issue, by correlating social inequalities (in the case of their study, in the U.S.) with educational level, arguing that educated people are likely to better take advantage of technological innovations in healthcare than their less educated counterparts.

Technology is a key driver of innovation in healthcare (Omachonu and Einspruch, 2010). Leider's (2010) examination of technological-informational innovation in hospitals enumerates seven information-based innovations in health care and the operational benefits they bring; however, not all units are too keen and quick in adopting these organizational changes, fact explained by a "misalignment of costs and benefits - many systems intended for healthcare providers offer benefits to patients and insurance companies, but not necessarily the providers themselves." (Shekelle et. al. 2006, as quoted in Leider, 2010). The human factor is, as always, a strong determinant of implementing organizational innovations - the strategic leadership, the staff attitude and the hospital's climate being associated with informational innovations. The article (Leider, 2010) studies also the contribution of organizational IT innovation in the overall IT impact of the hospitals, the latter which has a positive association with the performance of the health care unit.

For healthcare, innovation is therefore crucial. "*However, there is a need for solid performance measurement and impact assessment to depict its contribution to the efficiency of health care delivery, patient- and other stakeholder satisfaction and the overall performance of the health care system*" (Cucciniello and Nasi, 2013).

In the light of the above discussions, we can elaborate 4 hypotheses related to innovation in healthcare:

H1: The higher the level of organizational innovation, the higher the level of service innovation.

H2: The higher the level of organizational innovation, the higher the level of process innovation.

H3: There is a difference between the level of innovation in public hospitals and the level of innovation in private hospitals.

H4: There is a difference between the hospitals' level of innovation depending on their geographical localization.

2.2. Performance and performance measurement

Although it is widely used with meanings varying from robustness to return on investment, Lebas (1995) argues in his study that performance is not only a measure of past achievements, but foremost for "the potential for future successful implementation of actions in order to reach objectives and targets" (Lebas, 1995, p. 23-24). It is the key concept that makes the link between the questions: 'Where have we been?' 'Where are we now?' 'Where do we want to go?' 'How are we going to get there?', from one side and 'How will we know we got there?', on the other. Summarizing all these in one question only: 'What do we measure?' – introducing the concept of performance measurement. Although in general lines, the objectives of performance measurement are setting targets, time frames and concrete ways to achieve them, translating these steps differs for every industry, type of organization, etc.

Gunday *et al.* (2011) summarizes a very extensive model of corporate performance measures, given in the table below.

Table 2 – Performance measures, from Gunday *et al*. (2011)

Type of performance measures	**Measures**
Innovative performance	Composite construct based on indicators like no. of new patents, new products, new processes, new projects, R&D etc.
Production performance	Production cost Production speed Volume flexibility Conformance quality
Market performance	Market share Sales Customer satisfaction
Financial performance	General profitability Return on assets Return on sales Cash flow (excluding investments)

Relative performance of different sized companies can be compared through the use of financial ratios. Depending on the public or private nature of the organization, overall (organizational) performance can mean more than financial ratios, though. Compared to traditional enterprise performance measurement, public sectors not only have economic, profit-

bearing attributes, but also "non-economic obligations of environmental benefits and social benefits, which needs to set performance targets to balance multiple objectives, multi-agent interests" (Zhongua and Ye, 2012, p.795). Markets, market shares and scales, organizational goals and strategies, organizational types, structures and systems, organizational management level, culture, commitment and decision-making autonomy are factors which impact the public sector performance (Zhongua and Ye, 2012). Therefore, adequate methods for assessing performance are required. Benchmarking (imitating then exceeding) is a method used in several relevant studies, followed by systematic assessment, data envelopment analysis (return on investment as key ratio) and balanced scorecards (due to the multiple interests and targets, social and economic).

Studies use the most suitable method for their need to correlate performance with its determinant factors, which they are looking to test. In the healthcare area, though, key points should be pinpointed as being factors of core differentiation from business/profit orientated companies – performance, although defined in explicit goals that must be met, must include a quality study, as it is not just an objective assessment of numbers, but includes judgements of value and quality from the part of the end users of the service – the patients (Oslo Manual, 2005).

Referring to health care measures of performance, Berg *et al*. (2005) distinguish between internal and external measures, depending on who they are important to: the health care unit (internal measures – reflecting financial performance, efficiency etc.) or the external public and authorities (external measures, related to the quality of the services provides, an essential aspect of performance in health care). For this, they conducted a study to form measures of performance which led in the end to the elaboration of a standard set of measures based on operativity in different contexts (emergency room, controls, operability with different conditions etc). Several other studies look for the measuring of performance in healthcare use similar measures – data by hospital sectors (care units) in terms of quality: efficiency in treatment, satisfied patients, speed in responding to emergency situations etc. Caiado and Neto's article proposes for example as suitable measures, the numbers of readmissions 5 days after the end of treatment as proxy for quality of service, the access to services (area covered and number of first consults), assistencial performance and financial performance. Amado and Santos (2009) use similar measures in their study, which they categorize under the names of equity of access, efficiency, service effectiveness and cost effectiveness. To do so, they explain the need to use different models to correctly measure different dimensions of performance.

On what concerns the practical way to measure the hospital performance outcomes, as seen in most studies and summarized by the Oslo manual (2005), the most common ways to do so are by patients satisfaction survey, statistical data, regulatory inspections and third-party assessment.

Having now completed the theoretical basis about the concepts of innovation and performance, we can define two more hypotheses related to the connection between innovation and performance:

H5: The higher the level of organizational innovation (H3a), service innovation (H3b) and process innovation (H3c), the higher the level of service (operational) performance.

H6: The higher the level of service (operational) performance, the higher the financial performance.

3. Methodology and data

This study is performed on 34 Portuguese hospitals. Given the degree of complexity of the data that is the subject of the research, concerning both types of innovations implemented in the hospitals as well as operational, financial and marketing performance, the method employed for collecting it was a survey to the literature. The years in analysis were 2008-2012 in terms of

innovations implemented (due to the tedious nature of innovations it can take up to several years for the change to propagate and start having effects) and 2012 in terms of performance (or the latest data available about operational and market performance measures).

The Portuguese health care system is characterized by three coexisting systems: the National Health Service (NHS), special social health insurance schemes for certain professions (health subsystems) and voluntary private health insurance. Despite the public/ private mix, primary care is mainly delivered in the NHS health centers (Simões, 2012). Recently, in order to ensure the sustainability of this service, some user fees at the end of the treatments were implemented (Frayer, 2012).

In 2009, Portugal had 186 hospitals, with 35.593 beds. Recently, from 2010 onwards, several public hospitals (belonging to the NHS) have suffered organizational changes, transitioning from autonomous entities into health care centers grouping 2 or more hospitals in the same region, serving a population located in the same close geographical areas. While public hospitals are still major suppliers of health care in Portugal, the private sector is constantly growing, accounting nowadays for almost 40% of the health care delivered in the country, according to APHP statistics (the Portuguese Association of Private Hospitals).

Based on the similar studies and the key aspects they measured, the variables that were studied are:

2) Innovation variables
a) Service innovation: introduction of new treatments, introduction of new (innovative) equipment and machinery, improvement of quality of treatments/ services, increasing the safety of the patients;
b) Process innovation: improving the quality of processes, increasing the speed of patient processing, decreasing the variable costs of patient processing;
c) Organizational innovation: improving/ reorganizing the informational system of the hospital, diffusing the knowledge amongst staff, other organizational innovations (usually related to reorganization of departments of roles of staff in the administrative scheme).
3) Performance variables
a) Operational performance: number of readmissions after the end of treatment (adjusted to risk), beds occupation rate, average admission duration;
b) Financial performance: net income, assets, profits and return on assets (ROA);
c) Market performance: overall patient satisfaction.

The innovation information was found either on the sites of the Hospitals / Health care units or in their reports. Their classification into either Service, Process of Organizational innovation has been made according to their purpose and scope. Some of these innovations were explicitly mentioned in the reports or on the sites, others not, being mentioned in reports in categories like: Activity of the year... Assistencial activity... etc. As defined at the beginning of this study, innovation is the generation of something new, therefore innovation has been recognized in the reports or site where not being explicitly denominated.

The classification of the degree of innovation has been made on a scale from 1 to 5, with the following meanings: 1 = innovation not implemented (information about it not found in the sources); 2 = improvement of current (previous) services/ processes/ organizational structures; 3 = implementation of new services/ processes/ etc. imitated from the national health system; 4 = implementation of new services/processes/etc imitated from the international health system; 5 = implementation of totally new services/ processes/ etc. This is therefore a gradual differentiation between incremental (2) and disruptive (5) innovation. As disruptive innovations are, at their purest, complete novelties in the world, they are very rare to find (but not impossible) between the units from our sample. A grade of 4 marks already a disruptive innovation in the territory of Portugal.

The operational performance measures were taken from the hospitals' activity reports, as well as patients' overall satisfaction, representing the measure for market performance, was extracted

from a report issued by the Ministry of Health for the public hospitals, and from health care groups' reports for the private ones.

As far as the financial performance measures are concerned, they were extracted directly from the financial reports (balance sheets and cash flows statements) or extracted from the Sabi Bureau van Dijk database (https://sabi.bvdinfo.com), which provides financial information about Portuguese hospitals, considering them as Companies.

4. Analysis and findings

For purposes of studying if the level of innovation and of performance is affected by location of the hospital or type of property, we have grouped them. By the type of property, they are public (EPE entities), private or Private-Public Partnership (PPP). By region, the hospitals belong to one of the 4 regions: North, Center, Lisbon and Valley of Tejo and South. From the sample of 34 entities, 24 are public hospitals, 8 are private and 2 are Private-Public Partnerships; 13 of the hospitals studied belong to the North region, 8 to the Center one, 9 are localized in the Lisbon and Valley of Tejoarea and 4 are in the South region of Portugal.

Following the completion of the database, the first results calculated were the average values for the main categories of innovation and performance. The hospitals were grouped by localization and by type and the averages were calculated for each group.

4.1. Descriptive analysis

In terms of introduction of new treatments, the hospitals in the north of the country are the most innovative (score 3,115 out of 5), followed by the ones in the Lisbon and South region (with equal averages of 2,5) and lastly the Center region (2,171). The public hospitals have mostly average scores, between 1,5 and 2,5, the private ones score higher in new procedures/ treatments, average in new equipment and machinery and no innovations belonging to safety of procedures and continuous quality improvement. The PPP entities score the highest in new procedures and safer procedures, while new technical equipment and continuous improvement of quality services have not been undergone.

We should point out the mean values of the innovation in procedures and treatments as standing out compared to the other types of service innovation; with a mean of 3,115 in the North region, and 2,5 in the Lisbon and South region, it is safe to say Portuguese hospitals are innovative on overall when it comes to keeping constantly up to date with the latest procedures and treatments in the national and international scene.

As far as process innovations are concerned, the overall values are lower than the ones in service innovations. The improvement of the quality of processes is the most sough-after innovation by hospitals, with average values between 2,063 and 2,885, decreasing from north to south of the country. Public and PPP hospitals are more preocupied about increasing the quality of their processes than the private ones. The most common ways of innovating in quality of processes are the accreditations hospitals get which recognize and differentiate their outstanding quality of processes from other hospitals'.

Finally, on what concerns the last type of innovation, the organizational one, renewing the informational systems represents the main innovation effort of the hospitals, especially in the North region. It is a more significant effort for the PPP hospitals and the least for the private ones.

Other organizational innovations have been observed in a low rate on hospitals throughout the country, without differentiation of types or geographical region.

Besides the description of each measure of innovation inside each type, it is important to obtain a composite (global) measure representative of each type of innovation. We employed the Principal Component Analysis (PCA) to obtain a representative measure for each type of

innovation. Principal Component Analysis is, usually, a method of variable reduction. In this research, we employed it to compute a composite variable for each type of innovation. In the case of Service innovation, we collected, from the reports surveyed, 4 different ways of innovating; for Process and Organizational innovation, 3 measures for each. By using the PCA, we found appropriate weights for each measure to construct a composite (global) measure. After employing this method, the following composite global measures for innovation have been obtained (Table 3).

Table 3 - Global measures for innovation (means) (N=34)

	Service Innovation	Process Innovation	Organizational Innovation
Region			
North	1,624	1,665	2,307
Center	1,491	1,429	1,631
Lisbon and Valley of Tejo	1,534	1,384	1,687
South	1,169	1,248	1,681
Property Type			
Private	1,379	1,325	1,297
Public	1,568	1,557	2,072
PPP	1,426	1,281	2,419

We can see that the composite global measures for all three types of innovations are not very high, most of them having a global score lower than 2, with the exception of organizational innovation in northern hospitals and in public and PPP hospitals. The composite global averages are lower than the simple averages for each section, meaning several hospitals have scored higher degrees in subsections with a lower weight in the total measure than in the ones with a heavier weight.

The Center region is the one where the most service innovative hospital is found, while the North region hosts the most process innovative as well as the most organizational innovative hospital. In terms of type of property of the hospital, the public sector holds the most innovative hospital in all three categories. As far as minimums are concerned, there are overall hospitals with the same minimum values in all regions of the country, both public, private, or PPP. The organizational innovation holds higher numbers in terms of maximum and minimum global composite values than the other two types of innovation, being reflected in a similar way as is was in terms of mean global composite values.

Table 4 - Average performance measures (average per Region and Property), Data referring to year 2012, source Sabi database and hospital reports (N=34)

	Operational			**Market**	**Financial**			
	Readmission rate adjusted to risk (%)	Occupation rate (%)	Avg duration of hospitalization (days)	Satisfaction (%)	EBITDA (000 EUR)	Assets (000 EUR)	Net income (000 EUR)	ROA
Region								
North	1,31	84,98	6,95	85,1	-1714,2	125529,2	-1516,4	-0,061
Center	1,44	77,85	7,21	85,2	-5968,4	85730,6	-6550,3	-0,062
Lisbon and Valley of Tejo	1,17	81,56	6,93	85,1	-3123,9	140067,4	-5115,4	0,018
South	1,06	79,73	7,73	84,1	-2112,7	150446,4	-5267,4	-0,066
Property Type								
Private	0,64	---	5,107	81,00	4334,3	45002,6	3094,0	0,048
Public	1,38	81,86	7,380	85,87	-5891,2	154584,3	-6627,1	-0,069
PPP	0,99	78,40	6,950	81,30	58,7	55036,6	-157,9	-0,006

As far as performance is concerned, the averages displayed in Table 4 show some significant differences, especially when it comes to differentiating by type of hospital. Financially, the public hospitals are quite under performant, with an average loss per hospital of almost 6 million EUR in 2012. Almost all public hospitals have negative values, the average being raised by the few that have positive values. On the other hand, the private hospitals present on average positive gains, while the PPP are aproximately breakeven on average. The public hospitals weigh more on the value of assets, though, whose value is aproximately triple the value of private or PPP hospitals' assets (not surprising, given the bigger size of public units).

The same ranking in terms of performance (Private > PPP > Public) is observed when it comes to operational performances as well. Private hospitals have both a lower rate of readmission adjusted to risk and a lower average duration of hospitalization compared to the public and PPP ones.

It is interesting to notice that patients' satisfaction (market performance) is higher in the case of public hospitals than the private or PPP ones. It happened probably because their scoring decision was affected by the cost of the service, which shaped their expectations differently - a similar overall experience in a private and public hospital leading to a lower scoring for the first. This would be the subject of a psychological study, though, while we are aiming to explore objectively the performance results here.

From the perspective of the region they belong to, the North region differentiates itself as being the one with the least financial losses (of aprox. 1,7 millions of EUR per unit on average), as opposed to the Center region, which has the highest losses registered (almost 6 million EUR on average per unit of analysis). The South region has the lowest rate of readmissions, followed by the Lisbon region, the North one and lastly the Center. The North and Lisbon region have a lower duration of hospitalization on average than the Center and South regions, while, as far as satisfaction of patients, there are not big differences between the regions.

4.2. Hypotheses testing

H1: The higher the level of organizational innovation, the higher the level of service innovation.

We want to analyse the dependence (correlation) between the organizational innovation and the service innovation. According to Maroco (2010), the suitable test is the correlation, using the Spearman rho. The general form of the null hypothesis (H0) is: "There is no association between the organizational innovation and service innovation" (i.é, Spearman's rho = 0) against the hypothesis that "There is a correlation between the two variables" (rho $\neq$ 0).

Considering a significance level of 5% (or 1%), the null hypothesis is retained (the significance here is 7,4%). We can not conclude, in the case of the analysed Portuguese hospitals, that an organizational innovation implies a service innovation. This result is in accordance with the study of Gunday (2011), which reveals there is not a significant association between the level of organizational innovation and product/ service innovation, in the case in the case of production/ manufacturing firms. This can be due to the existence of other variables that determine the service innovation that render the effect of the organizational innovation minimum.

We want to test not only if the composite global measure of organizational innovation is correlated to the global service innovation measure, but also its components, therefore we formulate hypothesis H1a, as follows:

H1a: The higher the level of organizational innovation measured by i, the higher the level of service innovation measured by j, i= Renewing the information system of the hospital; Increasing the diffusion of knowledge among the hospital personnel; Structural organizational innovations and j= Introducing new procedures of treatment; Introducing new technical equipment; Safer conditions of treatment; Quality continuous improvement of services.

Table 5 - Correlations between Service and Organizational innovation (1-tailed Spearman's rho)

		Organizational: Renewing the information system of the hospital	Organizational: Increasing the diffusion of knowledge	Organizational: Structural organizational innovations
Service: Introducing new procedures of treatment	Correlation Coefficient	0,231	**0,343***	-0,205
	Sig. (1-tailed)	0,094	**0,024**	0,122
Service: Introducing new technical equipment	Correlation Coefficient	0,064	-0,053	0,073
	Sig. (1-tailed)	0,359	0,382	0,342
Service: Safer conditions of treatment	Correlation Coefficient	**0,337***	0,068	-0,039
	Sig. (1-tailed)	**0,026**	0,351	0,414
Service: Quality - continuous improvement of services	Correlation Coefficient	0,206	0,194	0,133
	Sig. (1-tailed)	0,121	0,136	0,227

Legend: Bold numbers represent significant correlations (* significant at 5% level)

We can see from the analysis of Table 5 that the measure of Service innovation "*Introducing new procedures of treatment*" is correlated with the Organizational measure "*Increasing the diffusion of knowledge*". In fact, the rho between the two variables is 0,343, being this correlation significant at the 0,05 level (1 tailed). We can reject the null hypothesis of no association between the two variables. We can explain this by the fact that a higher knowledge amongst the staff in terms of what is new and performance (shortly: innovative) in the medical world leads to a higher determination to make use of those innovations in terms of treatments and procedures.

The other pair that is significantly correlated is the Service measure "*Safer conditions of treatment*" and the Organizational measure "*Renewing the information system of the hospital*" (correlation = 0,337, significant at 5%). As technological innovations are mostly electronic softwares and means of help that come to replace the likes of: manual records of patients, intensive care units surveillance, communication between patient and physician, and others, and lead to: reduced errors in prescription; reduced waiting times, reduced hospitalization from improved disease management etc. (all in the view of Leidner *et al*, 2010), we can see how this type of innovation is related with the increase in the safety of patient treatments. We would have expected, nevertheless, to see a positive association between the organizational informational systems innovation and the quality improvement of services. The correlation is not significant though.

All the other associations, in fact, are not significant (at 5%). Concerning the stated hypothesis we can conclude that not all types of organizational innovation imply a service innovation.

H2: The higher the level of organizational innovation, the higher the level of process innovation.

This hypothesis is similar to the previous one. The Spearman rho coefficient will be used to assess the relation between the two kinds of innovations. Considering a significance level of 1% we can reject the null hypothesis. It means that the correlation between the two types of innovation is positive with a significant level of 1%. The rho=0,454, as it is far from 0 (rho=0 means no correlation) but also not very close to 1 or -1) means that the variables are correlated.

We can conclude that when the organizational innovation increases in a hospital, the process innovation also increases in a correlation of about a half (0,454). This result is in line with the study of Gunday (2011), who also finds a correlation between organizational and process innovation, in that case even higher, of 0,698 - a quite strong positive link between the two

measures. Organizational innovation is considered by Gunday a "preparatory field" for the other types of innovation, and according to our findings, it does give space for development to process innovation. We can bring into attention here a similar explanation as the one given in the case of the previously seen association between organizational informational innovation and safety of treatments; IT innovations in healthcare - by replacing manual, less precise work, with its electronic performant counterpart - contribute for a better, safer, quicker, less expensive processing of patients - all of which are aspects of process innovation.

As done previously in hypothesis H1a, we can analyse the behaviour of the several measures of innovation in study.

H2a: The higher the level of organizational innovation measured by i, the higher the level of process innovation measured by j, i= Renewing the information system of the hospital; Increasing the diffusion of knowledge among the hospital personnel; Structural organizational innovations and j= Quality, continuous improvement of processes; Increasing the speed of patient processing and care; Decreasing the variable costs of patient processing and care

The Spearman rho coefficient is the adequate test to assess the relation between the several measures of the two kinds of innovations. Table 6 contains the correlations among all them.

Table 6 – Correlations between Process and Organizational innovation (1-tailed Spearman's rho)

		Organizational: Renewing the information system of the hospital	Organizational: Increasing the diffusion of knowledge	Organizational: Structural organizational innovations
Process: Quality - continuous improvement of processes	Correlation Coefficient	**0,579****	**0,301***	0,270
	Sig. (1-tailed)	**0,000**	**0,042**	0,061
Process: Increasing the speed of patient processing and care	Correlation Coefficient	**0,377***	**0,327***	0,136
	Sig. (1-tailed)	**0,014**	**0,030**	0,222
Process: Decreasing the variable costs of patient processing	Correlation Coefficient	-0,127	0,105	-0,188
	Sig. (1-tailed)	0,237	0,278	0,143

Legend: Bold numbers represent significant correlations (* significant at 5% level, ** significant at 1%)

As it was to be expected, the correlation by components reflects the result of the correlation. The measure of Process innovation "*Quality - continuous improvement of processes*" is correlated with the Organizational measure "*Renewing the information system of the hospital*". In fact, the rho between the two variables is 0,579, being this correlation significant at the 0,05 (and 0,01) level (1 tailed). We can reject the null hypothesis of no association between the two variables. This shows that an upgrade in the informational systems of the Portuguese hospitals contributes to the overall improvement in the quality of processes (and to obtaining quality standards certifications and awards).

The other pairs that are significantly correlated are the Process innovation "*Quality - continuous improvement of processes*" and Organizational measure "*Increasing the diffusion of knowledge*" (correlation = 0,301, significant at 5%), Process measure "*Increasing the speed of patient processing and care*" and Organizational measure "*Renewing the information system of the hospital*" (correlation = 0,377, significant at 5%) and the pair "*Increasing the speed of patient processing and care*" - "*Increasing the diffusion of knowledge*" (correlation = 0,327). This can be explained by the fact that, in Portuguese hospitals, the organizational aspects are streamlined and reflecting in the functioning of processes; while as always, even in closely correlated measures, the change of one is not as deeply reflected in the change of the other, here the correlation level between an organizational change (innovation) and a change/ innovation in the processes of the health unit is of about a third (~0,33 on average).

Structural organization innovations are not significantly associated with process innovation components, nor are the decreasing variable costs of patient processing and care explained by organizational innovations.

H3: There are differences, concerning the level of innovation, between the hospitals depending on the geographical region.

To analyse and test this result we use the Kruskal-Wallis[3] non-parametric test, that allows to test if there are differences with statistical significance between the medians of the degree of hospital innovations in each region. All tests with a *p-value* $\leq \alpha$=0,05 are considered statistically significant.

The test returned a p-value higher than 0,3 for all 3 tests, therefore the null hypothesis is retained for every type of innovation. This means that we cannot conclude that there are differences concerning the degree of innovation between the regions where the hospitals are located in. Consequently, nothing can be said about the impact of the region on the innovation degree.

A more complete analysis is done by analysing the hypotheses considering not the composite measure, but each measure of innovation type. The tests lead to the same results, the null hypothesis being retained for all measures. It stresses the previous conclusion that we cannot conclude that the region influences the innovation effort. This confirms the results of the French study of Bonarte *et al.* (2014), which concluded the geographical localization of the French hospitals did not exert an influence on the implementation of innovative treatments (in our study, we have seen there is not an influence of localization on the other types of innovations either). This can be explained by the similarity of Portugal and France in terms of equal overall economical development of the geographical regions.

H4: There are differences, concerning the level of innovations, between the hospitals depending on the type of property.

This hypothesis, in terms of analysis is similar to the previous one. We start by doing the Kruskal-Wallis test, to assess if there are differences with statistical significance between the medians of the degree of hospital innovations in each property type.

The results of the testing point organizational innovation as the only one that allows us to reject the null hypothesis. This means that there are differences concerning the degree of organizational innovation between the Public, Private and PPP hospitals. In order to determine the group that has the higher level, we need to do the post hoc tests for the Kruskal-Wallis omnibus test. Through the pairwise comparisons, we can conclude that in the case of the analysed Portuguese hospitals, and concerning the degree of organizational innovation, there are differences between the public and private. Moreover, given the global composite values we have previously got, we can say that the public hospitals are the ones that have a higher degree of organizational innovation.

We can explain this difference based on the structural changes that the public hospitals have passed through in the past 5 years - the organization of independent hospitals into EPE health care centers (that was mentioned in the chapter 2.3) leading to major changes in management structures, overall organization and the need to merge different informational systems, patient databases and overall, align different systems into one. Such an alignment could have likely asked for a renewal in IT platforms and structural innovations in the public hospitals. On the other hand, private hospitals are overall newer than the public ones, and beneficiate since their opening of the latest performant informational systems (so these are not considered

[3] The Kruskal-Wallis test, tests the null hypothesis that the distribution of the dependent variable values are similar in the *k* populations, against the alternative hypothesis that there are least one population where the distribution of the dependent variable is different of one distribution of the other populations under study.

innovations); the public hospitals often need to "catch up" when it comes to the latest technologies, implementing them over time.

We cannot conclude anything concerning the service and process innovation, given the significance level higher than 5%.

For an in-depth analysis, we are analysing here too the hypotheses considering not the composite measure but each measures of innovation type. The null hypothesis is rejected in the case of two measures of innovation: the continuous improvement of the quality of services and the renewal of informational systems in the hospitals. We can conclude that in the case of those two types of innovation, there are differences between the hospitals depending on whether they are public, private or PPP. Proceeding, as in the previous case, to do the post hoc tests for the Kruskal-Wallis test, we see that the same public – private hospitals pair is the one that presents differences in the case of the service innovation measure. In the case of the organizational informational innovation, although the Kruskal-Wallis test rejected the hypothesis of no difference between the three groups, the pairwise comparison revealed no significant differences between any two of the groups. Based on the averages shown in the descriptive analysis, for the continuous improvement of the quality of services, public hospitals lead in terms of innovation, this being in fact a subtype of service innovation that was not implemented in any of the analysed private hospitals (mean=1).

The null hypothesis is retained in the case of all the other types of innovation, therefore we cannot say the property of the hospital plays a role on their degree of innovation.

H5: The higher the level of organizational innovation (H3a), service innovation (H3b) and process innovation (H3c), the higher the level of operational performance i; i= Readmission rate adjusted to risk; Occupation rate; Average duration of hospitalization (days).

All the 3 hypothesis are analysed using the same test. The general form of the null hypothesis (H0) is: "There is no association between the organizational innovation (H3a), service innovation (H3b), process innovation (H3c) and the Operational performance.

Table 7– Correlations between global measures of the 3 types of innovation and operational performance (1-tailed Spearman rho)

		Operational Perf: Readmission rate adjusted to risk (2012)	Operational Perf: Occupation rate (2012)	Operational Perf: Avg. duration of hospitalization (days) (2012)
Service composite measure	Correlation Coefficient	**0,410***	0,168	0,131
	Sig. (1-tailed)	**0,014**	0,206	0,249
	N	**29**	26	29
Process composite measure	Correlation Coefficient	0,337*	**0,493****	-0,091
	Sig. (1-tailed)	0,037	**0,005**	0,319
	N	29	**26**	29
Organizational composite measure	Correlation Coefficient	0,085	0,312	0,051
	Sig. (1-tailed)	0,330	0,061	0,396
	N	29	26	29

Legend: Bold numbers represent significant correlations (* significant at 5% level, ** significant at 1%)

The service innovation is correlated with the *Readmission rate adjusted to risk* (rho=0,410, sig=0,005). Strangely, the correlation is positive, meaning an increase in one of the measure is associated with an increase in the other. Is it that a higher innovation in the services offered by the hospitals (treatments, procedures, etc.) leads to a higher rate of readmissions? It could happen in the case of procedures of such novelty that the shorter or longer time effects could not

be foreseen. But on the other hand, a higher rate of readmission (therefore a negative operational performance) could in fact lead to a higher innovation in services, in order for the innovative services to provide better care that would lead to a lower number of complications and readmissions. When looking from this perspective on the relation, it makes much more sense.

In the case of the *Occupation rate*, it is correlated with the process innovation composite measure (rho=0,493, sig.=0,005). The level of association is high, meaning that when one increases, the other increases too. On average, when a hospital invests more in process innovation, it results in an increase of their occupation rate. This goes to show people are ready to embrace innovation, but on overall occupation rates should not exceed limits of around 85% as hospitals should always have free spaces for emergency cases.

Finally, if we consider the operational measure *Average duration of hospitalization*, none of the innovation types are associated to this performance. We can also conclude that the organizational innovation (measured by the composite variable) is not correlated with any of the operational performance measures. We retain the null hypothesis stated for H3a.

H6: The higher the level of operational performance, the higher the financial performance.

Similar to the way we have tested the previous hypotheses, we use a 1-tailed Spearman test to correlate the operational performance (divided into its 3 measures) and the financial performance (and its 4 components). Table 8 shows the results of the test.

Table 8 – Correlations between operational and financial performance component measures (1-tailed Spearman rho)

		Financial Perf: EBITDA 000EUR (2012)	Financial Perf: Assets 000EUR (2012)	Financial Perf: Net income 000EUR (2012)	Financial Perf: ROA (2012)
Operational Perf: Readmission rate adjusted to risk (2012)	Correlation Coefficient	-0,147	0,224	-0,129	-0,116
	Sig. (1-tailed)	0,223	0,122	0,253	0,275
	N	29	29	29	29
Operational Perf: Occupation rate (2012)	Correlation Coefficient	0,047	0,202	-0,069	0,111
	Sig. (1-tailed)	0,409	0,161	0,369	0,295
	N	26	26	26	26
Operational Perf: Average duration of hospitalization (days) (2012)	Correlation Coefficient	-0,226	**0,347***	**-0,318***	-0,259
	Sig. (1-tailed)	0,120	**0,033**	**0,046**	0,088
	N	29	**29**	**29**	29

Legend: Bold numbers represent significant correlations (* significant at 5% level, ** significant at 1%)

The only statistically significant correlations between operational and financial measures of performance are the correlations between the *Average days of hospitalization* and the *Value of Assets* (correlation = 0,347) and *the same operational measure* and *value of the net income* (correlation = - 0,318). The first of these two correlations is quite surprising, as the two measures have no apparent direct connexion. The second correlation though, the negative one, can be explained more easily by the fact that a longer average duration of hospitalization per patient means increased costs for the hospitals, therefore lowering their net income.

Going through a long stream of connecting variables, we have identified a correlation between organizational innovation and process innovation (not with the service innovation though). At the same time, service innovation and process innovation have somewhat of a connection with 2 of the 3 operational performance measures we have studied. But the only operational measure

that has an impact in the financial numbers of the hospitals is the third one (average duration of hospitalization). By association, then, innovation has not been proved to have an impact on the financial performance of the hospitals. Of course the nature of hospitals is not profit making, therefore the financial measures, although important, are not the most relevant when it comes to make a complete description of the situation of a certain hospital (especially dealing with public entities).

5. Conclusions and recommendations

This study reports on the dimensions and types of innovation in Portuguese hospitals, as well as looking into their performance measures and correlating the two areas.

Analyzing the innovation database we have put up altogether, we have found out that in terms of service innovations, hospitals tend to innovate the most in the introduction of new procedures/ treatments (in terms of the other types of innovations we can not note striking differences in their averages). The North region and the Lisbon and Valley of Tejo are the leading ones in overall innovation, reflecting in fact their leadership in most sectors in Portugal. But the geographical location of the hospitals throughout Portugal does not have an effect on the innovations implemented, as we have checked testing hypothesis H3, which was infirmed (our conclusion was in line with the finding of the somewhat similar Bonarte *et al.*'s 2010 study, given that Portugal is a country with no real different development of its regions). The tests have proven there are differences between the overall level of innovation between public and private hospitals, and averages show us there are also differences in certain subtypes of innovation.

Big differences are noticed in the financial performance of the hospitals by property types - public hospitals are under performant (negative results), private ones are performant (positive results) and PPP are break even. This is not a striking result, as private hospitals are in fact more profit-oriented than the public ones, charging accordingly for their services, while delivering top care to the patients. In terms of payment of the health services, situations are becoming somewhat confusing nowadays, are public hospitals charge some tariffs that, while lower than the ones practiced by the private entities, can become more expensive when not compensated by the health insurances. We assume the difference in terms of price is still a differentiating factor in terms of patient satisfaction evaluation (market performance), as they have evaluated public hospitals higher than the private ones. Operationally, the private hospitals are performing better as well.

The hypotheses testing revealed there is no significant positive correlation between the level of organizational innovation and the level of service innovation - global measures; but there is a correlation, not very strong, between one component of organizational innovation and one component of service innovation. There is, on the other hand, a correlation of almost half between organizational and process innovation, reflected also at the level of their components.

As far as the correlation between innovation itself and performance, service innovation and process innovation are correlated connection with 2 of the 3 operational performance measures (readmission rate adjusted to risk and occupation rate). But the only operational measure that has an impact in the financial numbers of the hospitals is the third one (average duration of hospitalization), leading therefore to the information of the hypothesis that there could be an association between innovation and the financial performance of the hospitals.

This study was limited by a number of factors, out of which we can enumerate:

- the lack of more comprehensive data;
- the particular nature of hospitals, particularly the public ones which benefit from public sponsorship and capital subsidizing and are not mainly directed towards profit making; great investments in modern innovative machinery may take years to see itself

generating a profit in the financial statements and even so, it is difficult to assess directly the role of the equipment in the generation of cash flows;

- difficulty in quantitating the data and assessing degrees of innovation;
- possibility that innovativeness in one area does not reflect in all the hospital (in the operational, financial and satisfaction results);
- possibility that some hospitals are a 'one wonder' case - they have a big breakthrough after which they do not continuously improve/ innovate;
- possibility that some newer hospitals were innovative since the beginning and did not need to implement a lot of innovations in the years in study, obtaining a low score, while other older hospitals have updated over the years and obtained points for innovation, while only reaching a similar level to the first ones;
- the implementation of innovations can take years to have visible results;
- impossibility of doing a first hand (direct) study through survey due to the very dense nature of information and difficulty in finding the right man-source

For further studies that want to deepen the understanding of the subject, for finding out the specific impact of innovation in a complete system that determines performance, our recommendation is to make a regression model. For accuracy, though, all or at least the major determinants of performance must be inserted in the equation. Such a study would have to look into great depth into performance measurement and gather the data for all measures that influence/ determine performance significantly (including measures that are not as easy to quantify, as the path and strength of the leadership, etc). Such a model may turn out very complex, which is probably why there aren't such studies performed as of yet (most studies relating innovation in healthcare to performance resorting to correlations or clusters analysis).

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