Does Innovation Influence the Performance of Healthcare Organizations?

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Innovation is a widely studied field, given its importance for any organization wishing to achieve and maintain a competitive advantage in the market, even though assessing the impacts of innovation represents a challenge due to the difficulty of isolating and measuring it. Furthermore, healthcare institutions are facing an increasing need for innovation in order to become competitive and offer new treatments for patients. Surprisingly, little is known about the nature of innovativeness in healthcare organizations and its relationship with performance. The aim of this research is to analyse whether the several types of innovation influence the relevant measures of performance in healthcare institutions, researching empirically the innovativeness–performance relationship. The study is based on a quantitative analysis on 34 Portuguese hospitals, collecting detailed information about the innovation portfolio of each one. Factor analysis and hypothesis testing were applied. Moreover, the hospitals were classified by type of property and geographical region they belong to, and statistical comparative tests were performed to test the existence of statistical differences. It was found that organizational innovation is correlated with process innovation and service innovation. Furthermore, service and process innovations influence operational performance. However, we cannot conclude that innovation in healthcare units has an overall impact on their financial performance. The results of this study may help hospital administrators to make better decisions with regard to their innovation policy design.

Key words: Innovation, performance measures, healthcare, hospitals

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Introduction

The relation between innovation and performance, and the extent to which the first determines the latter, has been the object of several studies over the past few years (e.g., Dias and Escoval, 2013; Irwin *et al.*, 1998; Kimberly, 1978; Labitzke *et al.*, 2014; Naranjo-Gil, 2009). These studies range from product-related industries (manufacturing - Gunday *et al.*, 2011) and service industries (e.g., Naranjo-Gil, 2009; Prajogo *et al.*, 2013) to health care units (Chen *et al.*, 2014; Dias and Escoval, 2013; Hernandez *et al.*, 2013; Leidner *et al.*, 2010; Tsai, 2013). The services field is of special interest due to the particularities of introducing innovations and the way they are embedded in the organization (Länsisalmi *et al.*, 2006). While for manufacturing firms a more general model is used to assess the impact of innovation on performance (Gunday *et al.*, 2011), for health care units the range of measures is narrowed by the specificity of the hospital or the type of innovation considered.

From a theoretical point of view, this research contributes to the existing literature, providing further insight into whether there is a binding relationship between the acquisition of innovative technology, reorganization of processes and organizational practices, and performance (financial and operational). From a practical point of view, this information may help hospitals to take better decisions with regard to their innovation policy design.

Conceptual Framework

The concept, types of innovation and innovation in health care

Innovation is the creation and adoption of new ideas or, generally speaking, of something new (Gopalakrishnan and Damanpour, 1997). 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).

Gunday *et al.* (2011) define the types of innovation and their main characteristics, summarized in Table 1.

The Oslo Manual (OECD, 2005) states that it is important – for data collection purposes – to have the innovations clearly allocated to one innovation type, even though it might prove difficult at times, as some innovations have characteristics spanning more than one type. The impact of innovations on firm performance can range from sales growth to increases in productivity and efficiency. It is important to identify the innovations (and type of innovations) that succeed in improving firm performance as they are of central importance to future company policy-making (Oslo Manual). Although incremental innovations are more frequent 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).

Table 1. Types of innovation

Type of innovation	Brief description
Product/service innovation	• Introduction of a new product/service or changes to existing ones in terms of characteristics, specifications, uses, etc. • Tends to be more incremental than radical, as a response to a customer need, rather than anticipating an unformulated need. • Service innovations are commonly implemented but are easier to imitate and less noticeable to 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 databases)
Marketing innovation	• Implementation of a new or significantly changed marketing method

Innovation in health care is subject to particularities that derive from its unique nature, in addition to 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 and their adoption has to be regulated by laws (Herzlinger, 2006). There is pressure both on the hospitals and on the government, as public authorities are constantly trying to reduce health care costs while improving quality (Länsisalmi *et al.*, 2006). Innovations in health care 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 standpoint, the desired benefits are often the enhanced efficiency of internal operations and/or the quality of patient care (Faulkner and Kent, 2001). Thakur *et al.* (2012) summarize innovation in health care 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)

Halvorsen *et al.* (2005) conduct an in-depth analysis of innovation in the public *versus* private sector. The profit motivation of the private sector has a big impact in their decisions about whether to invest in innovation or not, while the public sector does not have this motivation. The customer's perception is also brought to play, arguing that in the private sector the correlation between price and quality is considered important by people, while in the public sector, customers have to make complex decisions when it comes to choosing their social services or health care provider.

Analysing the differences in health care innovation between public and private hospitals, Harrington and Voehl (2010) describe a set of 'best practices' along with how the process of innovation is developing in the health care system. Bonastre *et al.* (2014) studied the case of the acquisition of expensive anti-cancer drugs in French hospitals (a service/treatment innovation), grouping them by region and property type. They concluded that equal access is provided to innovative solutions. But differences in access to health care exist in countries with social inequalities, like Brazil, as Noronha and Andrade (2002) pointed out.

Glied and Lleras-Muney (2003) offer further insight into this issue, by correlating social inequalities (in the case of their study, in the United States) with educational level, arguing

that educated people are more likely to take better advantage of technological innovations in health care than their less educated counterparts. Schultz *et al.* (2012) analyse the German health care system to investigate the key determinants of size and innovativeness. They found that although incentives for human resources increased the degree of innovativeness of activities, the reward systems did not have a direct impact on innovativeness.

Technology is a key driver of innovation in health care (Omachonu and Einspruch, 2010). Leidner *et al.*'s (2010) examination of technological-informational innovation in hospitals identified seven information-based innovations in health care and the operational benefits they bring; however, not all units are as keen and quick to adopt these organizational changes, a fact explained by a misalignment of costs and benefits. The human factor is a strong determinant of implementing organizational innovations – strategic leadership, staff attitudes and hospital environment are closely associated with information innovations.

Innovation is therefore crucial for health care. "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, 2014, p.96). More recently, Cucciniello *et al.* (2015) show the importance of coordination in introducing innovation in the health care sector.

In light of the above discussion, we propose the following hypotheses with regard to innovation in healthcare:

Hypothesis 1: The higher the level of organizational innovation, the higher the level of service innovation.

Hypothesis 2: The higher the level of organizational innovation, the higher the level of process innovation.

Hypothesis 3: There is a difference in the hospitals' level of innovation depending on their geographical location.

Hypothesis 4: There is a difference in the level of innovation in public hospitals and the level of innovation in private hospitals.

Performance and performance measurement

Although performance is widely used with meanings varying from robustness to return on investment, Lebas (1995) argues that performance is not only a measure of past achievements, but first and foremost a measure of "the potential for future successful implementation of actions in order to reach objectives and targets" (Lebas, 1995, p. 23-24). Although in general terms, the objectives of performance measurement are setting targets, time frames and concrete ways to achieve them, translating these steps differs for every industry and type of organization.

Gunday *et al.* (2011) summarize a very extensive model of corporate performance measures, presented here in Table 2.

Table 2. Performance measures

Type of performance	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 to 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" (Zhonghua 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 public sector performance (Zhonghua and Ye, 2012). Therefore, suitable 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 and balanced scorecards.

In health care, according to the OECD (2005), key areas should be pinpointed as factors of core differentiation from business/profit-oriented 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 on the part of the end users of the service – the patients.

With regard to health care performance measures, Berg *et al*. (2005) distinguish between internal and external measures, depending on whom 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 provided). Caiado and Neto (2013) propose, as suitable measures, the numbers of readmissions 5 days after the end of treatment as a proxy for quality, access to services (area covered and number of first consults) and financial performance. Amado and Santos (2009) use similar measures, which they categorize under labels such as equity of access, efficiency, service effectiveness and cost effectiveness. Salge and Vera (2009) offer further insight into this issue, by proposing a measurement model for hospital innovativeness (in the case of their study, in England).

In practical terms, as mentioned in most studies and put forward in the Oslo Manual (OECD, 2005), hospital performance outcomes are usually measured through patient satisfaction surveys, statistical data, regulatory inspections and third-party assessment. In

light of the above discussion, we propose the following hypotheses with regard to innovation in health care:

Hypothesis 5: The higher the level of organizational innovation (H5a), service innovation (H5b) and process innovation (H5c), the higher the level of operational performance.

Hypothesis 6: The higher the level of operational performance, the higher the financial performance.

Methods

The hypotheses were tested using the Portuguese Health Care System (HCS). The Portuguese HCS 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 centres (Simões, 2012). In 2013, Portugal had 226 hospitals, with 35 503 beds available (provisional data) (Pordata, 2015). 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 - APHP, 2014).

Data

A cross-sectional study using secondary data was used to gather the research data. 2012 was set as the year of reference to analyse the several measures (of innovation and performance) because it was the year with the most (and recent) information. The sources of data were: 1) the websites of the hospitals/health care units or their public reports (to assess the innovation measures), 2) the annual report issued by the Portuguese Ministry of Health for public hospitals (PMHC, 2014), and reports from health care groups for the private sector (e.g., JMS, 2014; ESS, 2014), 3) the hospitals' financial reports (balance sheets and cash flow statements) obtained through the websites, and 4) the SABI Bureau van Dijk database (SABI, 2014). The last three sources were used to assess the performance measures.

Based on a number of similar studies and the key aspects measured (summarized in Table 3), we selected six types of variables.

The variables we studied were classified into two groups, and in each group, into three types. In the first group we included innovation variables such as: i) service innovation (measured by the introduction of new treatments, the introduction of new (innovative) equipment and machinery, and improvement in the quality of treatments/services increasing the safety of patients); ii) process innovation measured by improvement in the quality of processes, increasing the speed of patient processing and decreasing the variable costs of patient processing; and iii) Organizational innovation measured by the improvement/reorganization of the hospital's information system, the diffusion of knowledge amongst staff, and other organizational innovations (usually related to reorganization of departments).

Table 3. Methodological considerations of similar studies

Authors	Country of study	Sample size	Industry sector	Data collection	Resp. rate	Key informant	Unit of analysis
Bonastre *et. al.* (2014)	France	448	Health	Statistics and health databases	---	Statistics and health French databases	Hospital
Cucciniello and Nasi (2014)	Spain, Italy	5	Health	Survey, interviews	100%	Clinician, nurses, patients	Hospital section
Dias and Escoval (2013)	Portugal	134	Health	Survey, interviews	70%	Hospital board administrator	Hospital
Gunday *et al.* (2011)	Turkey	1674	Manufacturing	Survey, interviews	11%	Firm top or middle manager	Firm/ company
Irwin *et al.* (1998)	U.S.	220	Health	Survey, financial reports analysis	85%	Doctors, practicioners	Hospital
Leidner *et al.* (2010)	U.S.	149	Health	Survey, interviews	47%	Hospital executives	Hospital
Naranjo-Gil (2009)	Spain	218	Health	Survey, archival data	51.4%	CEOs of public hospitals	Public Hospital
Prajogo *et al.* (2013)	Australia	1500	Services	Survey	12%	Operational or strategic manager	Firm/ company

Concerning performance variables we analysed i) the operational performance (measured by the number of readmissions after the end of the treatment (adjusted to risk), the bed occupation rate, and the average duration of admission); ii) the financial performance measured by net income, assets, profits, and the return on assets (ROA); and the iii) market performance measured by overall patient satisfaction.

Measurement of Hospital Innovation

The classification of the degree of innovation was recorded 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/organizational structures emulated from the national health system; 4 = implementation of new services/processes/organizational structures emulated from the international health system; 5 = implementation of totally new services/processes/organizational structures. There 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. A grade of 4 indicates a disruptive innovation in Portugal.

Measurement of Hospital Performance

The operational and market performance measures were taken from the hospitals' activity reports, from the annual report issued by the Portuguese Ministry of Health for public hospitals (PMHC, 2014) and from reports from health care groups for the private sector (e.g., JMS, 2014; ESS, 2014). The financial performance measures were extracted directly from the hospitals' financial reports (balance sheets and cash flow statements) or from the SABI Bureau van Dijk database (SABI, 2014).

Data Analysis

As control variables, we selected hospital size (measured by the number of beds, number of staff – including doctors, nurses, administrative personnel and other staff–, and number of persons in the area covered – the district/town), hospital location and hospital property type (Pordata, 2015).

The data collected was organized in a database[1]. Our sample consists of 34 Portuguese hospitals, the number of hospitals for which we have all the required information (innovation and performance measures). Given the extent of missing data, we had to discard all the other Portuguese hospitals from our sample.

Factor analysis, hypothesis testing and correlation analysis were carried out using IBM SPSS Statistics 22.0. Moreover, the hospitals were classified by type of property and geographical region they belong to, and statistical comparative tests were performed to test the existence of statistical differences using the same software.

Findings

The hospitals have been grouped according to their location (North, Centre, Lisbon region and South) or type of property (Public, Private or Private-Public Partnership (PPP)), in order to determine whether these features affect the level of innovation and performance. In our sample, 24 hospitals are public, 8 are private and 2 are PPPs; 13 are located in the North region, 8 in Centre, 9 in the Lisbon region, and 4 in the South region of Portugal.

Innovation Measures

Table 4 contains the average values for the main categories of innovation for the variables employed in our analysis, classified by property type and region.

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 those in the Lisbon and South regions (with equal averages of 2.5), and lastly the Centre region (2.171). The public hospitals have mostly average scores between 1.5 and 2.5, whereas the private ones score higher in new procedures/treatments, but have no innovations belonging to safety of procedures and continuous quality improvement. The PPP units score the highest in new procedures and safer procedures, although they fall behind in terms of new technical equipment and continuous improvement of service quality.

As far as process innovations are concerned, the overall values are lower than 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. Public and PPP hospitals are more concerned with increasing the quality of their processes than private ones. The most common means for innovation in the quality of processes consists in the accreditations hospitals are awarded, which recognize and differentiate the outstanding quality of their processes from other hospitals.

[1] The database can be obtained from the authors upon request

Table 4. Average measures for innovation per region and property type (N=34)

		Region				Property Type		
		North	Center	Lisbon region	South	Private	Public	PPP
Service Innovation	Introducing new procedures of treatment	3.115	2.171	2.5	2.5	3	2.432	4
	Introducing new technical equipment	2.058	1.938	2.139	1	2.125	1.938	1
	Safer conditions of treatment	1.481	1.375	1.278	1.25	1	1.427	2.25
	Quality, continuous improvement of services	1.808	1.796	1.667	2	1	2.12	1
Process Innovation	Quality, continuous improvement of processes	2.885	2.438	2.308	2.063	1.955	2.719	2.833
	Increasing the speed of patient processing and care	1.538	1	1.308	1.25	1.364	1.333	1
	Decreasing the variable costs of patient processing and care	1.346	1.375	1.192	1	1.227	1.313	1
Organizational Innovation	Renewing the information system of the hospital	2.538	1.531	1.808	1.688	1.364	2.146	3
	Increasing the diffusion of knowledge among the hospital personnel	1.846	1	1	1	1	1.458	1
	Structural / Other organizational innovations	1.5	1.719	1.5	1.625	1.364	1.719	1

Finally, with regard to organizational innovation, upgrading information systems represents the main innovation effort of hospitals, especially in the North region. It is a more significant effort for PPP hospitals and the least for private ones. Other organizational innovations have been observed at low rates in hospitals throughout the country, without differentiation of types or geographical region.

Performance Measures

As far as performance is concerned, the averages displayed in Table 5 show some significant differences, especially when it comes to differentiating by type of hospital. Financially, public hospitals are rather 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. In contrast, private hospitals present positive gains on average, while the PPPs break even on average. However, public hospitals carry greater weight in terms of the value of assets, reaching approximately triple the value of assets held by private or PPP hospitals (not surprising, given the larger size of public units).

The same ranking (Private > PPP > Public) is observed when it comes to operational performance 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 hospitals.

It is interesting to note that patients' satisfaction (market performance) is higher in the case of public hospitals than private or PPP ones. It is likely that their scoring decision was affected by the cost of the service, which shaped their expectations differently – i.e., a similar experience in a private and public hospital may lead to a lower score for the first. This could

be the subject of a psychological study, but falls beyond the scope of our analysis, since we are focused here on exploring objectively the performance results.

Table 5. Average performance measures per region and property type (N=34)

		Region				Property Type		
		North	Centre	Lisbon region	South	Private	Public	PPP
Operational Performance Measures	Readmission rate adjusted to risk (%)	1.31	1.44	1.17	1.06	0.64	1.38	0.99
	Occupation rate (%)	84.98	77.85	81.56	79.73	---	81.86	78.4
	Avg duration of hospitaliz. (days)	6.95	7.21	6.93	7.73	5.107	7.38	6.95
Market Perf. Meas.	Satisfaction (%)	85.1	85.2	85.1	84.1	81	85.87	81.3
Financial Performance Measures	EBITDA (000 EUR)	-1 714	-5 968	-3 124	-2 113	4 334	-5 891	59
	Assets (000 EUR)	125 529	85 731	140 067	150 446	45 003	154 584	55 037
	Net income (000 EUR)	-1 516	-6 550	-5 115	-5 267	3 094	-6 627	-158
	ROA	-0.061	-0.062	0.018	-0.066	0.048	-0.069	-0.006

From the perspective of the region they belong to, the North region stands out as having the least financial losses (of approx. 1.7 million EUR per unit on average), as opposed to the Centre region, which registers the highest losses (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 and lastly the Centre. The North and Lisbon regions have a lower duration of hospitalization on average than the Centre and South regions, while, as far as satisfaction of patients is concerned, there are no significant differences among the regions.

Hypotheses testing

In order to test our research hypotheses we had to obtain a composite (global) measure that was representative of each type of innovation. For this purpose, we employed Principal Component Analysis (PCA). 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 (service innovation measured in 4 different ways; process and organizational innovation measured in 3 different ways each). PCA serves to quantify the contribution of each variable to explain variance in the data. Therefore, this method can be employed to obtain the weights of measures when they are to be aggregated into a single composite variable. The PCA has been used successfully to build variables and composite indexes (e.g., Greyling, 2013). In 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 IBM SPSS Statistics 22.0 software, 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 obtained; 2. for each component, use the factor loadings in the rotated component

matrix as weights to obtain an intermediate composite variable for each component; 3. weight each intermediate composite variable by its percentage of variance explained obtaining the Total Variance Explained for each principal component analysis.

After employing this method, the following composite global measures for innovation were obtained (Table 6). We can see that the composite global measures for all three types of innovation are not very high, most 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.

Table 6. Global composite measures for innovation (means) (N=34)

		Region				Property Type		
		North	Centre	Lisbon region	South	Private	Public	PPP
Composite Innovation Measures	Service Innovation	1.624	1.491	1.534	1.169	1.379	1.568	1.426
	Process Innovation	1.665	1.429	1.384	1.248	1.325	1.557	1.281
	Organizational Innovation	2.307	1.631	1.687	1.681	1.297	2.072	2.419

A suitable statistical tool to analyse the dependence between organizational innovation and service innovation (H1), and organizational innovation and process innovation (H2), is the Spearman correlation test, with rho being the correlation coefficient.

Considering a significance level of 5% (or 1%), the null hypothesis (there is no association between organizational innovation and service/process innovation, i.e., Spearman's rho=0) is rejected. Table 7 contains the correlations between the composite innovation measures.

Table 7. Correlations between composite measures of the 3 types of innovation (N=34)

		Organizational innovation	Service innovation	Process innovation
Organizational innovation	rho	1.000	0.305*	0.564**
	Sig. (1 tailed)		0.040	0.000
Service innovation	rho		1.000	0.522**
	Sig. (1 tailed)			0.001
Process innovation	rho			1.000
	Sig. (1 tailed)			

** p-value ≤ 1% *p-value ≤ 5%

Since for both H1 and H2, the correlation is positive and the p-values are, respectively ≤ 5% and ≤ 1%, we can conclude, in the case of the Portuguese hospitals analysed, that an increase in the level of organizational innovation is associated with an increase in service innovation (rho=0,305), and an increase in the level of organizational innovation is associated with an increase in process innovation, with an higher impact than the former (rho=0,564).

We can explain this by the fact that more knowledge amongst the staff about what is new (the organizational innovation measure "*Increasing the diffusion of knowledge*") leads to higher determination to make use of those innovations in terms of treatments and procedures (the service innovation "*Introducing new procedures of treatment*").

Moreover, as technological innovations are mostly electronic software (the organizational innovation measure "*Renewing the information system of the hospital*") and they are a means to better organizing (manual) patient records, which improves communication between patient and physician, leading consequently to reduced errors in prescription and reduced waiting times (as stated by Leidner *et al.*, 2010), we can see how this type of innovation is related with an increase in the safety of patient treatments (the service innovation measure "*Safer conditions of treatment*").

We can also conclude that when organizational innovation increases in a hospital, process innovation also increases in a correlation of about a half (0.564). This result is in line with the study of Gunday *et al.* (2011), who also found a correlation between organizational and process innovation, in this case, an even higher one of 0.698. Organizational innovation is considered by Gunday *et al.* (2011) a "preparatory field" for the other types of innovation, and according to our findings, it does provide space for process innovation to develop.

To analyse and test whether there are differences, concerning the level of innovation, among the hospitals depending on geographical region (H3) and type of property (H4), we employed the Kruskal-Wallis non-parametric test, which served to test whether there are statistically significant differences among the medians of the degree of hospital innovation in each region (H3) and each property type (H4). All tests with a p-value $\leq \alpha$=0.05 are considered statistically significant.

The test for H3 yielded a p-value higher than 5% for all 3 innovation measures (0,472, 0.306 and 0.339, for service, process and organizational innovation, respectively), 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 among the regions where the hospitals are located. Consequently, nothing can be said about the impact of the region on the degree of innovation. This in line with the results of Bonastre *et al.*'s (2014) French study, which concluded that the geographical location of French hospitals did not influence the implementation of innovative treatments (in our study, we have seen that location does not influence the other types of innovation either). This can be explained by the similarity of Portugal and France in terms of equal overall economic development of the geographical regions.

The results from testing H4 point out that there are statistically significant differences among the medians of the degree of organizational innovation in each property type, as the corresponding p-value is smaller than 5% (0.020). For the other innovation measures – service and process – the p-values are higher than 5% (0.601 and 0.402, for service and process innovation, respectively), therefore the null hypothesis is retained for these types of innovation. Organizational innovation is the only one that rejects the null hypothesis (p-value=0.020).

This means that there are differences regarding the degree of organizational innovation among the Public, Private and PPP hospitals. In order to determine the group that has the

highest level, we need to carry out *post hoc* tests for the Kruskal-Wallis omnibus test. Through pairwise comparisons, we can conclude that in the case of the Portuguese hospitals analysed, in terms of degree of organizational innovation, there are differences between the public and private sector. Moreover, given the global composite values we obtained previously, we can say that public hospitals have a higher degree of organizational innovation.

We can explain this difference based on the structural changes public hospitals have experienced in the past 5 years – the organization of independent hospitals into EPE health care centres leading to major changes in management structures, overall organization and the need to merge different information systems, patient databases and. overall, align different systems into a single one. Such an alignment would have likely required the renewal of IT platforms and structural innovations in public hospitals. Furthermore, private hospitals are overall newer than public ones, and benefit since their opening from the latest performant information systems (so these are not considered innovations); public hospitals often need to "catch up" when it comes to the latest technologies, implementing them over time.

To conclude the analysis, we have to test whether there is any association between organizational innovation (H5a), service innovation (H5b), process innovation (H5c) and operational performance (measured by the readmission rate adjusted to risk; occupation rate; and average duration of hospitalization (days)). Table 8 presents the correlations between each innovation composite measure and each operational performance measure.

Table 8. Correlations between the innovation composite measures and the operational performance measures

		Readmission rate adjusted to risk	Occupation rate	Avg duration of hospitalization (days)
Organizational innovation: composite measure	rho	0.090	0.335*	0.039
	Sig. (1 tailed)	0.322	0.047	0.421
	N	29	26	29
Service Innovation: composite measure	rho	0.195	0.291	0.136
	Sig. (1 tailed)	0.155	0.075	0.241
	N	29	26	29
Process innovation: composite measure	rho	0.367*	0.498**	-0.032
	Sig. (1 tailed)	0.025	0.005	0.434
	N	29	26	29

** p-value ≤ 1% *p-value ≤ 5%

Process innovation is correlated with the *Readmission rate adjusted to risk* (rho=0,367, p-value≤5%. Oddly, the correlation is positive meaning an increase in one of the measures is associated with an increase in the other. This 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 higher innovation in services, so that the innovative services can provide better care and thus lead to a lower number of complications and readmissions.

In the case of the *Occupation rate*, it is correlated with the organizational and process innovation composite measure (rho=0.335 and =0.498, respectively). It means that, on average, when a hospital invests more in organizational and process innovation, it results in an increase of their occupation rate. Finally, if we consider the operational measure *Average duration of hospitalization*, none of the innovation types are associated to this performance measure. We can also conclude that service innovation (measured by the composite variable) is not correlated with any of the operational performance measures. We retain the null hypothesis stated for H5b.

The last hypothesis is H6 that states that the higher the level of operational performance, the higher the financial performance. Table 9 shows the results of the test. 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 net income* (correlation = - 0.318). The first of these two correlations is quite surprising, as the two measures have no apparent direct connection. 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 9. Correlations between operational and financial performance measures

			Financial Performance			
			EBITDA (000 EUR)	Assets (000 EUR)	Net income (000 EUR)	ROA
Operational Performance	Readmission rate adjusted to risk	rho	-0.147	0.224	-0.129	-0.116
		Sig. (1 tailed)	0.223	0.122	0.253	0.275
		N	29	29	29	29
	Occupation rate	rho	0.047	0.202	-0.069	0.111
		Sig. (1 tailed)	0.409	0.161	0.369	0.295
		N	26	26	26	26
	Average duration of hospitalization (days)	rho	-0.226	0.347*	-0.318*	-0.259
		Sig. (1 tailed)	0.12	0.033	0.046	0.088
		N	29	29	29	29

** p-value ≤ 1% *p-value ≤ 5%

To summarize, concerning H1 and H2, we conclude that an increase in the level of organizational innovation is associated with an increase in service innovation (H1), and that an increase in the level of organizational innovation is associated with an increase in process innovation (H2), with a higher impact than the former. Regarding H3, nothing can be said about the impact of the region on the degree of innovation, as the differences concerning the degree of innovation among the regions where the hospitals are located have no statistical significance. About hypothesis H4, we observed that there are differences regarding the degree of organizational innovation among the Public, Private and PPP hospitals.

The H5 was divided in 3 sub-hypotheses in order to test whether there is some association between organizational innovation (H5a), service innovation (H5b), process innovation (H5c)

and operational performance. Readmission rate adjusted to risk and Occupation rate are correlated with the organizational and process innovation composite measure.

According to the last hypothesis (H6), the higher the level of operational performance, the higher the financial performance. However, the only statistically significant correlations between operational and financial measures of performance are the correlations between Average days of hospitalization and Value of Assets, and the same operational measure and value of net income.

Discussion and Conclusions

Importance of the study

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

First, it contributed to the existing literature in this field giving further insights into whether there is a relationship between the acquisition of innovative technology, reorganization of processes and organizational practices, and financial and operational performance.

This paper adds knowledge to the empirical field of innovation practices in health care organizations and their impacts on performance. Actually, several studies have analysed this relationship in other countries, like Irwin *et al.* (1998) in United States, Salge and Vera (2009) in England, or Tsai (2013) in China. It also allows us to identify how hospitals are implementing several innovation practices and their potential benefits in operational and financial terms.

We found that in terms of service innovation, hospitals tend to innovate the most in the introduction of new procedures/treatments. The North and the Lisbon region are the leading ones in overall innovation, reflected in the fact of their leadership in most economic sectors in Portugal. But the geographical location of the hospitals does not have an effect on the innovations implemented (H3), a conclusion that is in line with the findings of Bonastre *et al.*'s (2010) study. Indeed, there are no really significant differences in development among Portugal's regions.

Another conclusion is that differences do exist in the overall level of innovation between public and private hospitals. Apart from property, there is no significant correlation between the level of organizational innovation and the level of service innovation (composite/global measures); but there is a positive correlation, albeit not very strong, between one component of organizational innovation and one component of service innovation. There is, on the other hand, a positive correlation of almost 0.5 between organizational and process innovation, reflected also at the level of their components.

Moreover, large differences are evident in the hospitals' financial performance by property type – public hospitals are underperforming (negative results), private ones are performant (positive results) and PPPs are breaking 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-quality care to their patients. We think 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 private ones. These findings are according to the study of Torchia *et al.* (2013) that suggest PPPs have, in terms of effectiveness, efficiency and convenience, some questions still unanswered. In terms of operational performance, private hospitals are performing better as well.

The results of this study provide hospital administrators with information that might help them to take better decisions regarding their innovation policy design, in deciding what type of innovation should be implement (or not), and whether and how it has impact on hospital performance. Actually, the consequences of these decisions have huge implications not only for the direct stakeholders (patients, physicians, nurses, administrative staff and, consequently, society) and for the health care system (in financial and clinical terms). In this study, we can point out that the innovation type that has impact on operational performance is process and service innovation. Consequently, hospital administrators facing several constraints to implementing innovation (e.g., financial or time), should start by introducing quality improvement processes and safer conditions of treatment.

It was found that organizational innovation is correlated with process innovation and service innovation. Furthermore, service and process innovations influence operational performance. However, we cannot conclude that innovation in healthcare units has an overall impact on their financial performance

Limitations and future research

This study was limited by a number of factors, among which we can highlight the lack of more comprehensive data; the specific nature of hospitals (particularly public ones which benefit from public sponsorship and capital subsidizing and are not mainly directed towards profit-making); and the fact that great investments in modern innovative machinery may take years to generate a profit in the financial statements. Moreover, this study found it difficult to quantify the data and assess the degrees of innovation; another limitation is the possibility that innovativeness in one area does not reflect on all the hospital's (operational, financial and market) results; the possibility that some hospitals are a 'one wonder' case – they have a big breakthrough after which they do not continuously improve/innovate; the possibility that some newer hospitals were innovative from the start and did not need to implement a lot of innovations in the year under study, obtaining a low score, while other older hospitals have updated over the years and obtained points for innovation. Finally, the implementation of innovations can take years to achieve visible results.

For further studies that are willing to deepen the subject, it would be interesting to analyse the adoption of innovation in hospitals over several years in order to assess the impact of each innovation type on each measure of performance even if they occur some years later.

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