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PMS developing for assessing and improving the
information system of Operating Room Theaters

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ABSTRACT

This manuscript is the result of the author's work as a doctoral student and as a passionate of health issues.

The objective of the research is to improve and optimize the process of continuous monitoring of performances with a view to improving the flow and efficiency of the operating room by creating a performance measurement system that combines the aspects of the so-called technical efficiency and the aspects related to the quality of care and customer satisfaction. This collaborative tool can be interfaced with information and communication technologies (ICT) upstream and downstream, as creative solutions and ERP (Enterprise Resource Planning).

Furthermore, the healthcare industry is a particular environment, characterized by high product and process complexity. The healthcare supply chain (SC) involves many players, with different goals and perspectives, both internal and external to the company. The lack of resources is forcing the sector to be more and more efficient compared to the needs of customers (both as patients but also as lenders, see the Regions) and, paraphrasing one of the main marketing dogmas, must offer the right product (intervention and subsequent checks), in the right place and at the right time (within decent time). Quality is also fundamental, as it allows to limit the cases of readmission and consequent waste of resources. Given this scenario, the development of an adequate monitoring system allows to intercept in real time the alarm signals given by a drift on one or more aspects that are considered by this study: efficiency performance, level of service, quality and customer satisfaction.

The following Research Questions guide the overall thesis:

1. Is it possible to define a dashboard of indicators for Operating Room Theatre that also integrates Customer Experience and Outcome measures? Which variables are considered?
2. Does Information Technology in Hospitals impact on Operating Room Efficiency and on Patient Outcomes Indicators?
3. What are the main differences in terms of performance between hospitals that differs in term of ICT implementation level?

The literature review prepares the ground for a further and deep analysis, conducted through multiple and single, in-depth case studies.

The purpose is explorative and explanatory, with the aim of describing the characteristics of a performance measurement system in the health sector and specifically for the operating block, and also to fill the gap in the literature, due to the lack of specific industry contributions.

In addition to those involved in the development and discussion of KPIs such as Health management, Surgeons, Nurses, ICT delegates of some healthcare facilities, 5 medium and large Tuscan structures are involved in case studies.

In order to create the dashboard of indicators, after a first part of literature review that provides an overview of all the KPIs present and monitored in the operative block,

collected thanks to the experience of the experts directly involved in the study, the number of KPIs was reduced using the Delphi method and defined the definitive dashboard that will also serve for the case studies.

Improvement initiatives are described that allow healthcare companies to change the classical flow of the operating block.

Between the two RQs dedicated to the evaluation of the performances a third one was pushed, fundamental for having a national overview on the structures, concerning the Benchmarking.

This analysis makes it possible to compare the behaviors and the choices in terms of technical and qualitative efficiency of all the healthcare companies that can be monitored with the data available to the Ministry of Health. In particular, after a first classical DEA analysis, we investigate if and what factors are related to performance management aspects that affect efficiency in a positive or negative way.

The overall set of research conducted over the years has had several implications on the ICT and on the management of the supply chain of the operating block, including the aspects related to the preparation of the surgery kit, supplying drugs and to the actual production (intervention and post-operative).

The research aims to extend to several cases at national level, representative of different national geographic areas and different performance delivery systems (i.e. Lombardia system differs from Emilia Romagna, etc.), allowing to better generalize the results. Furthermore, projects involving performance measurement systems must be made uniform throughout the territory in order to be comparable and tested.

CHAPTER 1 – INTRODUCTION

Research Topic

Before introducing the reader to the details of this research, it's important to provide an overview of the background.

Since my work of Master's Degree thesis in Polytechnic of Milan, I have studied healthcare systems, in synergy with some sanitary directions of the province of Milan in order to evaluate the efficiency of healthcare structures in Italy. In order to improve the efficiency of Italian healthcare sector, some intervention guidelines have been proposed. Moreover, the activities I have carried out as a researcher have often involved the Healthcare system and its stakeholders. However, during these years, my activities have been more heterogeneous: I have researched on Customer Satisfaction analysis, Fashion Supply Chain (SC), Total Quality Management (TQM), Logistic and distribution systems, Radio-Frequency Identification technologies (RFID), Fashion Retailing, Performance Measurement and Collaborative Networked Organizations (CNOs).

Since the very first time I have had to design my earlier research project, the topic has been related in improving efficiency in Healthcare structures.

Following Saunders et al. (2009), business and management research projects can be placed on a continuum, basing on their purpose and context: at one extreme of the continuum is research that is undertaken purely to understand the processes of business and management and their outcomes. Its key consumer is the academic community with relative little attention given to its practical applications. We call it "pure research". At the opposite extreme there is "applied research", addressing issues of immediate relevance to managers, very similar to consultancy in many cases.

This research can be defined as an applied research, due to its business-oriented purpose and its context, which is a merge of private (Italian hospitals and consultant companies) and public enterprises (Italian hospitals) and University.

The central issue of this research is to develop and test a specific performance measurement system for the operating room theatre of Italian healthcare structures, which takes into consideration not only the aspects related to efficiency and operations but also related to quality of care.

Originality

One of the hardest challenge when writing articles, proceedings and this thesis has been to explain the originality of the research topic.

The sector that has been investigated is full of studies because of the lack of resources and the need of transparency of National Health System.

What has been highlighted by the literature and by specific case studies is the lack of uniformity of the systems and the absence in them of a rewarding mechanism with respect to the quality of care and attention to the patient.

Healthcare units have their own specificities in terms of processes, projects, data management and ICTs. Their outputs are not comparable to a commodity, neither to a fully customised item. Hence, it can say that the PMS development and analysis in Healthcare structures that correlate KPIs, Benchmarking with National Health Systems is a newness for academics.

Another originality point is the process-oriented approach adopted to analyse these “companies” and their needs. From data management to the identification of relevant Key Performance Indicators (KPIs), processes and tasks have always been taken into account.

Finally, the last original contribution is in terms of methodology. This study is a mixture of different methods, evaluated in a long timescale, derived from the opportunity to experiment and describe all aspects of the national health system thanks to the valuable help of the regional ARS agency, being able to examine and evaluate closely the entire surgical process, each particular structure.

Research objectives

The main objectives of this research project are to:

- describe the introduction, management and integration of an "extended PMS" within healthcare companies;
- identify problems in the management of processes and data within healthcare companies;
- develop a DEA model to determine the efficiency gap between health facilities through Benchmarking;
- identify whether the information system has a positive or negative impact on the efficiency of these facilities;
- describe the variation of the performances along a time horizon based on the analysis of some healthcare companies in Tuscany.

Research Questions

The following research questions (RQs) will guide the overall thesis:

1. Is it possible to define a dashboard of indicators for Operating Room Theatre that also integrates Customer Experience and Outcome measures? Which variables are considered?
2. Does Information System in Hospitals impact on Operating Room Efficiency and on Patient Outcomes Indicators?
3. What are the main differences in terms of performance between hospitals that differs in term of ICT implementation level?

Research design

Saunders et al. (2009) wrote: the central role of the research questions, the combined use of observable phenomena and subjective meanings to provide acceptable knowledge and the importance of both quantitative and qualitative methods, are evident.

The research approach has been, above all, inductive because it is based on studies carried out in several contexts and, because of the lack of studies concerning PMS in Operating Room Theater, the ambition has been to understand these settings and build or reinforce theory.

In thinking about the RQs, it has been identified two main purposes of this research: exploratory, wishing to clarify the characteristics of a particular context through search of the literature and Delphi approach, and explanatory, trying to establish relationships between variables, collecting quantitative and qualitative data. In order to detect the diffusion of the performance measures of operating room and the related methods of monitor KPIs in the National Health System (NHS) panorama, a national survey was used. All local Italian health companies were invited to participate in the study. In particular, taking into account the fact that in Italian country the organization of primary care services is structured on a departmental or district basis, for each company a person in charge of the provision of primary care services was identified.

The questionnaire's writers, once identified, have been invited to join the search through e-mail communications, complete with exhaustive information on the aims of the research, the structure and how to complete the questionnaire. The process of defining the dataset list and gathering information required a total of six months.

This study examined data both from Ministry of Health, from OR electronic records of surgical cases and from direct experiences of expert involved in this study. A regression analysis was used for investigate if some factors can affect efficiency. The explanatory statistical model included four independent variables to reflect OR staff patterns and two dependent variables for OR outputs.

In summary, concerning the development of the PMS (RQ1) thanks to healthcare system experts and to the literature, the KPIs to be used, divided into the categories of performance, level of service, quality and customer satisfaction, were identified and summarized by means of the Delphi method. Considering the importance of the information system in a performance measurement system, we are going to investigate if this can have a positive or negative impact on the technical efficiency of healthcare facilities. Therefore, through a statistical analysis of DEA and an exploratory research by national survey, the correlation between efficiency and development of ICT technologies in the operating room (RQ2) was analyzed. Finally, with a series of case studies, the model was tested and data and implications analysed (RQ3).

This dissertation presents background, analysis plan, research findings, and conclusions of a study to assess a model of PMS and to Benchmark healthcare units.

Moreover, the structure of the present manuscript (Figure 1) is organized as follows.

A literature review, deriving from the research objectives and questions, describes the results gathered from the theoretical viewpoint: these are related to the aspects illustrated in Figure 1.

Then, in order to fill the research gap and to fully answer the RQs, the case study strategy, that has supported the analysis from the methodological point of view, is discussed.

The answers to the RQs and the related analytical examination of the results is presented in the fourth chapter.

The thesis concludes reviewing and remarking all the research objectives, results and future steps.

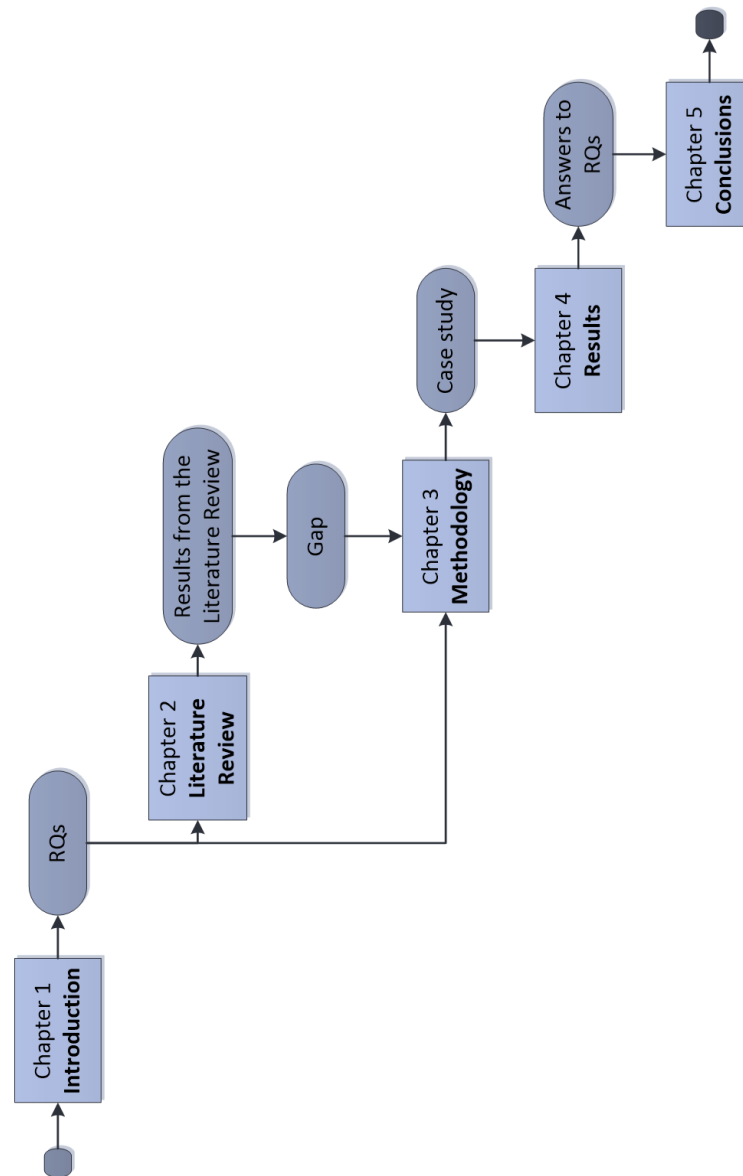


Figure 1 – Thesis structure

Background: the Healthcare System and its challenges

The Italian Servizio Sanitario Nazionale (or National Health Service, SSN/NHS) was established in 1978 to grant universal access to a uniform level of care throughout Italy, free at the point of use, financed by general taxation.

Italian healthcare system is organized in three administrative tiers: National, Regional and local. The Ministry of Health fulfils the function of the overall steward of the health system and defines the livelli essenziali di assistenza (or essential level of care, LEA) to be delivered across the country.

Healthcare is provided to all citizens and residents by a mixed public-private system. The national level is responsible to allocate healthcare resources and ensuring a uniform level of service. The central government sets the general objectives and fundamental principles for the national healthcare system. Recent reforms have delegated administrative, financial and organizational responsibility to the 20 Italian Regions.

The SSN is controlled by regional governments and is administered by local health authorities (“Azienda Sanitaria Locale”/ASL - often referred to by their former name “Unità Sanitaria Locale”/USL) (De Nicola and Gitto, 2013). Regional governments are responsible for legislative and administrative health functions, planning health care activities, organizing supply and monitoring quality, appropriateness and efficiency of the services provided (Lo Scalzo, 2009).

Articulation between central government’s steering role and regional government’s delivery role is expressed in the Patto per la salute (Pact for health), a three-year plan that is agreed jointly between central and regional governments.

Many regional health budgets ran into substantial deficit, leading to central authorities to imposing Piani di Rientro (Recovery Plans). These plans signalled the introduction of a dominant new player in national health care policy – the Ministry of Finance. Although the Ministry of Health maintained its role in ensuring that essential levels of care were provided at regional level, the Ministry of Finance became actively involved in designing and approving health care delivery. To a large extent, then, the focus of this abrupt resumption of central control was financial and quality of care risked becoming secondary. (www.oecd.org)

Also the Regions are obliged to adopt their own NHS, aimed at carrying out the interventions in order to achieve the health and operational objectives of the services that meet the specific needs of the regional population. Therefore, Regional Plan is not only a rule of implementation of National Plan but it must guarantee the participation of local authorities as well as private non-profit social organizations engaged in the field of social and health care, trade union organizations of public and private health care workers and private facilities accredited by the National Health Service.

In addition to general taxation, local ASL have direct revenue from health tickets and paid services.

The Region has 0.5% of the IRPEF to finance health expenses; which means that the regions with the lowest tax revenue, with the same population, have less resources for

healthcare. For example, in 2011 Lazio Region had about 700 M € deriving from the income tax IRPEF, while the same populated Campania Region had only 300 M € (Regions subject to repayment plan have an increase of 0.15 and 0,30% of IRAP and IRPEF). (Corte dei Conti, Rapporto 2012 sul coordinamento della finanza pubblica)

Hospital Competition, Technical Efficiency and Quality

The question of whether hospital competition improves or not efficiency is a long-standing issue in health economics. The literature analysis suggest that the relationship varies and depends on specific institutional and market setting.

Lindrooth et al. (2003) found a positive link for urban hospitals in the USA, whereas, in contrast, Preyra and Pink (2006) found a negative link between hospitals in the Province of Ontario, Canada; and yet Bates et al. (2006) did not find any statistically significant relationship for hospitals in various metropolitan areas of the USA.

The link between market concentration and efficiency is even less clear for public hospitals which are typically non-profit maximising and may not be thought of as economic agents that play the ‘competitive game’ in the same way as profit-maximising private enterprises. However, even if public hospitals do not consciously compete for patients, the variation in market concentration could have direct and indirect implications for their operations.

Microeconomic theory predicts that in most industries, productive efficiency – technical and allocative – is positively correlated with competition.

Thus, hospitals not only compete for the number of patients but also the type of patients in terms of case complexity. In addition, public hospitals also compete for private patients, not only with private hospitals but also among themselves (Hall & Savage, 2005). In a competitive market economy, successful industries normally increase quality as they increase efficiency and decrease cost. Medicine is starting to act like a competitive industry, and this tendency will be good for quality and efficiency in the operating room. Community and academic practitioners need to understand and participate in this transformation in order to be able to influence its evolution and to survive financially. (Archer et al, 2006)

Hospital Performance Evaluation

Performance evaluation plays a strategic role in healthcare organizations, in order to address the best use of resources and rationing of demand. Lack of resources has obliged to analyse and monitor technical efficiency of existing hospitals in order to improve hospital performance, so as to employ medical resources effectively and make the healthcare system more efficient and sustainable.

Measures of health care efficiency can be evaluated using the same framework as quality measures:

- Important—is the measure assessing an aspect of efficiency that is important to providers, payers, and policymakers? Has the measure been applied at the level of interest to those planning to use the measure? Is there an opportunity for improvement? Is the measure under the control of the provider or health system?
- Scientifically sound—is the measure reliable and reproducible? Does the measure appear to capture the concept of interest? Is there evidence of face, construct, or predictive validity?
- Feasible—are the data necessary to construct this measure available? Is the cost and burden of measurement reasonable?
- Actionable—are the results interpretable? Can the intended audience use the information to make decisions or take action?

An ideal health care efficiency measure does not exist, and therefore the selection of measures will involve tradeoffs.

There are a variety of definitions of efficiency currently in use and these different meanings for the same word drive some of the confusion among stakeholders about the adequacy or desirability of alternative measures of efficiency. In the Table 1 below, McGlynn et al. have resumed some of the definitions used for healthcare efficiency.

Entity	Definition
IOM (2001a)	Avoiding waste, including waste of equipment, supplies, ideas, and energy.
Palmer & Torgerson, 1999	Health care resources are being used to get the best value for money.
Economic theory	Technical efficiency means that the same level of the output cannot be produced with fewer of the inputs.
Economic theory	Productive efficiency refers to the maximization of output for a given cost, or minimization of cost for a given output.
Economic theory	Social (or Pareto) efficiency exists when no one can be made better off without making someone else worse off.
AQA	A measure of the relationship of the cost of care associated with a specific level of performance measured with respect to the other five IOM aims of quality.
GAO	Providing and ordering a level of services that is sufficient to meet patients' health care needs, but not excessive, given a patient's health status.
MedPAC	Using fewer inputs to get the same or better outcomes. Efficiency combines concepts of resource use and quality.

Table 1 – Efficiency definitions

Technical efficiency describes the ability of operating units to transform their inputs into outputs. Following this definition, when an operating unit is technically efficient, it works on its production frontier.

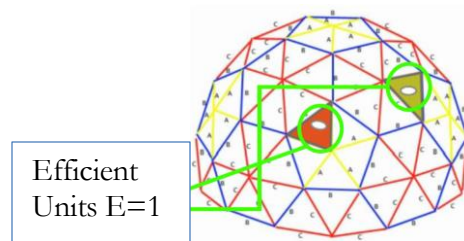


Figure 2 – Production frontier

Technical efficiency is measured as a distance to the frontier, the resulting scores are relative measures of efficiency. The ratio of a weighted sum of outputs to a weighted sum of inputs is obtained, with the condition that the ratio of outputs to inputs should not exceed unity for every so called Decision Making Unit (DMU). A score of 100% or $E=1$ indicates that a hospital is operating on the best practice frontier (i.e., efficient DMU). A score $<100\%$ indicates inefficiency with the difference between the actual score and 100 measuring the amount of all inputs which could be decreased whilst maintaining outputs constant.

Given this definition, a hospital is considered to be efficient if it produces the maximum amount of output from a given amount of inputs (output-oriented efficiency) or alternatively, if it produces a given output with a minimum consumption of resources (input-oriented efficiency). Most studies in healthcare use an input-oriented model because it is assumed that hospitals cannot reject their patients' demands, while they can reduce resource allocation and consumption levels. In other countries an output-oriented model is used because hospitals are required to improve the number of interventions, whilst maintaining the amount of resources consumed.

The performance evaluation, that is the evaluation of absolute effectiveness, can be summarized by comparing the objective level actually achieved with the maximum reachable level.

In real evaluations, it is not entirely easy to apply the micro-economic theory in its entirety, precisely because of the lack of information about the real T-border.

In fact, this is a relative efficiency measure and not absolute because it could exist, among world existing structures, someone more efficient. This calculation is exceeded from Bootstrap DEA method whose formulation goes beyond this thesis.

Briefly, hospital efficiency debate has grown through the years in all over the world and runs in parallel to the usage of rigorous statistical methods, such as non-parametric Data Envelopment Analysis (DEA) and parametric Stochastic Frontier Analysis (SFA). Hollingsworth analyses the number of papers dedicated to Statistical methods referred to Hospital Economy (Hollingsworth e Street, 2006; Hollingsworth, 2003).

In Italy, DEA has been used to evaluate relative efficiency at a national level and at regional level.

DEA is a non-parametric technique used in the estimation of production functions and has been used extensively to estimate measures of technical efficiency [24, 25]. In the standard input-based technical efficiency DEA, hospitals are considered as homogeneous decision making units (DMUs) which are responsible for converting inputs into outputs and whose performances can be evaluated. DEA derives a best practice frontier by solving linear programming problems, which identify the best performing hospitals, minimizing inputs for given outputs.

When evaluating technical efficiency, contextual and organizational factors, not controllable by management, can influence the ability of management to transform inputs into outputs.

Magherini et al. (2016) developed a model for evaluating the technical efficiency by considering different organizational and management aspects and for understanding whether the presence of differences on management, information technology, financial and innovation on healthcare delivery can affect the efficiency level. The results of a survey show the implementation status of the guidelines of the Italian “Patto per la Salute 2014 – 2016” to verify if some of the levers proposed by the survey can positively influence the efficiency. The analysis was carried out in two stages. In the first stage, healthcare efficiency was measured via bootstrapped DEA. In the second stage, the impacts of organizational and environmental variables on efficiency were investigated. Results show an increase of the efficiency gap between the best practice and small hospitals due to economies of scale and low reachability.

Information Systems Management in Healthcare industry

Information management is a broad topic that is still not set in an industry-specific frame. From this viewpoint, literature is very poor; hence, one of the aim of the next section is to fill this gap.

Nevertheless, many cross-industry analyses allow to overview the topic and to prepare the ground for further detailed investigations.

According to Bhatt (2001), information is as an organized set of data, while data are considered as raw facts and knowledge is perceived as meaningful information.

Product data are the definition of a product: they represent all the knowledge and the know-how about the product.

A data model is a representation, usually a diagram, of the data in a particular environment. There are different types of data model (conceptual, logical, physical, entity-

relationship) and different related diagram as well (data flow, class diagram and state diagram).

The main issues that are related to information management in any industry are (Stark, 2015):

- Access to product data has to be provided to people when they need it;
- Different users want to see different views of product data;
- Product data are valuable and confidential;
- Documents are often annotated informally and are lost forever;
- Each business department develops its own jargon. This may be misunderstood by other departments.

Management has a crucial role in controlling product data: it has to make sure that product data are of high quality, complete, secure, available to users when they need it and reusable.

Information systems in healthcare have become increasingly advanced over the last decade or so, and their ever-growing range of capabilities have led to widespread use of these systems throughout the healthcare industry. In fact, use of some level of information management has become virtually universal among healthcare providers, facilities and health systems. So why have these systems become so important?

Much of the importance of information systems in healthcare stems from, as mentioned above, their growing usefulness. While such systems were once largely geared towards mundane tasks like storage of patient records and tracking inventories, modern healthcare IT has evolved into a digital healthcare infrastructure. That infrastructure is responsible for collecting, managing and integrating the tremendous volume of clinical, financial and operational information generated daily by today's healthcare system, enhancing the safety, effectiveness and efficiency of that system.

For instance, clinical management is enhanced by electronic health records (EHRs), which place comprehensive patient data at the fingertips of healthcare professionals.

- EHR programs feature interactive clinical decision assistance tools, which alert providers to potential problems, such as medication interactions, allergies or critical lab values, and reminders about preventive care and/or clinical guidelines.
- Patient portal software improves patient engagement, offering online patient education, electronic communication with clinicians and digital access to personal health information.
- Financial and operational management is aided by accounting software for healthcare organizations, healthcare billing systems, healthcare policy and contract management software, and interactive and intuitive inventory control systems, among many other software solutions.

What is A Performance Measurement System?

It was so long time that Performance Measurement System (PMS) practices were used in history. According to Choong (2014) there were PMS practices in the early third century, 221–265 AD. Even the advent of the modern accounting framework dates back in the middle ages, beginning that time, the success of organisations had been assessed by financial measures (Kennerley and Neely, 2003) and the ability of companies to measure their performance increased from time to time (Lohman et al., 2004). Between the 1960s and 1980s, there was a directional shift in the economic engine from supply side to demand side resulted the shift in the focus of PMS towards new dimensions of performance, such as quality, time, flexibility and customer satisfaction (Bititci et al., 2012).

However, the emphasis on PM using financial measures only did not last, past the end of 1980s. Because, there were changes in technology, changes in business trends, changes in global trends and natural trends, the use of single dimensional performance measures subjected to numerous debates (Bititci et al., 2012).

The competitive environment therefore to be characterized by great uncertainty, discontinuity and crisis and, starting from the nineties, the concept of strategic innovation is introduced. In order to live on the market, companies can no longer afford to limit their value proposition to a simple production, sales and payment cycle, but must define a much more complex competitive strategy within a new and evolved business environment (Markides C., 2006).

After selecting the most coherent strategic objectives and having defined specific and detailed action plans, the next phase consist ih the implementation of the planned activities. Through the implementation are carried out all those activities aimed at translating into practical terms the theoretical idea contained in the strategy.

Finally, a fundamental importance phase will consist in the constant monitoring of both the implementation of the strategy implemented and the results produced by the activities carried out. A correct Performance Measure System (PMS) can also be the basis for starting improvement plans or important innovation processes (Bagnoli C. 2012).

PMS is a directional process that allows the company manager to be informed and directed towards achieving the planned objectives; in other words, the concept includes "routines and formal procedures based on information, which managers use to maintain or modify the behavior of the organization in carrying out its activities".

Simons R. (1995) identifies five main categories that summarize the main purposes for which performance information is collected and analyzed within the organization:

- *Improve decision-making processes* both in the planning phase - in which objectives are defined and the availability of resources for the achievement of these purposes is ascertained - and in the coordination phase of the various company functions.

- *Reporting*, or allow management to send signals with reference to their preferences, values and opportunities on which they believe that the efforts of the entire organization must be focused.
- *Training and learning*, ie allow members of the organization to understand what changes in the internal and external environment could influence it.
- *External communication* to all the stakeholders who, for different reasons, are interested in the direction and success of the company.
- *Control*, ie the use of feedback in order to ensure that the entire business is aligned towards achieving the objectives set.

Nowadays, the adopted approach by management in measuring performance is no longer solely based on the use of economic and financial indicators, but is increasingly oriented towards the use of multidimensional measurement models that tend to shift attention towards a non-financial analysis dimension.

The simple reading and analysis of financial statements is not sufficient due to the inability of economic and financial indicators to capture all the determinants underlying company performance. In particular, in addition to not providing assessments relating to intangible assets (ie human capital and knowledge), they cannot identify the best strategies to increase the performance of the organization's business model. Moreover, the classic models of corporate finance assume the complete predictability of all the events that involve the company and the surrounding environment, which today drives organizations to use measures of an operational and competitive nature to verify the degree of reliability of the economic value.

The indicators used in multidimensional models make it possible to translate objectives into measures of an economic-financial nature and not, and to create such articulated measurement systems able to direct the behaviors and decisions of economic subjects towards common objectives.

The idea is to make clear the numerous links of causality between the company's performance and its own determinants, on the basis of which to launch an effective strategic management of the production unit.

CHAPTER 2 – LITERATURE REVIEW

One of the first thing learned during PhD is the importance of reading.

Hence, before approaching to write anything, it is important to read as much as possible what other authors have written. Methodology, in this sense, is very helpful because guides the author to conduct a literature review, establishing the scope, the purpose and possible directions.

The literature review has been conducted according to the themes illustrated in RQs and developed in different periods. In this thesis, it has been recap all the results from the literature analysis and then to detail the different topics.

The first step during the literature analysis has been to plan a methodology ensuring to locate relevant and up-to-date contributions, as described in the following section.

Literature search strategy

The subject areas related to this research are engineering, computer science, information systems and operations, while the business sectors are Healthcare Management. It has been selected the most recent publications (last 20 years), without any constraint in terms of geographical area.

The keywords used are: Performance measurement, Healthcare, DEA, performance management, key performance indicators, balanced scorecard, metrics, Tobit regression, Delphi technique, Consensus, health services research, survey, performance measurement, efficiency.

Although performance measurement has begun to talk in reference to the public sector from this period with the emergence of the theories of New Public Management (Talbot, 1999), it should be noted that the theme of measurement and evaluation of performance is a key element that distinguishes every reform process (Pollitt and Bouckaert, 2004). Whether the reform specifically refers to one of the components making up the measurement system or one of the closely related operational systems, for example the budget or programming systems, whether the reform has sectoral content, the issue of measuring change induced and the effects produced are central since the process of defining the reform should include a phase of identification of measures and indicators. The extension of the concept and its versatility make it possible that over the last twenty years many interpretations and schools have arisen. In fact there is a heterogeneity in the definitions as much as in the practices that lead back to this concept and from this derives the fact that the measurement and evaluation of the performance is a research topic denoted but not isolated (Van Dooren et al, 2010) compared to other important topics such as management, human resources management, governance.

A literature study involves a series of choices (Bell, 1993). Regarding the choice of the KPIs set and the Input / Output indicators of the Benchmarking measures, the first choice made in this work was to take into consideration only articles taken from public administration / management magazines and public accounting magazines. The article selection strategy has favored an approach focused on a selection of international journals

in English and some reports in Italian provided by Italian regions and the Ministry of Health. This choice led to a narrowing of the sources but was motivated by the consideration that a large part of the reference literature and the debate on the subject of measurement and evaluation of performance took place at an international level.

The second choice made in the design of the study of literature concerns the selection of the time horizon, limited to the last 25 years and then to the period from 1993 to 2017. Although it is largely an arbitrary choice, it is worth pointing out that it was since the 1990s that the subject of measurement and evaluation of performance became itself the object of specific reform measures.

Time distribution. The contributions analyzed cover a span of 25 years, focusing in particular in the last period with the publication of about 50 percent of the papers. Figure 3 shows the results of the classification for years of contributions. The last time period analyzed has seen the publication of about 15 articles per year. Interest in measuring and evaluating performance has grown exponentially since 2000.

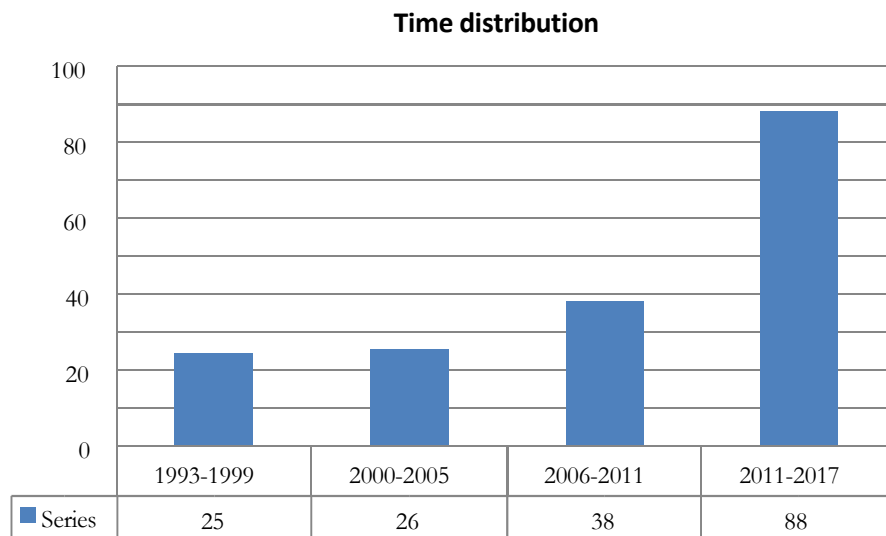


Figure 3 – Time distribution of performance measurement papers

Nations. Most of the contributions analyzed recall the experience of one or more countries and this is in the case of articles of theoretical setting and in the case of articles of empirical setting. Figure 4 shows the result of this classification, which shows a clear preponderance of references to experiences relating to the United States of America (38%) and the United Kingdom (18%). The experience of Northern European countries, in particular Denmark, Sweden and Norway, is interesting (it's important to know that Denmark is one of the first nations in the world for the analysis and development of health performances and processes, i.e. mini-HTA Health Technology Assessment).

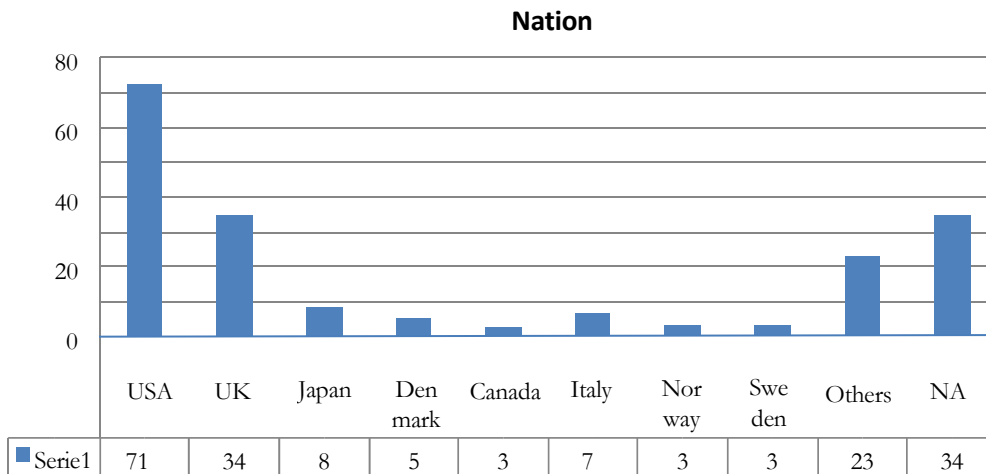


Figure 4 – Country distribution

Journals. There is also a wide spread of journals found to have substantial coverage of the research theme with the highest number of articles selected are the International Journal of Productivity and Performance Management (IJPPM), 14 articles, followed by International Journal of Operations and Production Management (IJOPM), eleven articles and Measuring Business Excellence (MBE), six articles, (Figure 5).

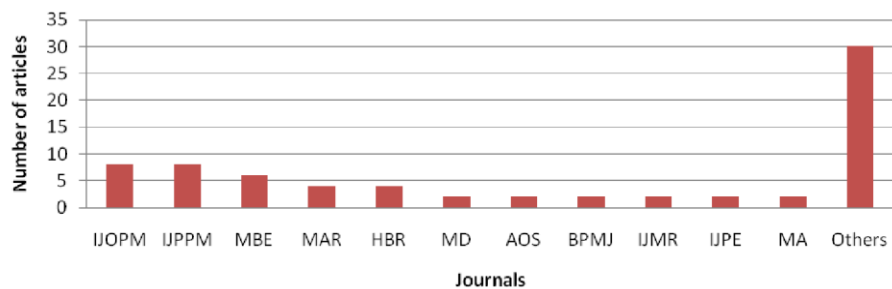


Figure 5 – Journals list

Except for articles that were only available on the web and very recent published articles, all other articles were well-cited, the lowest being six citations (Choong, 2013). On the other extreme, Kaplan and Norton (1996a, 1996b, 1996c) received a huge 5,300 citations (Figure 6).

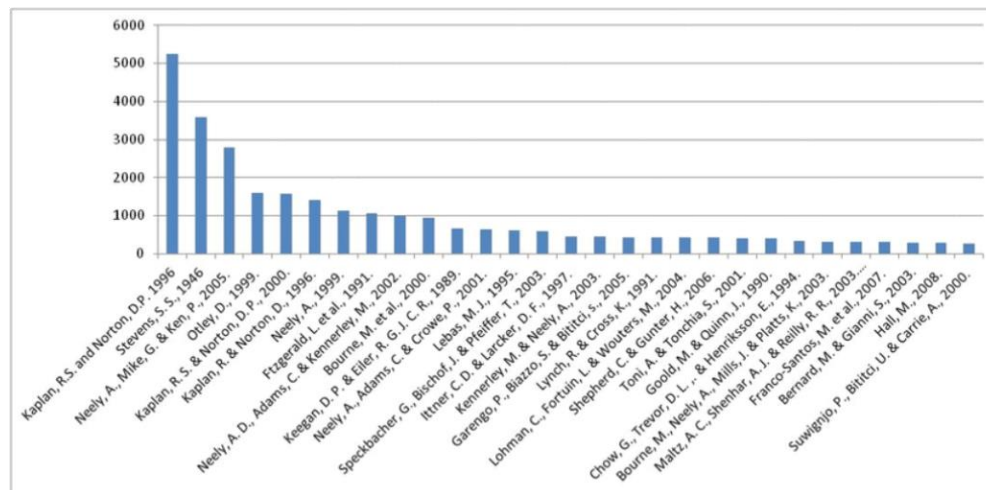


Figure 6 – Most important papers citations

The contributions analyzed in the review can be divided in two categories.

First of all, the category of articles with a theoretical setting (“Grounded Theory” in Table 2). In these articles, the authors provide a complete discussion with reference to one or more aspects related to systems for measuring and evaluating performance or performance in a broad sense. Of the 173 identified contributions, 84 are characterized by a theoretical approach.

To a first set of contributions dealing with the definition of a logical reference model for the measurement and evaluation of performance are joined contributions that identify useful guidelines for the design of performance measurement and evaluation systems. Beginning in 2000s, the topic of expected and unexpected consequences arising from the introduction of measurement and evaluation systems began to take hold.

Starting from the second half of the year 2000 the theme of the relationship between performance and network is affirmed and the need to develop a wider reflection on the theme of performance when contributions and responsibilities do not refer to a single public administration but to a set of organizations. Finally, after 2010, the issue of citizen service, quality of care and customer satisfaction comes into play both on the consumer side (the patients) and on the human resources side.

The second category of contributions analyzed in the review is that of articles with an empirical approach (“Case Study” in Table 2). These are articles in which the authors present hypotheses concerning the measurement and performance evaluation systems and Benchmarking measures and perform a study to test this hypothesis starting from concrete experiences. Of the 173 identified contributions, 89 are characterized by an empirical approach.

In order to built KPIs dataset, a total of 67 studies were identified for inclusion in the review. The search of databases provided a total of 11.731 citations. Initially, the title of

all the articles was checked out and 985 were excluded owing to contradiction with the study objectives. After adjusting for duplicates, 209 articles were remained. Of this number, 140 articles were omitted because after reviewing the abstracts it emerged that these articles clearly did not meet the criteria and there was a lack of indication to operating room theatre performance indicators in their results. 35 articles were rejected because the full text of the article was not accessible, the paper could not be feasibly translated into English, or the type of the article was not original. The full texts of the remaining 173 articles were studied in more detail. In total 75 indicators were obtained from a review of selected literature.

Finally, consulting Health management of a Tuscan surgeon unit, 55 indicators were selected. These performance indicators were classified into four perspectives: efficiency, quality, level of service, customer satisfaction.

These keywords have been searched within search engines (most of all Google Scholar and Scopus). I have had also the opportunity to access to important collection of publications from the Hospitals involved on this project.

Like previous studies, it has been classified the evaluated literature in order to organize the research and decide which are the most relevant contributions to be cited. The analysis allows me to perform statistics basing on several fields: authors, title, journal, year of publication, healthcare area, RQ focus and keyword. The methodology reports tools or procedure for identifying, delimitating, and gathering the relevant literature. Regarding the healthcare focus, four main typologies have been identified: a “general” field, that refers to dissertations about the topic without any industry-specific observation; “operating room”, “PMS development”, and “DEA”.

Once papers have been selected and classified, different macro-areas regarding the answer (often just in part) of the RQs, have been identified. Therefore, in the following sections, the main results from the literature review have been illustrated, concerning these themes:

- Operating Room and the Health Care Economy
- Operating Theatre Planning
- Performance measurement and tools
- Performance measurement system characteristics
- Performance measurement system design
- NHS & The Healthcare structures (AO Aziende Ospedaliere)
- Hospital performances (Benchmarking, DEA Analysis)

The classification of the papers has been proposed in Table 2. It has been considered as relevant 69 contributions: the large part of these researches has been performed through case studies. The keyword that has allowed finding more results has been “efficiency”, even if these are more focused on a management point of view.

Table 2 - Literature classification

ID	1 st Author	Title	Journal	Year	Methodology	Industry
1	Abhijeet	Green manufacturing performance measures: an empirical investigation from Indian manufacturing industries	Measuring Business Excellence	2013	Case Study	Manufacturing
2	Bititci	PM: challenges for tomorrow	International Journal of Management Review	2012	Case Study	Automotive
3	Bourne	Designing, implementing and updating PMSs	International Journal of Operations & Production Management	2000	Grounded theory	Manufacturing
4	Bourne	Implementing PMSs: a literature review	International Journal of Business Performance Management	2003	Grounded theory	General
5	Braz	Reviewing and improving PMSs: an action research	International Journal of Production Economics	2011	Case Study	Healthcare
6	Campbell	Consensus methods in prescribing research	Clin Pharm Ther	2001	Case Study	Healthcare

7	Corposanto	Metodologie e tecniche non intrusive della ricerca sociale	FrancoAngeli	2004	Case Study	Psychology
8	Crepaldi	La costruzione degli standard di qualità dei servizi sociali	Prospettive sociali e sanitarie	1999	Case Study	Social services
9	Dexter	Influence of procedure classification on process variability and parameter	Anesthesia and analgesia	2010	Case Study	Healthcare
10	Dexter	Operating room utilization: information management systems	Current opinion in anaesthesiology	2003	Grounded theory	Healthcare
11	De Deyne	Introduction of an operating room information management system improved overall	Studies in health technology and informatics	2004	Case Study	Healthcare
12	Fink	Consensus methods: characteristics and guidelines for use	Am J Public Health	1984	Survey	General
13	Franco	Factors that play a role in 'managing through measures	Management Decision	2003	Grounded theory	General
14	Goshu	Performance measurement and its recent challenge: A literature review	<i>International Journal of Business Performance Management</i>	2017	Case Study	General
15	Hasson	Research guidelines for the Delphi survey technique	Adv Nurs	2000	Case Study	General
16	McKesson	Comprehensive performance management in the operating room	Healthcare Financial Management Association	2002	Case Study	Healthcare
17	Hearnshaw	Expert consensus on the desirable characteristics of review criteria for improvement of health care quality	Qual Health Care	2001	Grounded theory	Healthcare
18	Kaplan	The balanced scorecard – measures that drive performance	Harvard Business Review	1992	Case Study	Finance
19	Kaplan	Linking the balanced scorecard to strategy (reprinted from the balanced scorecard)	California Management Review	1996	Grounded theory	General
20	Kaplan	The balanced scorecard: comments on balanced scorecard commentaries	Journal of Accounting & Organizational Change	2012	Grounded theory	General

21	Kaplan	Using the balanced scorecard as a strategic management system	Harvard Business Review	1996	Case Study	General
22	Kaplan	The Balanced Scorecard: Translating Strategy into Action	Harvard Business School Press	1996	Case Study	General
23	Kaplan	Having trouble with your strategy? Then map it	Harvard Business Review	2000	Grounded theory	General
24	Lebas	PM and performance management	International Journal of Production Economics	1995	Grounded theory	Manufacturing
25	Macario	Are your hospital operating rooms "efficient"? A scoring system with eight performance indicators	Anesthesiology	2006	Case Study	Healthcare
26	Markides	<i>Disruptive innovation: in need of better theory</i>	Journal Prod. Innovation Management	2006	Grounded theory	Manufacturing
27	Markides	<i>Special topic: strategic innovations</i>	Review of Management Science	2011	Grounded theory	General
28	Mundy	Creating dynamic tensions through a balanced use of management control systems	Accounting, Organizations and Society	2010	Case Study	Manufacturing
29	Otley	Performance management: a framework for management control systems research	Management Accounting Research	1999	Grounded theory	General
30	Pringle	Preventing ischaemic heart disease in one general practice: from one patient, through clinical audit, needs assessment, and commissioning into quality improvement	Bmj	1998	Case Study	Healthcare
31	Simons	Levers of Control: how managers use innovative control systems to drive strategic renewal	Harvard Business School Press	1995	Case Study	Manufacturing
32	Srimai	Evolutionary paths of PM: an overview of its recent development'	International Journal of Productivity and Performance Management	2010	Case Study	General

33	Tangen	Evaluation and Revision of PMSs	Royal Institute of Technology	2004	Case Study	General
34	Tangen	Analysing the requirements of PMSs	Measuring Business Excellence	2005	Case Study	General
35	Tessier	A conceptual development of Simons' Levers of Control Framework	Management Accounting Research	2012	Case Study	Manufacturing
36	Van Essen	Health care management science	Report	2012	Grounded theory	Healthcare
37	Zellermeyer	Report of the Surgical Process Analysis and Improvement Expert Panel	Ontario Ministry of Health and LongTerm Care	2005	Grounded theory	Healthcare
38	Adan	Patient mix optimisation in hospital admission planning: A case study	International Journal of Operations and Production Management	2002	Case Study	Healthcare
39	Agrell	DEA-Based Incentive Regimes in Health-Care Provision	The Royal Veterinary and Agricultural University	2010	Grounded theory	Manufacturing
40	Amaratunga	Assessment of facilities management performance in higher education properties	Facilities	2000	Grounded theory	General
41	Besstremyannaya	Managerial Performance and Cost Efficiency of Japanese Local Hospitals: a Latent Class Stochastic Frontier Model	Health Economics	2011	Grounded theory	DEA Healthcare
42	Clement	Is more better? An analysis of hospital outcomes and efficiency with a DEA model of output congestion	HealthCare ManageSci	2008	Grounded theory	DEA Healthcare
43	De Nicola	A two-stage DEA model to evaluate the efficiency of the Italian health system	Dipartimento di Ingegneria dell'Impresa, Università di Roma "Tor Vergata"	2011	Case Study	DEA Healthcare

44	De Nicola	Healthcare reform in Italy: an analysis of efficiency based on nonparametric methods	The International Journal of Health Planning and Management	2013	Grounded theory	DEA Healthcare
45	Dexter	Making management decisions on the day of surgery based on operating room	Anesthesiology	2004	Case Study	Fashion
46	Dyro	Clinical engineering handbook	Boston: Elsevier Academic Press	2004	Grounded theory	Fashion
47	Donabedian	Evaluating the Quality of Medical Care	The Milbank Quarterly	2005	Grounded theory	DEA Healthcare
48	France	The Italian health---care system	Health Economics	2005	Grounded theory	Healthcare
49	Freytag	Allocating and scheduling operating room time	Zeitschrift fur alle Gebiete der operativen Medizin	2005	Case Study	Healthcare
50	Franco-Santos	Contemporary performance measurement systems: a review of their consequences and a framework for research	Management Accounting Research	2012	Grounded theory	General
51	Gori	Le performance del servizio asili nido nei comuni italiani	Economia Aziendale Online	2011	Grounded theory	General
52	Grisham	The Delphi technique: A method for testing complex and multifaceted topics	International Journal for Managing Projects in Business	2009	Grounded theory	Manufacturing
53	Grote	Operation room management: from degree of utilization to distribution	Der Anaesthesist	2008	Grounded theory	Healthcare
54	Hinks	The creation of a management-by-variance tool for facilities management performance assessment	Facilities	1999	Grounded theory	General
55	Ho	Significant metrics for facilities management benchmarking in the Asia Pacific region	Facilities	2000	Case Study	General
56	Hood	The New Public Management in the 1980s: variations on a theme	Accounting, Organizations and Society	1995	Grounded theory	General
57	Hollingsworth	The Measurement of Efficiency and Productivity of Health Care Delivery	Health Economics	2008	Case Study	Healthcare

59	Ippoliti	Efficiency of the medical care industry: Evidence from the Italian Regional system	European Journal of Operational Reserach	2012		Healthcare
60	Kuo	Optimization of operating room allocation using linear programming techniques	J Am Coll Surg	2003		Healthcare
61	McNeeney	Selecting the right key performance indicators	Meridium	2005		General
62	Mikušová	Developing and implementing successful Key Performance Indicators	World Academy of Science, Engineering and Technology	2010		Manufacturing
63	Morfaw	Total Quality Management (TQM) A model for the sustainability of projects and programs in Africa	University Press of America	2009		Manufacturing
64	Neely	Performance measurement system design: a literature review and research agenda	International Journal of Operations & Production Management	1995		General
65	Neely	The performance measurement revolution: why now and what next	International Journal of Operation & Production Management	1999		General
66	Neely	Why measurement initiatives fail	Measurement Business Excellence	2000		General
67	Pandit	Is “starting on time” useful (or useless) as a surrogate measure for surgical	Anaesthesia	2012		Healthcare

Results from the literature review

Operating Room and the Health Care Economy

The Operating Room is a convergence of resources uniting people, equipment, coordination, and time. Time saving in the OR is one of the trending objective in Healthcare Management. Hospitals may capitalize on a reputation for efficient surgical services. Some of the strengths are reducing time within and between surgical cases, because patients spend less time in or waiting for surgery; staff are freed for other productive activities such as patient visits (McLaughlin, 2012). Yet in health care, efforts to reduce time have chiefly involved purchasing new equipment or adding rooms to accommodate parallel processing; labor has been infrequently the target of initiatives to improve efficiency (Kocher & Sahni, 2011). Changing longstanding labor structures and practices may be an extremely resource-intensive exercise (Taylor, 1911). Moreover, mandates such as the Ministero della Salute, restrict options for cutting costs by reducing staffing numbers (OECD, 2012). Sweeping changes such as reducing the number of beds in the so-called “rural hospitals” (Magherini et al, 2011) re-structuring nursing services through the hiring of assistive personnel and reducing training opportunities affect recruitment and retention (Buchan, 1999); ineffective use of available resources has also been cited as a cause of recent nursing shortages at the point of care (Buchan & Aiken, 2008). There is another option for improving efficiency in processes, that which involves a review of staffing patterns. Surgical teams may work more efficiently and trim minutes from OR processes simply by aligning staffing patterns to optimize the use of time.

Operating Theatre: Composition and Organization

Operating theatre represents that complex of premises and structures used for the development of surgical activity, in sanitary facilities (public and private) and in nursing homes. It is defined as an organized structure of human and material resources, whose goal is the provision of health services with a high degree of specialization and invasiveness (Ruggeri S., 1997).

Not only the operating theaters, which represent the nerve center of the activity, but also a series of environments and spaces are part of the operating block, dedicated to host a series of processes that support the surgical activity.

It becomes important to define:

1) All those rooms complementary to the operating theaters necessary for surgical practice (www.nurse24.it, 2018):

- Rooms for customer reception: in this space the patient, arriving from the inpatient wards, is welcomed by the room staff and stops there until the entrance into the operating room. During the waiting period, the patient is subjected to additional intervention preparation protocols, including the last preoperative assessment by health professionals.
- Rooms for pre-operative preparation: they represent a crucial junction so that the operators can proceed with the planned intervention. In these spaces all the necessary activities for the correct preparation of the patient are carried out.
- Rooms for washing and dressing of the surgical team.
- Sterilization rooms (when structurally connected with operating theaters).
- Filter zones.
- Rooms used to awaken the patient: the awakening room is the structure within which doctors and nurses perform post-operative assistance functions, such as monitoring of vital parameters and functions, drug delivery and infusion therapy, the surveillance of the state of consciousness and the overall clinical evaluation of the newly-ill patient before his return to the ward, where he will continue his clinical journey.

2) All the specialized figures that operate there:

- First Surgeon: ie the surgeon in charge of performing the operation.
- Surgeon Surgeon: he is also a surgeon. its task is to facilitate the surgeon's vision and the exposure of the anatomical structures on which the surgeon performs the operation.
- Instrumentalist (s): one or two people. This is the operating room nurse who has the task of giving the surgeon the necessary tools, taking care that every instrument is given at the right time.
- Anesthesiologist: a surgeon specialized in anesthesia and resuscitation. He has the task of administering narcotic drugs to the patient.
- Operating room nurse (s): One or two people. They must ensure that everything necessary for the operation is immediately available in the operating room (sutures, special instruments, valve or vascular prostheses, etc.).

The complexity and the duration of the intervention to be performed determines the number and composition of the team in charge of its realization.

ORs are probably among the most important areas of the hospital, contributing to both the workload and the revenue. Efficiency of use of OR time depends on scheduling of cases, allocation of staff, equipment, time required for preparation and induction of anesthesia, performance of surgery, recovery from anesthesia, preparation of the OR for the next patient and other resources. Inefficient OR management can result in case

cancellations and long patient waiting lists. A well-managed OR results not only in a high surgical turnover, but also in reduced postoperative complications, improved patient-centered outcomes and greater patient satisfaction.

In fact, the management of an operating room must necessarily take into account the need to simultaneously organize the activities of the professionals, with the aim of maximizing their efficiency. It is therefore necessary to have an overview of the problem: in fact it is not enough to efficiently organize each category of operator taken individually to achieve the optimal configuration of the operating room, but the activity must be planned taking into account the interactions and relationships between operators, and evaluate the possible configurations.

This problem, together with the growing attention to the costs of the operating room, requires the presence of professionals who deal with this aspect.

The aim is therefore to plan activities not only for a short period of time, facing unexpected events and special cases, but also for the medium to long term, in order to standardize operations and increase the quality of the service offered.

The operating room management must follow 5 important principles, that represent a constraint for any improvement project. They can be summarized as follows (Rossetto, 2011):

- a) safety must always be guaranteed to the patient, as well as the best possible level of service;
- b) the best working conditions must be guaranteed to the operators and the most practical access to the rooms possible;
- c) the use of the operating room and materials must be maximized in order to reduce the excess costs;
- d) delays towards the patient must be minimized;
- e) try to obtain the satisfaction of patients and operators.

An important role in fulfilling the observation of these principles is played by the planning unit, with which some improvement actions have been undertaken in the organization of the operating room of 6 hospitals in Tuscany (RQ3).

The planning unit refers to the working group that has the task of programming and managing the sequence of interventions and hospital processes with the support of IT structures.

It is coordinated by the Medical Executive, who has the task of evaluating the structural complexity of the planning unit and the level of presences desired according to the volume of activity required.

In order to make this activity as effective as possible, the programming unit needs to interact with the greatest number of professional skills within the hospital structure, so as to carry out, besides the usual planning activity, also the verification and control of all hospital processes.

For this reason it collaborates with primary physicians and room managers during the planning of the operating activities, it is constantly in touch with the performance of operations in order to improve in real time the established programs.

Furthermore, those who work within the programming unit have the task of verifying any updates of data for IT systems to support activities, checking the correct compilation of reports and schedules, checking the level of stocks of drugs and materials, indicating any reorder quantity.

The need to coordinate different professional skills in the management processes of an operating room brings with it inevitable management difficulties. To this must be added the problems that often cause the incorrect compilation of the daily and weekly operator programs.

Among these it is possible to find distortions in communications between operating room staff and units that manage such planning, errors in the compilation of procedures that lead to the planning of interventions, slowdowns due to bureaucratic practices, difficulty in controlling activities.

The end result of these phenomena is inevitably the incorrect formulation of the planning of the operative activity.

For this reason it is often necessary to implement IT structures, in particular information systems, to support this series of activities, in order to standardize the whole series of required procedures and to reduce errors in the compilation or communication between the users of the health process and to make the work done by the programming unit as error-free as possible.

The set of IT structures that, through data collection and processing of information, allows defining the sequence of activities, the methods of execution, the necessary equipment and the related control takes the name of an IT system. In summary, an IT system supports the programming activity of the operating activity as it allows:

- carry out patient identification procedures rapidly;
- prepare daily and weekly interventions;
- monitor ongoing activities.

The presence of IT structures supporting the hospital activity thus allows the standardization of numerous procedures and at the same time the reduction of the incidence of urgent cases on the planning of interventions.

Operating Theatre Planning

Managing the operating theaters is one of the most discussed topics in Operative Research studies applied to the management of health systems (ORAHIS).

In fact, the surgical departments play a crucial role and the surgical activities constitute the center of the efforts involved in the hospital management. This is because surgery represents a significant cost in the overall budget of a hospital, due to the direct involvement of expensive resources for the surgical activities, but also to the impact that the management of operating theaters has on the request of other hospital services and on the use of a multitude of indirectly associated resources. In the last decade the number of research studies has grown and has been focused on the effective organization and planning of surgical activities aimed at reducing costs while maintaining a good level of quality of care and of health treatments. Better planning and management of surgical activities and resources directly and indirectly involved (Operating Theater Planning), can therefore lead to a more efficient use of resources, a reduction in waiting times for patients and, therefore, a better overall performance of the hospital itself.

The elective patient's planning and scheduling literature is quite large compared to the emergency one. Although many researchers do not indicate what type of elective patients is being considered: some distinguish between hospitalized patients and outpatients. Inpatient are those who must stay overnight, while outpatients enter and leave the hospital on the same day. Adan and Vissers (2002) combine the two types, formulating a programming model to identify the cyclic number and the mix of patients who must be hospitalized in order to obtain the targeted use of different resources such as the operating room or the intensive care unit (ICU). In their case, outpatients are treated as hospitalized patients with a duration of stay of one day who do not necessarily need specialized resources such as intensive care.

In the case of non-elective patients, one can distinguish between urgent and emergency surgery based on the patient's response to arrival (ie the waiting time until the start of the operation). Surgery of emergency patients (emergencies) should be performed as soon as possible, while urgent patients (urgencies) are non-elective users who are sufficiently stable to receive assistance at a later time but always within a limited time frame. Wullink et al. (2007) examined that the A.S.L. prefer to reserve a dedicated operating room or reserve a certain capacity in terms of time in all the elective operating rooms to improve the response to emergencies. Using the simulation of discrete events, they found that the responsiveness, amount of overtime, and overall use of the operating room were greatly improved when the reserved capacity was distributed across multiple operating rooms.

The researcher may wonder why most of the articles focus on elective patients and ignore problems caused by non-elective patients. This observation is even more surprising when we realize that the greatest degree of uncertainty is the main reason why the programming of operating theaters requires different methodologies from the procedures used by the machines developed for industrial systems. Many authors use the degree of uncertainty in order to justify the need to develop a dedicated programming procedure. However,

since it is easier to generate financial gains even if delayed by elective cases, this category can be favored in the search for optimization.

One of the main problems associated with the development of accurate operating room programs or capacity planning strategies is the uncertainty inherent in surgical services. Deterministic planning and programming approaches ignore this uncertainty or variability, while stochastic approaches explicitly try to incorporate it.

There are two types of uncertainty founded in the stochastic literature: the uncertainty of the arrival and the uncertain duration dependent on the protracted cases or arising complications. Referring to the first point it can be find the unpredictable arrival of emergency patients or the surgeons' delay at the start of the surgical session, while the second represents a difference between the actual duration and the planned duration of the activities related to the surgical process.

It should be clear that some simulation techniques and analytical procedures allow stochasticity to be managed, and that due to an appropriate preventive planning and programming approach, the negative impact of uncertainty can be reduced. However, only limited attention is paid to reducing variability within individual processes. In other words, you should start to reduce uncertainty in individual processes instead of immediately focusing on reducing the variability of the system that specifies the relationship between individual processes. Considering the estimate of the duration of the surgical intervention it should be examined whether the patient population for which duration is taken into account is truly instead of the immediate determination of the distribution of the duration of a surgical operation. Otherwise, the separation of the patient population may result in less variability even before the planning and programming phase is performed.

Performance measurement and tools

As written above, hospitals can use different tools to measure the performance of the whole or part of operations in the effort to improve their effectiveness, efficiency and customer satisfaction. Analysis and management tools include Total Quality Management (TQM), Balance Scorecard (BSC), Key Performance Indicators (KPI) and benchmarking, used with varying degrees of success (Paranjape et al., 2006). The application of TQM by service providers challenges employees, from senior officials to the lower cadres, to have a sense of responsibility and commitment in order to achieve continuous improvement in the provision of services that will favor better satisfaction in the long run of the client. The goodness of the facts deriving from the use of TQM depends very much on the will and personality of individuals engaged in a common vision and an emphasis on customer needs (Morfaw, 2009). The development of people dedicated to customer research becomes crucial, because service providers can work in groups or individually. Until the individual assimilates the culture of work with the vision of customer satisfaction, this

goal is difficult to achieve. This is the development of capacity building capacity in TQM, which has helped improve customer service (Morfaw, 2009).

According to Morfaw, focusing only on TQM is not sufficient to improve an organization's future, despite the implementation of TQM can produce immediate and visible improvements.

The Balance Scorecard (BSC) has assumed a prominent position as tool for performance measurement and management (Meng and Minogue, 2011). At the operational level, the BSC component, "Customer Perspective", and its related question, "How do customers see us?" (Kaplan and Norton, 1992), it is appropriate to measure the level of customer satisfaction in supply management, and in management of support structures. This is because customer problems are placed within four interest groups - time, quality, service performance and cost (Kaplan and Norton, 1992). This customer perspective in the BSC requires a delicate balance between how service provider functions create customer value and how customers perceive, demand or expect values to be met (Amaratunga and Baldry, 2000 ; Kok et al., 2011). However, the complexity of collecting, analyzing and translating into action, in the real world of performance measurement, negatively affects the use of BSC, resulting in a high failure rate of up to 70% of its use (Neely and Bourne, 2000).

Benchmarking is an effective management tool that allows service providers to continuously measure the performance of their operations compared to the market (Ho et al., 2000). This exercise can be stimulated from external or internal sources, with the aim of continuous improvement (Ho et al., 2000; Wauters 2005). Benchmarking can be described as the process of comparing a product, service or process with identical samples of a peer group, with the aim of identifying the "best buy" or "best practice" that stimulates development and implementation of appropriate performance improvement strategies (Wauters 2005). Varcoe, (1996), notes that benchmarking is a continuous search for the best for the application of new practices that apportion improve performance. Ho et al. (2000), describe benchmarking as a tool that serves both to help organizations to have an external focus and to find the best practices of companies, constantly comparing their performance with those of others. The implications of benchmarking can be summarized as follows: a process of constant comparison between the performance of a service provider and the superior performance within a peer group of best practices. To obtain positive good from benchmarking it is necessary commitment, involvement and a certain investment by both the managerial staff and the operative staff. The potential factors influencing the results include the level of competence and skills of the operational staff, the quality of the collected and usable data and an accurate analysis. Like other performance measurement tools, benchmarking should be seen as a 'long-term' solution (Morfaw, 2009), which requires continuous adjustments and changes.

In general, adopting any performance measurement tool brings advantages and disadvantages. Two factors are responsible for failure to implement an effective performance measurement system: the first is a wrong design of the measurement system; the other the difficulty in implementing such systems (Neely and Bourne, 2000). This left

a wide gap between what to measure and how to measure it (Amaratunga and Baldry, 2003). In order to overcome these challenges, it is necessary to use performance measurement tools that can facilitate data collection, analysis and application; these and others can be achieved by adopting the KPIs tool.

KPI: Key Performance Indicators

KPIs are a set of measures whose purpose is to redirect the focus of an organisation on the most critical items that guarantee performance improvement for the current and future success of the organisation (Parmenter, 2007). They are specific, significant and measurable standards; starting with few indicators and build on them (McNeeney, 2005). One of the most appropriate KPI definitions is that the set of indicators provides feedback that challenges individuals, groups and the entire organization to channel their energies and resources towards achieving a common goal (McNeeney, 2005).

KPI is the most widely used performance measurement model in construction and healthcare facilities practices. Hinks and McNay (1999) identified eight categories of indicators: business benefit, equipment, space, environment, change management, maintenance/services, customer satisfaction and general financial efficiency. Kincaid (1994) selected six for building maintenance. Shohet (2006) developed 11 indicators for the strategic maintenance of healthcare facilities. Lavy et al. (2010), through literature review developed a list of 35 KPIs and classified these indicators into four categories: financial, physical, functional and survey based indicators. However, there are also drawbacks in this tool. Mikušová and Janečková (2010) identified five of this shortcomings:

1. Variety of definitions of the same indicator;
2. Averaging;
3. Indicators difficult to interpret;
4. Control limits and variability of processes;
5. Several possible interpretations of the result of an indicator.

More generally, Pidun and Felden (2011) have highlighted some limits in the use of KPI as a performance measurement system:

1. KPIs can not successfully measure non-numerical indicators such as customer satisfaction, achieving milestones, describing the inherent complexity of a given organization or the level of maturity.
2. The use of KPIs is too dependent on the generic framework, with little flexibility of adaptation to the real context.
3. KPIs are often used in isolation and ad-hoc during use, without proper context description and without the support of an adequate performance measurement framework.

Despite these cons, the simplicity of the system has made KPI a more attractive model for measuring performance in the industry. However, since there is not yet a complete and certified list of KPIs for the operating room used in the various organizations and functions, each organization is assigned the burden of developing its own set of KPIs leading to an innumerable number of measurement of performances and a consequent difficulty in carrying out benchmarking. The KPI lists required by any organization are dynamic and flexible depending on the organization's goals or the effects of support structures on the performance of the organization's main function. Operational KPIs for any organization can be developed and transmitted to the service provider to be adopted. However, the most effective KPIs are those developed through consensus creation with the active participation of core operators and support services or customers and service providers. Here comes the Delphi technique to generate consensus between the organization (Hinks and McNay, 1999; Grisham, 2009; Xia and Chan, 2012).

Performance measurement system characteristics

A Performance measurement evolutionary review study conducted by Srimai et al. (2010) shows that the evolution took place in four major ways; from operations to strategic, measurement to management, static to dynamic and economic-profit to stakeholder focus. The literature review by Franco and Bourne (2003) identified that the strategic PMS field evolution in literature is progressive: till the mid 1900s it was on the design of strategic performance system, while in the late 1990s and early 2000s, authors found interests in the implementation of strategic PMSs. Nowadays, practitioners and researchers are highly interested on “how organisations are measured with measures”, and how they extract value from the data they collect. In Table 3 is shown the evolutionary path of PMSs in relation to what organisations should fulfil changes from the sole measure characteristic being effectiveness, in 1950s and beyond to multiple requirements, progressively up to 2000s, effectiveness, productivity, efficiency, flexibility, creativity and sustainability (van Ree, 2002 and Tangen, 2004). The evidence of their studies shows how in this era, the dynamic change in business trends, global trends, natural trends (Bititci et al., 2012) and technological requirements push the organisations to become multiple.

Table 3 – Evolutionary path of PMSs

<i>Till 1950s</i>	<i>1960s</i>	<i>1970s</i>	<i>1980s</i>	<i>1990s</i>	<i>2000s</i>
Effectiveness	Effectiveness	Effectiveness	Effectiveness	Effectiveness	Effectiveness
	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency
		Productivity	Productivity	Productivity	Productivity
			Flexibility	Flexibility	Flexibility
				Creativity	Creativity Sustainability

Tangen (2004) & Van Ree (2002)

Another approach has developed, over the last decades, in relation to performance measurement systems in schools of thought belonging to different disciplines, such as accounting, strategy, marketing and operations management (ie. Kotler, 1984 ; Slack, 1991; Lebas, 19995; Otley, 1999).

In the debate generated in the literature concerning the overcoming of exclusively accounting performance systems, an interest reference point is represented by the setting of Kaplan and Norton (1996). The authors argue that companies should start measuring not only if they are doing "good things", but rather if they are doing the "right things". On the contrary, the improvement of performance is contained in the balancing of the two factors.

Along this line of thinking, Wilcox and Bourne (2002) identified three phases in the development of performance measurement systems. The first was developed starting from the 80s with a predominantly efficient focus, linked to the economic-financial component. The second phase, emerged as a reaction to the first, proposes a multidimensional view of the phenomena, which led to the development of systems such as the balanced scorecard (Kaplan, Norton 1996, 2004, Broccardo, 2010, Lucianetti 2013). Lastly, starting from the second half of the 1990s, performance measurement systems began to be characterized by the importance of strategic maps, highlighting also the correlations between the areas and the performance indicators (leading and lagging).

The use of performance measures can be investigated in terms of both purpose and process (ie why and how performance measurement systems are used). The analysis of the purposes of use, although it has also been studied in the most classic contributions, has taken particular emphasis in recent years (among others: Wiersma, 2009; Baars et al., 2010; Grafton et al., 2010; Hall, 2010; Mundy, 2010; van Veen-Dirks, 2010; Tessier and Otley, 2012; Macinati and Anessi Pessina, 2014). Among the most recent contributions, there are two in particular that are important to underline. The first, proposed by Speklé and Verbeeten (2014), highlights:

- an operational use, linked to short-term goal setting processes and process monitoring;
- an incentive use, which translates into the definition of targets, structuring of incentives and management of reward mechanisms;
- an exploratory use, which is associated with the search for new opportunities, strategic learning and revision processes.

Franco-Santos et al. (2012), thanks to a thorough analysis of the literature, identifies the following objectives of using contemporary systems for measuring performance:

- support for decision-making;
- assessment of company performance;
- assessment of managerial performance;
- support for the incentive policy.

According to Franco-Santos et al. (2007) business PMSs are characterised by three major components: PMS features, PMS roles and PMS processes. Below, a section dedicated to these characteristics of PMSs.

PMS features:

The same paper by Franco-Santos et al. (2007) indicates that there is still lack of consensus on what dimensions should be included in a PMS to have 'balanced' set of measures regardless of the strong agreement that measures should be balanced. While designing their PMSs, companies should, therefore, consider the main features or components including performance measures, goals, casual models, targets, support structures, hierarchy, performance contract and reward. Nonetheless, some of the attributes that characterize the efficiency measures are the Multidimensional, leading/lagging, efficiency/effectiveness, internal/external, vertically and horizontally integrated, and multi-level. The goals of the business organisations are usually referred to as the strategic goals and objectives. The important feature but usually not explicitly expressed in the PMSs literature are the support structures, which can include data acquisition, collation, sorting, analysis, interpretation, and dissemination (Neely, 1998; Franco-Santos et al., 2007). The level of supporting infrastructure can vary from a simple method of data collection and analysis (using, for example, Excel) to a sophisticated

information system supported by corporate resource planning platforms or business intelligence solutions (Franco-Santos et al., 2012).

With reference to the process of using performance measures, most of the literature is based on the model of control levers proposed by Simons (1995). The author, placing the strategy at the center of the control system, identifies a series of levers that should ideally be activated, with variable intensity, in the continuous process of formulation and implementation of the strategy. These include the diagnostic control levers (used to motivate, monitor and reward the achievement of predetermined objectives, according to traditional feedback mechanisms) and those of interactive control (used to stimulate organizational learning and the emergence of new strategic options). Along this line of thought, some in-depth analyzes have recently been proposed, with the aim of better clarifying how companies can use control systems by balancing, on the one hand, the focus on achieving company objectives and, on the other hand, stimulation in the search for new opportunities (Mundy, 2010, Tessier and Otley, 2012).

Some authors suggested what criteria should be considered for the design of a performance measures - Neely et al. (2005), Franco and Bourne (2003), Tangen (2005a), Akyuz and Erkan (2010) and Najmi et al. (2005). Franco and Bourne suggested on what criteria should be considered in order to design a performance measure of an organisation and prescribed the requirements a performance metric for a good Performance Measurement System. Conducting 24 interviews they underline that a successful PMS should have measures characterized by simple, balanced, accurate, few but sufficient, cost-effective indicators. Maskell (1989) wrote that a performance measure should directly be related to manufacturing strategy, should include non-financial measures and assure dynamism over time and depending on the organisation circumstances. Tangen (2005) suggested that the design characteristics of a performance measure need to provide accurate information, support strategic, tactical, and operational objectives, guard against sub-optimisation and include limited number. Other author recommended that performance measures should be aligned to the strategy of the organisation (Braz et al., 2011). The same authors observed several different categorisation of performance measures. Kaplan and Norton identified four perspectives of measures that have to be balanced: finance, internal process, customer, and learning and growth (Kaplan and Norton, 1992). In addition, in a further work, they suggested that the number of measures can be from 4 to 7 in each heading (Kaplan, 2012). Shepherd and Gunter (2006), on the contrary, reported 132 measures, which were classified under three categories as:

- 1) quantitative and qualitative measures
- 2) cost and non-cost measures
- 3) quality, time, flexibility and innovation measures.

Abhijeet et al. (2013) classified 12 set of green performance measures, proposed by different authors, in to sets as top management commitment, knowledge management, employ training, green product and process design, employ empowerment, Environmental, health and safety, suppliers and management, production planning and control, quality, cost, customer environment performance requirements and customer responsiveness and company growth. They pointed out that there is a lack of consensus in the literature on what could be the best way to classify performance measures (Braz et al., 2011). It would not be uncommon getting a contradicting suggestion on the type of performance measures that whether they should be generic or company specific (Goshu et al. 2017). Kaplan (2012) suggested at organisational/corporate level, the measures could be generic so that executives can learn and develop further business or departmental unit measures, as they once understand the logic.

If Kaplan suggested general measures, Suwignjo et al. (2000) underlines that there should be company specific measures and PMS. There are also a number of authors who proposed the number, type and classification of measures in literature including Grünberg (2007), Neely et al. (2000), Shepherd and Gunter (2006), Lai (2010) and Maltz et al. (2003). In Paranjape (2006) opinion there are adequate criteria and guidelines in literature for the design and selection of performance measures. Braz (2011), instead, claims that there is lack of consensus on which type of performance measure criteria should be pursued and what should be the number of performance measure at both the organisation level and at the different business and/or operational units of a company.

Roles of PMs

Healthcare companies are complex organizations in which various resources interact with each other, undergo transformations and activities that add value. If resources are not efficiently and effectively controlled, the competitiveness of those companies becomes low. Each must be equipped with appropriate techniques and systems to measure, analyse and link their actions and results to their strategies so that their objectives and goals can be met in an efficient and effective manner. A lot of researches tried to study and decline the use and roles of PMSs such as Lee and Yang (2011), Tătälä et al. (2014), Bititci et al. (2012), Braz et al. (2011), Lynch and Cross (1991), Lebas (1995), Kaplan and Norton (1996c) and Rogers (1990). In Table 4 it has been reviewed PMS literatures using systematic literature review technique and identify the roles of PMS in literature are multiple and about seventeen in number, helped by Franco-Santos et al. (2007) work. One may consider that a PMS can play a role in controlling managerial activities or are used to translate and deploy company strategies and objectives. Their use exceeds this simplistic vision, as they can play roles in various ways, for example by focusing on the critical values of companies, on the planning of activities, on comparison and benchmarking, on incentives and on the influence of behavior. The information obtained from the PMS could also be used for compliance with regulations, external

communications and relationship management. As written in the next paragraph, Neely et al. (1995) suggest that PMS should be examined at three different levels: individual performance measures, a set of performance measures and the relationship between the PMS and the environment in which it operates.

Communication	Indicators / Strategy	Feedback
Strategy implementation/execution	Strategy formulation	Focus attention/ provide alignment
Internal communication (communicating performance, and priorities/objectives)	Benchmarking	Influence behavior
External communication	Measure performance, evaluate performance evaluation	Managing relationships
Control	Monitor progress	Rewards
Organisational learning and improvement	Planning	Double-loop learning
Compliance with regulations	Performance improvement	

Table 4 – PMS roles

PMS processes

PMSs are a set of metrics that, when combined together, become useful for quantifying the efficiency and effectiveness of organizational actions. According to Bourne et al. (2000), the design and validation of a PMS is divided into four phases (Figure 7): system design, implementation of measures, use of measures to evaluate the implementation of the strategy and use of measures to challenge strategic hypotheses and update the measures.

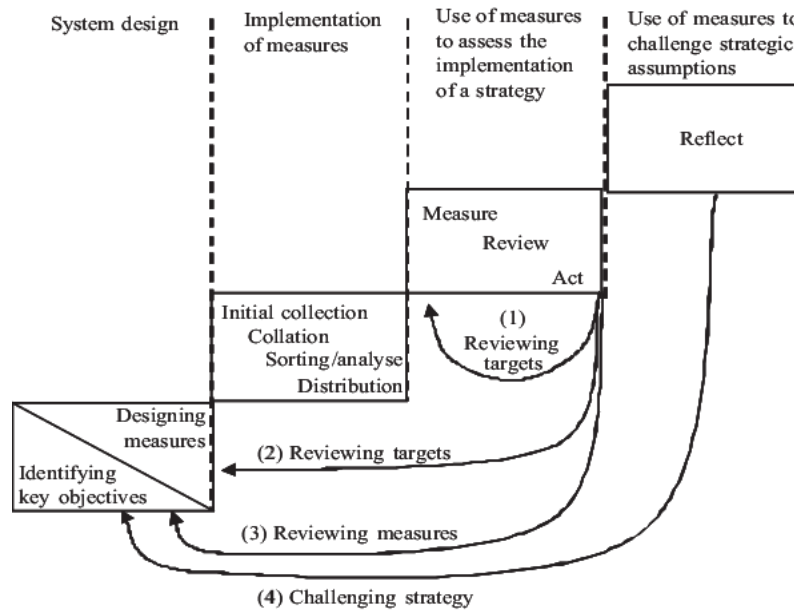


Figure 7 – PMS processes conceptual framework

However, what is described is only a conceptual framework. Bourne claims that he should not anticipate an easy progression from the system design to the refine of the performance measures and business strategy. Once again Franco-Santos et al. (2007) suggest that three processes of PM construction can be highlighted: namely "provision of information", "planning and selection of measures" and "acquisition of data". Therefore a company needs to have several processes embedded in the PM and improvement systems to identify or select the appropriate metrics, implement the system, evaluate and revise the PMS, generate relevant information from the PMS and provide it for decision making and receive feedback for the continuous improvement of the system.

They also suggested that there are three processes in PMS: “information provision”, “measure design and selection” and “data capture”.

In the current PM literature there is not only a single interpretation on maintenance of performance. In conclusion, the accuracy of the PMS is something that must be tailor-made built. There is no definition of the management activities about company resources, workstations, business units, plant, organisation and corporate level. Their hierarchical integration and interrelation requires a deep research in the field of PMS.

The reviewed literature focuses on the design, implementation, use and review of PM and PMS for large organizations. The information obtained from a PMS is realistically the real system in order to be managed in a sustainable way.

Because public and private organizations also differ, in a generic way, in their characteristics such as roles, responsibilities and main objectives, it is necessary to develop the PMS including these characteristics in a holistic and specific way. As the business trend changes, this time the supply chain management and collaborative organizations are emerging to attract the attention of researchers and professionals. The need for PMS to measure and manage the performance of the collaborative organization, which maintains coherent and conflicting interests along the supply chain as well as the individual organizations participating as a complete system, receives less attention in the current PMS literature. The development, implementation and use of PMS for the management of the flow of materials, finance and information from its source to the point of consumption requires an adequate framework and theoretical foundations (Goshu et al., 2016).

In conclusion, the literature agrees that, even in the presence of different models (BSC, MAF, CAF, etc.), contemporary performance measurement systems include different correlated analysis dimensions (including but not limited only to the economic-financial component), useful for operationalizing the strategic objectives (Franco-Santos et al., 2012). However, this evolution has called for a reflection on the epistemological preliminaries associated with the concept of measurement (Micheli and Mari, 2014).

A final relevant theme is represented by the use of performance measurement systems. Along this reflection, several contributions exceed the only measurement to achieve a real performance management (Otley, 1999, Ferreira and Otley, 2009, Broadbent and Laughlin, 2009): performance management systems offer, in fact, a holistic view which integrates measurement systems with the governance processes of the determinants of business success, including planning, scheduling and incentive mechanisms.

Performance measurement system design

According to the marketing perspective, organizations achieve their goals by satisfying their customers with greater efficiency and effectiveness than their competitors (Kotler, 1984). Every organization should measure, monitor and analyze its performance. Performance is defined as an accomplishment of a given task measured against preset known standards of accuracy, completeness, cost, and speed (Bierbusse & Siesfeld, 1997). Performance measurement is a complex issue that normally incorporates at least four disciplines: economics, management, accounting and information technology (Tagen, 2004). For healthcare firms, performance measurement systems (PMSs) is a relatively new branch of research, playing an important role in operations and in business strategy implementation. A PMS can help in giving the requisite information for the monitor, control, evaluation, and feedback functions for operations management. It can also become a lever for motivation, management action, continuous improvement, and the achievement of strategic objectives (Tapinos et al., 2005; Lohman et al., 2004; Kaplan and Norton, 1996; Neely et al., 1994; De Waal, 2003).

In terms of effectiveness, achieving a higher level on product reliability might lead to greater customer satisfaction. Explaining this statement in health terms we could say that having under control operating room processes increase a positive satisfaction level of the patient. In terms of efficiency, it might reduce the costs incurred by the business through decreased field failure and warranty claims. Once again, this means that hospitals can decrease their re-admission rate after an operation.

According to Neely (1994), performance measurement can be defined as the process of quantifying the efficiency and effectiveness of action. A performance measure can be defined as a metric used to quantify the efficiency and/or effectiveness of an action. Finally a *performance measurement system* can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions.

A performance measurement system can be examined at three different levels:

- 1) the individual performance measures;
- 2) the set of performance measures – the performance measurement system as an entity;
- 3) the relationship between the performance measurement system and the environment within which it operates.

The guidelines used to delve into the 3 pillars are summarized by Kaplan (1990):

- 1a) What performance measures are used?
- 1b) What are they used for?
- 1c) How much do they cost?
- 1d) What benefit do they provide?

- 2a) Have all the appropriate elements (internal, external, financial, non-financial) been covered?
- 3b) Have measures which relate to the rate of improvement been introduced?
- 2c) Have measures which relate to both the long- and short-term objectives of the business been introduced?
- 2d) Have the measures been integrated, both vertically and horizontally?
- 2e) Do any of the measures conflict with one another?

- 3a) Can the measures reinforce the firm's strategies?
- 3b) Do the measures match the organization's culture?
- 3c) Are the measures consistent with the existing recognition and reward structure?
- 3d) Do any measures focus on customer satisfaction?
- 3e) Do any measures focus on what the competition is doing?

Following the literature review and the above guidelines, *Individual measures of performance* measures can be categorized in 4 main topics (Table 5):

Quality	Performance Features Reliability Conformance Technical durability Serviceability Aesthetics Perceived quality Humanity Value
Flexibility	Material quality (Technology level of healthcare instruments) Output quality (PNE outputs, Piano Nazionale Esiti gives the quality index of a set of operations) New product (new kind of intervention) Modify product Deliverability Volume Mix Resource mix (Surgery, Anesthesia, Pharmacy)
Time	Manufacturing lead time (Operating Room intervention lead time)

	Rate of production introduction (Number of interventions) Deliver lead time Due-date performance Frequency of delivery
Cost	Manufacturing cost (Intervention cost) Value added (Quality, Quality Adjusted Life Years, including both the quality and the quantity of life lived after an intervention) Running cost Service cost

Table 5 – Performance measures categorizations

Regarding the *performance measurement system as an entity*, we can examine this section as a whole. It will begin by identifying the various dimensions of a performance measurement system (Neely, 2005).

One of the best known performance measurement framework is balanced scorecard (Figure 8) developed by Kaplan and Norton (1992).

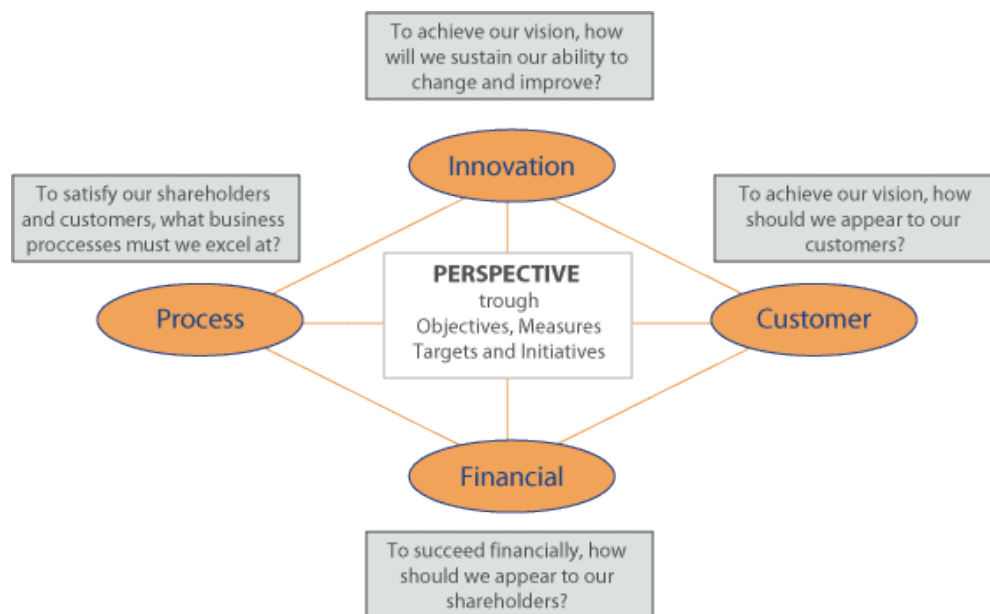


Figure 8 – Balanced scorecard framework by Kaplan & Norton, 1992

As it can be seen in the picture, a performance measurement system should provide managers with sufficient information to address the following questions:

- Financial Perspective: How do we look to our shareholders?
- Internal business perspective: What must we excel at?
- Customer perspective: How do our customers see us?
- Innovation and learning perspective: How can we continue to improve and create value?

One of the biggest criticisms of this framework is the lack of “competitor perspective”. The goal of realize a single unifying framework at this stage seems unrealistic.

Characteristics of PMS design process and measures (Neely et al., 2000)

The following Table 6 can be treated as checklist when the PMS and measures are being reviewed.

Characteristics of PMS design process	Characteristics of Measures
Performance measures should be derived from the company's strategy.	Performance measures should enable/facilitate benchmarking.
The purpose of each performance measure must be made explicit.	Ratio based performance measures are preferable to absolute numbers.
Data collection and methods of calculating the level of performance must be made clear.	Performance criteria should be directly under control of the evaluated organizational unit.
Everyone (customers, employees and managers) should be involved in the selection of the measures.	Objective performance criteria are preferable to subjective ones.
The performance measures that are selected should take account of the organization.	Non-financial measures should be adopted.
The process should be easily revisitable – measures should change as circumstances change.	Performance measures should be simple and easy to use.
	Performance measures should provide fast feedback.

Table 6 - *Characteristics of PMS design process and measures*

Once a performance measurement system has been developed it has to be implemented. This means that the performance measurement system will have to interact to two different dimensions of the environment (Neely, 2005).

The first is the organization itself - the internal one.

The second is the external one – that is the market within which the organization competes. We assumed to consist of two distinct elements – customers and competitors. In healthcare terms it means that an Hospital competes, for instance, with national excellence (Interregional Mobility) or with proximity hospitals around the same Regions (this event impacts differently on an financial level).

The interaction within internal organization is not always easy: because the marketers and manufacturers both want to be evaluated positively and rewarded well, each function responds as the system asks it to in order to protect its self-interest (KPMG study).

As written above, the external environment is assumed to consist of two distinct elements, customers and competitors. The technique that has been chosen to measure this perspective is Benchmarking (see next section).

In this dissertation we will try to decline these questions in health terms.

Diffusion and use of performance measures in the NHS

The relevance of research on multidimensional systems for measuring performance in the public sector bases its origins on the New Public Management theme, a term used to identify the principles and contents of the reforms that have developed since the 80s in numerous OECD countries. They have introduced in the public administrations the managerial systems usually used in private companies, with the aim of breaking the traditional bureaucratic culture in favor of achieving efficacy and efficiency objectives in providing of public services (Pollit, 1993; Hood, 1995; Terry, 1998; Gori and Fissi, 2011). Recently, the doctrinal program of New Public Management has been strongly debated due to several factors, among which the growing complexity of the public sector and, on the other hand, the controversial evidence about the impact that the reform processes generate in terms of effectiveness and efficiency of the services rendered (De Vries and Nemec, 2013).

Jääskeläinen and Sillampää (2013) have studied the factors that can facilitate or hinder the dissemination of performance measurement systems in these areas. More generally, they underlined the need to pay particular attention on how to introduce and develop local managerial practices. According to Humphrey and Miller (2012), the accounting systems require an in-depth analysis of the local implementation process, in terms, for example, of priorities pursued, aims and methods of use, management styles.

The introduction of programming and control systems has represented, for healthcare companies, one of the most important drivers of change (Casati, 2000; Radnor and

McGuire, 2004; Del Vecchio, 2008; Macinati and Anessi Pessina, 2014), especially as a result of the early 1990s reforms (Lecci and Longo, 2004). However, the push of several factors (Neely, 1999, Baraldi, 2000) has led healthcare companies to develop a mainly bureaucratic approach to the planning and control function, especially referring to the budget tool.

As a result of what has been said above, there has been widespread attention to advanced performance measurement systems (Franco-Santos et al., 2012), intended as tools to improve the process of achievement of the company objectives (Cavalluzzo and Ittner, 2003). This path has generated the development of different approaches and models that have progressively shifted the focus from economic-financial results to their determinants. Among the best known, it can be find:

- a) The activity-based approaches that emphasize the governance of activities and processes (Kaplan and Porter, 2011);
- b) Multidimensional performance measurement systems aimed at capturing the approved strategies, including the balanced scorecard (Kaplan and Norton, 2004; Baraldi, 2005).

The advantages of this evolution include the possibility of offering company management a more complete and objective representation of company performance (Dossi, 2010, Micheli and Mari, 2014) and, consequently, of being able to verify in real time the validity of own strategic vision, as well as the actual ability to realize it (Baraldi, 2005; Micheli and Manzoni, 2010).

If performance measurement tools are at the center of debate in the literature, health care management is faced with a paradigm shift in the epidemiological context: the prevalence of non self-sufficient elderly people and chronic patients (Istat 2013 data says that over a third of Italians suffer from one chronic disease and 20% of two). In fact, this change poses a risk of economic sustainability of the S.S.N. Longo and Cantù (2013), analyzing the tendency of the national and regional legislator to adopt interventions that focus largely on the control of inputs, rather than on the outputs and outcomes. This latter aspect imposes, therefore, a reflection not only on performance measurement systems, but also on their declination in primary care, as a reference framework for the appropriate management of frailty and chronicity.

However, it should be noted that PMS of operating room is still a relatively unexplored topic in the literature. If much has been written on the themes of the associations of general practitioners and their budget system (Longo and Vendramini, 2001; Tozzi and Tedeschi, 2004; Vendramini and Corsalini, 2010), little has yet been published on the topics of performance measurement, especially in relation to the availability and use of indicators relating to both the assistance provided by general practitioners and to other services offered at the district level (eg integrated home care, prosthetic assistance, residential and semi-residential assistance).

As noted in the previous research areas, both the characteristics and the use of performance measurement systems were investigated in the health sector.

Referring to the first aspect, Nuti et al. (2013) have recently highlighted the presence of a growing number of studies describing the implementation of multidimensional systems for measuring performance by healthcare companies. In particular, the phenomenon of multidimensionality and the breakdown of the information produced by the performance measurement systems has been highlighted significantly both at the system and at the company level.

Pollitt (1986), analyzing English health system (NHS), noted that as early as the second half of the 1980s, many health care companies had begun to introduce experiences in measuring performance. In fact, the British Health authorities, since 1986, had been obliged to include multidimensional performance indicators in their annual report.

In Italy, Bergamaschi and Lecci (2009) write that "the absence of a typical exchange mechanism and an objectified measure of the value of what is sold, the presence of non-standardizable processes, even in the face of the significant professional autonomy of doctors and of the consequent need to share the indicators, they represent only some factors that nourish the problem.

In public health companies, the problems mentioned above have translated into a progressive widening of the range of indicators used, often penalizing the selection of an "essential" set of variables able to fully express the set of results produced by each organizational unit". Nuti and Reginato have studied in-depth experiences of performance evaluation at national and regional level.

Based on evidence gathered in the United Kingdom, Germany and Italy, Jacobs et al. (2004) report a critical situation: Results of their work show that information on costs and activity carried out is not accessible to clinical professionals in a pervasive way, but only to clinical roles occupying positions of particular responsibility. This strongly biased vision of the management component, rather than clinical, of the control systems has recently been confirmed by Macinati and Anessi (2014): the results of their survey show, in fact, that the use of the most sophisticated programming and control systems by the companies of the S.S.N. was particularly affected by the pursuit of cost control strategies. With reference to the process of using performance measures, the literature argues two elements specifically related to the health sector. Various studies highlight the need to involve clinical professionals in the implementation process of performance measurement systems. For example, Abernethy and Brownell (1999), in a research on 63 public hospitals, show that the use of the budget as an interactive control system, rather than a diagnostic one, is more efficient as it facilitates learning in the processes of strategic change.

Lehtonen (2007) suggests the opportunity to stimulate the involvement of clinical professionals by leveraging the integration of clinical and administrative accountability mechanisms, responsibility assignment processes, freedom of choice in adopting the most appropriate control tools and on the flexibility of implementation of control systems. Similarly, Pettersen and Nyland (2006) show that, since the use of information

often presents a break between managerial processes and clinical processes, it is necessary to break down the information produced by the company control systems into indicators that are meaningful for clinical professionals, in order to activate an effective interactive control.

Another element of specificity is the behavioral factors linked to the introduction of performance measurement systems by clinical professionals. Still citing the survey proposed by Macinati and Rizzo (2014) in an Italian hospital, they highlight the importance of governing behavioral variables in the introduction of the budget, in order to stimulate a process of convergence between individual and organizational objectives that may have a positive impact on company performance.

The first Research Question aims to analyze the diffusion of performance measures of operating room theatre in the NHS/SSN and to study the degree of diffusion and use of economic and financial and not performance measures related to the operating room, within the local Italian health companies. In particular, the empirical analysis aimed to answer two research questions: what are the performance measures available within the local health companies? How are these measures used?

Benchmarking

Benchmarking is a process of comparing performances between several in competition production units, which is used to allow each unit to improve its performances in the market. Benchmarking also allows you to highlight where to innovate (for example a process, a product) to reach competitors' performance as quickly as possible or create a positive gap.

Benchmarking theory is based on performance comparison, gap identification and changes in the management process (Camp, 1989; Karlof and Ostblom, 1993; Watson, 1993).

From literature review (Camp, 1989; Zairi, 1992; Smith et al., 1993; Rogers et al., 1995), it's clear that Benchmarking:

- Helps the production units to understand strengths and weaknesses that may depend on changes in supply and demand or market conditions;
- Allows to understand what level (or levels) of performances are theoretically achievable by observing others and how far they are to be reached;
- Helps to better meet quality requirements, costs, products and services by establishing new standards and objectives;
- Helps the production units to increase the competitive advantage by stimulating continuous improvement to maintain quality performance and establish new competitive standards, "raising them";

- Promotes changes and suggests improvements in quality, productivity and efficiency that together produce innovation and competitive advantages;
- Favors an increase in the motivation of employees.

Despite these advantages, time constraints, costs, lack of management commitment, a general resistance to change, poor planning and too many short-term expectations are considered as the main problems affecting most of the potentially successful benchmarking research. (Bendell et al., 1993). A poorly executed benchmarking study will result in a waste of human and financial resources, as well as of time.

There is no real "Best Practice" because the objectives vary according to the mission, the environment and technological availability.

Improvement is a continuous process and benchmarking should be considered as a part of that process. As a result, even if several authors have defined benchmarking in different ways, all these definitions have a common theme: continuous measurement over time and improvement of an organization's performance against the best in the industry to get information about new methods of work and practices of the other competitors (Kozak, 2004).

Table 7 summarizes all the definitions that have been given for Benchmarking, since 1989.

Authors	Definitions
Camp, 1989	The continuous process of measuring products, services and practices against the toughest competitors or those companies recognised as industry leaders
Geber, 1990	A process of finding in the world class examples of a product, service or operational system and then adjusting own products, services or systems meet or beat those standards.
Vaziri, 1992	A continuous process comparing an organisation's performance against that of the best in the industry considering critical consumer needs and determining what should be improved.
Watson, 1993	The continuous input of new information to an organisation.
Kleine, 1994	An excellent tool to use in order to identify a performance goal for improvement, identify partners who have accomplished these goals and identify applicable practices to incorporate into a redesign effort.
Cook, 1995	A kind of performance improvement process by identifying, understanding and adopting outstanding practices from within the same organisation or from other business.
APQC, 1999	The process of continuously comparing and measuring an organisation against business leaders anywhere in the world to gain information that will help the organisation take action to improve its performance.

Even within the Health since the 90s the term has gained increasing importance. All professionals involved in health care are obliged to guarantee assistance with predefined standards; it involves ensuring a uniform supply of a high quality health service. A widely accepted definition of quality is "the extent to which health services for individuals and the population increase the likelihood that outcomes are consistent with current professional knowledge" (Institute of Medicine, 2001). Benchmarking has been transferred to the healthcare system from the management area and has been used to try to improve the quality of health services since the mid 1990s (Phillips, 1995, Bullivant, 1998 and Camp, 1998). Although it has become an integral part of most modern healthcare systems, the impact of benchmarking initiatives on improving system performance and their integration into existing policy processes remains to be clarified in a definitive manner (Blalock, 1999; Goddard et al. ., 2000). Benchmarking has developed in the health service through a quantitative assessment of the performance, a process evaluation and the qualitative achievement of best practices to improve the user experience. The benchmarking activity used by the health service has developed from a "simple" comparative analysis that focuses on the performance of the inclusion of the evaluation of the patient's processes and experience.

Operating Room Efficiency

The operating area is the nerve center of hospital activity, its efficiency is a primary objective to ensure adequate production levels, an economically and sustainable management of resources and the necessary levels of safety for patients and operators. Furthermore, its organization directly influences the correct management of many hospital departments and support services. The emerging needs of the actors involved - strategic management, surgeons, anesthetists, nursing and technical staff - are often different, so it is necessary to find an overall balance through the members.

The growing attention to the policies of optimization of the operating activity can be seen from the steep increase in scientific research in this sector, which has had an explosion in recent times. Cardoen (2010) underlines how more than half of the scientific work in this sense was published after 2000. The many studies on the perception of efficiency in an operating department show that the different professionals involved in the process, although working side by side, often have different sensitivities about the same problems. In fact, nursing staff tends to emphasize aspects related to experience and organizational efficiency, while the clinical part and the company departments tend to frame efficiency in terms of productivity per unit of time or completion of tasks assigned. Dexter et al. (2009) founded that those perceived to be the main causes of inefficiency are far from what was directly observed in ordinary activities performed.

The governance of management complexity requires not only the involvement of different professionals for the analysis of all the salient aspects, but also the need to use appropriate indicators for the continuous monitoring of activities to ensure, in case of need, the timeliness of the necessary corrective actions.

Operating room management aims to reduce non-surgical time to achieve greater productivity (such as number of interventions) during normal working hours, reduce the use of overtime, increase patient and operator safety, provide adequate working conditions for staff and ensure adequate care pathways for patients.

However, it is reductive to focus only on peri-operative efficiency to add new cases during the normal time because, despite the considerable time savings required to schedule a new intervention, most of them allow the recovery of a few minutes per case. The most recent researches have changed the basic paradigms for the turnover of the Operating Rooms, providing tools for reviewing the entire path of the patient in the OR to drastically reduce the unproductive times and increase the throughput (measure of productivity that generally indicates the number of units produced in a certain time space). An extensive scientific literature demonstrates that the additional expenditure needed to achieve efficiency gains is more than offset by financial returns (Krupka, 2006) and that, in any case, more than significant improvements can be made using the same resources.

One of the most important element for the operative planning is the correct prediction of the duration of the interventions.

The more reliable this data will be, the lower the probability of delays that could lead to the rescheduling of the operating activity with the risk of cancellations.

Many studies show a strong connection of the surgical duration parameters with the specific local realities, due to the strong correlation with the organizational parameters, with the specific professional skills, with the surgical expertise developed over time. In other words, although it is necessary to start from parameters shared in literature, it is advisable and advisable to perform a direct survey and analyze it on a statistical basis, to refine the data and obtain realistic reference times.

An important methodological study (Dexter, 2010) highlighted some fundamental aspects, providing the essential elements for conducting the analysis correctly, in particular:

- The Bayesian method is the one that proved most effective in the correct prediction of duration, allowing a detailed description of the procedure; for procedures with few historical data (which uses the frequency observed as an estimate of reliability of the prediction made);
- In case of recovery of room availability, the inclusion of additional interventions, does not affect the estimated duration of the intervention itself. In other words, if correctly calculated, the average duration of the elective interventions is valid even if such interventions are performed as additional;
- The effective timing of intervention times is strictly related to the specific surgical specialty. In other words, different surgical specialties are characterized by a specific parameter of precision.

There is a wide literature on the benefits deriving from the adoption of specific departmental information systems for the operative room block management (Van

Essen, 2012; De Deyne, 2004; Dexter, 2003), appropriately integratim in the hospital information fabric.

However, it is important to note that these systems are effective in creating and dynamically managing the management procedures already identified as being optimal for the reference operating sector; guaranteeing, in other words, an excellent tool for the realization of previously designed optimization and control strategies. In particular, in addition to offering the operating calendar scheduling tools, they support operators in rapid rescheduling of activities in case of unforeseen events, delays or cancellations.

Literature is lacking of contributions about KPIs regarding quality of care and customer satisfaction in Operating Room Theater.

Regarding purely health aspect, the use of indicators (and indicators systems) can be aimed at achieving four main objectives (Corposanto 2004):

- the characteristics of *systematicity* and "*scientificity*" in every decision-making process in healthcare;
- the possibility of clearly setting the objectives and therefore of verifying how much these objectives have been achieved;
- the possibility of basing these decision-making processes on the analysis of the benefits obtained from the decisions made and the costs that these decisions involve;
- the definition of a context of precise references within which to address the expression of the population's health needs and its participation in the activated process for their satisfaction.

The indicators most used in the health field can be grouped into some prevalent types:

- basic indicators;
- effectiveness indicators;
- efficiency indicators;
- quality indicators.

The basic indicators refer to structural or dynamic characteristics of human populations, explained in their demographic and social aspects. This demographic and social representation provides as a whole the necessary knowledge about the context in which the health / illness events and the organizational responses to these are developed, on which the management will be investigate through the indicators of effectiveness and efficiency.

Effectiveness indicators make possible to measure the "global" health status of a community. In this group some of the most "classical" epidemiological indicators are

included, i.e. those that refer to a reductive but immediate meaning of health as the absence of disease and avoidable death; the negative health indicators are indicators of morbidity and mortality.

The efficiency indicators refer to the cost / benefit analysis. This is one of the most typical methodologies of economic and management origin that are applied in healthcare, exploiting the possibility of equating the health system with a company. If this equation is questionable when considering the health system as a health producer (good health is too far from the characteristics of economic good to be considered in the same way as any market product), it is however acceptable if one considers the system as a service provider. A health system can, therefore, be assessed in terms of management efficiency: because of the complexity in the cost / benefit ratio evaluation of health (if not in terms of cost / result analysis), it is possible to analyse the relationship between costs and benefits obtained in terms of production and services. The tools for these assessments are resources and utilization indicators and productivity of health services.

Resource allocation indicators refer to: financial resources (per capita expenditure, current expenditure / capital expenditure, current expenditure per budget chapter); to structural resources (logistic resources intermediates of physical locations for the location of the main services such as hospitals, clinics, pharmacies, etc.); to human resources (availability of personnel and working time).

The *utilization and productivity indicators* consider (as the name implies):

- **Utilization:** it is the indication provided by a series of measures that correlate the different types of staff (employees) and structural resources (logistic and instrumental), in order to compare different situations between the elements. They therefore allow to quantify both the use of services by the population, in relation to a series of variables such as territorial units of institutional residence, etc., and the levels of activity of operators and facilities of the services themselves. These kind of indicators are divided schematically into "indicators of logistical resources utilization" (hospital, outpatient, basic health care, accessibility indicators) and "indicators of human resources utilization" that measure the operators' activity in quantitative terms. A cost measure of the operators' activity can then be provided by the productivity indicators and a quality measure of those activities from the quality indicators.
- **Productivity:** considering the difficulty of outlining the final product of the health organization (health status), productivity refers to services provided or at least in hours of production.

The *quality indicators* measure all the aspects of an intervention or health system in terms of quality assessment (effectiveness, efficiency, acceptability, coherence - ie compliance of the interventions to the real needs of the population's health - level of application of scientific knowledge, professional skills and available technologies). The evaluation of

technical, organizational and perceived quality of services represents an important completion of health planning as:

- satisfies the citizen-user;
- increases professionalism and therefore the operator's gratification;
- reduces costs (for example through the elimination of redundant diagnostic treatments and exams or the prevention of pathologies due to the inappropriateness of the assistance).

Indirect health status indicators are the intermediate results of a chain of effects whose ultimate goal is the global health status improvement, as explained above. Some of the examples in order to explain this kind of indicator are the increase of breastfeeding women, considering that it is now agreed that this situation favors a better development of the child and a more valid protection of his health in the first months of life; the rate of vaccination coverage achieved in the population; the decrease in the number of institutionalized minors or elderly; etc..

Organizational results indicators have the objective to improve the quality of the way of operating and greater equity in distribution and accessibility to resources. Some examples: the possibility of "rooming-in" (that is, the stay of the child with the mother during the first days of life) in the obstetrics-neonatology wards; persons with disabilities inserted in public nursery schools / total of the known cases of disabled persons aged between 3 and 5 years; construction of a risk map with respect to the risks identified as priority in the production sites; etc..

User satisfaction indicators take into account two elements: the *user* and the *operators* of a service. The indicators would serve to identify and quantify not only the changes in the attitude of the citizen-user, but also to emphasize the relationship between organization-user operator (Crepaldi, 1999).

CHAPTER 3 – METHODOLOGY

In this Chapter, it has been described the methodology adopted to conduct the projects in which I have been involved, according to the existing taxonomies.

This chapter presents the research design, measures, and analysis plan for this explanatory study. An overview of the selection of units for data analysis is also provided. The Tobit regression equation and DEA model representing the research model of OR efficiency for RQ2 is presented, and analytical methods to build PMS are described.

Research strategy

With the aim to fill the literature review gap and to ask the RQs, a research strategy has been designed.

It has been adopted a mixed approach Research strategy (deductive and inductive approach) based on Archival research, survey, Grounded Theory and Case Study. Case study involves empirical investigation to study contemporary phenomenon using multiple sources of evidence (Robson, 2002). Case study is opposite to experimental strategy which is not bound to a context. It is most suitable when to gain in-depth insight of the research context. This strategy involves an empirical investigation of a particular contemporary phenomenon within its real life context, using multiple sources of evidence (Saunders et al., 2009). It is normally used to gain a more in-depth understanding of the research, often in an effort to answer “how” and “why” questions (Yin, 1984). Grounded theory is the best example to mixed approach where the emphasis is on theory building. This strategy is adopted to predict and explain a behaviour. In this strategy, the research initiates with the development of theoretical framework. New theories are developed on the basis of the theoretical framework. Archival research is based on administrative records from Ministry of Health and documents as a source of data which can be both recent or historical. Data which is collected for different purposes is analysed to determine the implications of the same. Survey is associated with deductive approach. Most of the studies related to business and management adopt this strategy. Survey enables the researcher to collect huge amount of data from a sizeable target population. The data can be analysed using descriptive and inferential analysis tools.

Survey research is used to combine results from DEA analysis in order to measure efficiency of Operating Room Theaters and Survey results through Tobit regression analysis in order to demonstrate if any variables explained on survey are related to efficiency measures. Regression analysis measures the degree of influence of the independent variables on a dependent variable. In the case of a single independent variable, the dependent variable could be predicted from the independent variable.

The case study has been used, first of all, for exploration purposes and then also with a theory-building attempt. The RQs described in Chapter 1 and the research framework represented in Figure 7 have been defined in order to have a prior view of the constructs to be studied and their relationships. Of course RQs evolved over time and constructs have been modified and developed during the course of the research.

The aim of this manuscript is indeed to reinforce the structure of the research framework and provide answers to the RQs that are straightforward and lined up with academic and entrepreneurial goals.

Table 8 linked each topic from the research framework to its respective methodology and the project duration. Analysing the research framework, the reader understands that several topics are tightly connected.

Data interpretation has been inductive: once data were collected, then were analysed to see how filling the literature gap, generalizing or defining company-specific behaviours.

Ultimately, methodology has been particularly useful to ensure the alignment between research framework, RQs, data collection, analysis, results and conclusions.

RQs	Topic	Methodology	Duration (months)
RQ1	KPIs Dashboard	Literature Review + Delphi Method	3 – 6
RQ2	DEA efficiency scores & ICT regression analysis	Model + Survey	6 – 8
RQ3	5 Case Studies among Tuscany surgeon units	Case study	8 – 10 Period of analysis: 2 years

Table 8 – From research framework to methodology

Techniques and procedures

The case study analysis gives the opportunity to perform triangulation, providing stronger substantiation of constructs and hypotheses. It refers to the use of different data collection techniques within one study, both quantitative and qualitative. In fact, surveys, interactions, observations and archival sources have been combined.

In addition to the choice of multiple data collection techniques, also analysis procedures have often been merged, quantifying qualitative data and qualifying quantitative data. Hence, a mixed-model has been adopted (Saunders et al., 2009).

From the population of Healthcare facilities, it has been selected a sample that was representative of the strategies and features typical of the sector. Because of the differences in terms of PSR (Piani Sanitari Regionali) it has been selected homogeneous healthcare units. In order to be included in the sample, the firms considered must have had some key features:

- Having at least the location in Italy;
- Having an Operating Room Theater with at least 3 rooms;

- Playing in different specialistic segments (I.E. we have to exclude Rizzoli Istituto Ortopedico and all of the mono-specialistic structures);
- Having at least 30 acute beds.

Fortunately, the Italian database meeting the above requirements has about 250 structures, even if not distributed in a homogeneous way on the national territory.

Interviews have represented the primary contact with these companies. Then, depending on the purpose of the project, It has been also designed and administered questionnaires, always accomplished by interactions, personal observation and review of archival sources. Standardized surveys were used to collect quantitative data or to perform benchmarking between the cases, basing on key variables or drivers (the main questionnaires that have been dispensed are reported in the Appendix I Chapter).

The DEA model elaborated and revised to analyse efficiency measures is hosted by R environment.

The different topics analysed required different knowledge, skills and expertise: health management, anesthesiologists, planning and operations managers, Regional government have been involved. Dissimilar viewpoints within the same organization and often simultaneously have been analyzed. Then, these multiple perspectives have also allowed to reduce the risk of subjectivity and bias.

In this work all the cases have been conducted as a single investigator.

Moreover, comparisons of emergent concepts with existing literature have always been performed in order to check similarities or conflicts.

Reliability, i.e. the extent to which a study's operations can be repeated, with the same results, has required a particular concern. Even if the Italian government often changes the way to share their database and the performance evaluation is not at the same level along national borders, several validation meetings have allowed to review the analysis with the stakeholder, to refine the kpi-dashboard and to find the best way to validate it. Summing up, in order to answer to RQ1, a Literature Review has been conducted. The literature review provides insight into how performance measurement is approached in academic journals and performance measurement books. Here the focus is on theoretical frameworks, design and use of the system as well as on other factors affecting performance measurement such as different organizational cultures and employee motivation.

The empirical part is based on data provides from Estar (Ente di Supporto Tecnico Amministrativo Regionale) where a constructive research approach is used to create a performance measurement model in order to measure outcomes and customer satisfaction level. The findings from the empirical research are reflected against the theoretical background and a reviewed performance measurement framework is created based on the different forces affecting the measurement system. In order to identify the hospital's performance indicators, first related literature has been reviewed and then the experts' panel and Delphi method have been used.

The information required to develop performance indicators can be obtained using systematic or nonsystematic methods. Nonsystematic approaches such as case studies are based on data availability and real-time monitoring of critical incidents (Pringle, 1998). Although these approaches play an important role, they fail to exploit much of the available scientific evidence. In systematic approaches, in contrast, indicator selection relies directly on the available evidence, complemented when necessary with expert opinion (Campbell, 2001; Hearnshaw, 2001). Experts examine the evidence and reach a consensus. Systematic methods enhance decision making (Hasson et al., 2000); facilitate the development of performance indicators (specially about outcomes and customer satisfaction) or review criteria for areas where the evidence alone is insufficient or controversy (Fink et al., 1984); and synthesize accumulated expert opinion. Among these methods, the Delphi technique has been widely used for indicator development in healthcare.

A search of the literature for articles on PubMed, Scopus, Sciences direct, Google scholar, DOJA, SID, Research Gate, Taylor & Francis, and other databases has been conducted. Keywords used for searching was a combination of “performance”, “operating room”, “KPI”, “assessment”, “measurement”, “hospital”, “indicator”, “evaluation” and “criteria”. The Boolean AND / OR operators were placed between keywords in the searches.

Then, using the values provided by the National health system and results from a survey, a Tobit model is designed to answer to RQ2 and then perform a correlation research.

The Tobit model, also called a censored regression model, is designed to estimate linear relationships between variables when there is either left- or right-censoring in the dependent variable (also known as censoring from below and above, respectively). Censoring from above takes place when cases with a value at or above some threshold, all take on the value of that threshold, so that the true value might be equal to the threshold, but it might also be higher (Long, J. S., 1997).

Answering RQ3 a case study research in order to validate the PMS and to test RQ1 is conducted. In particular measuring the difference in KPIs terms between healthcare units before and after implementation of ICT in Operating Room Planning and management it is possible to demonstrate if technology helps to increase the efficiency of ORs.

How to Identify operating room efficiency indicators using Delphi Technique

To measure operating room (OR) performance and their efficiency, hospitals need scorecards or dashboards displaying and tracking core performance indicators.

The main challenge in developing a scorecard for measuring and monitoring OR performance is determining which indicators are most important for inclusion. The major constraint of service providers is their inability to marry their performance priorities with the customers' priorities, perception and expectations (Hinks and McNay, 1999). In order to bridge this divide, there is need to adopt suitable performance measuring system, such as Key Performance Indicator (KPI), which is developed through the active participation of all relevant stakeholders (Beatham et al., 2004). Indicators ideally should consist of data already available in OR information systems, and qualitative measures, such as satisfaction surveys. The qualitative measures probably are rejected because most of them are not validated.

However, variations between hospitals are possible in terms of which data elements and indicators are collected and analyzed, making external benchmarking difficult. Only with uniform data and indicator definitions hospitals proceed with benchmarking and maybe share knowledge, and best practices. It is often difficult to achieve consensus on which indicators are most important for measuring performance. In fact, because of the multiplicity of stakeholders involved — surgeons, anesthesiologists, nurses and hospital administrators — finding a uniform judgment is not always easy.

Operational KPIs may be adopted from a generic list, or developed using relevant consensus building tools such as the Delphi technique. Hasson and Keeney (2011), describes the Delphi technique as “a method used to obtain the most reliable consensus opinion of a group of experts by a series of intensive questionnaires interspersed with controlled feedbacks”. In simple terms, it is a consensus building tool. The Delphi technique is useful where information gathering and feedback from interested parties (experts) are difficult due to external commitments, geographical limitations and the need to ensure anonymity (Geist, 2010; Xia and Chan, 2012). The distinguishing feature of the method concerns the type of decisions that are made through the informed consent of the experts. In the case of a general survey (Grisham, 2009), instead, the opinions of "uninformed" participants would be used. The fact that the results derive from the opinion of a group of experts from the "real world" suggests that the decision taken may be more valid than a decision made by a single person (Hasson and Keeney, 2011).

Summarizing, the Delphi technique is useful where a proposed solution to a given problem is developed by harnessing the information from experts or people knowledgeable in the given field.

The basic principles underlying the Delphi technique include the identification and use of participants similar to the hospital environment that can respond to the research question (Franklin and Hart, 2007). The group interacts with the same problem through

a series of iteration processes, in which the information of the previous iterations are communicated to all the participants. All requests are processed through a coordinator or a central facilitator, who reports feedback to participants after each iteration (Green and Price, 2000; Franklin and Hart, 2007).

The contribution of each participant is treated anonymously and no participant can be traceable to its contribution and viceversa. Consensus is reached by adopting the stipulated benchmark agreed upon at the beginning of the exercise.

Regarding the size of the panel, researchers agree to establish the minimum number of 3 units and the maximum number of 8. Taking for granted the abandonment of some members, it is necessary to recruit a large number of participants in the initial phase, exceeding the score established for "preferred group size". In this regard, the concept of "Delphi funnel" by Donohoe and Needham was adopted (2009). The explanation is simple: following Hasson et al. (2000) research participants are not selected by following random sampling but rather the 'purposive or criterion sampling' because the participants are selected for a purpose.

A variant of the classic Delphi technique is known, with a lot of imagination, as the classic modified Delphi technique, which serves as a tool for collecting data during the development of KPIs. In particular, the difference with the classic method lies in the type of approach. In the classic method we talk about a qualitative approach: in the first round the participants generate perspective solutions to the research question. The iteration process then starts from the second round. In the modified method, a list of generic solutions is given to the participants in response to the research question from the first round (Franklin and Hart, 2007). Then, the iteration process starts already in the first round.

Through the ARS Toscana (Agenzia Regionale Sanitaria Toscana) the potential stakeholders of the activity were contacted. To ensure effective participation, potential participants were involved in one-on-one interaction where possible (Day and Bobeva, 2005; Donohoe and Needham, 2009).

The process can be administered using online tools provided by Ascom UMS, a company that deals with information systems for operating theaters. Geist (2010) confirmed that the results obtained when he used, in his Delphi research, both paper and online tools to address the same problem were identical. At this point, the procedure adopted involves circulating information to participants who must interact with the document and send the response to the coordinator within a certain time frame. The present study started in September 2017 and ended in February 2018, involving 9 experts, whose job descriptions are summarized in Table 9. The coordinator collects the answers and recirculates anonymous feedback to all group members. The process continues until the unanimous consent is reached, through iteration. There are no a priori rules defined regarding the number of rounds in the Delphi method. What matters is that the level of consensus or convergence of opinions is reached or the participants are no longer modifying their previous decisions (Franklin and Hart, 2007, Adnan and Daud, 2010). To compete in any

case with scientific research, in some papers it is possible to find a consensus percentage between 51 and 80% agreement among the participants (Hasson et al., 2000).

In order to show the participants the tendency towards the acquired opinion, descriptive and inferential statistics were also given; in particular information on central trends (averages, means and modes) and on dispersion levels (standard deviation and interquartile range) as suggested by Hasson et al. (2000); Day and Bobeva, (2005); Adnan and Daud, (2010).

To start this path, the project proposed by Fixler et al. (2012) has been followed. Fixler et al. (2012) identifies in The Canadian Paediatric Surgical Wait Times (CPSWT) Project, launched in 2007, a good solution to identify KPIs with Delphi method.

This project provides a unique opportunity to share knowledge across these participating hospitals to identify which performance indicators were most commonly used and viewed as most critical for measuring OR performance, particularly from a utilization and efficiency perspective.

At a methodological level, it is interesting to proceed to the evaluation and selection of the most significant KPIs, trying to identify them as a function of three families (Calzolaro 2012):

- KPIs that measure **efficiency performance**, ie the ability to use resources. The indicators measure the productivity and unit costs with which the process outputs are obtained. Typical measures of efficiency are the average cost of preparing an order line, unit cost of transport, volumetric saturation of means of transport, the saturation of drivers, time to check the material received;
- KPIs that measure the **level of service**. The indicators measure the response times to customer requests and the flexibility of the supplier. Measurements of the level of service are delivery time, preparation time for scheduled patient and for urgent one, percentage of urgent patient processed, average time to process an urgent order;
- KPIs that measure the **quality**, that is the conformity of the outputs with respect to the client's expectations. Typical indicators are the percentage of re-admissions, the number of intervention errors, number of preparation errors, etc.

Among these 3 areas, **customer satisfaction** is not mentioned. It is difficult to evaluate in objective terms but becomes important in order to monitor the customer's perspective, not only in terms of survival and maintenance of a good state of health, but also in terms of effectiveness of care.

1. **Customer Satisfaction** becomes the fourth macro-category. It is important that the system is oriented towards a logic of continuous improvement of the quality of the performances. These macro-indicator measure all aspects of an intervention or health system in terms of patient perspective (ie compliance of interventions with the real needs of the population's health, level of application of scientific knowledge, professional skills and available technologies,

informations given to the patient, etc.) and of staff perspective. The evaluation of technical, organizational and perceived quality of services represents an important completion of health planning in order to satisfy the citizen who benefits from the service; increases the professionalism / gratification of the health system operator; reduce costs by eliminating unnecessary diagnostic treatments and exams or preventing pathologies due to inadequate assistance. As mentioned, customer satisfaction indicators should also take into account not only the user satisfaction but also the operator satisfaction. The indicators would serve to identify and quantify not only the changes in the attitude of the citizen-user, but also to emphasize the relationship between organization and staff operators (Crepaldi et al., 1999).

Once the set of indicators has been identified, they proceed with their reconfiguration. It is extremely important to reorganize the KPIs on the basis of an ad hoc structure that can propose the joint reading of different measures, grouped in such a way as to allow the best interpretation of the main phenomena that the company considers critical. In this way it can be easier to manage the management of these critical factors, thanks to a more secure control.

It is important that the indicators follow an inverted funnel strategy and are organized into a structure divided into levels: a few initial indicators that can be deepened as needed thanks to drill-down operations (data disaggregation).

In order to define indicators it has been asked the management and all the staff involved in the hospital to rank the most important indicators, and they finally identified 15 parameters which will be explained in the results section.

The modified classic variant of the Delphi technique was used as the tool for data collection.

Following Calzolaro (2012) and adding the customer satisfaction category, a generic list of KPIs have been arranged around four main families.

The participants for the research were selected from the strategic level of the healthcare units. To qualify, each participant was expected to have served in their current position for not less than one year or not less than five years as staff of the respective department (Ogbeifun et al., 2016).

Table 9 resumes the characteristics of the participants to the Delphi exercise.

Professional Category	Participants during all phases	Partial participants	Round I	Round II	Round III
Health management	5	1	6	5	5
Surgeons	4	3	7	6	4
Nurses	3	1	4	3	3
ICT delegates	4	0	4	4	4
TOTAL	16	5	21	18	16

Table 9 – Participant characteristics of Delphi exercise

To prevent the drop-out rate, a greater number of target experts were recruited at the initial stage, who met the selection criteria and were prepared to participate in the exercise. In total 21 people were recruited assuming a 25% drop-out rate during the sessions and a target number between 15 and 18. Respectively 21, 18 and 16 experts participated in each of the three rounds of the Delphi activity, meeting the minimum conditions of the sample size for Delphi participants (Hallowell and Gambatese, 2010).

The list of KPIs were given to the participants in order to be evaluated in a Likert scale between 1 and 5, where 1 is the minimum score and 5 the highest score. It was agreed that only articles with a score greater than 2.0 would pass to the next round with the obligation to maintain 7 for efficiency category, 4 for quality and 2 for each other category of indicator. Before reaching unanimity of opinions, the method went through three cycles of successive iterations of information. The statistical average was used to obtain the level of consent (Day and Bobeva, 2005; Adnan and Daud, 2010). After analyzing each iteration, the elements that did not measure up to 3.0 benchmarks did not exceed the next round.

DEA Analysis

Magherini et al. (2016) developed a model for evaluating the technical efficiency by considering different organizational and management aspects and for understanding whether the presence of differences on management, information technology, financial and innovation on healthcare delivery can affect the efficiency level. The results of a survey show the implementation status of the guidelines of the Italian “Patto per la Salute 2014 – 2016” to verify if some of the levers proposed by the survey can positively influence the efficiency. The analysis was carried out in two stages. In the first stage, healthcare efficiency was measured via bootstrapped DEA. In the second stage, the impacts of organizational and environmental variables on efficiency were investigated. Results show an increase of the efficiency gap between the best practice and small hospitals due to economies of scale and low reachability.

With reference to RQ2, the research aims to perform an efficiency assessment through benchmarking among the operating rooms of the Italian health structures using the dataset provided by the Ministry of Health which will be discussed in the Results section. The idea is to use the non parametric DEA approach to compare performances between several production units. The benchmarking result is useful for each structure to monitor its positioning with respect to the other operating blocks and to highlight where to innovate (for example a process, a product) to reach the "competitors" performances as quickly as possible.

Then, through a regression analysis designed by Tobit and using the survey responses developed and dispensed in 2017 to the health management of the hospital companies, we want to investigate whether the presence of ICT technologies to support patient management leads to an improvement in performances of the operating room theatre. In fact, an Information System is an important part of PMS. We would like to investigate if this Systems can help surgical units.

This evaluation is one of the key points in the process of building a PMS since (Camp, 1989; Zairi, 1992; Smith et al., 1993; Rogers et al., 1995):

- It helps the production units to understand strengths and weaknesses that may depend on changes in supply and demand or market conditions;
- it allows to understand what level (or levels) of performances are theoretically achievable by observing others and how far they are to be reached;
- helps to better meet quality, cost, product and service needs by setting new standards and objectives;

- it helps the production units to increase the competitive advantage by stimulating continuous improvement to maintain quality performance and establish new competitive standards, "raising";
- promotes changes and suggests improvements in quality, productivity and efficiency that together produce innovation and competitive advantages;
- promotes an increase in the motivation of employees.

After the work of Farrell (1957), Charnes - Cooper - Rhodes (1978) introduce the Data Envelopment Analysis (CCR model). The three researchers propose to evaluate the efficiency of a decision-making unit (DMU) as a ratio between the quantity of output and the corresponding quantities of inputs, both suitably weighted. The DMU is efficient, and it is assigned a score of 1, if this ratio is greater than or equal to the analogous ratio calculated, using the same system of "weights", for the other operating units of the sample, which must be homogeneous. The weights therefore constitute the unknown variables of the maximization problem, while the ratio between the weighted quantities of output and input constitutes the objective function (to be maximized). In this model, each operating unit can "choose" the weights in such a way as to maximize its efficiency score, overcoming the problem of distortive discretion in the choice of weights (external decision). In the CCR model, the only constraints concern the weights that must be non-negative and such that the ratio for all the other DMUs is not greater than 1. For each "dominated" company, the reference targets (peers) are identified, identifying the most efficient (dominant) DMUs, in terms of production process, to which they are related.

The actual method was developed in 1978 by Charnes, Cooper and Rhodes, and has been used over the years to calculate the production function in various business areas (hospitals, banks, schools, university departments, manufacturing companies are just some of the different businesses units to which this technique has been applied).

The Authors introduce, for each production unit, an efficiency measure defining it as the maximum ratio between a weighted average of the outputs and a weighted average of the inputs, which characterize the process of the analyzed unit, with the constraint that the other reports can be defined the remaining production units are less than or equal to one. The determination of the relative efficiency of each unit is formulated through an ordinary linear programming problem. It is called relative efficiency because it is based on the comparison between the combination of output and input of a certain DMU and that of the most efficient DMU, the latter calculated from those available to the observed sample.

On the one hand the non-parametric approach ensures greater flexibility in the description of the technology and in the measurement of technical efficiency; on the other hand, the disregard of a certain stochastic variability, determines an excessive dependence of the results from the data observed, that brings in a strong sensitivity to

abnormal values, as in the case of the deterministic approach (Simar and Wilson, 2000; Cazals, Florens and Simar, 2002).

In a formal way:

m inputs for the k-th productive unit::

$$x^k = (x_1^k, \dots, x_m^k) \in \mathbb{R}_+^m$$

n outputs for the k-th production unit

$$y^k = (y_1^k, \dots, y_n^k) \in \mathbb{R}_+^n$$

technological set-up or set of production possibilities:

$$T = \{(x, y) \in \mathbb{R}_+^m \times \mathbb{R}_+^n \mid x \text{ produces } y\}$$

since T is unknown, the model proposes an approximation of the T* frontier defined as the smallest subset of $\mathbb{R}_+^m \times \mathbb{R}_+^n$ that contains

(x^k, y^k) , $k=1, \dots, K$ and satisfy certain specific hypotheses for the purpose, such as the aforementioned convexity and free disposability.

Newhouse (1994) has sustained the difficulty of obtaining an appropriate measurement of the output and the inability to better manage the quality of care quality, raising some doubts about the correctness of an efficiency measurement in this field. We recognize these concerns, but these are no longer problematic than other service sectors. In the works of Olesen and Petersen (2001) or Chilingirian (1995) these drawbacks have been almost totally overcome by introducing in their works ICM, Case Mix and DRG index. Following a classic micro-economic orientation, the performance of a given DMU is defined by its ability to choose the best way to achieve its goals. The performance evaluation, that is the evaluation of absolute effectiveness, can be summarized by comparing the level of objective actually achieved with the maximum level reached.

In real assessments, it is not entirely easy to apply the micro-economic theory in its entirety, precisely because of the lack of information about the real T frontier. The DEA approach, as mentioned, tries to overcome it.

The lack of information includes the problem of resources allocation, for example for the treatment of patients with different diagnoses, the allocation problem for a patient admitted and how the available resources are used. Resources and products should be evaluated by analyzing the trade-off between them, bearing in mind that each production unit has its own function of Utilities U. The DEA overcomes this problem by shifting the focus from an evaluation of effectiveness, ie objective function, to a efficiency evaluation, generally defined as the production of the maximum output using the minimum input. One problem, already mentioned above, is the lack of information about the real technological frontier. The idea is to replace a real frontier, of which we do not have enough information, an estimated border. The T* technology is estimated based on the "minimum extrapolation" principle. By this we mean that the DEA constructs the

smallest set of production plans that constrain the observed data and satisfy a series of (weak) validation conditions. By constructing the smallest set containing the actual observations, the method extrapolates the smaller one.

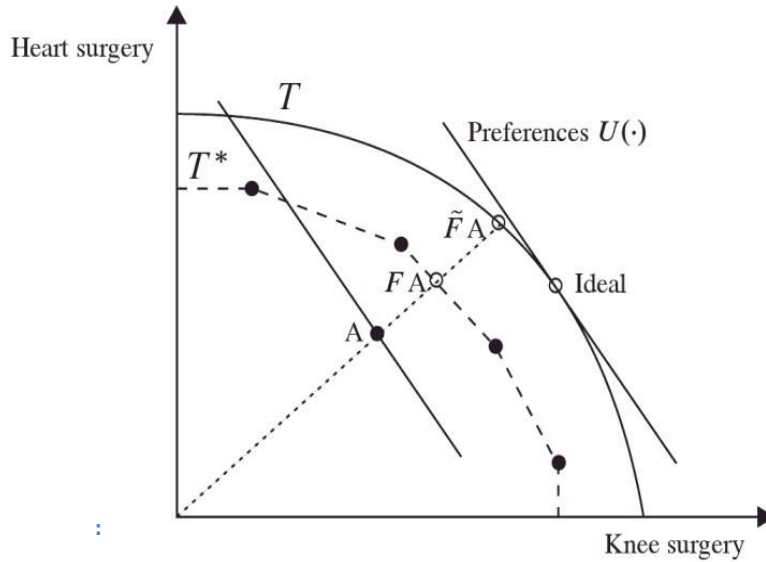


Figure 9 – Finding real T^* frontier

Figure 9 (Bogetoft, 2010) shows a summary of what has been described up to now by placing on the X axis knee interventions of a given DMU and on the Y heart interventions and we can underline:

- The T frontier, traceable if the whole structure of the frontier of the possible utilities was known (all the points of a curve corresponding to

utility levels that ensure efficient allocations in the Paretian sense).

- The DMU defined by the letter "A" and the 4 points that are along the efficient border in dotted line T^* given the DMU.

Finally, it is possible to build T^* and define the Efficiency F . Since the comparison takes place between DMU and not at the absolute level, it can be define the Relative Efficiency.

$$\text{Relative Farrell Output Efficiency} = F = \max \{ f \mid fA \in T^* \}$$

$$\text{Relative Farrell Input Efficiency} = E = \min \{ e \mid ex \in T^* \}$$

The DEA models are distinguished by the set of hypotheses imposed on the set T^* (in addition to the requirement that T^* contains the data set). The three most used hypotheses are:

1. *Free Disposability*: the idea is that if it is possible to produce a certain amount of output with a given amount of input, it will also be possible to produce the same amount of output with a greater amount of input: we are able to freely dispose of excess inputs.

2. *Convexity*: from a benchmarking perspective, convexity allows to interpolate companies with real observations and companies with different input-output profiles. This hypothesis extends the technology set T ; this would allow, to determine the border, to rely on a smaller number of real observations and still obtain interesting results in which not all companies lie on the border.
3. *Return To Scale*: if some production plan is feasible, then we can also use somewhat fewer inputs to produce somewhat fewer outputs and slightly increased inputs to produce slightly increased outputs.

The DEA frontier incorporates all those Units that are efficient and identifies the best practices. This evidence is fundamental in the benchmarking studies because the Units placed along the border represent objectives to be achieved for inefficient Units.

The advantage of the DEA is not having to hypothesise a priori a specific parametric functional form of the link between input and output, allowing maximum flexibility in this regard; further advantages derive from the possibility of considering multi-output production technologies (Giuffrida, Gravelle, 2001).

A disadvantage of the DEA is the high sensitivity of the estimates of efficiency due to the presence of outliers and measurement errors: the production frontier, precisely because it has not been parametrized a priori, could also be identified starting from the data related to a single observation or a linear combination referring to several observations. At the same time, there is the problem of exchanging a best practice for a lucky practice.

If a DMU by pure chance crosses a favorable moment, not accounted for in the model, or if there is an increase in the output given by chance / fortune or a lower use of resources at the same output, the unit will appear more efficient than in reality it is not. The reverse also applies. The first situation is particularly problematic as it may affect the evaluation of other DMUs, in fact evaluating how inefficient a structure, compared to another that is efficient only for "case" leads to a strong distortion in the results.

The estimate of the entire sample could be conditioned by the fact that the production unit that functions as a benchmark could represent an outlier or that the productive combination that identifies it is affected by measurement errors.

Unfortunately, the statistical theory concerning the DEA is not fully developed to permanently eliminate the "noise" impact. Although there are numerous contributions involving sensitivity analysis, stochastic programming, bootstrapping, such as the works of Simar and Wilson (2000).

In a scenario regulated by laws and constraints, it is usually the regulatory authority that identifies, which is the goal of inefficiency to "eliminate" in future periods. In this case, a sort of safeguard against noise can be guaranteed.

Moreover, given the flexibility of the production structure, the noise of a single DMU or an outlier problem can have local and limited effects. As can be seen from the literature, it becomes fundamental to pay attention to a correct modeling of hypotheses and data in order to achieve a final result as close as possible to reality (Bogetoft and Pruzan, 1991).

In this work the DEA will be used paying maximum attention to the possible presence of outliers (whether or not due to the presence of measurement errors).

The first step will be to verify the presence of anomalous observations and the robustness of the results when they are eliminated, redefining the position of the production frontier (the method will be explained later).

PRO and CONS of DEA methodology are described in the following Table.

PRO	CONS
Allows to not to know a priori the prices of input and output	Relatively weak theory of significance tests (sensitivity, resampling, bootstrap, asymptotic theory)
Requires little or no information of the technology	It is impossible to give an absolute evaluation of the efficiency of the single unit
Allows to investigate individual observations and not the average ones	Unable to find all inefficient units
Incorporates dummy variables	Possibility of approximation errors, measurement
Allows the use of multi-input and multi-output	Ease with which the efficient border can be moved
Highlights best practices	
Allows producing an aggregate measure of efficiency for each DMU, using the production factors (independent var) and the goods produce (dependent variables) as known variables	
Minimal extrapolation leads to conservative and precautionary assessments	
Obtain efficient Pareto solutions	
It is a support for planning, learning and motivation	

Table 10 - PRO and CONS of DEA methodology

DEA Model

When the idea of *minimum extrapolation* is combined with Farrell's idea of measuring efficiency, the mathematical model of the DEA approach is achieved.

• *Input Side*

The efficiency of a generic unit o is formally written:

$$E^o = E((x^o, y^o); T^*) = \min \{E \in \mathfrak{R}_+ \mid (Ex^o, y^o) \in T^*\}$$

Minimum extrapolation technology $T^*(\gamma)$ is described as follows:

$$T^*(\gamma) = \{(x, y) \in \mathfrak{R}_+^m \times \mathfrak{R}_+^n \mid \exists \lambda \in \Lambda^K(\gamma) : x \geq \sum_{k=1}^K \lambda^k x_i^k, y \leq \sum_{k=1}^K \lambda^k y_j^k\}$$

where

$$\Lambda^K(vrs) = \{\lambda \in \mathfrak{R}_+^K \mid \sum_{k=1}^K \lambda^k = 1\}$$

$$\Lambda^K(crs) = \{\lambda \in \mathfrak{R}_+^K \mid \sum_{k=1}^K \lambda^k \text{ free}\} = \mathfrak{R}_+^K$$

Combining the two formulations we obtain:

$$\begin{aligned} & \min_{E, \lambda^1, \dots, \lambda^k} E \\ \text{s.t.} \quad & Ex_i^o \geq \sum_{k=1}^K \lambda^k x_i^k, & i = 1, \dots, m \\ & y_j^o \leq \sum_{k=1}^K \lambda^k y_j^k, & j = 1, \dots, n \\ & \lambda \in \Lambda^K(\gamma) \end{aligned}$$

As it can be seen, the DEA model is due to a problem of mathematical optimization.

• *Output Side*

Similarly we measure the efficiency of a unit o according to the orientation of the output:

$$F^o = E((x^o, y^o); T^*) = \max \{F \in \mathfrak{R}_+ \mid (x^o, Fy^o) \in T^*\}$$

Inserting the formulation of the T^* we will have that:

$$\begin{aligned} & \max_{F, \lambda^1, \dots, \lambda^k} F \\ \text{s.t.} \quad & x_i^o \geq \sum_{j=1}^k \lambda^k x_j^k, & i = 1, \dots, m \\ & Fy_j^o \leq \sum_{j=1}^k \lambda^k y_j^k, & j = 1, \dots, n \end{aligned}$$

$$\lambda \in \Lambda^k(\gamma)$$

In the case of crs it is necessary to confront an inverse relation between input and output efficiency, for example with $F = 1 / E$

In other cases, the optimization problem is relatively simple. It involves $K + 1$ variables, a linear function, m input, n output, plus possibly a further linear constraint and the introduction of the constraint of wholeness, deriving from $\lambda \in \Lambda^k(\gamma)$

Slack considerations

One of the drawbacks of Farrell's traditional approach is that a production unit can have a score of 1 but still be inefficient in the sense of Koopmans.

Koopmans (1951) defines what we refer to as technical efficiency: an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input.

This phenomenon is not only theoretically possible, but it is also very common in DEA models. The problem arises in the evaluation of the DMU that lie on the part of the broken that is parallel to the axes, for which it can be at least strange, although formally correct an efficiency label since it is possible to reduce the use of at least one input without corresponding reduction of output. This situation is characterized by the presence of positive input slacks (input excesses). This leads to considering the opportunity to report, together with the score of technical efficiency, also the slacks that take a positive value, for a better interpretation of the results of the DEA model.

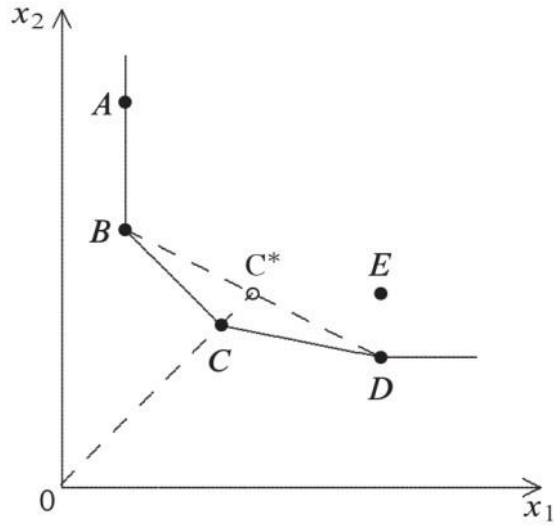


Figure 10 – DEA slack problems

Referring to the Figure 10 on the side, considering the production unit A, its efficiency will be = 1 because it is not possible to proportionally reduce both inputs and remain on the iso-frontier. However, it is evident that A is wasting resources, as it could produce the same output by going to point B, and saving OA - OB input.

Technically it is said that there is a slack in the second input.

The problem of the slack was clear from the first development of the DEA and two main solutions were found:

The first is to "penalize" this slack from the known border with an infinitesimal factor of penalty, which is large enough to recognize the possible slack but small so as not to impact on the numerical result.

The second solution is to solve the dual problem by using a strictly positive input and applying price values to the outputs.

The solutions are, to say it using the terminology of linear programming, dual.

Formally:

$$\min_{E, \lambda} E - \delta \sum_{i=1}^m z_i^- - \delta \sum_{j=1}^n z_j^+$$

s.t.

$$\begin{aligned} Ex_i^o + z_i^- &= \sum_{k=1}^k \lambda^k x_i^k & i = 1, \dots, m \\ y_j^o - z_j^+ &= \sum_{k=1}^k \lambda^k y_j^k & j = 1, \dots, n \\ \lambda &\in \Lambda^k(\gamma), \quad z_i^- \geq 0, \quad z_j^+ \geq 0, \quad E \leq 1 \end{aligned}$$

The slack variable z_i^- includes the excess resources used in Ex_i^o compared to the reference unit. Likewise z_j^+ measures the excess of output with respect to the production unit o .

Finally, the parameter $\delta > 0$ was introduced as a penalizing factor. For $\delta = 0$, we return to the initial program.

At this point a problem arises: looking at the formulation it seems that we must minimize E and at the same time maximize the slack. The trade-off between these two objectives depends on the δ .

The greater the value of δ the more the objective becomes the maximization of the slacks. It is not surprising that this double face leads to different results. If δ is large enough, $E = 1$ will be chosen and there will be many slack in the minimization of the objective function.

What we would like to find is a value of δ that is not too small not to affect efficiency E , but big enough to bring out the maximum possible of slacks.

The best way to make the procedure clear is to reason in lexicographical terms. First E is minimized, then the sum of the slack values is maximized for a prefixed value E (procedure known as twostage approach).

A simple analysis of input-oriented efficiency is initially conducted à la Farrell, after which the maximum sum of the slacks is calculated, given a level of efficiency. If positive slacks are identified, the production unit is efficient, but there is potential for additional resource savings, or an opportunity for expanding output.

A good way to get the best results is to select a good reference production unit. The idea of having slack in the problem becomes problematic if a document such as this study is submitted to the attention of a "customer" and this can find a more efficient combination than the production unit marked as efficient.

Unfortunately, the 2-stage approach brings with it a problem: it varies according to the measurement unit used. If an input is measured, for example in tons or kilograms, the choice influences the results obtained and, more importantly, on the efficient reference unit that we have to present to the "client" who asks to perform benchmarking on his company.

One way to work around this problem is to look at the slack in relative terms instead of in absolute terms. Here's how the question could be solved:

$$\begin{aligned}
& \min_{E, \lambda, z^-, z^+} \quad E - \frac{1}{m} \sum_{h=1}^m \frac{z_h^-}{x_h^o} - \frac{1}{n} \sum_{i=1}^n \frac{z_i^+}{y_i^o} \\
& \text{s. t.} \quad Ex_h^o + z_h^- = \sum_{k=1}^k \lambda^k x_h^k \quad h = 1, \dots, m \\
& \quad \quad y_j^o - z_i^+ = \sum_{k=1}^k \lambda^k y_i^k \quad i = 1, \dots, n \\
& \quad \quad \lambda \in \Lambda^k(\mathcal{Y}), \quad \tilde{z}^- \geq 0, \quad \tilde{z}^+ \geq 0, \quad E \leq 1
\end{aligned}$$

Also in this case we could use the two-stage approach: first it is minimized and then maximized the sum of the average, relative to the values of the slack. As a result, the value of the slack will not depend on the unit of measurement used. It is always possible to dispute that the weight allocation for the slack remains arbitrary. Recent studies suggest that slack can not simply be a function of the DEA (linear) approximation.

An excessive slack would show how the model's specifications are wrong and what is modeled as a joint production would be nothing more than a combination of independent sub-processes, in the sense that some inputs are used to produce certain outputs, and other inputs are used for produce other outputs, different from the previous ones. In this case it would be evident that one of the two processes is efficient, while the other is not.

In this study a slack $\delta = 0.1$ will be used as reported in most of the literature.

Outliers identification

Outliers are production units that differ for a large amount from the rest of the units and which could create distortions in the model or have a negative impact on the model's goodness.

They are useful when empirical methods are being used but they can be particularly annoying as the outlier, positioning itself on the border, creates a distortion effect on the real efficient frontier.

What are the reasons for which a structure can be an outlier?

- First, the database may be affected by errors. Inputs or outputs may have been badly written, forgotten and much more (this happened also in this study, as far as the University Hospital of Tor Vergata is concerned, unfortunately it was not possible to recover the data relating to the doctors - in all the data provided the total result of the number of doctors is marked as 0);
- Second, the observation could be potentially correct but numerically atypical. For example, a data that is too high or low compared to what one would expect. The solution is to identify this data and delete it. Also this point has been found in the present study, referring to efficiency values equal to 1 regardless of the output, when the number of doctors working in an operating block was less than 5 (this theme will be discussed later);
- Third, observations that refer to data that are too high or too low in efficiency both in a parametric and non-symmetric model could be candidates for outliers. In particular, benchmarking in the literature implies that observations that influence estimates in part of the reference set must correspond to replicable performance for the same input mix. If the relative performance is "extreme" the data is classified as an outlier as a precaution, which is not necessarily the same situation as written in the second point. On the other hand, some observations may represent an important phenomenon: they could represent the first introduction of a technological innovation within a production process or an innovation in a management practice from which competitors could learn in a period of time following the detection.

The methods to find outliers are varied and all effective. The method that is used in this study, implemented with Excel, is able to identify groups of outliers.

The concept of cloud points is introduced (Figure 11): it is a set of points characterized by their position in a coordinate system by a volume and by any intensity values (color, depth, etc.) associated with them. They usually serve as a representation of three-

dimensional structures such as objects or surfaces in relief. In light of this definition the

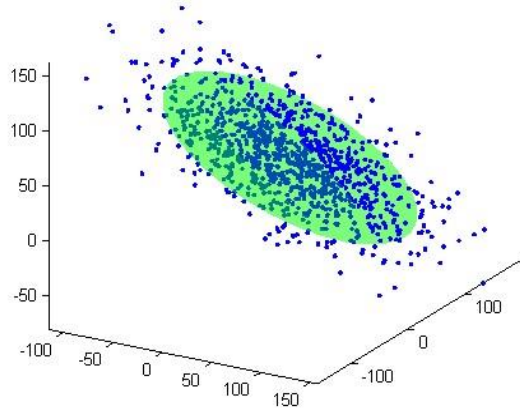


Figure 11 – Cloud points

outlier will be identified as the element that, if removed, will lead to a reduction in the volume of the point cloud.

To find more than one outlier, you can look at how the cloud volume changes when one or more observations are removed.

Formally:

An $[X \ Y]$ array is created that contains all the observations. The various lines of it can be seen as a cloud of points in space

$\mathcal{R}_{+}^m \times \mathcal{R}_{+}^n$ where each

point represents a productive unit. The volume of the cloud is proportional to the determinant of the matrix given by: $[X \ Y]' [X \ Y]$

Point cloud volume $V \simeq D(X, Y)$

Denoting with $D^{(i)}$ the determinant after having removed the productive unit i , the relationship between the new and the previous Volume is considered

$$V^{(i)} = \frac{D^{(i)}}{D}$$

It is important to underline how $V^{(i)}$ is dimensionless. If unit i is not an outlier, $V^{(i)}$ will not change, but if i is an outlier, $V^{(i)}$ will be much less than 1.

With this method it is not necessary to eliminate one observation at a time and restart the analysis to subsequently eliminate another and so on.

It will stop once the minimum possible value of $V^{(i)}$ is reached. How to find it goes beyond this analysis because, as mentioned, both the software R, both Excel, provide through some commands the solution of finding outliers.

Bootstrap Method

The bootstrap is a statistical resampling technique with re-entry that approximate the sample distribution of a statistic. The process is repeated several times creating a sample of replicas. Therefore it allows to approximate mean and variance of an estimator, to build confidence intervals and to calculate test p-values when, in particular, the

distribution of the statistic of interest is not known. For example, with a sample of n observations $x_1, x_2, \dots, x_n$ is calculated mean, standard error with the classical method. If instead the objective was to find the median and the variance of the median, it would become a much more complicated process, and in this case the bootstrap method helps the study.

For example, with 5 observations x_1, x_2, x_3, x_4, x_5 the order of numbers is changed and for each one the median is calculated, so for example we would have $x^b = x_2, x_1, x_4, x_3, x_5$. Based on this method, the median is calculated for each sample bootstrap $t(x^b)$ ($b = 1, \dots, B$). As an estimate of the bootstrap of the standard error of $t(x^b)$ with B replicas, this formulation is used:

$$\hat{s}_B = \sqrt{\frac{1}{B-1} \sum_{b=1}^B (t(x^b) - \bar{t})^2}$$

Where

$$\bar{t} = \frac{1}{B} \sum_{b=1}^B (t(x^b))$$

is the average of the bootstrap replicas of the statistics you are interested in.

The idea behind the bootstrap method is that if the empirical distribution of x^b corresponds more or less to the real distribution of x , then the empirical distribution of $t(x^b)$ will correspond more or less to the real distribution of $t(x)$. This means that it is possible to use the empirical distribution $t(x^b)$ as if it were the real but unknown distribution $t(x)$. When we are interested in the variance of the median $t(x)$, which is difficult or impossible to determine, we simply use the empirical variance of the median from the bootstrap $t(x^b)$, which is easier to obtain.

The limit of $\hat{s}_B$ with B that tends to infinity is the ideal estimate of the bootstrap.

What is the ideal number of replicas to do to develop an estimate as close as possible to reality?

In this study, 2000 replicates were performed, as described in the literature.

In addition, using this method, confidence intervals can be directly determine. The approach is much more precise than what can be done by building confidence intervals starting from the estimated standard deviation since the latter technique is based on the assumption that the distribution in question is symmetric and can be well approximated by a normal distribution.

How the variance of efficiency measures is estimated for a sample of production units using the bootstrap method in DEA?

With $(x^1, y^1), \dots, (x^K, y^K)$ the values of the observations of the production units are named and with $E^1, \dots, E^K$ the corresponding efficiency values à la Farrell (input oriented). The same is true for input oriented too.

Formally:

$$E^K = \min \{ \theta \in \mathbb{R}_+ \mid (\theta x^K, y^K) \in T \}$$

It doesn't make sense to calculate the variance as $\frac{1}{n-1} \sum_{k=1}^K (E_k - \bar{E})^2$ since it would be assumed that all production units have an efficiency based on a distribution with the same mean and therefore all differences in efficiency would all be random and non-systemic. In this case the DMUs with high efficiency would be so efficient only by chance and not because they use their productive factors well.

Instead, the observations are used as a sample $\omega = \{(x^1, y^1), \dots, (x^K, y^K)\}$ of input and output from the K production units that will be used as estimators of the set of T technologies through the DEA, assuming variable returns to scale VRS:

$$\hat{T} = \left\{ (x, y) \mid x \geq \sum_{k=1}^K \lambda^k x^k; y \leq \sum_{k=1}^K \lambda^k y^k; \lambda^k \geq 0; \sum_{k=1}^K \lambda^k = 1 \right\}$$

The estimate of the DEA efficiency scores will be:

$$\hat{E}_k = \min \left\{ \theta \in \mathbb{R} \mid (\theta x^k, y^k) \in \hat{T} \right\} \quad (k = 1, \dots, n)$$

in which it is evident how the estimate of the technological frontier $\hat{T}$ was used in place of the unknown T.

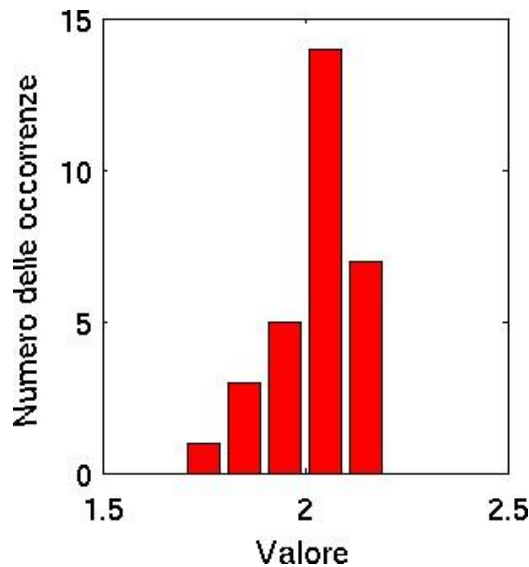
This procedure is used to consider the sample $\omega = \{(x^1, y^1), \dots, (x^K, y^K)\}$ as the realization of an identical and independent random distribution of variables (X, Y) with a probability distribution P with support in T.

The distribution of $\hat{E}_k$ and $\hat{T}$ depends on the distribution of the samples of the observations ω .

This relationship is difficult to define: the sample ω is created by the probability distribution P , of which there is no direct knowledge. To derive a reasonable estimate P^* of P is used the bootstrap creating a “sample of resampling” from the original set of observations. Using the estimation Bootstrap P^* a sample ω^* is generated from the P^* distribution, then a DEA estimate of T^* is calculated for the technology and for the efficiency, estimated as

$$\hat{E}_k^* = \min\{\theta \in \mathbb{R} \mid (\theta x^k, y^k) \in T^*\}$$

When the process of generating samples is repeated many times, many estimates of $\hat{F}_k^*$ are obtained and can be calculated the empirical variance of $\hat{E}_k^*$ ($k=1, \dots, n$).



Before defining the method used to bootstrap for the DEA model it is interesting to give a hint if the number of samples to bootstrap is reduced and there will be values that are repeated: es. sample of 7 numbers to bootstrapping 1000 times.

To avoid peaks, as in Figure 12, it is advisable to use the smoothed bootstrap method in the distribution. A “device” that allows you to “smooth” the frequency peaks in the distribution.

Figure 12 – Smoothed bootstrap example

For $r = 1, \dots, K$ these are the steps to follow:

- Choose the value randomly of k to be replicated from set $\{1, \dots, K\}$
- Generate ϵ from one distribution normal standard
- Place $\tilde{x}^k = x^k + h\epsilon$ and call h bandwidth

Now the sample bootstrap has become $(x^1, \dots, x^k)$, not a realistic sample from the original, $(x^1, \dots, x^k)$ but a "smoothed" sample.

This solution serves to imitate a function of continuous distribution of the inputs x . The distribution, for these smoothed values, is a normal distribution with variance h^2 and is therefore symmetrical. When this method is used to calculate efficiencies E , there may be a problem with the value of the unit. To overcome it, a reflection method is used, increasing the data set by adding the reflections of all the points in the bootstrap. To clarify, whenever there is an efficiency E , the dataset is increased with a reflection on 1, $2 - E$, so that E and $2 - E$ are specular and symmetric around 1. So the value is simply used close to or equal to 1.

How to assess BLAS in Bootstrap DEA

Closed the parenthesis concerning the blunt bootstrap method, valid in the case of a low number of production units, the important topic of Bias how to correct the efficiency values in relation to this is now addressed.

The estimation of the efficiency with the DEA is subject to Bias, this means that a value of efficiency is shown slightly higher than that which is the real score of relative efficiency.

Before moving on to the actual model it is necessary to give a definition of the symbology adopted:

θ^k = the real efficiency based on the real, but unknown, technology T

$\hat{\theta}^k$ = the estimated efficiency (with the DEA)

$\hat{T}$ = the estimated technology boundary (with DEA)

θ^{kb} = the estimated bootstrap b replications based on the replicated technology boundary T^b

θ^{k*} = the bootstrap estimate of θ^k

$\tilde{\theta}^k$ = the bias-corrected estimate of θ^k

If there are no measurement errors, then all the observations of the sample come from the $\hat{T} \subset T$ technology.

Therefore in $\hat{E}_k \geq E_k$, as mentioned, since a minimization is made on a smaller set, the estimated efficiency is higher than the actual efficiency.

The magnitude of $\hat{T}$ depends on the sample and therefore E^k is sensitive to sampling variations in the obtained boundary. If measurement errors were present, it could not be said with certainty that $\hat{T} \subset T$.

In order to eliminate the bias, first it is estimated, obtaining an estimate of the correctness:

$$bias^k = EV(\hat{\theta}^k) - \theta^k$$

Unfortunately, the distribution of θ^k is unknown, and it is impossible to calculate $EV(\hat{\theta}^k)$. The bootstrap intervenes here: when θ^{kb} is an estimate of the bootstrapped sample θ^k , the bootstrap estimate of the bias becomes the following:

$$bias^{k*} = \frac{1}{B} \sum_{b=1}^B \theta^{kb} - \hat{\theta}^k = \bar{\theta}^{k*} - \hat{\theta}^k$$

therefore, a correct estimator of θ^k becomes:

$$\tilde{\theta}^k = \hat{\theta}^k - bias^{k*} = \hat{\theta}^k - \bar{\theta}^{k*} + \hat{\theta}^k = 2\hat{\theta}^k - \bar{\theta}^{k*}$$

The accuracy of the estimate is given by the variance of the bootstrap estimate:

$$\hat{\sigma}^2 = \frac{1}{B} \sum_{b=1}^B (\theta^{kb} - \bar{\theta}^{k*})^2$$

Finally we arrived at the definitive algorithm used to perform the DEA bootstrap, used in this study, which leads to obtaining in order the efficiency results, the Bias-corrected efficiency results, the confidence intervals and the bootstrap estimates.

As we have come to understand, it is a process that requires a lot of time for the length of the calculations and especially of the replicas that are carried out, 2000 in this work.

The definitive algorithm is shown in the results of RQ2, as well as the results of the analysis. The integral script used to calculate the efficiency measurements with the DEA through the R software is shown in the appendix.

Tobit Regression

Once the efficiencies of a given production unit are estimated, one might be interested in understanding why some operating room firms are more efficient than others. Is their efficiency related to the size? To use Information Systems? To the environment present in some Regions? Or to other factors?

It is also possible to ask whether the variations in the estimated efficiency correspond to changes in real performance or are due to the fact of having forgotten or not having used important inputs or outputs (you might be interested in validating the model).

In the health field there are numerous additional variables that could be analyzed and in the subsequent chapters a list will be provided with the relative results. Both objectives can be clarified and achieved through the so-called secondstage analysis: "a post-efficiency analysis that aims to explain the changes and validate the model" (Bogeltoft, 2011).

The relevance of this part is not confined to the studies on the DEA, but also in other areas we are interested in the functions of the second stage analysis.

To investigate whether a category of variables can explain a part of the variations in the efficiency of the production units, it is possible to use a good number of non-parametric tests.

For example, the Mann-Whitney-Wilcoxon rank-sum test, is one of the most powerful non-parametric tests to verify, in the presence of values from a continuous distribution, if two statistical samples come from the same population. If the Wilcoxon test is applied in the presence of data for which Student's parametric t test could be used, then its power-efficiency is around 95% for both small and large samples. Depending on the sample size, it may be preferred to the Kolmogorov-Smirnov test or the Kruskal-Wallis test.

The most usual approach to determine if a set of continuous variables can explain the different efficiency values is to conduct a Tobit regression. This approach is similar to conducting a classical regression analysis except that with Tobit the noise part is "truncated".

Formally denoting with E the input oriented Farrell efficiency, one is interested in how E depends on other variables $z = (z_1, z_2, \dots, z_q)$. We are interested in estimating the model $E = g(z, a)$ where the efficiency E is explained by the variables z and by the parameters a .

Although classical regression methods are widely used in practice, they suffer from a theoretical problem in the benchmarking environment: they do not take into account that the efficiency is between 0 and 1 and that many efficiency values are typically at the upper end 1. There is no constraint to ensure that the estimated value, expected value or average is less than or equal to 1.

The Tobit model solves the problem of the Ordinary Linear regression OLS.

When the dependent variable is censored, the value of a measurement or observation is only partially known. Values within a specific range are reported as a single value. Censorship should not be confused with the connected idea of truncation. With the censorship, it is known that the censored observations exceed a certain threshold or are in a certain range, and this partial information can be used when the phenomenon is statistically modeled. With truncation, observations never give rise to values outside a certain range; the values of the population outside this range are entirely discarded (Baccini, Mealli, 2001).

In the case of efficiency E , the underlying efficiency values are seen as a stochastic variable and the efficiency observations E as a censored version where the values below 0 are reported as 0, the values above 1 are shown at 1.

Formally:

$$E = \begin{cases} 0 & \text{se } az + \varepsilon \leq 0 \\ az + \varepsilon & \text{se } 0 < az + \varepsilon < 1 \\ 1 & \text{se } az + \varepsilon > 1 \end{cases}$$

The objective is to estimate, on the basis of the observed efficiency, the value E^k from K production units $k = 1, \dots, K$

In general, there are no firms with an efficiency value of 0. That constraint could also be eliminated.

With K_1 the number of efficient production units is indicate, for which $E = 1$ and with K_0 those for which $E < 1$. The result is $K = K_0 + K_1$.

The probability that $E = 1$ is the probability that $az + \varepsilon \geq 1$. Denoting with F the function of probability distribution for ε and with f the corresponding density function, it will be that the probability of having $E = 1$ will be:

$$P(E = 1) = P(az + \varepsilon \geq 1) = 1 - P(az + \varepsilon < 1) = 1 - P(\varepsilon < 1 - az) = 1 - F(1 - az)$$

And the probability to have $E = 0$

$$P(E = 0) = P(az + \varepsilon \leq 0) = P(\varepsilon < -az) = F(-az)$$

The case for which $0 < az + \varepsilon < 1$ corresponds to $E = az + \varepsilon$ or to $\varepsilon = E - az$ and the density in this case will be equal to $f = E - az$

The probability function for K efficiency observations is given by the production of K single terms for the aforementioned cases:

$$L = \prod_{k: E^k=1} P(E^k=1) \prod_{k: 0 < E^k < 1} f(E^k - az^k) = \prod_{k: E^k=1} (1 - F(1 - az^k)) \prod_{k: 0 < E^k < 1} f(E^k - az^k)$$

The possibility that $E = 0$ is not taken into account. To estimate the previous model, it can be chosen a probability distribution F . The most common and most used distribution is the normal distribution and in this case the model is called *Tobit regression*. The optimization process is conducted through the iteration standards present in the R software. The variance of the estimated parameters is also calculated, where possible. In Benchmarking applications, knowing the change in explanatory variables z is interesting. To distinguish the efficiency E with the average or the expected random variable, the latter is denoted by EV . One is interested in understanding how a variation of z influences average efficiency, or specularly as $EV(E | z)$ varies with z .

$$\begin{aligned}
 EV(E | z) &= \int E dP(E | z) = \int 0 dP(E = 0 | z) + \int E dP(0 < E < 1 | z) + \int 1 dP(E = 1 | z) \\
 &= \int_{1-az}^{\infty} \epsilon dP(\epsilon | z) + 1 - P(\epsilon < 1 - az | z)
 \end{aligned}$$

the last equality can be verified by inserting the definition of E with a series of reformulations.

The two probability terms are calculated separately. The latter is simple to calculate when it is assumed that the error term is normally distributed, example $\epsilon \approx N(0, \sigma^2)$.

The first term is slightly more complicated because it contains a real integration. The final result will be:

$$(EV(E | z) = az(\Phi\left(\frac{1-az}{\sigma}\right) - \Phi\left(\frac{-az}{\sigma}\right)) + \sigma(\phi\left(\frac{-az}{\sigma}\right) - \phi\left(\frac{1-az}{\sigma}\right)) + 1 - \Phi\left(\frac{1-az}{\sigma}\right)$$

The last two terms, $1 - \Phi$, correspond to the effect of the productive units when $E = 1$ multiplied the probability of that event. The first term is the linear effect az multiplied by the probability that $0 < E < 1$. The second term is the effect of the error term ϵ . In the linear OLS model, this effect is 0 because the expected value of ϵ is 0, but in this case the mean of ϵ is conditioned by the interval where $0 < az + \epsilon < 1$ for example $-az < \epsilon < 1 - az$. On this basis it is possible to say that:

$$EV(E | 0 < E < 1, z) = az + \sigma \frac{\phi\left(\frac{-az}{\sigma}\right) - \phi\left(\frac{1-az}{\sigma}\right)}{\Phi\left(\frac{1-az}{\sigma}\right) - \Phi\left(\frac{-az}{\sigma}\right)} = az + \sigma M(az)$$

where the $M(\cdot)$ function is called "inverse Mills ratio".

Now it is possible to determine how $EV(E | z)$ varies with z by deriving $EV(E | z)$ in z .

It will be that:

$$\frac{\partial EV(E | z)}{\partial z_h} = a_h \left(\phi \left(\frac{1 - az}{\sigma} \right) - \phi \left(\frac{-az}{\sigma} \right) \right)$$

The term a_h corresponds to the linear term that can also be found in the OLS model but in this case it is corrected for the probability that $0 < E < 1$. If $E = 0$ or $E = 1$, a marginal change of z will not influence efficiency E .

The same demonstration can be replicated for the output-oriented efficiency F , represented as follows:

$$F = \begin{cases} az + \varepsilon & \text{se } az + \varepsilon > 1 \\ 1 & \text{otherwise} \end{cases}$$

There is no Upper Bound, what was the upper bound in input efficiency, has now become lower bound in output efficiency.

To determine the expected value of F , the procedure is similar.

$$\begin{aligned} EV(F | z) = & az \left(1 - \Phi \left(\frac{1 - az}{\sigma} \right) \right) + \Phi \left(\frac{1 - az}{\sigma} \right) + \sigma \left(\phi \left(\frac{1 - az}{\sigma} \right) \right. \\ & \left. - \phi \left(\frac{1 - az}{\sigma} \right) \right) + 1 - \Phi \left(\frac{1 - az}{\sigma} \right) \end{aligned}$$

and the derivative z_h becomes:

$$\frac{\partial EV(F | z)}{\partial z_h} = a_h \left(1 - \Phi \left(\frac{1 - az}{\sigma} \right) \right)$$

The interpretation is as follows: the linear effect a_h is multiplied by the probability that $F > 1$.

The "tobit" function in R will perform the necessary calculations for this study, presented in the following paragraphs.

As anticipated, the second stage analysis makes it possible to verify the presence of some systematic links between efficiency and structural and organizational characteristics of the operating room theatre and, for example, if technology helps to make more efficient the OR and the settings within which they operate. Furthermore, the links between efficiency, technical and overall measures must be taken into account. For the

econometric estimate the model used, widely described, is Tobit, which takes into account the characteristics of the distribution of the efficiency index that has a mass of points at the maximum value (Dusansky and Wilson, 1994).

The main purpose of the analysis is to obtain efficiency measures purified by the above factors and whose link with the ICT, organizational and market structures of OR and health systems can be analyzed. In particular, through a survey, this study will focus on three factors:

- a) a set of dummies able to grasp, residually, the set of elements that differentiates the different ownership structures;
- b) variables that capture the good organization or not of a hospital structure as a rate of occupation of OR;
- c) if the presence or absence of ICT systems like scheduler, PMS, digital devices, and other health 4.0 systems favors efficiency.

It is set only a "right" censorship around the value 1, as anticipated, since the probability that the efficiency of a structure is close to 0 is practically 0.

In RQ2 Results is shown the entire procedure done with R software whose data were taken from the results of the survey.

Survey Analysis

In order to detect the diffusion of ICT systems as described above in the operating theaters and the related methods of use in the S.S.N. panorama, a national survey was used. All local Italian healthcare companies were invited to participate in the study (about 180 active companies at the data collection start date). In particular, for each company a person responsible for the provision of operating theater services was identified that could be adequately representative of the specific company context. The list of potential respondents to the survey has been defined including: health management, the director of the department and the management of the associated social-health district. In addition, the survey was also submitted to the expert groups of the activity on KPIs of RQ1. From an initial population of 180 units, via e-mail communications, accompanied by exhaustive information on the research objectives, the structure and how to fill in the questionnaire, it was down to 65 respondents.

Taking into account the fact that they represent 36% of the active companies at the survey date, it is believed that the results are representative and generalizable (Kaissi and Charland, 2013, Macinati, 2008). The list of KPIs is divided into three categories, each of which includes a detailed set of items. The questionnaire was preliminarily tested by two academic experts in performance measurement in healthcare and by eight practitioners directly involved in the organization and management of primary care services (the same of the Delphi exercise).

The diffusion of the performance measures of primary care services within each local health care company was, first of all, detected through five questions. Using a binomial scale (Yes / No), it was asked to indicate the availability or not of at least one indicator (estimated to quote and / or recorded in the final balance) for each of 21 types of performance measures, in turn grouped into three classes. The three classes - measure efficiency performance, quality, level of service - have been identified following previous studies related to health performance measurement systems (Nutti et al., 2012; Baars et al., 2010). The list of questions is entirely shown in the appendix.

The Healthcare structures

The research involved a sample of six different operating room theaters of 6 different healthcare structures located in Tuscany. Table 11 shows the sample's key features: four large firms, one is small and the last one has a medium size.

The categorization was made based on the number of operating theaters present in each structure:

Small Size: <4

Medium Size: <7

Large Size: ≥ 7

Case 1: Case Mix Index (CMI) = 0,95

Case 2: Case Mix Index (CMI) = 0,96

Case 3: Case Mix Index (CMI) = 0,92

Case 4: Case Mix Index (CMI) = 0,99

Case 5: Case Mix Index (CMI) = 0,96

Case 6: Case Mix Index (CMI) = 0,95

The Case Mix index of the 6 structures is similar and this implies that units can be compared.

Each case has allowed to “discover” different settings, practices and specificities. Even if several interviews and interactions required the expertise of users or process owners, it has been always asked a validation to the health management so that results were checked from the operational and strategic viewpoints.

All data and analyzes are available on request.

Cases description

Cases	Unit Size	Acute Beds	Surgeons	Nurse (+OS S)	Anesthesiologists/Other	Admissions	Hospitalization days * Case Mix	#operating room
Case 1	Small	16	10	14 (+4)	4	798	10.979	2
Case 2	Medium	40	18	27 (+3)	9	2.992	35.358	6
Case 3	Large	70	19	27 (+7)	10	2.262	52.477	8
Case 4	Large	123	45	70 (+16)	20	5.226	70.164	15
Case 5	Large	86	27	40 (+27)	13	6.553	58.833	7
Case 6	Large	71	38	57 (+19)	17	4.941	99.211	12

Table 11 – Key features of healthcare facilities

A within cases analysis has allowed to become familiar with each case as a standalone entity, in order to define unique patterns of each case before generalising across cases. Hereafter, each company has been described basing on the features summarized in Table 11.

Case 1

Physical / technical resources:

- Operating rooms: 2

Green Room: both election and urgency;

Sala Vecchia: both election and urgency;

- 16 Hospitalization beds:

16 (shared with Urgency care); 16/16 have an allocation plane.

- Other constraints:

Urgency cases have an operating room dedicated in the afternoon (every day);

Bariatric surgery can operate only in the Green room;

Otolaryngology prefers to operate in the Green room;

Duration of sessions: 6 hours in the morning (8 hours on Tuesdays and Thursdays), 4 hours in the afternoon.

Case 2

Physical / technical resources:

- 6 Operating rooms

"east" side: A, B, C rooms

"West" side: 1, 2, 3 rooms

- 40 Hospitalization beds:

40 in total, divided in:

3 female cells (5 beds each)

3 man cells (5 beds each)

2 mixed man / woman cells (from 3 beds each)

2 single rooms (1 used as wild card and 1 comfort room)

2 rooms are not in use due to the lack of nurses resources.

Then only 38 can be used.

- Other constraints:

Room A is entirely dedicated to Urgenza every day;

Room 1 has Traumatology interventions every day;

Maximum number of daily sessions sustainable by nursing staff: 5;

Room C has an Otolaryngology morning session every 15 days;

Room 3 is like a jolly on Fridays morning between the various disciplines / functional area (jolly).

Case 3

Physical / technical resources:

- 8 Operating rooms:

Day Surgery Room: the morning is used for Day Surgery. The afternoon is dedicated to outpatient activities;

Room 1: used by General Surgery (it can also be used by other disciplines, except Orthopedics and Ophthalmology);

Room 3: is dedicated to Orthopedics. In this room there are interventions of both Traumatology and electives;

"Ex Gine" Room (of Ophthalmology): this room, both for strategic location and for organizational reasons, is for the exclusive use of the Ophthalmology;

Room 4: used for ordinary operations (it can be used by all disciplines, with the exception of Orthopedics and Ophthalmology);

An unused room (potentially usable).

24-hour emergency room.

A room used only on Wednesday for electrophysiology, potentially used for elective sessions.

- 70 Hospitalization beds:

There are 4 different departments for the hospitalization of patients who have undergone surgery:

Day Surgery beds: 10

Week Surgery beds: 12

Beds dedicated to Orthopedics: 26

Beds for ordinary operations: 22 total, 4 of which are dedicated to Gastroenterology Case

Case 4

- 15 Operating rooms

Green block: 5 rooms (1,2,3,4,5)

Yellow block: 6 rooms (6,7,8,9,10,11)

Blue block: 4 rooms (12,13,14,15)

Room 2 is reserved for urgencies except the third Monday of the month that is dedicated to Odontomastology;

Urology works in room 5 because it requires specific surgical kit;

Otolaryngology operates in room 6 because it is the only one with 1 monitor and with specific equipment that is expensive to move;

Rooms 7-10-11 are dedicated to Orthopedics (rooms 7 and 10 used alternately);

Rooms 8 and 9 currently used as a warehouse;

Rooms 12 to 15 are used almost exclusively for the outpatient with the exception of some ophthalmology Day surgery, they have a dedicated access, there is no area dedicated to pre-anesthesia

- 123 Hospitalization beds:

22 for general surgery;

54 for Urgency, Otolaryngology and orthopaedics;

32 for general purposes

15 for Day Hospital

Case 5

- 7 Operating rooms

1 for Urgency (exclusively)

1 for Traumatology (exclusively)

- 86 Hospitalization beds

24 of them are dedicated to Traumatology and the others 62 are shared between Urgency and Election.

Case 6

- 12 Operating rooms

6 used for election;

1 used for emergency;

1 dedicated to traumatology

1 dedicated to Ophthalmology (mainly outpatient activity)

2 rooms used mainly for outpatient activities

1 unused room;

Hours of activity: 6 hours in the morning – 4hours and a half in the afternoon

- 71 Hospitalization beds

9 Day Surgery

16 Weekly Surgery

46 Ordinaries / elective surgery

Listing and analyzing the characteristics of the individual case studies were the first steps to examine the data. The next step was the search for cross-case schemes, with the aim of also improving the generalisability of the conclusions drawn from the cases (Voss et al., 2002). The sample is homogeneous and all cases share predefined characteristics.

CHAPTER 4 – RESULTS

This Chapter has been designed with the aim to fully achieve the objective of this thesis and to answer the RQs.

We tried to link the results of the each research question. In particular, KPIs indicators resulting from Delphi method of RQ1 have been used both for the Tobit RQ2 regression and for case studies.

The performance analysis was related to the RQ3 and used to perform benchmarking among the structures.

The final step to reach the research objective has been to perform a cross-industry analysis. The sectorial investigation has demonstrated that every healthcare facility has its own specificities determining a difficulty to create a universal PMS, but these might be common to other industries with similar business models.

For each topic and for each answer to the RQs, findings are equipped with brief interpretation of facts, then thoroughly discussed and summarised in the next Chapters.

Dataset and Data Source

The provision of hospital services in the national health system is guaranteed by public and private accredited facilities (which in turn are distinguished in for-profit and non-profit).

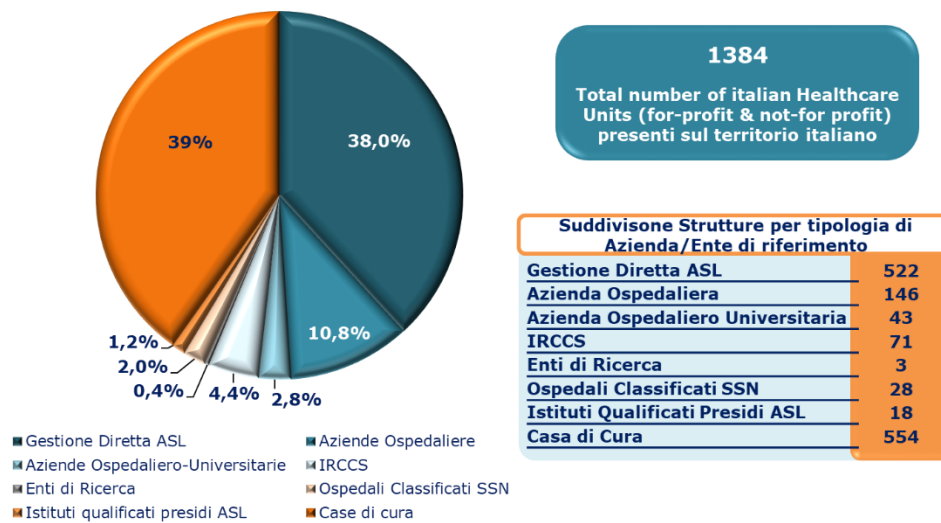
Among the public facilities, according to the ISTAT classification are the Hospital Companies (Aziende Ospedaliere – AO), the structures managed directly by the Local Health Units, the public IRCCS (Scientific Institutes of Hospitalization and Care as for example the San Raffaele in Milan or the Gaslini pediatric hospital in Genoa), University Hospital and Public Policlinics.

AO are the structures separated by the ASL and established in autonomous companies with legal personality and entrepreneurial autonomy that, firstly with the 502/1992 decree then with 229/1999 decree, met the requirements. ASL managed hospitals maintain autonomy, guaranteed by the presence of a medical and administrative manager, with economic and financial autonomy and separate accounting. Policlinics, such as the Gaslini of Rome, have organizational, managerial, patrimonial and accounting autonomy. The Statute of the University determines, on the proposal of the Faculty of Medicine, the organizational and management modalities, in compliance with the institutional aims, in analogy to the principles of the present decree established for the hospital. The management of university polyclinics is informed of the principle of economic and financial autonomy and of estimates and balances for cost centers, based on the services performed.

IRCCS can be both public and private. They have organizational, administrative, accounting, patrimonial and managerial autonomy and, in addition to hospitalization and care, carry out biomedical scientific research activities. Among the private facilities are the Nursing Homes, which are not included in this study, the IRCCS of a private nature, the hospitals classified as the ASL, mostly non-profit (coming from a dependence on

Religious Orders) or for-profit. As a result of Law 132/1968, classified hospitals can only be ecclesiastical bodies that are civilly recognized as general hospitals or specialized in long-term care, convulsions. Even institutes classified as ASL can be for profit and not for profit.

A general picture of the health structures in 2016 (last Ministry of Health available datas) is provided by the following graphs showing the number of public, private, private structures accredited with the relative name (Figure 13).

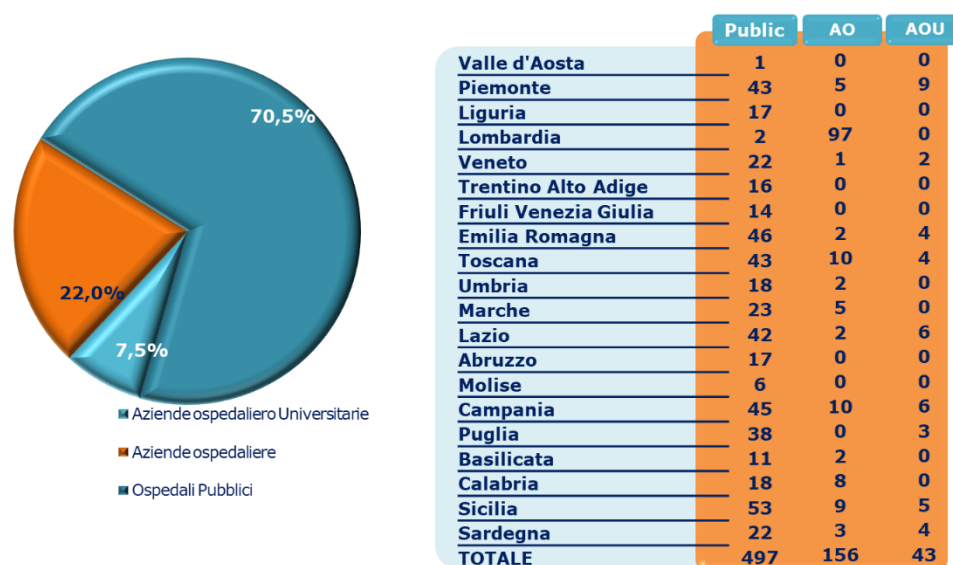


Source: Elenco delle Strutture di ricovero - Anno 2016 - Ministero della Salute

Figure 13 – Health structures picture / 2016

It should be noted that the total number of structures is not the total of “hospital buildings” in Italy. In fact it is possible that the structure is subdivided into various principals but only one is cataloged. Since the database is referred to this classification of the Ministry of Health, also in this section it was preferred to represent the various structures in the number that will be used later. Starting from this point, nursing homes and hospitals that do not perform surgery are removed from the dataset. In particular, nursing homes, and classified hospitals are eliminated.

Below are highlighted the regional values for public facilities (directly managed hospitals), which are considered to be public according to the ISTAT classification (hospitals, AOU, public IRCCS, public research bodies) and the private ones accredited by the NHS, always for the year 2016 (Figure 14).



Source: Elenco delle Strutture di ricovero - Anno 2016 - Ministero della Salute - Magherini elaboration

Figure 14 - Category of hospitalization facilities

RQ1: Is it possible to define a dashboard of indicators for Operating Room Theatre that also integrates Customer Experience and Outcome measures? Which variables are considered?

This part studies the topic of KPIs measures in order to build PMS through an analysis of the relevant scientific literature highlighting the actions for the increase and monitoring of efficiency.

Strategies Introduction

As anticipated in methodology, the modified classic variant of the Delphi technique was used as the tool for data collection.

Following Calzolaro (2012) and adding the customer satisfaction category, a generic list of KPIs have been arranged around three main families.

The participants for the research were selected from the strategic level of the healthcare units. To qualify, each participant was expected to have served in their current position for not less than one year or not less than five years as staff of the respective department (Ogbeifun et al., 2016).

In the first step of this RQ, the participants were asked to choose, from a set of indicators proposed, for each single Dimension, those preferable to represent the Dimension itself in the process of defining the Performance.

The Dimensions of the Performance of the health systems assumed are those, of the so-called perspectives of the Balanced Scorecards (Kaplan and Norton): an approach that has increased its consideration also in the field of Public Health that it has been modified in order to reach the main scope of this RQ.

In fact, the public nature of health systems has suggested the opportunity to integrate the classic perspectives proposed by Kaplan and Norton with a further perspective, represented by equity (Fioravanti, Spandonaro, 2010); so the Performance Dimensions adopted were that:

- Economic and Financial (efficiency and cost-effectiveness, etc.)
- Social (Customer Satisfaction, equity of access, the financial burden on families etc.)
- Outcomes (perceived quality, etc.)
- Level of Service (Timing, clinical appropriateness, organizational etc.).

One simplification has been adopted: the predetermination of the set of indicators is chosen by consulting ARS (Agenzia Regionale di Sanità) Toscana which selected them according to various criteria, i.e.:

- Availability at Regional level;
- Replicability;
- specificity (compared for the project)
- standardizability
- robustness.

A note should be spent on standardizability, which has been considered a substantial element, in order to avoid that spurious variability effects (for example, attributable to different conditions of population need) could distort the Performance measure expressed by the indicator: for this reason many indicators, although frequently used, have been excluded.

Identification and use of operating room efficiency indicators

The numerous measures of clinical patients' outcomes that are monitored during treatment are an important source of information and help for the improvement of the health system. Traditionally, quality of care has been examined using post-treatment mortality, but over time the tools have matured and interest has increasingly focused on more specific indicators of improving the patient's health, often in the form of functional outcomes, reported by the patient (PROMs: Patient Referred Outcomes) and his experience of care (PREMs: Patient Experience Measures).

This type of recently introduced tools are joining those already present for the strategic control of the performances that for decades have represented the "hard core" of the tools used by the health departments.

Among these multidimensional models, which often have found application in the public sector in Italy, the most common models are (Vagnoni, 2018):

- *Balanced ScoreCard (BSC)* offering an interesting perspective of the link between results, processes, resources and objectives, indicators and actions. It is a strategic tool created in the last decade by Norton and Kaplan, which aims to overcome the limitations of traditional monitoring models, as well as to translate competitive strategies into performance indicators (ScoreCard) ensuring balance (Balance) between short-term performance, measured through parameters of a financial nature, and those non-financial factors that should lead the company to superior and sustainable performance over time.
(www.eccellere.com/Rubriche/GestioneStrategica/BSC.)
- *Common Assessment FrameWork (CAF)*: tool of Total Quality Management conceived and developed by the administrative summits of European Commission and managed by the European Institute of Public Administration

(EIPA). It is a tool designed for the public sector and quality management aimed at continuous improvement. Provides tools to managers for self-assessment and comparison between similar organizations (Benchmarking) (Di Grazia, 2012).

- *Performance Prism* whose distinctive feature is the use of all the stakeholders of an organization as a starting point, including investors, customers and intermediaries, employees, suppliers, regulators and communities, rather than the strategic top. Five "aspects" of Performance Prism lead to key issues for strategy formulation and measurement design:
 - 1) Satisfaction of the interested parties;
 - 2) Strategies;
 - 3) Processes;
 - 4) Capacity;
 - 5) Contribution from stakeholders.

Developing a scorecard or dashboard tracking a set of core performance indicators is essential for measuring, monitoring and benchmarking OR performance and efficiency. The most logical course would be for professional associations to agree to develop common metrics and definitions. While each institution may have specific needs, a core set of measures must be developed.

One of the main challenges in developing a scorecard for measuring and monitoring OR performance is determining which indicators are most important for inclusion. Indicators ideally should consist of data already available in OR information systems (readily measurable), and qualitative measures, such as satisfaction surveys, should probably be avoided because most of them are not validated (Macario et al, 2006). However, there appears to be variation among hospitals in terms of which data elements and indicators are collected and analysed (Zellermeyer, 2005) posing significant challenges for external benchmarking. Only with uniform data and indicator definitions hospitals can proceed with benchmarking and hopefully share learning, leading ultimately to best practice. Moreover, owing to the diverse group of stakeholders involved — surgeons, anesthesiologists, nurses and hospital administrators — it is often difficult to achieve consensus on which indicators are most important for measuring performance (Healthcare Financial Management Association, 2002). For example, to a hospital administrator, optimal performance may mean minimum variance from the budget. To a surgeon, it may mean on-time starts, rapid turnovers and few cancellations.

In the methodology proposed in the present work, for the purpose of determining a PMS for Operating Room Theatre, the objectives are represented by the Dimensions, on which the Performance is to be evaluated.

Each Dimension can possibly be disaggregated into multiple sub-dimensions, described at the lowest level by indicators (attributes).

The methodology was implemented by setting up a panel of experts who received a questionnaire containing the kpis indicators monitored in their operating room., That

panel is representatives of diversified professional experiences, who were asked to provide indications from which to draw their personal preferences on various possible indicators and their relative importance.

The choice of using experts is justifiable also because of the complex nature of health, which notoriously implies relevant information asymmetries.

The first “survey” was submitted to experts from all over Italy, belonging to some categories: 'Users' (citizens associations, trade unions, press), 'Health professions' (surgeons, hospital in general, anesthesiologists, nurses, pharmacists), 'Business Management' (General Managers, Health and Administrative Management), 'Institutions' (Regional Assessments, National Health Agency, Agenas and ARS).

The members of the panel were first involved in the selection of the Performance Dimensions, then in the choice of indicators that represent them; then, again, in the elicitation of the social value that experts attribute to the various indicators; and finally, the in choose which ICT technology works in the Operating Room Theatre. The entire survey is resumed in Appendix. Regarding the ICT part, the answers work for the regression model for RQ2.

Application Areas of the Main KPIs for the Operating Room Theatre

Calzolaro (2012) divided the generic list of KPIs in three macro-categories, the so-called Key Performance Areas (KPA), that will be correlated with each other, as a function of essential hierarchical relationships (it is not possible that a public health structure prefers financial performance instead of the quality and therefore the health of its patients):

1. KPIs that measure **efficiency performance**, ie the ability to use resources. The indicators measure the productivity and unit costs with which the process outputs are obtained. Typical measures of efficiency are the average cost of preparing an order line, unit cost of transport, volumetric saturation of means of transport, the saturation of drivers, time to check the material received;
2. KPIs that measure the **level of service**. The indicators measure the response times to customer requests and the flexibility of the supplier. Measurements of the level of service are delivery time, preparation time for scheduled patient and for urgent one, percentage of urgent patient processed, average time to process an urgent order;
3. KPIs that measure the **quality**, that is the conformity of the outputs with respect to the client's expectations. Typical indicators are the percentage of re-admissions, the number of intervention errors, number of preparation errors, etc..;

4. **Customer Satisfaction** measures all aspects of an intervention or health system in terms of patient perspective (ie compliance of interventions with the real needs of the population's health, level of application of scientific knowledge, professional skills and available technologies, informations given to the patient, etc.) and of staff perspective. As mentioned, customer satisfaction indicators should also take into account not only the user satisfaction but also the operator satisfaction.

1. Efficiency Performance / Operations

- *Starting on Time – Average Late Start Minutes:*

The regular and effective functioning of an operating block the surgery day can be significantly improved thanks to careful planning and preparation of both the operating room and the patient.

For this reason, a preoperative assessment of the patient must be carried out. In sequence: establishes that the patient is fully informed and wishes to undergo surgery; supports the optimization of patient suitability for surgery and anesthesia; minimizes the risk of late cancellations by ensuring that all essential resources and discharge requirements are identified in advance.

One of the key factors to improve efficiency is starting on time. Starting a list on time and as planned ensures a greater likelihood of ending up on time (and therefore minimizing overtime costs), avoiding unnecessary cancellations and maximizing the use of time available to the theater in order to increase productivity.

The timely start of a surgical operation can be calculated as the time difference between the beginning of the actual intervention and the scheduled start time. As an immediate consequence, it is easy to understand how the average of the start-up delays can also be calculated; simply adding the number of minutes of delay of all the operations divided by the number of operations performed.

A timely start is defined as the patient who is in the operating room at the scheduled start time; however, hospitals usually allow some margin for this indicator (for example, the patient must be in the room within a certain number of minutes from the scheduled start time for the case to be considered in time). This period varies depending on the hospital facilities, and in this study a time frame ranging from 0 to 15 minutes is considered.

An alternative definition of the start time offered in the literature is the incision time. This has been suggested as a superior benchmark for the start time, because the patient and all operating room staff must be present before the incision can be performed (Fixler et al., 2012).

There are a number of factors that can contribute to the late start of a scheduled intervention, including:

- Patient arriving late or unprepared (eg wrong food intake);
- Patient not prepared in time by the hospital (eg due to unavailability of personnel, department not ready for transfer);
- Change the order in the list on the day of surgery;
- Incomplete documentation (eg consent);
- Equipment / Room not available / Machines not working;
- Staff not available / late;
- Complex anesthetic preparation;
- Emergency cases / priority cases that delay selective cases.

- *Turnover*

Turnover time refers to the time between the exit of a patient from the operating room and the entry into O.R. of the next patient within the same session, be it morning or afternoon. This time is necessary for cleaning the rooms, removing unsterilized equipment and replacing it with clean equipment. An efficient transition is under the control of a hospital and depends on the availability of staff, the preparation of the equipment and the proper preparation of the next patient.

The replacement time depends on a number of factors, including:

- The layout of the operating room and adjoining rooms;
- The processing capacity in parallel;
- Communication processes (eg push / pull approach to notify the next case ready to enter or exit the operating room);
- Emergency cases during admission during the elective sessions;
- Case mix and / or anesthetic complexity.

- *Finishing on Time*

The delay in the end of an operation may be the result of a series of factors such as bad planning, unnecessary delays, inefficiencies on the day of surgery, cancellations on the day of surgery, surgical and anesthetic complications and / or a misalignment between the processes booking and actual operating time (eg overbooked or under-booked lists). Interventions concluded late not only increase the likelihood of cancellations on the day of surgery, but are also expensive (due to staff overtime) and contribute to staff dissatisfaction, especially if they occur regularly. Likewise, interventions made in advance

are just as expensive due to the potential waste of time that was expected / employed and resources and that could have been used to complete another case.

Health services should adopt a balanced approach to manage overruns and under-utilizations to minimize unnecessary cancellations.

Attention should be focused on the proactive identification of potential overruns or cancellations to enable a timely, balanced and well-informed decision to be made that maximizes the exploitation of resources and impacts as little as possible on patient bookings.

When implementing an escalation procedure, when making decisions regarding overruns and cancellations, the following factors must be taken into account:

- Clinical urgency of the patient and / or if the cancellation will result in a violation of the clinically recommended waiting times;
- Demographic data and place of residence of the patient;
- Possible cancellations / modifications of the patient's intervention already initiated previously by the hospital;
- Availability of staff, even working late and for how many hours outside normal working hours;
- Budget constraints in terms of overtime expenses;

- *Total Delation*

The cancellation rate on the same day measures the percentage of surgery canceled (ie rescheduled to another day or canceled permanently) on the day of surgery. There is a certain variability in the way hospitals define "one day" cancellations. In some cases there are cancellations only on the day of surgery, while in others it has been settled a range time cancellations after 12.00 / 13.00 p.m. of the day before the intervention. In addition, some hospitals only intercept optional cancellations, others all cancellations. All types of cancellation, including those of the previous day, with explicit categories, must be included.

Obviously in this type of analysis the evaluation of the type of intervention has to be included, if it is programmed and then if it is elective or emergency surgery.

Hospitals and health services, as already underlined, should carefully consider the planning and management of emergency surgery and non-surgical procedures, so that the demand for such activity is adequately met to reduce the impact on already planned elective sessions. The provision of these services will depend on the demand, the workforce and the resources of individual hospitals.

Surgery out of hours then measures the volume or percentage of surgical operations performed outside the timetable or scheduled during the evenings, nights, weekends and holidays. The overtime intervention can derive from urgent / emerging cases or from a

normal overtime (ie an intervention that exceeds the scheduled time). Overtime surgery should differentiate between these 2 scenarios, as they require different response strategies.

- *Average O.R. Utilization Rate*

The use of the operating room measures the percentage of time the operating room is used compared to what was budgeted. More specifically, the indicator can be used to measure how long the perioperative unit as a whole uses regular hours of patient care or how long a service or surgeon uses the allocated slot time for patient care. Depending on the use made of it, it has been considered:

- only the time for which a patient is in the operating room;
- the time a patient is in the operating room added to the time for cleaning and set-up between one procedure and another.

- *Equipment Utilization Rate*

This indicator shows the utilization rate of resources of whatever nature they are. As written above, in the operating room the concept of efficiency is linked to the utilization rate and the concept of time; consequently it is easy to understand how inadequate use of resources leads to unnecessary costs and inefficiencies for the system. This indicator assumes a different importance and is calculated differently depending on the type of resource to be measured. E.g. if we want to calculate the exploitation of the operative unit as an O.S.S. o a room nurse will only have to calculate a simple ratio between the number of working hours of the employee including any overtime or early / postponed entry and the number of actual hours for which the resource serves in the hall during the interventions. If the aim is to calculate the same rate related to the utilization of operating rooms, we can repeat the same report by place at numerator the number of hours in which the room is free (potentially 24 H) net of the hours for which the hospital decides to do not operate and denominate the number of hours in which the room is actually operational without considering the time of tooling and cleaning after treatment.

In addition to the uncertainty regarding the arrival and duration of the intervention, other types of uncertainty can be found, but there are only few papers that refer to the uncertainty of the resources despite being a central theme. Suppose, for example, that a surgeon drops an instrument that is unique to the hospital while the surgery is still ongoing. This would represent an interruption of resources, as the medical team must wait for the resumption of its activities until the instrument is once again sterile.

- *Case duration accuracy*

It measures the percentage of OR cases with durations that are accurately estimated. Typically, an accurate estimate is when the variance between the actual and estimated (scheduled) case duration is within a certain threshold (most commonly 15 min).^{7,8} There is variability, however, among surveyed hospitals and in the literature in terms of how case duration is defined. Case duration can be defined as the time from the start of room set-up (before the case) to the completion of room clean-up (after the case); the time from patient in the room to patient out of the room; or cut-to-close time. The first option considers the accuracy of turnover time estimates, whereas the latter 2 do not. Case duration should be measured as patient in the room to patient out of the room, with a separate measure of turnover.

- *Finance*

The National Institute for Health and Care Excellence (NICE) in the UK has published a report that evaluates different types of available economic analyses in order to support investments in public health with the aim of comparing ROI (a useful tool that compares the costs incurred return generated by an investment) in healthcare. Thus the "ROI Tool" was born to provide concrete data on economic returns and, more generally, on the returns that a public health program could generate (Pokhrel, 2015).

Decision makers in the field of public health can use ROI to make their commercial cases explicit, both for investments and for disinvestments. Public health is already quite over-stimulated by the amount of cost-effectiveness data available for individual interventions, but what contemporary decision-makers are seeking is to have this information developed in a different, more practical format. This introduction serves to outline how the ROI has evolved, as a function of changes in the global economic scenario.

The ROI as we know in its extended formula,

$$\text{ROI (\%)} = (\text{Investment Gain} - \text{Cost of Investment}) \times 100 / \text{Cost of Investment}$$

now provides a superficial view of reality, not allowing to fully understand what could be the benefits of an investment. Obviously when the topic is about the investments in areas such as health care, reference is made to the possibility of enhancing:

- Structures by adopting new enabling technologies or innovations;
- human Resources, assuming highly competent professionalism;
- quality thus raising the standard of care rendered through services.

It would therefore be appropriate for any investment assessment to be taken into consideration important non-economic variables that in addition to generating a greater profit, could also allow:

- Provide more precise indications to make appropriate strategic decisions;
- save time;
- increase the level of patient satisfaction;
- improve the Outcomes by generating a positive correlation of patient monitoring and reduction of the mortality rate, the rate of readmission to hospital etc ...

2. Level Of Service

- *Patient Wait Time*

Patients spend a significant amount of time in clinics waiting for services to be provided by doctors and other health professionals. This type of indicator provides an overview of the average waiting rate and of course, although it is useful for health facilities to evaluate the quality of service offered, this type of indicator reflects the level of patient satisfaction. Health organizations with the aim of providing good level of services must effectively manage waiting in the clinic. If a structure doesn't integrate consumer-driven features into the design of the waiting experience could lead to patient and supplier dissatisfaction. Waiting time refers to the patient's time spent in the clinic before being seen by one of the doctors or undergoing an elective treatment.

The waiting time of the patient's clinic is an important indicator of the quality of the services offered by the hospitals. The amount of patient waiting time is a factor that influences the use of health services. Patients perceive long waiting times as an obstacle to effective service delivery. Keeping patients waiting unnecessarily can cause stress to both the patient and the doctor, thus becoming a tangible variable of the practice to judge the health personnel, even more than their knowledge and skills.

The Institute of Medicine (IoM) recommends that at least 90% of patients should be seen within 30 minutes of the scheduled appointment, but this benchmark in practice is never respected.

The duration of waiting varies from Country to Country, and also within the country varies from center to center and obviously depending on the type of health service to be received.

- *Off-hours surgery*

It measures the volume or percentage of surgery performed outside of scheduled OR time during evenings, nights, weekends and holidays. Off-hours surgery may result from urgent/emergent cases or from normal over-run hours (i.e., surgery exceeding its

scheduled time). Off-hours surgery should differentiate between these 2 scenarios, as they require different response strategies if deemed excessive.

- *Same-day cancellation rate*

It measures the percentage of surgical procedures cancelled (i.e., rescheduled to another day or cancelled altogether) on the day of surgery. Some variability exists in terms of how the surveyed hospitals define “same-day” cancellations. In some cases, this refers only to cancellations on the day of surgery, whereas in other cases it refers to any cancellations after 12:00 pm or 1:00 pm the day before the scheduled day of surgery. Moreover, some hospitals capture only elective cancellations, whereas others capture all cancellations. All types of cancellations, including those cancelled the previous day, with explicit categories need to be captured.

- *Percentage of unplanned closures*

It measures the percentage of OR time lost owing to unplanned closures, which can result from the unavailability of human resources or hospital resources (e.g., beds, supplies or equipment), in- adequate notification of OR time forfeited by services or surgeons, and environmental factors (e.g., flu pandemic). For the purposes of this indicator, what constitutes an unplan closure varies across surveyed hospitals. However, hospitals surveyed expressed the importance of tracking the reasons for any unplanned closures to facilitate appropriate corrective action, as unplanned closures negatively impact resource use. This indicator needs to be captured with consensus to explain reasons and definitions.

3. Quality

Quality indicators are provided by the PNE, Piano Nazionale Esiti which develops in the health service the evaluation of outcomes of health interventions, definable as: estimate, with observational (non-experimental) study drawings, of the occurrency of health intervention / treatment outcomes.

In this database it can be find indicators such as mortality rate of a given intervention or re-admission rate after an intervention. The data are updated on the basis of the analysis of each patient's hospital discharge cards, which must be filed and sent to the Ministry of Health every year by law.

Another important monitored data concerns the variation between the number of planned interventions and those actually performed. The latter represents another index of quality of care.

4. Customer Satisfaction

In order to create a synthetic performance indicator, it is now also necessary to introduce indicators and a structured basis of data that certify the level of customer satisfaction with respect to the care received.

Multiple key areas could be critical, such as the efficiency of hospital staff, the degree of structure innovation, the level of safety and productivity.

For example, the level of innovation and change within a healthcare facility is difficult to perceive and there are no tools to quantify it and compare it to benchmark companies.

However, the literature has tried to provide an overview of supporting tools, illustrating how rating scales could be generated towards some reference parameters.

- *Restored Health Level*

In order to measure operating room performance and efficiency (OR), hospitals need evaluation boards or dashboards that display and track these newly suggested performance indicators. Assessment forms should be monitored on an ongoing basis and compared both internally with performance over time and externally with consolidated best practices with the aim of continuously improving performance.

Only with uniform definitions and relative available data hospitals can proceed with benchmarking and hopefully share learning, and ultimately leads to best practices. Furthermore, because of the different group of actors involved (surgeons, anesthesiologists, nurses and hospital administrators) it is often difficult to reach a consensus on which indicators are most important for measuring performance. However, common definitions were lacking between hospitals, which was a critical consideration and a major challenge for external Benchmarking.

Delphi Results

A total of 39 studies were identified for inclusion in the review. The search of database provided a total of 8.810 citations. Initially, the title of all the articles was checked out and 7.998 were excluded owing to contradiction with the study objectives. After adjusting for duplicates, 39 articles were remained.

Finally, throughout the help of internal expert panel, 71 indicators were selected (Table 12).

It has been asked to them to rank the most important indicators, and in order to help the participants, indicators are divided in 4 categories.

The generic list of KPIs was circulated in the first round. Results are shown in Table 12.

The indicators that did not pass the score of 2 were rediscussed and then eliminated.

PMS perspectives	Indicators		Indicators	
Efficiency performances	E1	Average Number of Patient Rooms in Use at One Time	E15	Average Minutes Per Surgery
	E2	Occupancy Rate	E16	Bed/Room Turnover
	E3	Average hospitalization expenditures	E17	Number of Patients Served Per Month
	E4	Starting on time	E18	Equipment Utilization Rate
	E5	OR rate utilization/medical staff	E19	Discharge Process Time
	E6	average Length of stay	E20	Cancelled operations
	E7	% extensions sessions due to the delayed start	E21	Average delay
	E8	Surgeries / Scheduled Number of Surgeries	E22	Surgery Duration Forecast Accuracy
	E9	Patient in Room Time or Cycle Time (T)	E23	OR rate utilization/nursing staff
	E10	Turnover Time	E24	Operating Room Turnaround Time
	E11	Staff Overtime	E25	Vacancy Rate
	E12	Overtime costs	E26	Makespan
	E13	Bed Turnover Interval	E27	Waiting time of surgeons
	E14	Bed occupancy	E28	bed turnover
Quality / appropriateness / Outcome	Q1	Mortality rate	Q11	Patient falls rate
	Q2	Wrong-site surgery	Q12	Hospital accidents prevalence rate
	Q3	% Repeated surgeries	Q13	Sentinel event rate
	Q4	Number of Mistake Events	Q14	Impact of Mistakes
	Q5	Hospital infection rate	Q15	Leaving a foreign object during surgery
	Q6	Clinical errors	Q16	Patient Safety
	Q7	Readmission rate	Q17	
	Q8	% Occupational accidents	Q18	Mean Length of stay in emergency department
	Q9	Pressure Ulcers rate	Q19	Medication errors
	Q10	Medical errors	Q20	Waiting time from triage to see doctor
Level of Service	G1	Waiting time for admission operation room	G8	the amount of the electronic medical record
	G2	Arrival to Physician	G9	Patient Wait Times by Process Step
	G3	Patient Wait Time	G10	Employee absenteeism rate

	G4	Arrival to Bed	G11	Perception of waiting times from taking charge to discharge
	G5	Average hours of Internet use	G12	Arrival to Nurse
	G6	Patient Follow-Up	G13	Emergency Room (ER) waiting time
	G7	Percentage of unplanned closures	G14	Off-hour surgery
Customer	C1	The facilities for families and visitors	C6	Other Stakeholders satisfaction
	C2	Patients satisfaction percentage	C7	Social satisfaction
	C3	Rate of Patient complaints	C8	Employee Satisfaction
	C4	Staff turnover	C9	Patient Retention Rate
	C5	Quality of Nursing Care		

Table 12 - KPIs list

In Delphi method, data were analyzed by descriptive statistics using Excel software. The experts rated the importance of the indicators, on a five-point Likert scale (“Not important,” “Somewhat important,” “Relative important,” “Very important,” and “Extremely important,” respectively). The required level of consensus was defined. Two necessary conditions had to be fulfilled:

1. a minimum value of at least 3 (Relative important, very important and Extremely important);
2. a consensus percentage of at least 80%. In the consensus calculation, the consensus percentage was calculated by classifying the values 1-2 as not important (0) and 3-4-5 to (1) as important.

The following Table 13 shows the Delphi scores of all the three rounds.

KPI	Round I	Round II	Round III
Occupancy Rate	3.6	4.44	4.29
Starting on time	3.47	3.78	4.36
Surgeries / Scheduled Number of Surgeries	4.0	4.56	4.64
Turnover Time	3.27	4.11	4.79
Discharge Process Time	3.47	4.67	4.50
Average delay	3.13	3.89	4.57
Operating Room Turnaround Time	3.8	4.56	4.57
Mortality rate	3.27	4.33	4.07
Readmission rate	3.27	4.22	4.64
Perception of waiting times from taking charge to discharge	3.27	4.11	4.64
Patient Wait Times by Process Step	3.33	3.89	4.93
Employee absenteeism rate	4.22	4.29	
Waiting time for admission operation room	3.20	2.82	
Rate of Patient complaints	4.20	4.22	4.93
Staff turnover	4.56	2.64	
Quality of Nursing Care	3.4	3.78	4.88
% Repeated surgeries	3.27	4.22	4.29
Number of Mistake Events	3.6	4.22	4.21
Social satisfaction	3.93	3.73	
Employee Satisfaction	3.73	3.99	
Patient Retention Rate	3.81	4.14	
amount of the electronic medical record	3.46	3.95	
Vacancy Rate	3.72	4.21	
Makespan	3.82	4.23	
Waiting time of surgeons	3.1	3.37	
bed turnover	3.54	3.65	
Patient falls rate	3.77	3.93	
Hospital accidents prevalence rate	3.98	3.21	
Sentinel event rate	3.44	3.67	
Impact of Mistakes	4.02		
Leaving a foreign object during surgery	3.09		

Patient Safety	3.68		
Mean Length of stay in emergency department	3.43		
Medication errors	4.31		
% Occupational accidents	3.98		
Pressure Ulcers rate	3.19		
Medical errors	4.1		
Waiting time for admission operation room	2.43		
Arrival to Physician	2.56		
Patient Wait Time	2.12		
Arrival to Bed	2.45		
Average hours of Internet use	2.76		
Patient Follow-Up	2.56		
Percentage of unplanned closures	2.44		
The facilities for families and visitors	2.47		
Arrival to Nurse	2.59		
Emergency Room (ER) waiting time	2.23		
Off-hour surgery	2.35		
Other Stakeholders satisfaction	2.96		
OR rate utilization/medical staff	2.67		
average Length of stay	2.47		
% extensions sessions due to the delayed start	1.7		
Average Minutes Per Surgery	1.78		
Bed/Room Turnover	1.98		
Number of Patients Served Per Month	1.87		
Equipment Utilization Rate	1.56		
KPI	Round I	Round II	Round III

Table 13 – Delphi scores

Confirming what is written in Hasson et al. (2000) and Mullen (2003) papers, in round two more indicators were eliminated. This is an indication that the participants changed their opinion from the rating they provided in the first round. As will be written in the following paragraphs, some of the critics of the Delphi technique comes from the tendency of changes in participants opinion from one round to another. However, the fact that the study participants are experts (or knowledgeable persons) shelters this type of problem. Continuing to quote Hasson and Keeney (2011), experts changing their opinion should be seen as strength and not weakness, because the fact that opinions can be compared in the same research is seen as an added value to the Delphi method. The controlled feedbacks allow participants to view their individual submissions in the light of the whole group, tailoring the opinion of the participants towards group consensus (Hasson and Keeney, 2011; Ogbeifun et al., 2016). The scores on each item improved in the subsequent rounds.

In the second round the minimum for the qualification was moved to 4 on the Likert scale. The KPIs who reached the minimum in the second round were re-proposed in the third round to allow the participants to interact again. After analysis, the number of items were retained until a consensus of at least 80% was reached. The developed KPIs are shown in the Table 14 circled by red colour.

All of the Likert scale of other KPIs, all the statistical tables are provided in Appendix.

PMS perspectives	Indicators		Indicators	
Efficiency performances	E4	Starting on time	E2	Occupancy Rate
	E8	Surgeries / Scheduled Number of Surgeries	E19	Discharge Process Time
	E10	Turnover Time	E21	Average delay
	E24	Operating Room Turnaround Time		
Quality / appropriateness / Outcome	Q1	Mortality rate	Q3	% Repeated surgeries
	Q4	Number of Mistake Events	Q7	Readmission rate
Level of Service	G9	Patient Wait Times by Process Step	G11	Perception of waiting times from taking charge to discharge
Customer	C3	Rate of Patient complaints	C5	Quality of Nursing Care

Table 14 – KPIs list developed by Delphi method

KPIs developed through a consensus-building process are the product of the synthesis of independent individual contributions. Since the traditional method of the session of the committee or focus group was used to develop these KPIs, the exercise required very long meetings. If we had not used the Delphi method there would have been the possibility of encountering difficulties in convincing the members to participate in the scheduled meetings and in managing the excesses of characters who tended to prevaricate on other components of the group. These problems were avoided using the Delphi technique that allowed individual participants to respond to the research question as they pleased (within the scheduled time), anonymously and each contribution was devoid of coercion. The quality of KPIs in the medium and high priority categories are adequate performance indicators that can guarantee better performance, verifying that the Delphi technique is a reliable tool for building consensus.

According to the results, 15 indicators were selected for KPI of hospitals using the opinion of the experts' panel. 7 indicators were selected in efficiency/operations perspective, 4 for Quality/Care and 2 for each for the other categories (Table 14). Through this study, operating room theatre hospital indicators were classified based on a sort of balance scorecard under four categories as efficiency, customer satisfaction, level of service and quality.

Reliability e validity

The Delphi method is heavily criticized for poor reliability. In other words, if the same information is provided to different panels, one does not have the certainty of obtaining the same results (Williams and Webb, 1978; Walker and Selfe, 1996). However, other researchers found that the technique was accurate. For example, Ono and Wedemeyer (1994) report the results of a study designed to replicate a Delphi study 16 years earlier, demonstrating the accuracy of the results in terms of predictions made over the next 16 years. Even the technique has been criticized in relation to validity, Goodman (1987) states that the researcher can not influence in any of the phases of development of the investigation, which may have resulted in a faulty validity. However, Goodman (1987) also states that if the panels participating in the study are representative of the group or area of knowledge, then the content can be assumed to be valid. Accepting the above criticisms can be leveled with any qualitative research method. Therefore, perhaps we should not judge the 'Delphi' using the psychometric criteria developed for more positivistic approaches. Other criteria such as transferability, credibility, applicability or compatibility of results may be more appropriate. Jairath and Weinstein (1994) reaffirm the importance of the pilot tests not only in identifying the difficulties of formulation, but in improving the feasibility of the administration. Although few Delphi researchers report to undertake pilot tests before implementation, it is not clear how many pilot tests should be performed when using this technique. For example if there must be one for each round or only one for the initial round.

RQ2: Does Information System in Hospitals impact on Operating Room Efficiency and on Patient Outcomes Indicators?

Strategy Introduction

The dataset used was constructed from the database of the Ministry of Health that in 2018 provided data for the year 2016, making this elaborate, at the time of writing, one of the first to use these observations.

The dataset covers all hospital facilities excluding accredited and non-accredited nursing homes and classified hospitals for which it would be possible to make only a partial one-stage analysis, which is beyond the scope of this part of the study.

Starting from RQ1, considering the data available in the public dataset, we chose to use as input values those of the staff related to the operating room divided into surgeons, anesthetists, nurses and the number of operating rooms in the operating theater and the number of surgeon beds. Dataset like personal cleanings, technicians, administrative staff is not considered due to the differences in contractual status and to the lack of informations. The first inputs are used as a proxy of human / working capital available to the structures while the remaining as a proxy of the capital employed.

It would be very difficult to disaggregate variables such as energy expenditures, material / drug / device expenditures due to the difficulty in finding this information and the difficulty in identifying correlations with efficiency aspects.

The outputs chosen refer to the number of interventions weighed for the structures' Case Mix Index and the relative number of days of hospitalization, also weighted by the Case Mix Index (ICM). This is a slightly different choice from the one in the literature that often uses the ICM only to weigh one of the two or more output variables. This choice falls within the perspective of giving greater importance to the medical component and to the different medical / clinical complexity. The number of interventions is chosen as output because it is used to take into account the different use of resources of the surgical unit. Unlike the Diagnosis-Related Group (DRG), which is more commonly used to weigh admissions to a higher level of disaggregation, using the ICM it can be highlighted the complexity of the hospital case study. In fact, with the ICM, the activity of a hospital is standardized for an index built-ad-hoc, built starting from a standard average hospitalization for specific DRG.

Remaining in terms of "standardization", as already highlighted in the model, the variables are normalized. The standardization allows both to not lose the characteristics of variability and to facilitate the reading of the performance of efficiency.

In this study, as in all the others, an ICM value > 1 means that the complexity index of that surgical unit is higher than the average (standard). Lower ICM values indicate a case

study with complexity lower than the Italian hospital standard. Why does it make sense to weight the output?

It is assumed that greater complexity affects efficiency by requiring more input utilization, a lower complexity requires less input.

The second output, the number of days of hospitalization, is used to take into account that the production of hospitalizations has required a daily use of resources to perform the care activity. Since this last variable has been much debated in recent years because of the tendency to reduce the days of hospitalization to the minimum necessary, we chose to weigh this variable for the Case Mix Index, in order to penalize more those structures that despite a lower Case Mix, they take care of the person more days than necessary. The fact that the reimbursements are not paid on the basis of the number of days of presence but on the type of service performed (based on the DRG code, unique for each type of service possible within a hospital), ensures that in general the hospitalization is not prolonged more than necessary and therefore using the number of days of hospitalization is still an important variable. Surely the average hospital stay will be, the fewer potential hospitalizations will be possible.

Within the Dataset the observations with missing value were eliminated, with null values in one of the five dimensions and those with anomalous values.

A second thinning was carried out when it was realized that the structures with lower number of doctors (or around) to 3 all had efficiency values equal to 1. In fact, these structures are often used for long-term care or rehabilitation, which by definition have a limited number of beds and a limited staff. As a result, with the same output, it would have been difficult to be more efficient than these structures. All these structures have been eliminated. Finally also structures without intensive care were eliminated leading to a total of 348 structures involved in the analysis distributed in a rather homogeneous way along the national territory, taking into account the chronic lack of infrastructure that characterizes the south of Italy.

Introduction: R Environment, Benchmarking package

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS.

R is an integrated set of software resources for manipulating data, calculating and displaying graphs. It has, among other things:

- An effective data manipulator and an equally effective storage device;
- A set of operators for calculations on arrays, in particular matrices;
- A large, coherent, integrated collection of intermediate tools for data analysis;
- Graphic resources for data analysis with visualization directly on the computer;

- A well-developed, simple and effective programming language that includes conditional institutions, loops, user-defined recursive functions and input / output tools.

The term "environment" is intended to characterize it with an entirely planned and coherent system, rather than a system that increases through very specific and inflexible parts, as frequently happens with other statistical software.

R was initially written by Ross Ihaka and Robert Gentleman, from the Statistics Department of the University of Auckland, New Zealand, and is considered a clone of S, a statistical programming language developed in 1980 in Bell Labs.

There is an important difference between R (and therefore S) and the other main statistical environments. In R a statistical analysis is normally done through a series of steps with intermediate results that are stored in objects. Thus, while SAS or SPSS will give a copious output of relative results, for example, to a regression analysis, R will give the least production, storing the results in objects that can be recalled by other R functions.

R constitutes, in the statistical software context, a valid alternative to the most widespread statistical environments. In particular, R is a statistical environment distributed for free under the GPL license and developed by a team of researchers in the field of statistics and information technology world-renowned. There are versions of R for different platforms and therefore also for the most common operating systems within the PC, ie Windows, Mac and Linux.

R and S-Plus are particularly popular in medical statistics, but are also used in economic or social statistics, in geography, in financial mathematics. The high level of the language allows to easily create function libraries for new applications. The weak point is the speed of execution in numerical calculations in large dimensions, while the graphic capabilities are very rich.

Although thus directed towards the statistics, R should not be considered only a statistical package. It is a true programming language, indeed a very advanced programming language, and allows us to adapt it to any computer task. In the same statistic this flexibility is very important today, where new applicative needs are constantly discovered, new necessities to translate mathematical methods, for example in the statistics of complex clinical or geographical data, in computer tools.

R is an open source software, its source code is freely distributed, constituting a system open to anyone who wants to increase its possibilities of use and calculation. The source code can be downloaded from the The R Project for Statistical Computing website.

The package used in this RQ2 is Benchmarking.

This package contains methods to support frontier analysis, using Data Envelopment Analysis (DEA), supported under different technology assumptions (fdh, vrs, drs, crs, irs, additivity / frh and fdh +, as explained before), and using different measures efficiency (input-based, output-based, hyperbolic charts, additivity, super efficiency and directional efficiency).

It is possible to highlight the peers and slacks, information on prices and the optimal cost, revenues and profits can be calculated. Methods for evaluating a merge are supported. The package also supports comparison methods based on stochastic frontier analysis (SFA). In general, there are not only standard models but many other variants can also be used and implemented. The package integrates the book by Bogetoft and Otto, Benchmarking with DEA, SFA, and R, Springer-Verlag, 2011. The interface and programming of the functions is very similar to the interface of the FEAR package (Wilson 2008). Input and output matrices can contain negative numbers, and it is thus possible to manage fixed or constrained inputs and outputs. What is returned is not only efficiency, but also slacks, dual values, peers, lambda (weights).

Bootstrap DEA algorithm

In the methodological section are listed the procedures for carrying out the evaluation of DEA efficiency and for the second stage analysis of Tobit. This section highlights how the algorithm is applied; the list of "steps" used for the software R script that leads to the results of RQ2 is shown in the appendix.

1. Calculate $\hat{\theta}^k$ as a solution of $\min \left\{ \theta \mid (\theta x^k, y^k) \in \hat{T} \right\}$ for $k = 1, \dots, n$
2. Use the bootstrap from a smoothed sample by $\hat{\theta}^1, \dots, \hat{\theta}^k$ to obtain a bootstrap replica $\hat{\theta}^{1*}, \dots, \hat{\theta}^{k*}$, executed as follows:
 - i) Bootstrap the sample with re-entry from $\hat{\theta}^1, \dots, \hat{\theta}^k$ and assign to results $\beta^1, \dots, \beta^k$
 - ii) Simulate a standardized independent random variable $\varepsilon^1, \dots, \varepsilon^k$
 - iii) Calculate:

$$\check{\theta}^k = \begin{cases} \beta^k + h\varepsilon^k & \text{if } \beta^k + h\varepsilon^k \leq 1 \\ 2 - \beta^k + h\varepsilon^k & \text{otherwise} \end{cases}$$

By construction we will have $\check{\theta}^k \leq 1$

- iv) Vary $\check{\theta}^k$ in order to obtain parameters with corrected asymptotically variance and the estimated variance

$$\hat{\sigma}^2 = \frac{1}{n} \sum_{k=1}^K (\hat{\theta}^k - \bar{\theta}^k)^2$$

And calculate:

$$\theta^{k*} = \bar{\beta} + \frac{1}{\sqrt{1 + h^2/\hat{\sigma}^2}} (\check{\theta}^k - \bar{\beta})$$

Where

$$\bar{\beta} = \frac{1}{n} \sum_{k=1}^K \beta^k$$

- 3) Calculate input-based values in "bootstrapped" efficiency

$$x^{kb} = \frac{\hat{\theta}^k}{\theta^{k*}} x^{k1}$$

- 4) Solve DEA program in order to estimate θ^{kb}

$$\theta^{kb} = \min \left\{ \theta \geq 0 \mid y^k \leq \sum_{j=1}^K \lambda_j y_j, \theta x^k \geq \sum_{j=1}^K \lambda_j x_j^{kb}, \lambda_j \geq 0, \sum_{j=1}^K \lambda_j = 1 \right\}$$

$$k = (1, \dots, n)$$

- 5) Repeat 2) steps until we get bootstrap estimates

$$(\theta^{1b}, \dots, \theta^{nb}) \quad (b=1, \dots, B)$$

- 6) Calculate the mean and the variance of $(\theta^{1b}, \dots, \theta^{nb})$ to get the bootstrap estimates of θ^* , the bias corrected estimate $\check{\theta}^k$ and the variance.

DEA efficiency measures the radial distance in the input space from the observation point to the limits of the technological boundary.

A first bootstrap of the efficiencies is performed which is used to calculate the input vectors with this "bootstrapped" efficiency: this is done in step 3 of the description.

These bootstrapped input vectors are the inputs that will determine the technological set of step 4 from which the final bootstrapping efficiency will be calculated.

This algorithm concludes the analysis of the 1st stage that was carried out with 4 input variables and 2 output variables, which will be discussed in detail in the following chapter.

Results

In this study, an input oriented both VRS and CRS DEA model is used, whose implications have already been discussed in the previous paragraphs, also indicating the effects of BIAS on efficiency.

Why the input-oriented choice?

This choice is linked to the fact that hospitals in general can't stop access to surgical treatment and therefore can not control the output variables. In many models, especially in the US, the output-oriented approach is used both because the legislation in this area is completely different, and because the objective of these structures is that of growth and maximization of revenues.

In this study the exclusion of for - profit hospitals leads to the identification of the objective not to maximize revenues but to reduce costs by using resources in an optimal manner, given production prices.

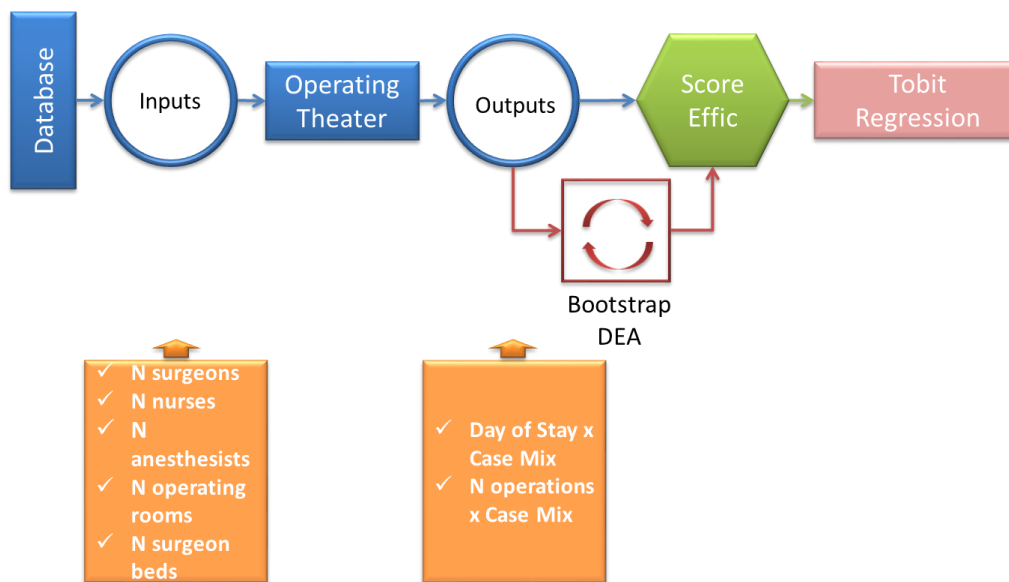


Figure 15 – Bootstrap DEA model, adaptation from Magherini 2016

The model developed by Magherini et al. (2016) is shown in Figure 15.

It is still necessary to point out that the original model taken into consideration is the one proposed by Simar and Wilson (2007) who propose to use the bootstrap technique to calculate the DEA-scores. This technique allows to correct the results obtained with the aim to exclude problems of endogeneity between the considered variables and of autocorrelation among the residues. In addition, the two authors recommend it especially

if a study want to use the efficiency scores in a subsequent regression analysis, as will be done in the present work.

In this study, there are 2000 iterations performed.

N = 348 Year 2016	TOTAL	MEAN	STD DEV	z	MIN	MAX
# Operating rooms	3.881	4,8	5,1	760	3	42
# Surgeon beds	40.688	24,4	22,1	1840	6	146
# Surgeons	43.533	184	195	222,3	19	922
# Nurses	93.262	232	259	359,2	20	1.708
# Anesthetist	199.769	354,8	449,6	443,5	14	4.652
# interventions x case mix	2.247.157	1.430	1.732	1296,6	89	20.679
(day)Lenght of stay x case mix	10.622.223	33.033	24.918	425	636	75.478

Table 15 - Descriptive statistics of DEA input/output

In the Table 15 is shown the descriptive statistics of the input & output used in order to perform DEA I Stage model.

The data entered in the model are taken from the database of the Ministry of Health and reflect what is done in literature with the variation given by the Case Mix. This modification serves to intercept the different specific weight of a more burdensome intervention in terms of resource absorption. In fact, a major Case mix will lead to an increase in the weight of the output compared to other structures that operate with simpler areas.

Features

Below a summary of the features of the modeling used.

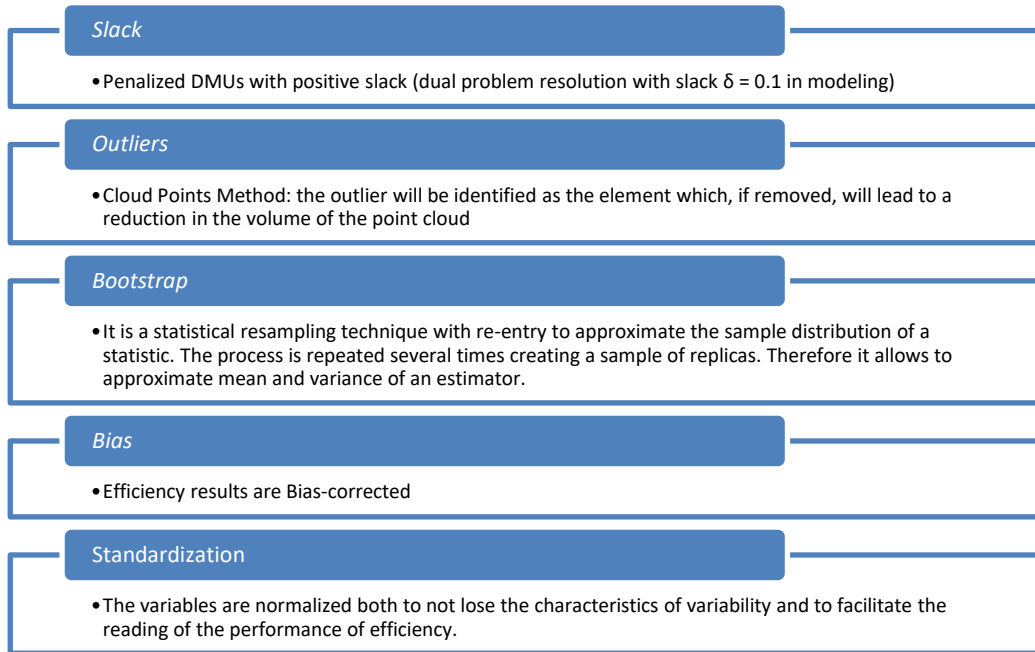


Figure 16 – DEA features

The results of the technical efficiency of the I Step are summarized below.

	VRS	VRS (BIAS)	CRS	CRS (BIAS)
MEAN	0,752	0,711	0,702	0,660
STD DEV	0,117	0,100	0,119	0,111
1 QUARTILE	0,677	0,638	0,620	0,581
MEDIAN	0,749	0,708	0,691	0,657
3 QUARTILE	0,836	0,786	0,766	0,734

Table 16 – DEA efficiency scores – I stage analysis

The analysis shows that the average efficiency of the 348 facilities for 2016 is 0,752 out of a maximum of 1 for the variable returns of scale method. This specifies that, according to the VRS model, there would be the possibility to save 25% of resources to produce the same mix output.

The next step is to understand where the differences are found, which are the most efficient structures, which is the type of structure that needs to be rethought and which one to incentivize.

For this reason a new differentiation is proposed, distinguishing the structures according to the type of management:

Public or Private Accredited: the first case refers to the structures directly managed by the ASL, all hospitals, public polyclinics, public IRCCS. All other categories are among Private Accredited hospitals.

Another distinction that requires some changes to the classification given by the Ministry of Health is that concerning University hospitals. In fact, according to what is written Ministry of Health classification documents, there are only 27 university hospitals in the Italian territory. This, if we want to fit into the rigorous definition, is true, but structures such as the San Paolo Hospital or the Luigi Sacco Hospital, a University Campus that hosts courses in Medicine and Surgery at the University of Milan, would be excluded from the calculation. It has been decided to include in the discussion also the facilities of university courses of Medicine and Surgery of the Italian Universities (where it was clear and evident the teaching within previous premises). If an hospital is both IRCCS and university, its classification will refer to the number of beds used accredited and contracted with the Health Service in agreement with the University.

As can be seen from the following representative tables, the number of university hospitals will increase to about 41 units.

Azienda Ospedaliera or Direct Management by ASL is the last unpacking identified.

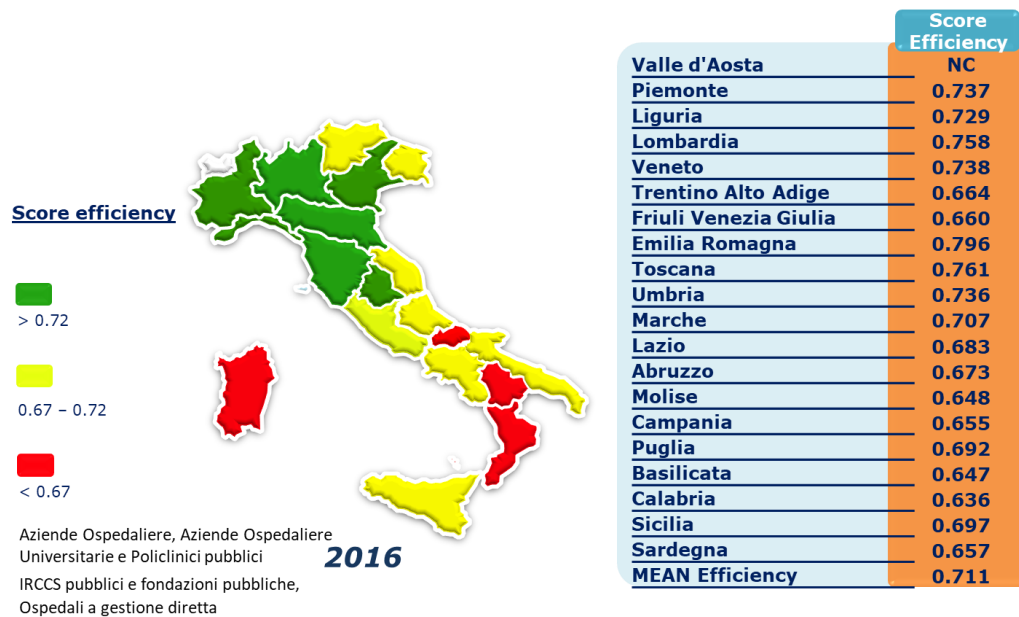
Below are the values of technical efficiency only, carried out with the input and output data described above:

2016	CRS Original Score			CRS Bias Score		
	Mean	St. Dev	Median	Mean	St. Dev	Median
UNIVERSITY Hospital						
n = 41	0,793	0,121	0,809	0,754	0,113	0,776
CLASSIC Hospital						
n = 300	0,691	0,112	0,682	0,649	0,103	0,648
PUBLIC						
n = 316	0,696	0,113	0,689	0,658	0,109	0,656
PRIVATE ACCREDIT.						
n = 25	0,777	0,161	0,725	0,69	0,133	0,678
AZIENDE OSPEDALIERE						
n = 74	0,754	0,109	0,748	0,716	0,109	0,715
ASL DIRECT MANAGEMENT						
n = 243	0,682	0,107	0,673	0,643	0,1	0,641

Table 17 - Technical efficiency divided in subcategories

The results refer to average values deriving from the application of the DEA Model with 4 inputs and 2 outputs using the dataset discussed above.

It is not surprising that among the most efficient structures there are the accredited private ones ($E = 0.77$) towards the ASL direct management facilities ($E = 0.68$): this means that the resources are used better than the ASLs. It is important to note how the record of efficiency is held by the university structures that, thanks also to a different funding system, have often more avant-garde technologies than the others.



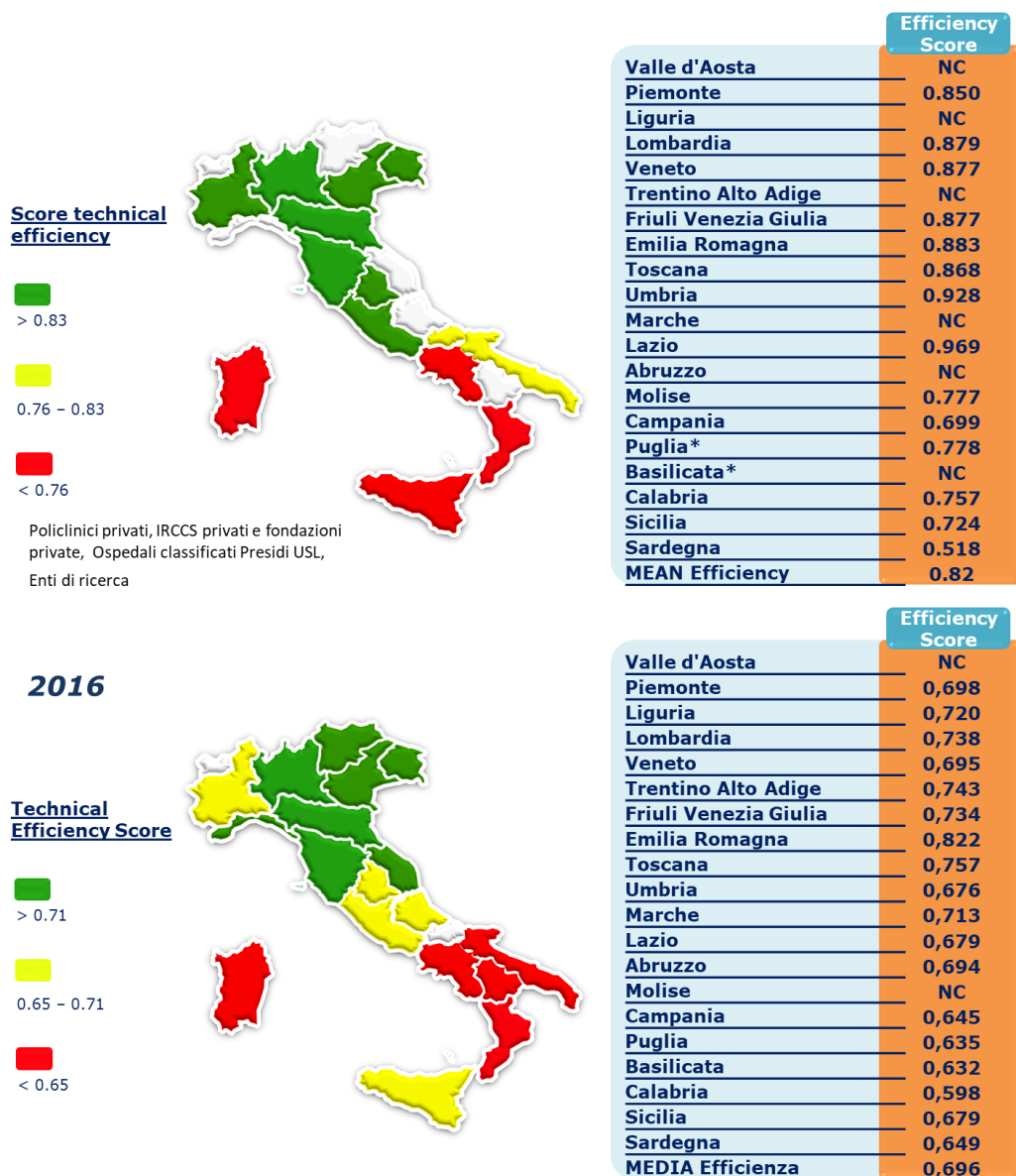


Figure 17 - Efficiency maps divided by category

These results are presented here again with a discussion at regional level, perhaps more interesting in order to highlight regional diversity. Anyway, in Appendix 2 all efficiency scores are listed.

The three bands of efficiency subdivision in the different colors are arbitrary and subjective, but it has been tried not to put rigid separations between efficiency classes. Example: where the barrier threshold between one band and the next one was 0.6, if a

production unit showed an efficiency of 0.595, it would be included in the upper category, because of the impossibility to determine in absolute terms the efficiency of a health facility.

The Valle d'Aosta is always excluded from the representation as only one observation is available.

The various regional efficiencies have been analyzed, observing those that are the parameters with which the hospital facilities have been classified.

In particular it has been highlighted some different and important categories:

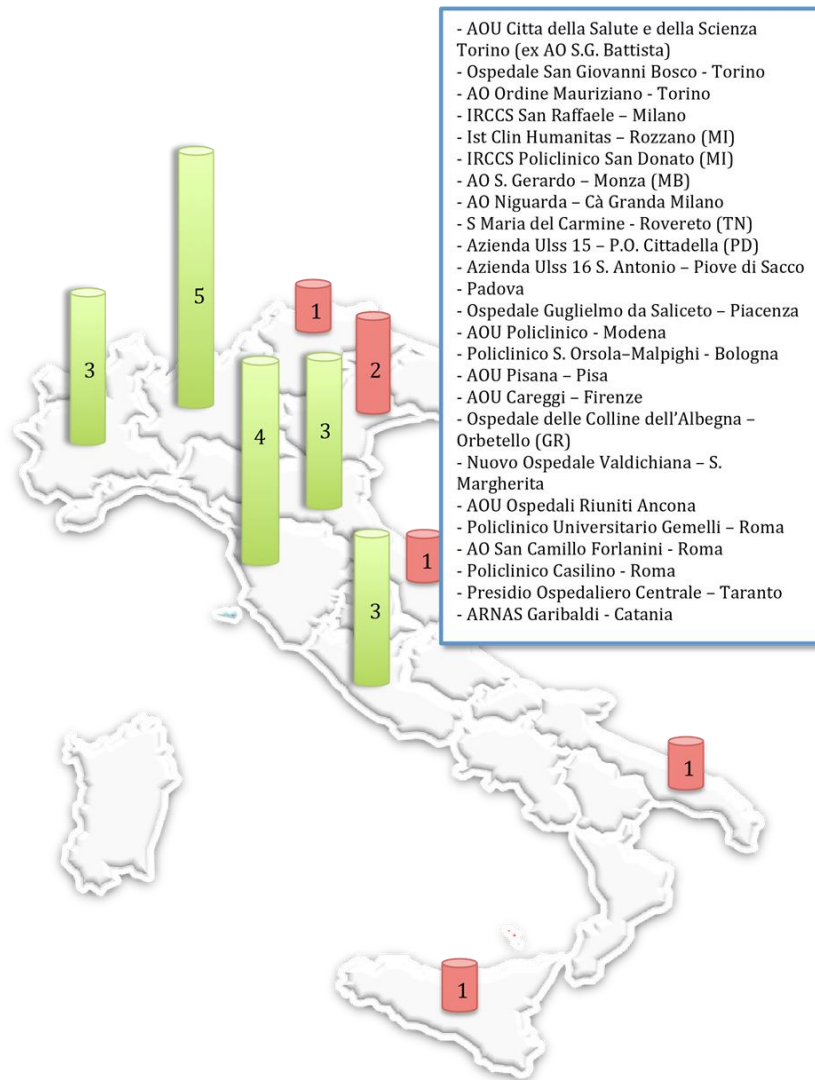
- Public Structures (hospitals directly managed by ASL, hospitals, university hospitals, public policlinics, public IRCCS, public foundations.
- Private Structures (private IRCCS and private foundations, private polyclinics, research institutions).

These representations are useful for immediately understanding the differences in regional efficiencies. Unlike other papers analyzed in the literature, a precise regional classification has not been drawn because the measurement is affected by errors and a few decimals of difference can not and must not be discriminatory.

The results of the graphs are quite explanatory, but what is found can not be separated from the methodology used. Other models can also be used to analyze panel data.

The analysis of the implemented DEA model shows that 24 structures lie on the efficient frontier (DEA - VRS) of a total of 348 in 2016.

In the following Figure 18 the resulting list of structures lying on the efficient frontier.



Generally speaking, the regions of the Center-North are the most efficient with Emilia Romagna, Tuscany, Lombardy, Veneto in the lead and following Piedmont, Liguria, Friuli Venezia Giulia, Umbria and Marche. The southern regions present a difficult situation apart from some centers of excellence of Roma Capitale. As for the "best performing" regions of Southern Italy, Puglia and Sicily are worth mentioning.

The analysis of the data shows that the causes of the lack of efficiency recovery observed in the southern regions are to be found not only in relation to the lowest levels of output per inhabitant compared to what is done in the Center and North of the peninsula but, probably, also because of the not balanced proportion of the inputs (human resources i.e.) compared to what observed in the most efficient regions.

Among the causes of the delay in terms of efficiency of the southern regions it is important to deepen the impact generated by the adoption of the repayment plans that mainly concerned the southern regions.

The reduction of production factors and health consumption has been more impacting in the regions subject to the Repayment Plan, which have been forced to ensure a containment of expenditure to re-enter the financial targets, in particular the central-southern regions of Campania, Calabria, Sicily.

According to the Ragioneria Generale dello Stato (2016) report, " Repayment Plan are a fundamental tool of the NHS governance system whose purpose is to resolve issues related to efficiency and effectiveness in the use of resources made available to provision in relation to the demonstration, in certain regions, of high and unsustainable structural deficits and the presence of serious shortcomings in the appropriate disbursement of the LEAs ".

In these regions, for at least five years no staff has been replaced at the end of their working life: all this has caused a reduction in the number of employees by about 10-15%.

This affected the quantity of guaranteed services, since the staff cut took place quite randomly, and if a structure did not have a guaranteed number of doctors for that type of intervention, the department was closed. This condition of non-generational change, of precariousness of the professional paths and of the impossibility to govern the staff's leverage has several negative repercussions.

The objective of the individual return plans is to identify and address the causes that have led to the emergence of significant deficits, resembling real industrial restructuring programs that affect the factors of expenditure that have escaped the control of the regions by restoring a more appropriate and efficient delivery of LEAs.

These last statements generate many suspicions, confirmed by the analysis just carried out, that the repayment plans have thus improved the public finance balances by acting primarily on the input price side, but have not made improvements in technical efficiency and above all they did not stimulate a higher level of performance in terms of quantity and quality.

The time has come to rethink these governance tools by developing other systems and methods that, in parallel with the improvement of financial balances, do not lead to a collapse in performance.

As anticipated, this section is divided into two parts. This second part examines the results of a survey sent to the 348 hospitals examined in this paper.

The econometric analysis of the relationship between the level of efficiency of health facilities and a series of instrumental explanatory variables is developed starting from the Tobit regression model. The adoption of a Tobit regression model is motivated by the fact that the dependent variable E (efficiency) represents a proportion that assumes values between 0 and 1 (Houseman, 2001; Cappelli and Neumark, 2004; Lee and Kim, 2005). It is set only "right" censorship around the value 1, as anticipated, since the probability that the efficiency of a structure is close to 0 is practically nil.

The model takes into account the characteristics of the distribution of the efficiency index that has a mass of points at the maximum value (Dusansky and Wilson, 1994).

The Tobit estimates of the regression equation may however be subject to problems of distortion and identification, linked to the existence of phenomena of unobserved heterogeneity. These problems are relevant insofar as there are unobservable factors that simultaneously influence both the efficiency and the selected explanatory variables.

The second stage analysis makes it possible to verify the presence of some systematic links between efficiency and structural and organizational characteristics of the hospitals and the settings within which they operate (Grosskopf and Valdaminis, 1987). Furthermore, the links between efficiency, technical and overall measures will be taken into account.

The model is represented above (Figure 19).

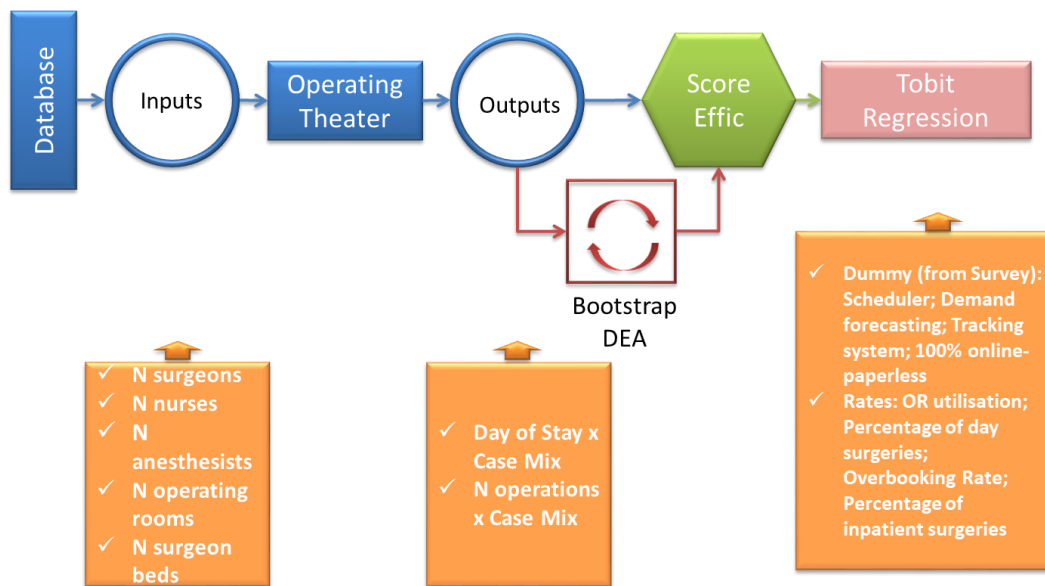


Figure 19 – II stage DEA Model with dummies & ratios

The main purpose of the analysis is to obtain efficiency measures purified by the above factors and whose link with the organizational and market structures of hospitals and health systems is analyzed. In particular, the focus is related on two types of factors:

1. the type of tools and information systems available to support the operating room. This information is translated into a set of dummies.
2. KPIs that capture the good organization or not of a hospital structure, such as the operating room occupancy rate.

Referring to 1), thanks to the precious collaboration with Dr. Alessandro Rosselli of ARS Toscana, a survey has been proposed (the contents of which are shown in the appendix) which aimed to understand if in the surgical units were implemented any information systems and Health 4.0 tools. The idea behind this survey is that the lack of resources can be overcome using IT to support healthcare within the structures. We would like to investigate if, where there are implemented information systems and monitoring tools of operating room theater, the efficiency of these structures is greater than those who do not have these tools.

Within the survey there are questions regarding the presence of advanced scheduling systems of operating theaters (i.e. a system that has the functions of demand forecasting, real-time management of the surgery operations and allocation of patients in the rooms in relation to the type of instrumentation and pharmaceutical kits available).

In support of this question, it was asked about the use of these digital equipment regarding EMR technology, Electronic Medical Record. It was asked whether the use of software reduces the risk of errors, favors the elimination of paper, facilitates the operator in monitoring the patient, increases the quality of care. The general feeling is not complete acceptance of the instrumentation and not complete awareness of the advantages of information systems. The average rating was 3 out of 5 (it must be considered also some distorting factors such as the Central tendency not to give extreme evaluations).

About the layout of the departments and operating theaters: it was asked whether particular planning had been taken into account during the design of the building phase as regards, for instance, the minimum distance traveled by the patient, an horseshoe layout operating rooms, or depending on the minimum distance traveled by staff (this answer was selected in 40% of cases).

Another question refers to the tracking of the patient's path: only 5 out of 65 structures have taken measures on this front, and 15 are studying implementation projects.

Concerning online management and therefore completely paperless of a hospitalization (including an operating checklist), good results are reported regarding the archiving of interventions on computer support; less well as regards the online vision of the availability of beds and access to the list of reservations or the management of IT treatment plans, in many cases the main use is paper.

Electronic Clinical Folder is similar to a clinical record of hospitalization (Fascicolo Sanitario Elettronico) consists of the set of all the medical records, preventive diagnostic

investigations and everything concerning the present and past health of the patient. In this case 14 out of 65 use it, although around 25 have answered that they are being implemented.

Finally, it was asked whether the operating theater provided performance measurement systems and whether these were monitored in real time using Industry 4.0 tools (RFID, proximity i-beacon, etc.): only 12 of 65 have implemented some projects.

In conclusion, there is a certain pessimism regarding the evaluation questionnaires of the work or to evaluate the customer satisfaction of the doctor, management and nurses (to take one of the answers given, similar to many others: "There is a system of evaluation but in good Italian style there is a widespread distrust towards the same").

As anticipated, a regression was made with the Tobit model compared to the 2016 data to understand if these factors influenced the efficiency of the structure, and if so, would influence it positively.

In the study the answers "in phase of, in planning" are excluded as the evaluation was carried out at the turn of the years 2017-2018 while the efficiency evaluations date back to 2016.

2 cycles of 300 e-mails were sent each to the health directors of the Italian hospital facilities containing the indications for the survey. The response rate of 20% appears comforting and good, even if it is curious to point out something.

The first e-mail cycle was sent from the e-mail address of the University of Florence (@unifi.it), inserting the qualification of PhD engineer candidate in the opening of the e-mail. The number of replies was 16 out of 310.

In the second cycle of mail, sent to the same contacts (excluding 16) after 2 months, a doctor from the AO of Trento came to the rescue, among the organizers of the Forum Per. Chir., National conference on the news of the surgical procedure, which sent the mails for this study.

The number of responses rose surprisingly (but not too much) to 49 out of 294, 300% more.

What are the structures that responded to the questionnaires can not be revealed but the map in Figure 20 shows the regional location of the various responses, highlighting the dominance of Lombardy and Tuscany as regards given answers (red dots indicate the distribution of the responses and not the punctual localization).



Figure 20 – Survey respondent location

The closed answers regarding the presence or not of some Health 4.0 systems have been included within the Tobit algorithm in the form of Dummy variables.

In particular the following dummies have been included in the Tobit regression:

Presence of OR scheduler;

Presence of a Patient Tracking system;

Presence of a Demand Forecasting;

100% paperless control system (i.e. checklist, etc.).

Referring to part 2) of the KPIs of the Tobit modelling, the following Table 18 contain the metrics related to the so called “Rates”.

Label (%)	Variable	Definition	Formula
OR Utilization by day of week	ORUtilization%	Ratio of time spent* by patients in OR to total OR time available. In most hospitals the goal is to have each OR in use 75-80% of the time. This allows the OR scheduler to add emergency cases as required.	$\frac{\text{time spent by patients in OR (h)}}{\text{OR time available (h)}}$
Block utilization	BU%	Typically a surgeon unit is divided in room dedicated to specific intervention. Typically, a surgeon that does hip and knee replacements, blocks an OR for “x” number of cases per day for “x” number of cases per week. This rate includes the turnaround time to get the OR ready for the next case.	$\frac{(h)\text{surgical activity} + \text{turnaround}}{\text{available block (h)}}$
Overbooking rate	OB%	When in a workday input>output, the patient split to the following day	$\frac{\text{surgical discharged}}{\text{\#available beds}}$
Daily frequency of cancellation of elective intervention	Cancellation%	The cancellation of an intervention implies organizational repercussions and waste of resources (eg hospitalization costs). The data is significantly influenced by the surgical use of the structure.	$\frac{\text{\#deleted interventions}}{\text{\#interventions}}$
Delay in admitting the patient	Delay%	It is calculated as a % of days when there is a delay of more than 10 minutes (the main cause is often the unavailability of a free bed). It is a parameter of interest for the central role of the recovery room (RR) in patient time management. A quick admission of the patient guarantees a rapid recovery of the availability of the RR, which in turn allows a fast post-operative patient transfer.	$\frac{\text{delayed admitting patient to interventions (+10 mn)}}{\text{\#interventions}}$
Surgical operations on surgical discharges	Surgical %	Indicates how many surgeries are completed on each user. It can represent an indication of appropriateness of care.	$\frac{\text{\# surgical operations}}{\text{\# surgical discharges}}$
Punctuality	OnTimeStart%	The beginning of the activities is represented by the time of the first induction and has been divided into 6 time slots.	$\frac{\text{\#beginning timely intervention}}{\text{\#interventions}}$

Table 18 - Ratio metrics

Variable	Mean [%]	Min [%]	Max [%]	[%] Low performance	[%] Good performance
ORUtilization%	79,22	10,64	123,61	NA	NA
BU%	72,23	57,76	88,54	<70	>70
OB%	95,25	45,15	147,55	<100	>100
Cancellation%	1,1	0,023	5,1	<2	>2
Delay%	15,4	5,2	47,98	<15	>15
Surgical%	100,55	100,05	101,99	>100	=100
OnTimeStart%	75,25	45,89	86,5		

Table 19 – Ratio descriptive statistic

However, the Tobit estimates of the regression equation may be subject to problems of distortion and identification, linked to the existence of phenomena of unobserved heterogeneity. These problems are relevant insofar as there are unobservable factors that simultaneously influence both the efficiency and the selected explanatory variables.

The regression results are highlighted in the following Table 20. This table summarizes the most investigated parameters in the literature for the measurement of OR efficiency; the reference values for the evaluation of the specific performance are also reported, although they are to be considered as indicative, since they are very dependent on the objectives, the reference healthcare systems and the local peculiarities.

Variabili	Estimate	Std. Error	Z value	Pr(> z)	Codes
(Intercept)	-0,126	0,188	-0,671	0,503	
Surgical%	0,008	0,002	3,359	0,001	
OnTimeStart%	0,018	0,062	-0,293	0,770	***
ORUtilization%	0,020	0,018	1,137	0,256	***
OB%	-0,119	0,270	-0,439	0,661	
Cancellation%	-0,003	0,011	-0,250	0,803	
Delay%	-0,104	0,009	0,501	0,016	*
Privato BU%	0,112	0,028	3,998	0,000	***
Scheduler	0,093	0,006	0,545	0,046	.
Demand Forecasting	0,019	0,005	3,652	0,000	***
100% online paperless	-0,062	0,039	1,587	0,012	*
Tracking System	0,026	0,067	0,390	0,696	
(Intercept)	0,013	0,031	0,413	0,680	
Log(scale)	-0,126	0,188	-0,671	0,503	***
Signif. codes:	0 '***'	0,001 '**'	0,01 '*'	0,05 '.'	0.1 ' ' 1
Scale: 0.1197					
Gaussian distribution					
Number of Newton-Raphson Iterations: 5					
Log-likelihood: 71.72 on 17 Df					
Wald-statistic: 117.2 on 15 Df, p-value: < 2.22e-16					

Table 20 – Tobit regression results

Effect of *Block utilization* and *OR Utilization by day of week*: Both OR Utilization by day of week and Block utilization have a significant effect on efficiency. With a p-value of 0.001 the parameters are significant at a level of 99.99%. Increased the OR Utilization rate or the Block utilization, greater the efficiency.

Effect of *Punctuality*: The start on time index assumes positive values and is statistically relevant and it has a significance at a level of 99.99%
That is, the higher the value of on time starts ratio, the higher the technical efficiency.

Effect of *Delay in admitting the patient*: The Delay in admitting the patient assumes negative values and this would favor the good organization of the structures that have a better OR organization. The higher the Delay ratio, the lower the efficiency. The variable has a significance level of 99%

Surgical operations on discharge, Daily frequency of cancellation of elective interventions, Tracking System and Overbooking rate take negative values (as the value increases, the efficiency decreases), but statistically not relevant.

Dummy Variables.

Scheduler: The variable is positively correlated with efficiency and has a 95% significance. Hospital facilities with a scheduler seem more efficient.

Demand Forecasting: Also in this case, the variable is positively correlated with efficiency. The level of significance is 99.99%

Private Hospital: The same goes for the two previous variables: positive correlation, even if much weaker, and 99% significance

100% online paperless: In this case the higher the use of online instruments, the lower the efficiency. It may seem like a problem, but the fact that paper-based errors (operative checklist, hospital discharge card, instrumentation checklist, patient activity monitoring) are limited by online admission management. This can affect, for example, greater ease in retrieving documentation and cataloging it.

RQ3: What are the main differences in terms of performance between hospitals that differs in term of ICT implementation level?

Strategy Introduction

As highlighted by the survey responses, not all healthcare facilities are equipped with the same level of technology. According to the results of the Tobit regression with the efficiency values, it is possible that the implementation of information systems can positively impact on the KPIs and on the performances in general.

The interviewees and the data collection highlighted that all the facilities have their own simplified PMS based on the following tools: strategic plan, annual report, budget plan, performance plan based on past and expected performance data. The annual report follows the decree 16.02.2001 of the Italian Ministry of Health and presented the past economic and financial performance data as well as a master budget designed to present a complete view of the economic and financial activity of the Operating Room.

The performance plan must be structured in three main sections. The first presents general information on the identity of the hospital in terms of activity and institutional mission. The second describes the normative settings in terms of legislation, demographic and economic framework. The last one defines the strategic and operating targets and designs the actions and the processes aimed at improving the performance management cycle.

The PMS part has been already discussed but every hospital has his own. Analyzing the structures emerges that they often divide the measurement in two main categories of indicators. The former is related on the outcomes activities (e.g. number of re-admissions, etc) while the latter focuses to the clinical activity (e.g. the total number of beds available at the department, number of total admissions, average length of stay).

While the interviews were conducted, a general dissatisfaction has emerged with regard to the existing PMS. The respondents underline that the PMS was unable to capture both the non-financial performance and satisfaction and quality outcome measures.

2016, II semester Results

In this part, through an analysis of the case studies the performances of 6 health facilities of Tuscan SSN will be analysed. The analysis is restricted to the availability and to the type of the monitored data.

In particular, the following table lists the structures analyzed and the type of information system used.

Over the last 3 years improvements and innovations have been made in some of the the structures analyzed, mainly those listed as large. The Table 21 is self-explanatory and

allows us to highlight how the small and medium structures of the analysis are not equipped with advanced information systems. Regarding patient tracking systems, only in case study 5 there is an implementation project that has not yet seen its activation.

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 1												
Case 2												
Case 3												
Case 4												
Case 5												
Case 6												

Table 21 – Improvement and innovations over last 3 years

Because of the lack of informations, the performance analysis can be done only on available datas. The following Table 22 shows which are the KPIs under control of the 6 healthcare units. For each structure, changes in performances will be monitored following the changes described in the previous table.

The implemented innovations can lead to changes in the operating theater performances.

KPI	Likert Rate	Data is in the database?
Occupancy Rate	4.29	
Starting on time	4.36	
Surgeries / Scheduled Number of Surgeries	4.64	
Turnover Time	4.79	
Discharge Process Time	4.50	
Average delay	4.57	
Operating Room Turnaround Time	4.57	
Mortality rate	4.07	
Readmission rate	4.64	
Perception of waiting times from taking charge to discharge	4.64	
Patient Wait Times by Process Step	4.93	
Rate of Patient complaints	4.93	
Quality of Nursing Care	4.88	
% Repeated surgeries	4.29	
Number of Mistake Events	4.21	

Table 22 – KPIs in Healthcare facilities database

The table shows which structures have implemented the information system. In particular, through interviews and visits to health facilities, the presence of a PMS, a patient tracking system, a non-manual scheduler, a demand forecasting, an electronic medical record, and a completely online management was monitored. and paperless of the patient.

It's time to show which are the main differences in terms of performances of the 6 hospitals. Then, after a process review and after implementation of some information systems innovation, the present study would like to know whether performances increase or not.

Hospital 1 has implemented Electronic medical record systems during the two years period.

Case 1				
Human resources	14 Nurses 4 OSS			
Average Age	40 years			
Expertise	9 years			
Category	ELECTIVE	EMERGENCY / URGENCY	TRAUMA TOLOGY	TOTAL
(h) Room hours available per week	78	Monday-Friday evenings	0	
(#) Average interventions per week	32	6	0	38
(#) Interventions 2 nd semester 2016	830	157	0	987
(h) Total Surgical Time cute-cute 2 nd semester 2016	999	181	0	1180
(%) OR Occupancy	82,6%			
(%) Starting on time	55%			
Turnover Time (% of total intervention time)	40,1%			
Average delay (h x week)	7,5			

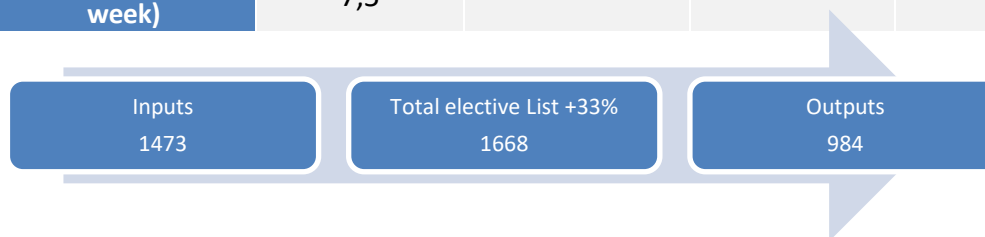


Table 23 – Case 1 performances

The number of elective interventions performed in the 2nd semester of 2016 in the hospital was equal to 67% of new entries. This means that the productivity of the hospital establishment was not sufficient to completely respond to the list insertions. Overall, in the two months, the list is increased by 342 cases due to the high gap between inputs and operated.

Hospital 2 has implemented Electronic medical record systems during the two years period and has his own PMS, whose KPIs are described in the table.

Case 2				
Human resources	27 Nurses 3 OSS			
Average Age	49 years			
Expertise	11 years			
Category	ELECTIVE	EMERGENCY / URGENCY	TRAUMA TOLOGY	TOTAL
(h) Room hours available per week	108	H24	32	
(#) Average interventions per week	49	17	17	83
(#) Interventions 2 nd semester 2016	1270	446	436	2152
(h) Total Surgical Time cute-cute 2 nd semester 2016	1612	541	466	2650
(%) OR Occupancy	85,5%			
(%) Starting on time	65%			
Turnover Time (% of total intervention time)	32,9%			
Average delay (h x week)	7			
Surgeries / Scheduled Number of Surgeries	98%			
Rate of Patient complaints (1-5 rate)	3,1			
Quality of Nursing Care (1-5 rate)	4,7			

Inputs
1947

Total elective List +38%
1962

Outputs
1200

Table 24 - Case 2 performances

The number of elective interventions performed in the 2nd semester of 2016 in the hospital was equal to 62% of new entries. This means that the productivity of the hospital establishment was not sufficient to completely respond to the list insertions. Overall, in the two months, the list is increased by 762 cases due to the high gap between inputs and operated.

Hospital 3 has implemented Electronic medical record systems during the two years period and has his own PMS, implemented in 2018. From 2015 Dedalus system help the health management to schedule elective intervention.

Case 3				
Human resources	27 Nurses 7 OSS			
Average Age	49 years			
Expertise	18 years			
Category	ELECTIVE	EMERGENCY / URGENCY	TRAUMA TOLOGY	TOTAL
(h) Room hours available per week	63	H24	Monday- Friday mornings	
(#) Average interventions per week	34	12	7	83
(#) Interventions 2 nd semester 2016	893	315	194	2152
(h) Total Surgical Time cute-cute 2 nd semester 2016	839	254	180	2650
(%) OR Occupancy	73,9%			
(%) Starting on time	65%			
Turnover Time (% of total intervention time)	31,3%			
Average delay (h x week)	5			

Inputs
1176

Total elective List +3%
729

Outputs
1137

Table 25 - Case 3 performances

The number of elective interventions performed in the 2nd semester of 2016 in the hospital was equal to 97% of new entries. This means that the productivity of the hospital establishment was not sufficient to completely respond to the list insertions.

Hospital 4 has implemented Electronic medical record systems, PMS, Scheduler from Dedalus system integrator and Demand Forecasting in order to make a forecast on access to the emergency room and on new requests for intervention in election.

Case 4				
Human resources	70 Nurses 16 OSS			
Average Age	47 years			
Expertise	15 years			
Category	ELECTIVE	EMERGENCY / URGENCY	TRAUMA TOLOGY	TOTAL
(h) Room hours available per week	259	H24	Monday- Friday	
(#) Average interventions per week	102	30	19	151
(#) Interventions 2 nd semester 2016	2658	791	483	3932
(h) Total Surgical Time cute-cute 2 nd semester 2016	4879	866	449	6194
(%) OR Occupancy	76,4%			
(%) Starting on time	40%			
Turnover Time (% of total intervention time)	15,5%			
Average delay (h x week)	9			

Inputs 3330	Total elective List +25% 3182	Outputs 2496
----------------	----------------------------------	-----------------

Table 26 - Case 4 performances

The number of elective interventions performed in the 2nd semester of 2016 in the hospital was equal to 75% of new entries. This means that the productivity of the hospital establishment was not sufficient to completely respond to the list insertions.

Hospital 5 is the most advanced technological innovations both in terms of medical devices and in terms of software management. It is also the largest of the case studies analysed.

Case 5				
Human resources	40 Nurses 27 OSS			
Average Age	46 years			
Expertise	13 years			
Category	ELECTIVE	EMERGENCY / URGENCY	TRAUMA TOLOGY	TOTAL
(h) Room hours available per week	210	H24	6 mornings + 3 afternoons	
(#) Average interventions per week	88	21	20	129
(#) Interventions 2 nd semester 2016	2293	548	531	3372
(h) Total Surgical Time cute-cute 2 nd semester 2016	2238	372	530	3140
(%) OR Occupancy	86,1%			
(%) Starting on time	60%			
Turnover Time (% of total intervention time)	40,1%			
Average delay (h x week)	7			

Inputs
2703

Total elective List +5%
1498

Outputs
858

Table 27 - Case 5 performances

The number of elective interventions performed in the 2nd semester of 2016 in the hospital was equal to 95% of new entries. This means that the productivity of the hospital establishment was not sufficient to completely respond to the list insertions.

The last hospital has increased their information systems during last year, introducing a completely paperless management of the patient and of the instruments and a scheduler.

Case 6				
Human resources	57 Nurses 19 OSS			
Average Age	47 years			
Expertise	16 years			
Category	ELECTIVE	EMERGENCY / URGENCY	TRAUMA TOLOGY	TOTAL
(h) Room hours available per week	153	H24	5 mornings	
(#) Average interventions per week	68	26	12	106
(#) Interventions 2 nd semester 2016	1761	666	300	2727
(h) Total Surgical Time cute-cute 2 nd semester 2016	2221	686	227	3135
(%) OR Occupancy	90,7%			
(%) Starting on time	55%			
Turnover Time (% of total intervention time)	37,3%			
Average delay (h x week)	6			

Inputs
3438

Total elective List +34%
3749

Outputs
2268

Table 28 - Case 6 performances

It is important to note that the elective production of 2nd semester 2016, compared to the same months of the previous semester, is increased by 84 interventions (thanks to the increase in the number of operating sessions).

All the disciplines (with the exception of the Ophthalmology) showed a decrease in the waiting list (overall, there was one of 188 patients on the Day Surgery / Ordinary list). In particular, the list of orthopedics dropped by as many as 124 cases during the two-month period. All this was possible thanks to the cleaning of waiting lists.

The only discipline that saw its list increase was the Ophthalmology (+283 cases on the list). This is due to the fact that many cases of Cataracts, previously included in the outpatient list, have been included in the Ordinary / Day Surgery list.

2018, I semester Results

During the two-year period some innovative projects in order to optimize the operating block have been completed. Of the 6 case studies, 3 were monitored and analyzed personally. Regarding other 3 case studies, only post-implementation results are described, without the possibility to find further information about the operation and performance data of the new systems.

In particular this section consists of 3 parts.

The first describes the so-called "innovation" adopted by the health unit. The second part describes the performances of the first half of 2018, the last one compares (where data can be compared) the data of the two semesters, considering only elective cases.

If the analyzed KPIs do not change during the two-year period, part 2 and part 3 are analyzed together.

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 1												

Table 29 – case study 1 improvements

Case 1 is the smallest hospital of the case studies set.

As the table underlines, they have started to use EMR in order to monitor the health status of the patient.

Electronic medical records (EMRs) are a digital version of the paper charts in the clinician's office. An EMR contains the medical and treatment history of the patients in one practice. EMRs have advantages over paper records. For example, EMRs allow clinicians to:

- Track data over time;
- Easily identify which patients are due for preventive screenings or checkups;
- Check how their patients are doing on certain parameters;
- Monitor and improve overall quality of care within the practice.

But the information in EMRs doesn't travel easily out of the practice. In fact, the patient's record might even have to be printed out and delivered by mail to specialists and other members of the care team. In that regard, EMRs are not much better than a paper record.

Case 1	2016, II semester	2018, I semester	Gap
Human resources	13 Nurses 3 OSS	13 Nurses 3 OSS	-1 -1
Average Age	40 years	39 years	-1
Expertise	9 years	8 years	-1
(h) Room hours available per week	78	78	=
(#) Average interventions per week	32	29	-3
(h) Total Surgical Time cute-cute	999	915	-84 [h/week]
(%) OR Occupancy	82,6%	76,3%	-6,3%
(%) Starting on time	55%	59%	+4%
Turnover Time (% of total intervention time)	40,1%	38,6%	-1,5%
Average delay (h x week)	7,5	6	-1,5 [h/week]

Table 30 – Case 1 results

The results obtained are not related to the new EMR, in fact, as it can be seen, there is a reduction in the number of interventions that is probably reflected in a lower saturation of the operative block. Probably this is due to the reduction of personnel occurred in recent years. This, if on the one hand it goes to improve the performances from a point of view of the times, from another it goes to worsen the so called financial performances.

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 2												

Case 2 has already implemented PMS in 2016. Regarding the PMS it has been widely discussed and the performance table is presented below.

Case 2	2016, II semester	2018, I semester	Gap
Human resources	27 Nurses 3 OSS	29 Nurses 3 OSS	+2 =
Average Age	49 years	39 years	-2
Expertise	11 years	10 years	-1
(h) Room hours available per week	108	110	+2
(#) Average interventions per week	49	50	+1
Total Surgical Time cut-cute	1612	1687	-75 [h/week]
(%) OR Occupancy	85,5%	86,3%	+0,8%
(%) Starting on time	65%	61%	-4%
Turnover Time (% of total intervention time)	32,9%	38,6%	+5,7%
Average delay (h x week)	7	9	+2 [h/week]
Surgeries / Scheduled Number of Surgeries	98%	98,5%	≈
Rate of Patient complaints (1-5 rate)	3,1	3,3	≈
Quality of Nursing Care (1-5 rate)	4,6	4,5	≈

Table 31 - Case 2 results

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 3												

Case 3 has implemented PMS, EMR and a scheduler.

Effective scheduling of the operation rooms, for the purpose of reducing costs while maintaining a good quality of care, has become one of the major priorities of the healthcare institutions.

Operating rooms scheduling determines the surgical operations (hereafter referred to as “operations”) to be performed in the surgical center of a hospital, as well as the resources assigned to each operation, over a period of a week or a day.

The planning system of the operating theaters allows the management of the entire scheduling of the interventions: from the visit with the first surgeon to the planning of the intervention passing from the compilation of the surgical waiting list, to the requirements for the intervention, to the necessary devices, to the operating staff.

The priority of the intervention allows to fill out the operating list with criteria. The system allows the definition of the operator slots, on which the operating units program the operator interventions. "Slot" refers to the time frame in which a room is available for planning. On the user interface the slot is represented by an area where it is possible to plan the interventions. For each operating room it is possible to define the start and end time of the operating session.

Case 3	2016, II semester	2018, I semester	Gap
Human resources	27 Nurses	30 Nurses	+3
	7 OSS	6 OSS	-1
Average Age	49 years	50 years	+1
Expertise	18 years	19 years	+1
(h) Room hours available per week	63	64	=
(#) Average interventions per week	34	37	+3
(h) Total Surgical Time cute-cute	839	895	-56 [h/week]
(%) OR Occupancy	73,9%	75,3%	-1,4%
(%) Starting on time	65%	64%	≈
Turnover Time (% of total intervention time)	31,3%	29,1%	-2,2%
Average delay (h x week)	5	8	+3 [h/week]

Table 32 - Case 3 results

Cases 4, 5 and 6 will be analyzed together because they have undergone two years of implementation of a new operating theater management software. In particular, the new schemes for allocating slots to operating theaters and the effects of the implemented system will be analyzed.

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 4												

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 5												

Information Systems	Scheduler		PMS		Demand Forecasting		EMR		Tracking		online management	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018
Case 6												

During the three years there was the possibility to follow the implementation of a new operating theater management software.

The proposed solution fully covers the management of the patient's surgical path. The complexity derives mainly from the fact that the surgical path crosses heterogeneous fields among them, from the management of the planning to the intraoperative anesthetic card.

As discussed in the previous chapters, there are two intervention macro-sectors to optimize the OR's efficiency: to make the operating planning process efficient; act on the operating sector work flow to optimize workflows and reduce non-surgical times.

The surgical path of election develops in different moments (Figure 21) in which more professional figures cooperate in the compilation of the documentation:

- Visit with the surgeon, fill out the surgical list and schedule
- Anesthesiological examination
- Intraoperative
 1. Induction
 2. Intraoperative
 3. Awakening
- Postoperative intensive care

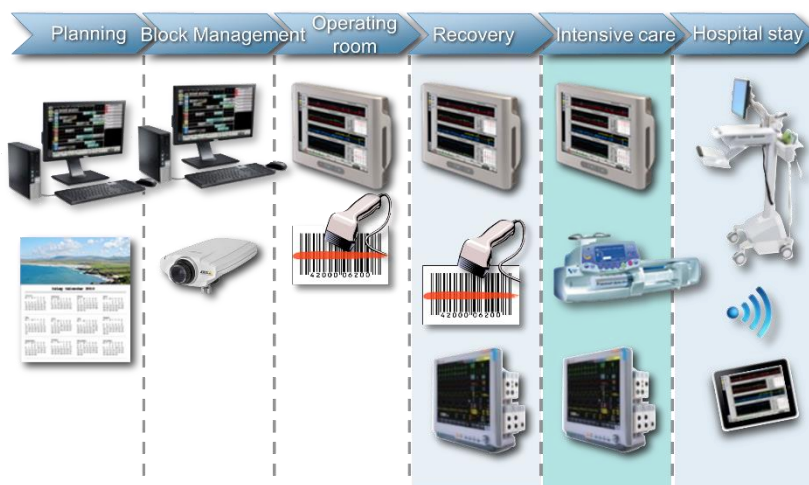


Figure 21 – Surgical path

The planning system of the operating theaters allows the management of the entire scheduling of the interventions: from the visit with the first surgeon to the planning of the intervention passing from the compilation of the surgical waiting list, to the requirements for the intervention, to the necessary devices, to the operating staff.

The priority of the intervention allows to fill out the operating list with criteria. The system allows the definition of the operator slots, on which the operating units program the operator interventions. "Slot" refers to the time frame in which a room is available for planning. On the user interface the slot is represented by an area where it is possible to plan the interventions. For each operating room it is possible to define the start and end time of the operating session.

Inside the OR, in the central stations, the operative program is graphically displayed (Figure 21) in which all the planned, completed, ongoing and reserves interventions are shown for each block. This plan is updated in real time (Figure 23) during the operating day in order to show the real progress of the interventions and the changes in the daily

operating plan resulting from urgencies, longer than expected, cancellations and inclusion of reserves.

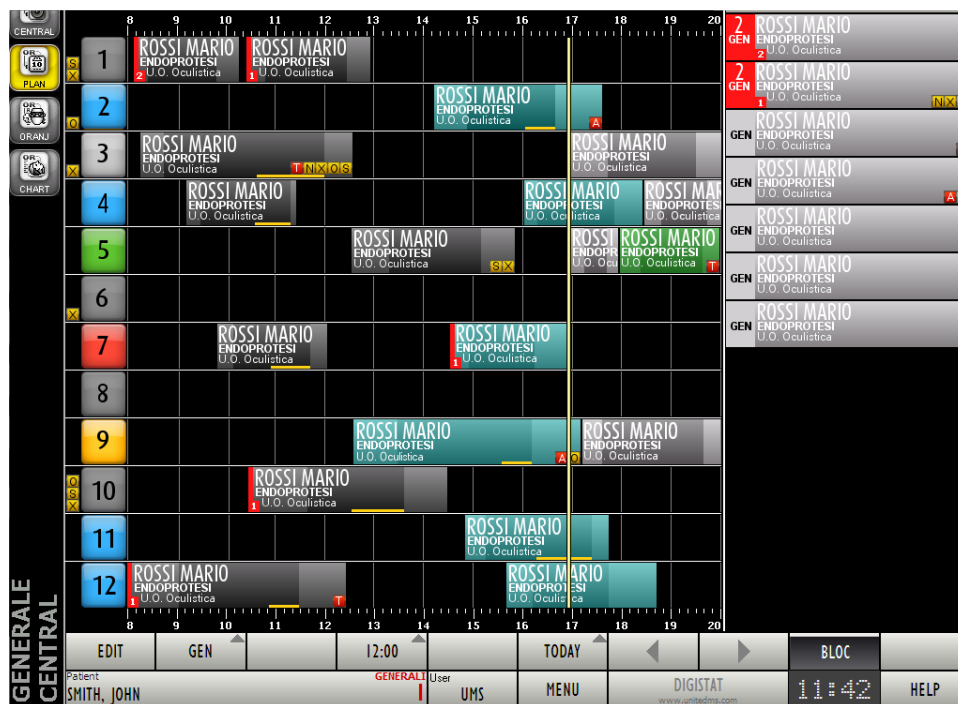


Figure 22 – Slot Allocation

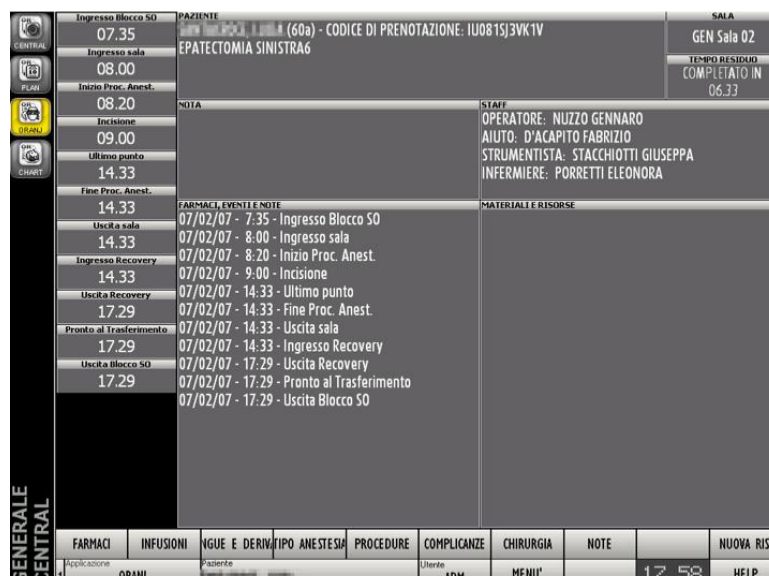


Figure 23 – Real Time advances

IDENTIFICAZIONE PAZIENTE

Codice Paziente: pc34210

Codice Ammissione:

Codice di Prenotazione:

Blocco Effettivo: GENERALI

Sala Effettiva: Sala 01

Parola chiave:

VERIFICA ANNULLA

JOHN SMITH
 Nato il 26/10/1969, età 40a
 Maschio, Peso 80 kg
 Io sottoscritto UMS, dichiaro di aver personalmente verificato l'identità del paziente JOHN SMITH e di essere sicuro del suo riconoscimento.

Figure 24 – patient identification

The introduction of the time for the intervention is facilitated by the use of the touch screen, without the need for a mouse and keyboard. Simply touch the screen at the desired time marker so that the system immediately records the event with the current date and time.

RISORSE UTILIZZATE						
LAMA DA BISTURI STERILE N. 10	1		0			
TISSUCOL 2 ML PRONTO USO	1		0			
GARZA STERILE CM 10X10 CON BARIO (CONF X 10) 16	20		0			
LAMA DA BISTURI STERILE N. 11	1		0			
LAMA DA BISTURI STERILE N. 20	1		0			
GUANTO LATEX MEDIGRIP PLUS N.7,5	2		0			
GUANTO LATEX MEDIGRIP PLUS N.8,0	1		0			
GENTAMICINA FI 80 MG	1		0			
SIRINGA PL.ST.CC 20 CON AGO-N.1(308210+301300)	1		0			
GARZA STERILE CM 7X9 CON BARIO (CONF X 10) 8 str. (10)	20		0			
POVIDERM 1 LITRO	1		0	7	8	9
UREOFIX ART.441500	1		0	4	5	6
GUANTO LATEX MEDIGRIP PLUS N.6,5	1		0	1	2	3
CS-15802-E SET X INFUSINE A 2 LUMI (SP2)	1		0	0		
LAMA DA BISTURI STERILE N.15	1		0	+/-	C	SUCC.
GARZA STERILE CM 30X30 CON BARIO (CONF X 5) 4 str.	60		0			
GARZA STERILE CM 40X40 CON BARIO (CONF X 5) 4 str.	20		0			
GUANTO LATEX MEDIGRIP PLUS N.7,5						

NUOVO MODIFICA USATI PLANIFICATO USA TUTTI OK ANNULLA

Figure 25 – Resources planning

It is possible to configure all materials and resources necessary for operator interventions (Figure 25 - 26). The registration of the use of the material takes place directly in the operating room. Since the operating theater station is linked to the intervention in progress, the discharge of the material in the room is implicitly linked to the intervention, to the patient and to the operative unit for carrying out the intervention. The unloading takes place by reading the product code both with Barcode and with RFID technology. During the configuration phase of the interventions it is possible to associate to each intervention the material for the execution of the operation. Therefore



Figure 26 – Resource checklist

the requests of materials to the Warehouse will be directly linked to the planned interventions. As regards the possibility of recording the sterilization process on the system, it is suggested that the sterilization unit can issue a unique and identifying barcode for the sterilization process of the surgical instruments baskets, as it is possible to configure the system so that at the time of reading the barcode of a given resource the reading of an additional barcode is required; this barcode will be the identifier of the sterilization process. In this way the traceability of the surgical instruments sterilization process will be guaranteed at the time of use in a completely automated way.



Figure 27 – Data reports

and types of interventions, the operating registry data, the timing operators, consumption, etc. for an evaluation in relation to the time and to the different structures belonging to the surgical area, as required in the Specifications (Figure 27). Likewise, the system will make available all the information collected to the company dashboard for the analysis of efficiency / effectiveness, level of activity and quality.

The computerization of the surgical path is accompanied by a system of statistics management and reporting of data based on visual instruments, configurable by the user, for the structuring of calculations. The screens can contain charts of various types, tables, lists, pointer indicators, pivot tables. It will therefore be easy to configure the specific dashboard for monitoring consumption reporting data (drugs, materials, prostheses) rather than for production statistics, relating the number

Finally, management is 100% paperless, including operating checklists (Figure 28).

PAZIENTE PRE-RICOVERO INTERVENTO REGISTRO RISVEGLIO CHECK LIST IMMAGINI

CHECK LIST INTERVENTO

SIGN IN

1) Il paziente ha confermato:

Identità **SI** **NO**

Sede Intervento **SI** **NO**

Procedura **SI** **NO**

Consensi: **SI** **NO**

1bis) Controllo con documentazione: lista op, cartella, altro: **SI** **NO**

2) Il sito di intervento è stato marcato: **SI** **NO** **N.A.**

3) Controlli per la sicurezza dell'anestesia completati: **SI** **NO**

4) Posizionamento del Pulsossimetro sul paziente e verifica del corretto funzionamento: **SI** **NO**

Identificazione dei rischi del paziente:

5) Allergie **SI** **NO**

6) Difficoltà di gestione delle vie aeree o rischio di aspirazione? **SI** **NO**

7) Rischio di perdita ematica > 500 ml (7ml/kg nei bambini)? **SI** **NO**

NOTE

SIGN IN TIME OUT SIGN OUT

Figure 28 – Operating checklist

Below are the performances of the 3 hospitals compared with the first half of 2016. The last two years has brought innovations in the 3 health structures. In particular, operating flows and slot management have been changed thanks to the help of the new Digistat system.

Case 4	2016, II semester	2018, I semester	Gap
Human resources	70 Nurses 16 OSS	67 Nurses 16 OSS	-3 =
Average Age	47 years	45 years	-2
Expertise	15 years	14 years	-1
(h) Room hours available per week	210	212	≈
(#) Average interventions per week	88	90	+2
Total Surgical Time	2238	2222	-15 [h/week]
(%) OR Occupancy	86,1%	87,4%	+1,3%
(%) Starting on time	60%	69%	-9%
Turnover Time (% of total intervention time)	40,1%	38,6%	-1,5%
Average delay (h x week)	7	9	+2 [h/week]
Surgeries / Scheduled Number of Surgeries	98,5%	98,2%	≈
Rate of Patient complaints (1-5 rate)	3,0	3,2	≈
Quality of Nursing Care (1-5 rate)	4,3	4,5	≈

The analysis of the performances shows that, compared to a reduction in nursing staff, there is an increase in the employment of the operating block and the number of interventions performed every week. The punctuality rate at the start of the intervention has increased. Another interesting data concerns the results of the customer satisfaction questionnaires related to nursing care for patients. To determine if the analysis is the result of chance or is a trend, the analysis should be performed for the subsequent semesters.

Case 5	2016, II semester	2018, I semester	Gap
Human resources	40 Nurses 27 OSS	39 Nurses 28 OSS	-1 +1
Average Age	46 years	45 years	-2
Expertise	13 years	13 years	≈
(h) Room hours available per week	210	190	-20
(#) Average interventions per week	88	79	-9
Total Surgical Time	2238	1887	-351 [h/week]
(%) OR Occupancy	86,1%	86,3%	+0,8%
(%) Starting on time	60%	71%	+11%
Turnover Time (% of total intervention time)	40,1%	34,6%	-5,5%
Average delay (h x week)	7	7	≈
Surgeries / Scheduled Number of Surgeries	99%	98,5%	≈
Rate of Patient complaints (1-5 rate)	3,6	3,9	≈
Quality of Nursing Care (1-5 rate)	4,2	4,6	+0,4

It is important to make a clarification. Due to "technical" problems, an operating room was closed in 2017. This inevitably reflects the productivity performances of the operating block. Taking into account KPIs developed in RQ1, it can be seen that all the performances items have improved.

Starting on time improves from 60 to 71%. In 71 cases out of 100 there is a start in intervention time, with an increase of 11 percentage points. The turnover Time decrease of 5 percentage points due to, probably, a better organization of the Theater. In particular, thanks to this closure, it was possible to reorganize the OR theatre as is shown in Appendix 5.

Case 6	2016, II semester	2018, I semester	Gap
Human resources	57 Nurses 19 OSS	59 Nurses 18 OSS	+2 -1
Average Age	47 years	48 years	+1
Expertise	16 years	17 years	+1
(h) Room hours available per week	153	150	-3
(#) Average interventions per week	68	70	+2
Total Surgical Time cute-cute	2221	2287	+66 [h/week]
(%) OR Occupancy	90,7%	87,4%	-3,3%
(%) Starting on time	55%	62%	+7%
Turnover Time (% of total intervention time)	37,3%	37,1%	≈
Average delay (h x week)	6	5	-1 [h/week]
Surgeries / Scheduled Number of Surgeries	98%	98,5%	≈
Rate of Patient complaints (1-5 rate)	3,1	3,3	≈
Quality of Nursing Care (1-5 rate)	4,2	4,5	+0,3

The analysis of the performances shows that, compared to a reduction in nursing staff, there is an increase in the employment of the operating block and the number of interventions performed every week. The punctuality rate at the start of the intervention has increased. Another interesting data concerns the results of the customer satisfaction questionnaires related to nursing care for patients. To determine if the analysis is the result of chance or is a trend, the analysis should be performed for the subsequent semesters.

It is possible that the new instrumentation allows the room staff to dedicate more time to the patient and his care, to devote time to information and satisfy any requests. This translates into a higher rating from the point of view of customer satisfaction as regards both the nursing staff and the evaluation of the structure as a whole.

CHAPTER 5 – CONCLUSIONS

This last Chapter collects and recaps all the key-points thoroughly analysed in the previous ones. I have tried to provide a focused viewpoint, allowing the reader to understand each research topic, how it has been developed and the results from the analysis.

The research framework, the literature review, the methodology and the results from the case study analyses are not standalone paths of the thesis. Hence, the aim of this Chapter is to connect the findings to the main goal of the thesis.

The thesis concludes summarizing the main themes of this manuscript, the achievement of the research objective and future steps to improve and finalize the research topic.

Conclusions

This thesis is the result of the work as a PhD student.

The objective of the researches conducted over the years, has been to develop and test a PMS for operating room theatre of healthcare facilities. In order to clarify the areas of analysis and the relationships in between, it has been designed a research framework (Figure 1), illustrating the main topics and the RQs.

Before approaching the core part of the study, it has been described the background for this research.

Hospitals not only compete for the number of patients but also the type of patients in terms of case complexity. In addition, public hospitals also compete for private patients, not only with private hospitals but also among themselves.

In a competitive market economy, successful industries normally increase quality as they increase efficiency and decrease cost. Medicine is starting to act like a competitive industry, and this tendency will be good for quality and efficiency in the operating room. Community and academic practitioners need to understand and participate in this transformation in order to be able to influence its evolution and to survive financially.

Performance evaluation plays a strategic role in healthcare organizations, in order to address the best use of resources and rationing of demand. Lack of resources has obliged to analyse and monitor technical efficiency of existing hospitals in order to improve hospital performance, so as to employ medical resources effectively and make the healthcare system more efficient and sustainable.

The growing attention to the patient caused on the one hand by the competition between health facilities promoted by national governments, on the other by the need to manage patient feedback to obtain ideas for improvement has led to rethinking performance measurement systems. For this reason we have tried to deepen the aspect of the operating room theater, central and critical node of a health facility that absorbs most of the human and economic resources.

Starting from an in-depth bibliographic research, all the measurable KPIs were analyzed within the operative block, trying to keep in mind those related to the quality of care and customer satisfaction on the patient and the employee side.

Through the Delphi method, 7 indicators were selected on the operations side, 4 on the quality of care, 2 on the level of service and 2 on customer satisfaction (RQ1).

To complete the performance analysis framework, a DEA model was developed that used input and output variables that health structures must mandatorily provide to the Ministry of Health, trying to identify the different care complexity by weighing the output values for the Case Mix Index. This analysis showed a gap between the northern and southern regions, caused partly by the return plans of some regions, by the outgoing mobility of the region by those who go to care in the virtuous regions and finally by the chronic scarcity of technological and human resources (RQ2).

Technical efficiency values were then correlated with a set of ratios and dummy variables using the Tobit model.

In particular, the dummies variables are represented by the results of a survey that aimed to investigate the presence of certain Health 4.0 tools such as Scheduler, Demand Forecasting, online management of the patient flow (paperless), patient tracking system, electronic health record, etc.

The ratios are represented by the KPIs (unfortunately unable to measure the performances in a complete way) that the health structures are obliged to monitor how the operating room occupancy rate, the turnover index, the deviation from the number of planned interventions, the daily delay on scheduled time.

The analysis of the results showed that in most of the cases, the presence of a good IT structure and innovative management tools, together with values above the average of the ratios, is linked to a good production efficiency.

In summary we have seen how the healthcare units that work with modern equipment and that are supported by innovative ICT devices, can get benefits from a performance point of view.

The last part of the thesis is dedicated to the analysis of 6 case studies of structures belonging to the health system of the Tuscany Region. Thanks to ARS Toscana and the ASL Toscana Centro health management, it was possible to "touch" the theoretically based approach (RQ3).

In this three-year period, as regards three health facilities, it was possible to witness a change in the management system ERP of three health structures. In particular, the new system has allowed us to start monitoring the performances in real time and to have a completely paperless management of the operating flow, from taking charge to discharge. The analysis of the results showed an improvement of some indicators included in the PMS, while for others it was not possible to compare them as they were not present in previous surveys.

This analysis of the case studies have shown the importance of the operating programming process which is going to cascade over the entire working week of medical and nursing resources. In particular, proper management of the operating room reduces waiting time in the room, and improves patient turnover within the healthcare facility. Greater order increases the satisfaction of operators and patients.

The operative planning process is the essential element to guarantee the correct functioning of the operating department because it allows the best use of surgical and anesthesiological professional resources, nursing and support staff, structural and technological resources. An effective planning process must provide an operating program that allows elective surgical procedures to start on schedule, while ensuring the availability of resources for urgent or emergency procedures.

Operating room management aims to reduce non-surgical time to achieve greater productivity (such as number of interventions) during normal working hours, reduce the use of overtime, increase patient and operator safety, provide adequate working conditions for staff and ensure adequate care pathways for patients. However, it is reductive to focus only on peri-operative efficiency to add new cases during the normal time because, in view of the considerable time savings required, most of the interventions allow the recovery of a few minutes per case. However, the most recent research has changed the basic paradigms for the turnover of the OR, providing tools for reviewing the entire path of the patient in the OR to drastically reduce the unproductive times and increase the throughput (measure of productivity that generally indicates the number of units produced in a certain time space).

The main statistical analyzes based on direct observation show that ensuring only the respect of the start time of the interventions or on the reduction of the gap time does not lead to significant increases in productivity. To obtain significant results, it is necessary to act on the scheduling of the operative list and on the restructuring of the activities viewed as a whole.

The correct preparation of the operative calendar determines: increased productivity, better use of resources, reduction of the cost of surgical procedures, improvement of production quality and greater involvement of anesthesiology and nursing staff.

Having an instrument able to monitor, even in real time, the performances of a structure allows to know possible drifts of efficiency and remedy. In addition, as we have found out, it is a valid tool for benchmarking with other healthcare facilities. Although each structure has its own performance measurement systems, it is still possible to find common points of contact for effective comparative evaluations. The objective of this study is to encourage healthcare management to create a common system and implement real-time measurement tools.

The optimization of technological resources, finally, represents one of the elements of more complex management but safer effectiveness, especially in multi-specialist and highly complex surgical operators. The technological equipment, in fact, must be shared among several surgical specialties in order to guarantee full use, avoiding unnecessary and expensive redundancies. For this reason it should be emphasized that strategies for the information integration of medical devices in the company information fabric are increasingly necessary. Thinking about the operating department, it becomes essential to allow operators to consult radiographic exams or clinical examinations on the operating theater; integrate clinical data produced by devices in the operating room with dedicated information systems (patient monitoring systems, infusion systems, etc.); correctly

determine costs and availability of resources. The profound correlation highlighted in the RQ2 between the efficiency of the operating department, an appropriate management of the complexity of technology and the need to strengthen the planning systems with adequate analysis tools, therefore candidates the clinical engineer to contribute to the optimization strategies of the sector operation together with the other health workers involved.

The process of technological improvement must be included within a single vision that allows to get for all the structures the advantages of using new information and communication technologies that are already available today.

Another challenge is to reduce the strong presence in the information systems of applications developed ad hoc and fragmented with suppliers that at most operate at the regional level.

It will be important to definitively implement in the structures the models of assessment of technological innovation (Health Technology Assessment) and exploit the endless opportunities of EHealth. Some of the advantages are given by the increase in patient empowerment, by timely access to clinical data by specialists able to control and manage all the life values and prevent duplication of services and their saturation, thus generating, a reduction in costs and a saving of time for medical personnel.

The short-term strategic objective is to reorganize and speeding up the system of responses to the citizen and favoring the development of conditions that allow the maintenance of the highest possible level of health.

The reorganization of services and ways of responding to needs is therefore the real future challenge for the NHS, a challenge that must be pursued by seeking the greatest possible coherences with the epidemiological framework. Not only that, the aging of the population will lead to a change in the needs for assistance from people, the discovery of new diseases, new treatments will contribute to increasing life expectancy. People who access assistance will have different needs and if the National Health Service does not foresee them in advance, it will always be forced to follow the customer's constantly evolving needs.

Research limitations

The greatest limitation attributable to this research is about methodology and is due to its generalizability. Six case studies (considering just those ones belonging to the public sector) are not enough to generalize to the entire sector due of the complexity of the system.

This is the reason why it is advisable to suggest future researches in the field and an enlargement of the sample.

Another limitation is related to information systems implementation projects. It's very difficult to adapt and generalize a database architecture, already designed by a software house, to the needs of a each hospital.

It would have been interesting to test different user interfaces, issues, performance and project features.

It is possible that these limitations, both methodological and related to ICT projects, affect the reliability of the results. The hope is that further researches will be conducted to fill these gaps.

Further research focus

The first recommendation that emerges, lined-up with the conclusions, is to enlarge the sample, considering more cases belonging to healthcare facilities. The chronic lack of information in the public administration, together with the problem of managing sensitive data, inevitably leads to analysis but 100% complete for all the aspects that we want to analyze.

In addition, more companies belonging to mono-specialistic facilities (Like CTO Centro traumatologico Ortopedico) industries may be involved, to increase generalizability and validate the results of this manuscript.

Moreover, experiencing and reporting improvement projects with customised solutions different from the one already examined, could enhance the value of this thesis.

It would be important to stress also new areas of investigation, as future research areas:

- **Develop a ROI Tool** in order to analyse, i.e. new ERP softwares and to assess the impact on social satisfaction and on efficiency performances of operating room theatre.
- **Real time Social Satisfaction**
Even if companies are surveying customers immediately after service interactions, monthly, they compiled the results and sent to an executive team member for review. While reports are important to analyze the big picture, the executive team member is often not in a position to respond to any unhappy customers. This delay makes customers feel like facilities don't value their feedback. By the time they forwarded the feedback to the appropriate front line member, but patient has already moved on.

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APPENDICES

APPENDIX 1 – Operating Room Performance Measures Kpis - Questionnaire

Importance and utilisation of performance measures

1) DELPHI Method In the following tables, the main performance measures are listed basing on the process they support. Please fill-out the tables as specified below:

- In the column "Use" write *Y* if the corresponding KPI is employed within the company or *N* if not

If the Use is=Y, then complete the other fields:

- In the column " Importance " specify the degree of importance of the indicator, according to this scale:
 1. Not important
 2. Low importance
 3. Indifferent
 4. Important
 5. Very important
- In the column "Business Unit owner" write for each measure the BU/Department that is in charge to measure and control the corresponding KPI
- In the column "ICT" write the typology of ICT tool adopted in order to store and monitor the corresponding KPI
- For each process also indicate the additional performance measures (in the " Other " row) typical of your business or your industry, specifying its importance

DATI DEL RISPONDENTE

Tutti i dati contenuti in questa sezione saranno trattati nel pieno rispetto delle norme sulla Privacy ai sensi del D. lgs. 101/2018

1. Posizione lavorativa ricoperta in Ospedale * *Mark only one oval.*

- ☐ Direzione Sanitaria
- ☐ Direzione Operativa
- ☐ Direzione Amministrativa
- ☐ Controllo di Gestione
- ☐ Medico / Chirurgo
- ☐ Infermiere
- ☐ Anestesista
- ☐ Other:

PANORAMICA DELL' OSPEDALE

2. L' ospedale è attualmente coinvolto in progetti che utilizzano uno o alcuni dei seguenti approcci di "Miglioramento delle Performance"? (qualora la risposta fosse affermativa ma diversa dalle opzioni della seguente lista barrare l'opzione "altro" * *Check all that apply.*

- ☐ Utilizzo di "Tecniche Lean" (snellimento produttivo)
 - ☐ Utilizzo di "Tecniche combinate Lean / Six Sigma"
 - ☐ Utilizzo di "Tecniche combinate Lean / Six Sigma e Change Management" (Performance Improvement)
 - ☐ Benchmarking/ comparazioni con altre Aziende Sanitarie
 - ☐ Value Based HealthCare
 - ☐ Nessun progetto in atto
 - ☐ Other:
-

3. **L' ospedale è stato coinvolto in progetti di miglioramento delle performance?** * *Mark only one oval.*

- ☐ Si
☐ No

4. **Quali delle seguenti "Unità Organizzative" sta attualmente utilizzando i principi e gli strumenti del "Lean"?** * *Check all that apply.*

- ☐ Controllo di gestione
☐ Bilancio
☐ Risorse Umane
☐ Sistemi Informativi
☐ Chirurgia
☐ Medicina d'Urgenza
☐ Blocco Operatorio
☐ Attività Economiche e di Approvvigionamento
☐ Other:

COINVOLGIMENTO DEL PERSONALE

5. **Quali dei seguenti soggetti partecipano attivamente alla programmazione e realizzazione del progetto "Lean"?** * *Check all that apply.*

- ☐ Direttore Generale (o Amministrativo se rilevante all'interno dell'ospedale)
☐ Responsabile della Gestione Operativa
☐ Personale Infermieristico / Operatori di sala
☐ Dirigenti del Dipartimento Economico - Finanziario
☐ Dirigenti del Dipartimento Sistemi Informativi
☐ Dirigenti del Dipartimento
☐ Risorse Umane
-

IL BLOCCO OPERATORIO

6. **Quali tipologie di KPI's (indicatori di performance) di riferimento vengono utilizzati?** * *Check all that apply.*

- ☐ Tecnico - Operativi
- ☐ Finanziari
- ☐ Logistici
- ☐ Customer Satisfaction (soddisfazione del cliente)

KPI'S (INDICATORI DI PERFORMANCE) UTILIZZATI DALLA STRUTTURA IN CUI OPERA

7. **Operating's KPI's (indicatori di performance)** * *Check all that apply.*

- ☐ Patient Wait Time (tempo di attesa tra Check-in e Visita)
- ☐ Equipment Utilization Rate (tasso di sfruttamento effettivo delle apparecchiature/locali)
- ☐ Average Minutes per Surgery (tempo medio necessario per ogni intervento)
- ☐ Cycle Time / Patient in Room Time (tempo di ciclo da quando il paziente entra nella struttura a quando viene dimesso)
- ☐ Timing (percentuale di interventi iniziati puntualmente rispetto all'orario programmato)
- ☐ Average Delay (ritardo medio di inizio interventi)
- ☐ Early End surgery (Percentuale di interventi terminati in anticipo)
- ☐ Operating Room Turnaround Time (tempo medio necessario per preparare la sala operatorio per l'intervento)
- ☐ Bed / Room Turnover (tasso di rotazione dei pazienti in degenza ospedaliera pre/post chirurgica)
- ☐ Code Response Operating Room Time (calcola il tempo di risposta necessario per far fronte a un'emergenza in ingresso in sala operatoria)
- ☐ Nessuno
- ☐ Other: _____

8. **Financial KPI's** * *Check all that apply.*

- ☐ Single/Total Operating Margin (indice di efficienza operativa sul singolo paziente e complessiva)
- ☐ Average Treatment Charge (indice di costo medio addebitato per ogni trattamento)
- ☐ Average Cost per Discharge (indice di costo medio per il soggiorno di ogni paziente)
- ☐ ROI (Return On Investment)
- ☐ Nessuno
- ☐ Other:

9 **Quanto spesso il dipartimento Economico - Finanziario fornisce ai manager previsioni sui Flussi in entrata (ricavi di diversa natura) e in Uscita (costi)?** * *Mark only one oval.*

- ☐ Mensilmente
- ☐ Ogni 3 mesi
- ☐ Ogni 6 mesi
- ☐ Annualmente

10. **KPI's of Customer Satisfaction** * *Check all that apply.*

- ☐ Quality of Nursing Care (indice di soddisfazione dei pazienti per il livello di assistenza ricevuto dal personale)
- ☐ Patient Return Rate (percentuale di pazienti che tornano in ospedale perché necessitano ulteriori interventi)
- ☐ Patient Follow-Up (percentuale di pazienti che tornano in ospedale per controlli)
- ☐ Delay (percentuale del numero di interventi rimandati a causa di complicazioni operatorie)
- ☐ Comfort (indice di soddisfazione del livello di soddisfazione del paziente)
- ☐ Nessuno
- ☐ Other: _____

11. Con quali strumenti viene analizzato il livello di Customer Satisfaction * *Check all that apply.*

- ☐ Questionari cartacei (Autosomministrazione)
- ☐ Questionari on – line
- ☐ Interviste telefoniche
- ☐ Intervista Faccia a Faccia
- ☐ Non viene rilevato
- ☐ Other: _____

12. Quali degli strumenti sopra citati trovano maggior riscontro nei pazienti e forniscono più informazioni all' azienda ospedaliera? * *Check all that apply.*

- ☐ Questionari cartacei (Autosomministrazione)
- ☐ Questionari on – line
- ☐ Interviste telefoniche
- ☐ Intervista Faccia a Faccia
- ☐ Non viene utilizzato alcuno strumento di rilevazione
- ☐ Other: _____

15 Quale profilo di indagine mostra un maggior livello di soddisfazione del paziente? * *Check all that apply.*

- ☐ Accoglienza Ricevuta Dal Personale Infermieristico
- ☐ Competenza del Personale Ospedaliero (Medici, Infermieri, OSS..)
- ☐ Qualità del Servizio Ricevuto durante la Degenza (Qualità Pasti, Pulizia Ambienti, Cortesia..)
- ☐ Efficacia Clinica Operazione
- ☐ Costo del Servizio (Se a Pagamento)
- ☐ Tempistiche (Programmazione Intervento, Degenza, Puntualità Servizio..)
- ☐ Non viene rilevato il livello di soddisfazione del cliente
- ☐ Other: _____

16. **Quale risultato di performance può essere principalmente attribuito all'implementazione di "Tecniche Lean"?**

Check all that apply.

- ☐ L'eliminazione di sprechi di materiali di consumo
- ☐ La riduzione di costi amministrativi
- ☐ La riduzione della durata media di degenza
- ☐ Il miglioramento dei risultati di soddisfazione dei pazienti
- ☐ La riduzione del Turnover degli impiegati
- ☐ La riduzione di complicanze derivanti da infezioni acquisite durante la degenza ospedaliera
- ☐ Other: _____

APPENDIX 2 – Operating Room Performance Measures DEA – Efficiency Scores

Firm	VRS	VRS (BIAS)	CRS	CRS (BIAS)	Firm	VRS	VRS (BIAS)	CRS	CRS (BIAS)
1	0.630	0.568	0.616	0.562	52	0.840	0.720	0.629	0.585
2	0.528	0.487	0.494	0.459	53	0.835	0.769	0.709	0.671
3	0.529	0.491	0.510	0.477	54	0.648	0.590	0.623	0.542
4	0.467	0.435	0.459	0.425	55	0.486	0.448	0.471	0.438
5	0.458	0.415	0.456	0.418	56	0.609	0.553	0.600	0.524
6	0.635	0.586	0.565	0.534	57	0.611	0.524	0.562	0.464
7	0.461	0.429	0.445	0.416	58	0.886	0.792	0.882	0.795
8	0.523	0.485	0.411	0.378	59	1.000	0.791	0.706	0.641
9	0.904	0.828	0.824	0.777	60	0.658	0.618	0.653	0.604
10	1.000	0.887	0.929	0.842	61	0.540	0.505	0.526	0.482
11	0.534	0.469	0.494	0.440	62	0.571	0.522	0.543	0.497
12	0.688	0.640	0.681	0.628	63	0.548	0.484	0.522	0.442
13	0.545	0.512	0.525	0.495	64	0.685	0.596	0.685	0.604
14	0.638	0.581	0.550	0.507	65	0.877	0.779	0.866	0.792
15	0.539	0.492	0.459	0.432	67	1.000	0.756	0.797	0.681
16	0.566	0.529	0.554	0.507	68	0.915	0.745	0.633	0.510
17	0.523	0.487	0.505	0.472	69	0.599	0.510	0.518	0.426
18	0.530	0.504	0.489	0.460	70	1.000	0.737	1.000	0.769
19	0.561	0.526	0.525	0.493	71	0.965	0.844	0.855	0.771
20	0.519	0.479	0.505	0.470	72	0.852	0.776	0.846	0.768
21	0.475	0.444	0.469	0.435	72a	0.636	0.591	0.562	0.517
22	0.477	0.432	0.461	0.422	73	0.711	0.622	0.552	0.510
23	0.712	0.656	0.665	0.623	74	0.513	0.469	0.458	0.418
25	0.652	0.516	0.640	0.495	75	0.658	0.583	0.507	0.465
26	0.602	0.568	0.592	0.557	76	1.000	0.724	0.566	0.528
27	0.702	0.596	0.657	0.531	77	0.470	0.415	0.470	0.421
29	0.509	0.478	0.497	0.457	78	0.624	0.566	0.482	0.433
30	0.757	0.645	0.727	0.604	79	0.655	0.583	0.528	0.479
31	1.000	0.770	0.695	0.628	80	0.545	0.509	0.507	0.469
32	0.644	0.580	0.553	0.490	81	0.567	0.519	0.460	0.418
33	0.422	0.378	0.383	0.344	82	0.659	0.585	0.536	0.492
34	0.735	0.705	0.638	0.593	83	0.884	0.783	0.609	0.555
35	0.740	0.665	0.593	0.550	84	0.465	0.401	0.423	0.380
36	0.809	0.724	0.608	0.560	85	0.518	0.458	0.446	0.397
37	0.770	0.713	0.634	0.596	86	0.610	0.533	0.471	0.413
38	0.903	0.860	0.766	0.722	87	0.753	0.716	0.648	0.612
39	0.552	0.441	0.551	0.421	88	1.000	0.831	0.707	0.658
40	0.627	0.514	0.622	0.518	89	0.489	0.444	0.388	0.343

41	0.616	0.581	0.566	0.533	90	0.469	0.432	0.439	0.405
42	0.564	0.528	0.550	0.504	91	0.538	0.506	0.490	0.458
43	0.514	0.473	0.508	0.459	92	0.659	0.562	0.614	0.531
44	0.593	0.519	0.591	0.508	93	0.584	0.549	0.513	0.479
45	0.456	0.388	0.443	0.366	94	0.703	0.608	0.522	0.480
46	0.372	0.333	0.370	0.328	95	0.545	0.499	0.447	0.407
47	0.758	0.698	0.741	0.662	96	0.452	0.412	0.395	0.358
48	0.921	0.858	0.912	0.836	97	0.674	0.570	0.484	0.441
49	0.776	0.682	0.607	0.507	98	0.746	0.667	0.584	0.520
50	0.699	0.596	0.669	0.592	99	0.529	0.488	0.467	0.433
51	0.782	0.715	0.775	0.695	100	0.616	0.538	0.483	0.449

101	0.476	0.420	0.400	0.352	152	0.793	0.668	0.509	0.471
102	0.650	0.580	0.524	0.478	153	0.836	0.699	0.548	0.512
103	0.569	0.504	0.549	0.486	154	0.828	0.742	0.813	0.702
104	0.515	0.464	0.506	0.446	155	0.397	0.369	0.318	0.287
105	0.515	0.473	0.501	0.449	156	0.555	0.515	0.541	0.507
106	0.639	0.562	0.533	0.445	157	0.495	0.437	0.437	0.370
107	0.626	0.570	0.498	0.440	158	0.783	0.758	0.648	0.608
108	0.512	0.438	0.455	0.363	159	0.452	0.421	0.439	0.403
109	1.000	0.853	0.794	0.739	160	0.489	0.459	0.479	0.444
110	0.622	0.582	0.554	0.515	161	0.446	0.414	0.433	0.394
111	0.381	0.361	0.329	0.298	162	0.456	0.403	0.446	0.394
112	0.758	0.716	0.675	0.624	163	0.478	0.436	0.462	0.414
113	0.414	0.383	0.325	0.289	163b	0.533	0.513	0.507	0.482
114	0.371	0.338	0.338	0.301	167	0.541	0.504	0.501	0.451
115	0.447	0.406	0.371	0.325	168	0.611	0.552	0.463	0.419
116	0.501	0.426	0.428	0.336	169	0.830	0.735	0.646	0.601
118	0.669	0.590	0.658	0.596	170	0.799	0.692	0.605	0.561
119	0.664	0.561	0.576	0.449	171	0.620	0.556	0.540	0.498
120	0.822	0.670	0.820	0.670	172	0.713	0.681	0.619	0.582
121	0.631	0.566	0.623	0.541	173	0.596	0.529	0.558	0.506
122	1.000	0.836	0.931	0.738	174	0.442	0.413	0.414	0.383
123	0.597	0.537	0.585	0.511	175	0.979	0.815	0.664	0.565
124	0.557	0.500	0.519	0.447	176	0.546	0.515	0.489	0.462
125	0.704	0.578	0.607	0.477	177	0.601	0.560	0.534	0.498
126	0.420	0.378	0.401	0.348	178	0.789	0.697	0.631	0.593
127	0.663	0.613	0.659	0.599	178b	0.655	0.580	0.450	0.418
128	0.999	0.907	0.996	0.918	180	0.315	0.281	0.314	0.280
129	0.697	0.652	0.676	0.613	183	0.528	0.483	0.493	0.436
130	0.658	0.577	0.416	0.389	184	0.917	0.796	0.633	0.544
131	0.382	0.348	0.343	0.304	185	0.587	0.526	0.526	0.485
132	0.465	0.411	0.459	0.409	186	0.570	0.516	0.557	0.495
133	0.551	0.504	0.507	0.468	187	0.613	0.559	0.604	0.551
134	0.401	0.367	0.390	0.356	188	0.465	0.417	0.411	0.354
135	0.446	0.400	0.423	0.380	189	0.675	0.610	0.558	0.521

136	0.700	0.617	0.515	0.481	190	0.868	0.742	0.523	0.483
137	0.559	0.513	0.496	0.458	191	0.598	0.548	0.567	0.522
138	0.588	0.539	0.511	0.480	193	0.836	0.679	0.505	0.476
139	0.905	0.768	0.554	0.502	194	0.869	0.760	0.634	0.583
140	0.536	0.502	0.492	0.460	195	0.622	0.566	0.532	0.487
141	0.878	0.775	0.613	0.576	196	0.569	0.521	0.555	0.507
142	0.566	0.507	0.493	0.452	197	0.591	0.545	0.578	0.533
143	0.439	0.413	0.424	0.397	198	0.600	0.540	0.528	0.483
144	0.791	0.684	0.532	0.455	199	0.586	0.537	0.500	0.465
145	0.575	0.504	0.524	0.482	200	0.614	0.553	0.484	0.435
146	0.551	0.507	0.519	0.481	201	1.000	0.720	1.000	0.681
147	0.573	0.491	0.513	0.466	202	1.000	0.816	1.000	0.894
148	0.527	0.464	0.514	0.445	204	0.865	0.733	0.602	0.563
149	0.555	0.517	0.529	0.497	205	0.758	0.670	0.601	0.559
150	0.593	0.525	0.552	0.502	206	0.779	0.701	0.604	0.555
151	0.449	0.419	0.442	0.416	207	0.970	0.763	0.590	0.550

Firm	VRS	VRS (BIAS)	CRS	CRS (BIAS)	Firm	VRS	VRS (BIAS)	CRS	CRS (BIAS)
208	0.686	0.627	0.556	0.524	267	0.628	0.548	0.516	0.434
209	0.769	0.664	0.745	0.676	267b	0.437	0.401	0.433	0.399
210	0.542	0.495	0.506	0.447	267c	0.457	0.420	0.457	0.422
211	0.670	0.586	0.610	0.557	267d	0.579	0.534	0.561	0.516
212	0.475	0.437	0.455	0.408	267e	0.428	0.403	0.401	0.362
213	0.693	0.640	0.643	0.595	267f	0.467	0.423	0.431	0.365
214	0.597	0.556	0.544	0.499	267g	0.452	0.419	0.445	0.405
215	0.543	0.507	0.533	0.492	267h	0.610	0.561	0.560	0.520
216	0.847	0.721	0.543	0.454	267i	0.502	0.466	0.479	0.424
217	0.619	0.572	0.516	0.471	267l	0.723	0.619	0.705	0.598
218	0.665	0.559	0.662	0.548	267m	1.000	0.721	1.000	0.714
219	0.448	0.418	0.423	0.379	267n	0.532	0.497	0.507	0.468
220	0.660	0.610	0.592	0.550	291	0.910	0.782	0.687	0.609
221	0.529	0.509	0.494	0.461	292	1.000	0.854	0.656	0.604
222	0.515	0.479	0.431	0.400	295	0.409	0.352	0.172	0.154
223	0.640	0.605	0.557	0.518	296	0.631	0.596	0.543	0.503
224	0.564	0.520	0.463	0.425	298	0.545	0.509	0.477	0.432
225	0.641	0.590	0.596	0.558	299	0.568	0.525	0.519	0.469
226	0.538	0.486	0.463	0.407	300	0.552	0.491	0.545	0.483
227	0.535	0.501	0.490	0.447	301	0.872	0.767	0.632	0.583
228	0.597	0.541	0.420	0.387	302	1.000	0.842	0.724	0.644
229	0.545	0.507	0.531	0.502	303	0.659	0.564	0.507	0.422
230	0.519	0.499	0.480	0.447	304	0.412	0.384	0.381	0.349
231	0.536	0.497	0.507	0.470	305	0.452	0.432	0.425	0.394
232	0.556	0.488	0.530	0.489	306	0.561	0.522	0.544	0.498
235	1.000	0.785	0.484	0.452	307	0.461	0.443	0.429	0.401
236	0.495	0.462	0.471	0.429	308	0.514	0.488	0.480	0.450

237	0.559	0.533	0.532	0.491	309	0.432	0.404	0.353	0.328
238	0.620	0.555	0.589	0.552	310	0.494	0.468	0.388	0.364
239	0.539	0.512	0.518	0.479	311	0.455	0.433	0.384	0.361
240	0.554	0.503	0.513	0.470	312	0.894	0.733	0.665	0.514
241	0.597	0.536	0.524	0.454	313	0.516	0.483	0.507	0.476
242	1.000	0.770	0.635	0.571	314	0.511	0.481	0.470	0.434
243	0.742	0.658	0.590	0.545	315	0.440	0.386	0.281	0.250
244	1.000	0.721	0.730	0.635	316	0.504	0.456	0.488	0.438
245	0.645	0.597	0.638	0.595	317	0.484	0.453	0.414	0.382
246	0.640	0.545	0.368	0.316	318	0.534	0.493	0.533	0.497
247	1.000	0.882	1.000	0.881	320	0.963	0.873	0.802	0.735
249	0.835	0.744	0.818	0.704	321	0.679	0.623	0.655	0.617
250	0.659	0.584	0.615	0.545	322	0.596	0.545	0.574	0.504
254	0.550	0.484	0.549	0.481	323	0.584	0.492	0.537	0.455
255	0.459	0.432	0.444	0.409	324	0.647	0.603	0.616	0.576
256	0.584	0.554	0.553	0.508	325	0.536	0.505	0.518	0.474
257	0.546	0.509	0.504	0.448	326	0.420	0.388	0.393	0.353
258	0.495	0.469	0.459	0.422	326b	0.848	0.776	0.793	0.682
259	0.572	0.537	0.550	0.513	327	0.535	0.500	0.530	0.493
260	0.704	0.644	0.668	0.584	328	0.687	0.543	0.654	0.485
261	0.898	0.777	0.653	0.603	329	0.571	0.531	0.568	0.522
262	0.812	0.732	0.654	0.610	330	0.850	0.733	0.824	0.721
266	0.704	0.638	0.575	0.500	331	0.720	0.646	0.635	0.579

#	LEGEND		
	Structure name	Structure type	Prov
1	OSPEDALE MARIA VITTORIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
2	OSPEDALI RIUNITI A.S.L. TO 5	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
3	OSPEDALE UNICO PLURISEDE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VB
4	ISTITUTO S.S. TRINITÀ - BORGOMANERO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NO
5	OSPEDALE MARTINI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
6	OSPEDALI RIUNITI ASL AT	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AT
7	OSPEDALE UNICO DEL VERCELLESE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VC
8	TORINO NORD EMERGENZA SAN GIOVANNI BOSCO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
9	OSPEDALE CIVICO CHIVASSO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
10	OSPEDALI RIUNITI DEL CANAVESE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
11	OSPEDALI RIUNITI ASL AL	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AL
12	OSPEDALI RIUNITI PINEROLO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
13	OSPEDALI RIUNITI RIVOLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TO
14	OSP.DEGLI INFERMI DI BIELLA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BI
15	OSP. S.LAZZARO-ALBA E S.SPRITO BRA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CN
16	AZIENDA OSPEDALIERO UNIVERSITARIA S.LUIG	A.O. INTEGRATA CON L'UNIVERSITA'	TO

17	AZIENDA OSPED. NOVARA E GALLIATE	A.O. INTEGRATA CON L'UNIVERSITA'	NO
18	AZ. OSPEDAL. S. CROCE E CARLE	AZIENDA OSPEDALIERA	CN
19	AZ. SS.ANTONIO E BIAGIO E C.ARRIGO	AZIENDA OSPEDALIERA	AL
20	OSPEDALE MAURIZIANO UMBERTO I - TORINO	AZIENDA OSPEDALIERA	TO
21	AO CITTA' DELLA SALUTE E DELLA SCIENZA D	A.O. INTEGRATA CON L'UNIVERSITA'	TO
22	FONDAZIONE DEL PIEMONTE PER L'ONCOLOGIA	IRCCS FONDAZIONE	TO
23	OSPEDALE REGIONALE UMBERTO PARINI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AO
24	OSPEDALE VALCAMONICA - ESINE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BS
25	FOND.IRCCS "ISTIT.NAZ.LE TUMORI" MILANO	IRCCS FONDAZIONE	MI
26	POLICLINICO S. MATTEO - PAVIA	IRCCS FONDAZIONE	PV
27	FONDAZ.IRCCS CA' GRANDA - OSPEDALE MAGGI	IRCCS FONDAZIONE	MI
28	CENTRO CARDIOLOGICO "FOND. MONZINO" - MI	IRCCS PRIVATO	MI
29	IRCCS S. RAFFAELE - MILANO	IRCCS PRIVATO	MI
30	FOND.MAUGERI-CENTRO MEDICO DI PAVIA	IRCCS PRIVATO	PV
31	ISTITUTO EUROPEO DI ONCOLOGIA- MILANO	IRCCS PRIVATO	MI
32	IST. CLIN. HUMANITAS - ROZZANO	IRCCS PRIVATO	MI
33	ISTITUTO ORTOPEDICO GALEAZZI SPA - MILAN	IRCCS PRIVATO	MI
34	I.R.C.C.S. POLICLINICO SAN DONATO	IRCCS PRIVATO	MI
35	IRCCS MULTIMEDICA - MILANO	IRCCS PRIVATO	MI
36	A.O. OSP.CIRC. FONDAZIONE MACCHI-VARESE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VA
37	A.O. S.ANTONIO ABATE - GALLARATE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VA
38	A.O. OSPEDALE DI CIRCOLO - BUSTO ARSIZIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VA
39	A.O. SPEDALI CIVILI - BRESCIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BS
40	A.O. "MELLINO MELLINI" - CHIARI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BS
41	A.O. DESENZANO DEL GARDA - DESENZANO G.	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BS
42	A.O. ISTITUTI OSPEDALIERI - CREMONA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CR
43	A.O. OSPEDALE MAGGIORE - CREMA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CR
44	A.O. SANNA - COMO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CO
45	A.O. OSPEDALE DI LECCO - LECCO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LC
46	A.O. PAPA GIOVANNI XXIII	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BG
47	A.O. OSP.TREVIGLIO CARAVAGGIO-TREVIGLIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BG
48	A.O. "BOLOGNINI" - SERIATE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BG
49	A.O. "CARLO POMA" - MANTOVA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MN
50	A.O. "LUIGI SACCO" - MILANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
51	A.O. "OSP.NIGUARDA CA'GRANDA"- MILANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI

52	A.O. "IST.CLIN.PERFEZIONAMENTO"- MILANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
53	A.O. FATEBENEFRAATELLI E OFTALMICO- MILANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
54	A.O. "SAN PAOLO" - MILANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
55	A.O. "S.CARLO BORROMEO" - MILANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
56	A.O. OSPEDALE CIVILE - LEGNANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
57	A.O. "G. SALVINI" - GARBAGNATE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
58	A.O. OSPEDALE DI CIRCOLO - MELEGNANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MI
59	A.O. OSPEDALE CIVILE - VIMERCATE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MB
60	A.O. "S.GERARDO" - MONZA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MB
61	A.O. DELLA PROVINCIA DI LODI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LO
62	A.O. DELLA PROVINCIA DI PAVIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PV
63	A.O. VALTELLINA E VALCHIAVENNA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SO
64	OSPEDALE CENTRALE DI BOLZANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
65	OSPEDALE AZIENDALE DI MERANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
66	OSPEDALE AZIENDALE DI BRESCIANONE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
67	OSPEDALE AZIENDALE DI BRUNICO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
68	OSPEDALE DI BASE DI VIPITENO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
69	OSPEDALE DI BASE DI SAN CANDIDO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
70	OSPEDALE DI BASE DI SILANDRO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BZ
71	OSPEDALE DI TRENTO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TN
72	OSPEDALE DI ROVERETO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TN
73	ISTITUTO CODIVILLA - PUTTI CORTINA	ISTITUTO QUALIFICATO PRESIDIO DELLA A.S.L.	BL
74	OSPEDALE DELL'ULSS N. 1 BELLUNO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BL
75	OSPEDALE DI FELTRE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BL
76	OSPEDALE DELL'AZIENDA ULSS N. 3	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VI
77	OSPEDALE ULSS 4	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VI
78	OSPEDALI AZIENDA ULSS 5 ARZIGNANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VI
79	AZIENDA ULSS.6 VICENZA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VI
80	OSPEDALE DI ULSS 7	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TV
81	AZIENDA ULSS N.8 - ASOLO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TV
82	OSPEDALE DI TREVISO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TV
83	OSPEDALE AZIENDA ULSS N. 10	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VE
84	OSPEDALE DELL'ULSS VENEZIANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VE
85	STRUTTURE OSPEDALIERE ULSS 13 - MIRANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VE
86	AZIENDA U.L.S.S. N° 14	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VE
87	OSPEDALE AZ. ULSS N° 15 'ALTA PADOVANA'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PD
88	OSPEDALI AZ ULSS 18 ROVIGO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RO
89	OSPEDALE CIVILE DI ADRIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RO
90	AZIENDA ULSS 20 DI VERONA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VR
91	AZIENDA U.L.S.S. 21	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VR

92	ALS 22 BUSSOLENGO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VR
93	AZIENDA OSPEDALIERA DI PADOVA	AZIENDA OSPEDALIERA	PD
94	AZ.OSP.UNIVERSITARIA INTEGRATA VERONA	A.O. INTEGRATA CON L'UNIVERSITA'	VR
95	I.R.C.C.S. ISTITUTO ONCOLOGICO VENETO	IRCCS PUBBLICO	PD
96	O.C. S. MICHELE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	UD
97	OSPEDALE CIVILE DI LATISANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	UD
98	OSPEDALE CIVILE DI PALMANOVA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	UD
99	OSPEDALE 'SANT' ANTONIO'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	UD
100	O.C. S.ANTONIO ABATE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	UD
101	OSPEDALE DI GORIZIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	GO
102	OSPEDALE DI MONFALCONE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	GO
103	I.R.C.C.S. BURLO GAROFOLO	IRCCS PUBBLICO	TS
104	CENTRO RIFERIMENTO ONCOLOGICO	IRCCS PUBBLICO	PN
105	AZIENDA OSPEDALIERA 'S. MARIA DEGLI ANGE	AZIENDA OSPEDALIERA	PN
106	AZ.OSP.UNIV. OSPEDALI RIUNITI DI TRIESTE	A.O. INTEGRATA CON L'UNIVERSITA'	TS
107	AZIENDA OSPEDALIERO-UNIVERSITARIA	A.O. INTEGRATA CON L'UNIVERSITA'	UD
108	IRCCS AOU S.MARTINO - IST'	IRCCS PUBBLICO	GE
109	IST.G.GASLINI	IRCCS PUBBLICO	GE
110	OSPEDALE "GUGLIELMO DA SALICETO" PIACENZ	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PC
111	OSPEDALE "S.MARIA" BORGO VAL DI TARO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PR
112	OSPEDALE "SANTA MARIA DELLE CROCI" RAVEN	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RA
113	OSPEDALE "UMBERTO 1°" LUGO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RA
114	OSPEDALE "DEGLI INFERMI " FAENZA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RA
115	NUOVO OSPEDALE CIVILE DI SASSUOLO S.P.A.	O. GESTIONE DIRETTA PRESIDIO A.S.L.	MO
116	ISTITUTO DELLE SCIENZE NEUROLOGICHE DI B	IRCCS PUBBLICO	BO
117	AZIENDA OSPEDALIERO-UNIVERSITARIA DI PAR	A.O. INTEGRATA CON L'UNIVERSITA'	PR
118	AZIENDA OSPEDALIERA DI REGGIO EMILIA	AZIENDA OSPEDALIERA	RE
119	AZIENDA OSPEDALIERO-UNIVERSITARIA DI MOD	A.O. INTEGRATA CON L'UNIVERSITA'	MO
120	AZIENDA OSPEDALIERO-UNIVERSITARIA DI BOL	A.O. INTEGRATA CON L'UNIVERSITA'	BO
121	AZIENDA OSPEDALIERO-UNIVERSITARIA DI FER	A.O. INTEGRATA CON L'UNIVERSITA'	FE
122	ISTITUTO ORTOPEDICO RIZZOLI	IRCCS PUBBLICO	BO
123	SPEDALI RIUNITI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PT
124	OSPEDALE DELLA VALDINIEVOLE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PT
125	NUOVO OSPEDALE DI PRATO S.STEFANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PO
126	OSPEDALE CECINA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LI
127	OSPEDALE LIVORNO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LI

128	OSPEDALE PIOMBINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LI
129	OSPEDALE DI PORTOFERRAIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LI
130	OSPEDALE DEL CASENTINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AR
131	OSPEDALE DELLA VALTIBERINA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AR
132	OSPEDALE AREA ARETINA NORD	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AR
133	OSPEDALE S.ANDREA MASSA MARITTIMA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	GR
134	OSPEDALE DELLE COLLINE DELL'ALBEGNA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	GR
135	OSPEDALE DELLA MISERICORDIA GROSSETO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	GR
136	OSPEDALE DI BORGO SAN LORENZO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FI
137	OSPEDALE FIORENTINO SUD-EST	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FI
138	OSPEDALE FIORENTINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FI
139	OSPEDALE DELL'ALTA VAL D'ELSA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SI
140	OSPEDALI RIUNITI DELLA VAL DI CHIANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SI
141	OSPEDALE VERSILIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LU
142	OSPEDALE NUOVO VALDARNO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AR
143	NUOVO OSPEDALE VALDICHIANA S. MARGHERITA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AR
144	AZIENDA OSPEDALIERO-UNIVERSITARIA PISANA	A.O. INTEGRATA CON L'UNIVERSITA'	PI
145	AZIENDA OSPEDALIERA UNIVERSITARIA SENESE	A.O. INTEGRATA CON L'UNIVERSITA'	SI
146	AZ. OSPEDALIERO - UNIVERSITARIA CAREGGI	A.O. INTEGRATA CON L'UNIVERSITA'	FI
147	AZIENDA OSPEDALIERA MEYER	A.O. INTEGRATA CON L'UNIVERSITA'	FI
148	POLO OSPEDALIERO SPOLETO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PG
149	SANTA MARIA DELLA STELLA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TR
150	POLO OSPEDALIERO FOLIGNO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PG
151	AZIENDA OSPEDALIERA DI PERUGIA	AZIENDA OSPEDALIERA	PG
152	AZIENDA OSPEDALIERA 'S. MARIA' - TERNI	AZIENDA OSPEDALIERA	TR
153	OSPEDALE SS DONNINO E CARLO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PU
154	ASUR-AREAVASTA2 PRESIDIO OSP.UNICO JESI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AN
155	P.O. ZT12 MADONNA DEL SOCCORSO - S.BENED	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AP
156	A.O. OSPEDALI RIUNITI MARCHE NORD	AZIENDA OSPEDALIERA	PU
157	A.O.U.OSPEDALI RIUNITI - ANCONA	AZIENDA OSPEDALIERA	AN
158	OSPEDALI INRCA MARCHE	IRCCS PUBBLICO	AN
159	OSPEDALE DI CIVITACASTELLANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VT
160	OSPEDALE DI TARQUINIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VT
161	POLO OSPEDALIERO UNICO INTEGRATO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RI
162	OSPEDALE GENERALE SANTO SPIRITO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
163	OSP. ANZIO-NETTUNO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
164	OSP.RIUNITI ALBANO-GENZANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
165	OSPEDALE SAN PAOLO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM

166	OSPEDALE L.PARODI DELFINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
167	OSP. S.SEBASTIANO FRASCATI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
168	OSPEDALE SS. GONFALONE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
169	OSPEDALE CIVILE CONIUGI BERNARDINI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
170	OSPEDALE A. ANGELUCCI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
171	OSPEDALE S. GIOVANNI EVANGELISTA(TIVOLI)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
172	OSP.'PAOLO COLOMBO' VELLETRI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
173	OSPEDALE PADRE PIO DI BRACCIANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
174	OSPEDALE G. B. GRASSI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
175	OSPEDALE S. EUGENIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
176	POLICLINICO CASILINO	ISTITUTO QUALIFICATO PRESIDIO DELLA A.S.L.	RM
177	OSPEDALE F. SPAZIANI FROSINONE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FR
178	OSPEDALE SAN BENEDETTO ALATRI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FR
179	OSPEDALE CIVILE S.S.TRINITA' N.SEDE SORA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FR
180	OSPEDALE S. SCOLASTICA CASSINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FR
181	OSPEDALE SANDRO PERTINI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RM
182	COMPLESSO OSPEDALIERO DI BELCOLLE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	VT
183	AZ.OSP.SAN CAMILLO-FORLANINI	AZIENDA OSPEDALIERA	RM
184	AZIENDA OSP. S.GIOVANNI/ADDOLORATA ROMA	AZIENDA OSPEDALIERA	RM
185	AZ. COMPL. OSP. S.FILIPPO NERI	AZIENDA OSPEDALIERA	RM
186	OSPEDALE PEDIATRICO BAMBINO GESU'	IRCCS PRIVATO	RM
187	POLICLINICO A. GEMELLI E C.I.C.	POLICLINICO UNIVERSITARIO PRIVATO	RM
188	POLICLINICO U. I	A.O. INTEGRATA CON IL SSN	RM
189	ISTITUTI FISIOTERAPICI OSPITALIERI	IRCCS PUBBLICO	RM
190	I.D.I.	IRCCS PRIVATO	RM
191	POLICL. UNIV. CAMPUS BIO MEDICO	POLICLINICO UNIVERSITARIO PRIVATO	RM
192	INMI 'L.SPALLANZANI' - IRCCS	IRCCS PUBBLICO	RM
193	AZIENDA OSPEDALIERA SANT'ANDREA	A.O. INTEGRATA CON L'UNIVERSITA'	RM
194	AZ. OSP. UNIV. POLICLINICO TOR VERGATA	A.O. INTEGRATA CON L'UNIVERSITA'	RM
195	OSPEDALE SAN SALVATORE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AQ
196	PO AVEZZANO 'S. FILIPPO E NICOLA'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AQ
197	OSPEDALE MAZZINI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TE
198	OSPEDALE MARIA S.S. DELLO SPLENDORE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TE
199	OSPEDALE SAN LIBERATORE DI ATRI (TE)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TE
200	OSPEDALE DELLA VAL VIBRATA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TE
201	P.O. 'SPIRITO SANTO' PESCARA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PE
202	P.O.'S.S. TRINITA' POPOLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PE
203	P.O. CLINICIZZ. 'SS. ANNUNZIATA' CHIETI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CH
204	P.O. LANCIANO Renzetti	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CH
205	P.O. VASTO S.Pio da Pietralcina	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CH

206	COMPLESSO OSPEDALIERO 'S TIMOTEO- TERMOL	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CB
207	COMPLESSO OSPEDALIERO ISERNIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	IS
208	NEUROMED I.R.C.C.S.	IRCCS PRIVATO	IS
209	OSPEDALE SAN GIUSEPPE E MELORIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CE
210	P.O. S.ALFONSO MARIA DE' LIGUORI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BN
211	OSPEDALE CIVILE S. GIOVANNI DI DIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
212	OSPEDALE SAN GIULIANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
213	OSPEDALE RIZZOLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
214	ISTITUTO DI CURA MARIA SS.DELLA PIETA'	ISTITUTO QUALIFICATO PRESIDIO DELLA A.S.L.	NA
215	OSPEDALE LANDOLFI SOLOFRA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AV
216	OSPEDALE ARIANO IRPINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AV
217	OSPEDALE S.ANGELO DEI LOMBARDI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AV
218	P.O. UMBERTO I NOCERA INFERIORE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
219	P.O. MARIA SS. ADDOLORATA EBOLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
220	P.O. MARTIRI DI VILLA MALTA SARNO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
221	OSPEDALE S.LUCA VALLO LUCANIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
222	P.O. S.M.SPERANZA BATTIPAGLIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
223	OSPEDALE S.M.DELLE GRAZIE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
224	OSPEDALE DI ROCCADASPIDE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
225	OSPEDALE CIVILE DI AGROPOLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SA
226	OSPEDALI RIUNITI GOLFO VESUVIANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
227	OSPEDALI RIUNITI AREA STABIESE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
228	OSPEDALI RIUNITI PENISOLA SORRENTINA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
229	OSPEDALI RIUNITI AREA NOLANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NA
230	AZIENDA OSPEDALIERA 'A. CARDARELLI'	AZIENDA OSPEDALIERA	NA
231	A.O.SANTOBONO-PAUSILIPON	AZIENDA OSPEDALIERA	NA
232	A.zienda Ospedaliera dei Colli	AZIENDA OSPEDALIERA	NA
233	A.O.OO.RR.S.GIOVANNI DI DIO E RUGGI D'AR	A.O. INTEGRATA CON L'UNIVERSITA'	SA
234	AZIENDA OSPEDALIERA S.G. MOSCATI	AZIENDA OSPEDALIERA	AV
235	AZIENDA OSPEDALE 'G.RUMMO'	AZIENDA OSPEDALIERA	BN
236	A.O. SANT'ANNA E SAN SEBASTIANO CASERTA	AZIENDA OSPEDALIERA	CE
237	AZIENDA UNIVERSITARIA POLICLINICO	A.O. INTEGRATA CON IL SSN	NA
238	UNIV.STUDI NAPOLI-FEDERICO II- FAC.MEDIC.	A.O. INTEGRATA CON IL SSN	NA
239	OSPEDALE CERIGNOLA 'G.TATARELLA'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FG
240	OSPEDALE GALATINA 'CATERINA NOVELLA'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LE
241	OSPEDALE GALLIPOLI-'SACRO CUORE DI GESU'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LE
242	OSPEDALE MANDURIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TA
243	OSPEDALE MARTINA FRANCA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TA

244	OSPEDALE DI ALTAMURA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BA
245	OSPEDALE BARI 'SAN PAOLO'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BA
246	OSPEDALE MONOPOLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BA
247	OSPEDALE PUTIGNANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BA
248	OSPEDALE OSTUNI (FASANO)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BR
249	OSPEDALE FRANCAVILLA FONTANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BR
250	OSPEDALE SAN SEVERO - TERESA MASSELLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FG
251	OSPEDALE MANFREDONIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	FG
252	OSPEDALE COPERTINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LE
253	OSPEDALE SCORRANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LE
254	OSPEDALE CASARANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LE
255	OSPEDALE CASTELLANETA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TA
256	OSPEDALE BARI 'DI VENERE' (TRIGGIANO)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BA
257	OSPEDALE BRINDISI 'PERRINO'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BR
258	OSPEDALE LECCE - 'V FAZZI' (SAN CESARIO)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	LE
259	OSPEDALE TARANTO -SS. ANNUNZIATA/MOSCATI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TA
260	OSPEDALE ANDRIA - 'L. BONOMO'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BT
261	OSPEDALE BARLETTA - 'MONS. R. DIMICCOLI'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BT
262	OSPEDALE BISCEGLIE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	BT
263	OSPEDALE GROTTAGLIE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TA
264	ISTITUTO TUMORI GIOVANNI PAOLO II	IRCCS PUBBLICO	BA
265	IRCCS 'SAVERIO DE BELLIS'	IRCCS PUBBLICO	BA
266	OSPEDALE CASA SOLLIEVO DELLA SOFFERENZA	IRCCS FONDAZIONE	FG
267	AO UNIV. CONS. POLICLINICO BARI	A.O. INTEGRATA CON L'UNIVERSITA'	BA
268	AO UNIV. 'OO RR FOGGIA'	A.O. INTEGRATA CON L'UNIVERSITA'	FG
269	OSPEDALE CIVILE VILLA D'AGRI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PZ
270	OSPEDALI UNIFICATI DEL LAGONEGRESE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PZ
271	AZIENDA OSPEDALIERA REGIONALE 'S. CARLO'	AZIENDA OSPEDALIERA	PZ
272	C.R.O.B. - I.R.C.C.S.	IRCCS PUBBLICO	PZ
273	OSPEDALE CIVILE FERRARI - CASTROVILLARI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CS
274	Ospedale Spoke Rossano-Corigliano	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CS
275	Ospedale Spoke Cetrao-Paola	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CS
276	OSPEDALE CIVILE SAN GIOVANNI DI DIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	KR
277	OSPEDALE DI LAMEZIA TERME	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CZ
278	OSPEDALE BASSO IONIO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CZ
279	OSPEDALE CIVILE LOCRI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RC
280	OSPEDALE 'TIBERIO EVOLI' - MELITO P.S.	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RC
281	AZIENDA OSPEDALIERA DI COSENZA	AZIENDA OSPEDALIERA	CS
282	Azienda Ospedaliera Pugliese De Lellis	AZIENDA OSPEDALIERA	CZ

283	A.O. MATER DOMINI CATANZARO	AZIENDA OSPEDALIERA	CZ
284	Azienda Osp. Bianchi-Melacrino-Morelli	AZIENDA OSPEDALIERA	RC
285	FOND. IST. S. RAFFAELE - GIGLIO	ISTITUTO QUALIFICATO PRESIDIO DELLA A.S.L.	PA
286	P.O. BARONE LOMBARDO - CANICATTI'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AG
287	P.O. S. GIACOMO D'ALTOPASSO LICATA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AG
288	P.O. GIOVANNI PAOLO II	O. GESTIONE DIRETTA PRESIDIO A.S.L.	AG
289	P.O. Sant'Elia (ex AO)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CL
290	P.O. VITTORIO EMANUELE (ex AO)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CL
291	P.O. S. Marta e S. Venera Acireale	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CT
292	P.O. Maria SS.Addolorata Biancavilla	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CT
293	P.O. Castiglione Prestianni Bronte	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CT
294	P.O. Gravina e S. Pietro Caltagirone	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CT
295	P. O. 'UMBERTO I'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	EN
296	P. O. 'M. CHIELLO'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	EN
297	P. O. 'FERRO-CAPRA-BRANCIFORTE'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	EN
298	P. O. 'CARLO BASILOTTA'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	EN
299	P.O. 'NUOVO CUTRONI ZODDA' BARCELLONA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	ME
300	P.O. 'G. FOGLIANI' MILAZZO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	ME
301	P.O.' S. VINCENZO' TAORMINA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	ME
302	P.O. 'BARONE-ROMEO' PATI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	ME
303	STABILIMENTO OSPED. S. AGATA MILITELLO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	ME
304	P.O. DEI BIANCHI CORLEONE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PA
305	P.O. CIVICO PARTINICO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PA
306	P.O. MADONNA DELL'ALTO - PETR. SOTTANA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PA
307	P.O. S. CIMINO TERMINI IMERESE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PA
308	P.O. G. F. INGRASSIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	PA
309	OSPEDALE REGINA MARGHERITA COMISO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RG
310	OSPEDALE MAGGIORE MODICA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RG
311	OSPEDALE BUSACCA SCICLI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RG
312	OSPEDALE GUZZARDI VITTORIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	RG
313	P.O. DI MARIA AVOLA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SR
314	P.O. TRIGONA NOTO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SR
315	P.O. UMBERTO I (EX A.O.)	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SR
316	P.O. MUSCATELLO AUGUSTA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SR
317	OSPEDALE GENERALE DI ZONA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SR
318	OSPEDALE SAN VITO E SANTO SPIRITO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TP
319	P.O. S. ANTONIO ABATE - TRAPANI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TP
320	P.O. V.EMANUELE II CASTELVETRANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TP
321	P.O.PAOLO BORSELLINO EX S.BIAGIO-MARSALA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	TP
322	A.O. per l'Emergenza Cannizzaro	AZIENDA OSPEDALIERA	CT

323	ARNAS GARIBALDI	AZIENDA OSPEDALIERA	CT
324	A.O.U. POLICLINICO - VITTORIO EMANUELE	A.O. INTEGRATA CON IL SSN	CT
325	aorpardopiemonte	AZIENDA OSPEDALIERA	ME
326	Azienda Osp. Univ. G. Martino	A.O. INTEGRATA CON IL SSN	ME
327	A.O.R Villa Sofia Cervello	AZIENDA OSPEDALIERA	PA
328	Azienda Ospedaliera 'Civico-Di Cristina-	AZIENDA OSPEDALIERA	PA
329	AZ.OSP.UNIV.P.GIACCONI	A.O. INTEGRATA CON IL SSN	PA
330	Dipartimento Rizzoli-Sicilia	IRCCS PUBBLICO	PA
331	OSPEDALE CIVILE SASSARI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SS
332	OSPEDALE CIVILE ALGHERO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SS
333	OSPEDALE A. SEGNI OZIERI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SS
334	P.O. PAOLO DETTORI - TEMPIO P.	O. GESTIONE DIRETTA PRESIDIO A.S.L.	OT
335	OSPEDALE MARINO REGINA MARGHERITA ALGHER	O. GESTIONE DIRETTA PRESIDIO A.S.L.	SS
336	P.O. GIOVANNI PAOLO II OLIA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	OT
337	P.O. SAN FRANCESCO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NU
338	P.O. 'NOSTRA SIGNORA DELLA MERCEDE'	O. GESTIONE DIRETTA PRESIDIO A.S.L.	OG
339	P.O. San Camillo	O. GESTIONE DIRETTA PRESIDIO A.S.L.	NU
340	P.O. 'A.G. MASTINO' - BOSA	O. GESTIONE DIRETTA PRESIDIO A.S.L.	OR
341	P.O. S.GIUSEPPE	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CA
342	P.O. MARINO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CA
343	P.O.SIRAI	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CI
344	P.O. A. BUSINCO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	CA
345	P. OSPEDALIERO 'SAN MARTINO' - ORISTANO	O. GESTIONE DIRETTA PRESIDIO A.S.L.	OR
346	AZIENDA OSPEDALIERA G.BROTZU	AZIENDA OSPEDALIERA	CA
347	AZIENDA OSPEDALIERO UNIVERSITARIA SS	A.O. INTEGRATA CON IL SSN	SS
348	A.O.U. Cagliari	A.O. INTEGRATA CON IL SSN	CA

APPENDIX 3: R script for DEA & Tobit Regression

R version 3.0.2 (2013-09-25) -- "Frisbee Sailing"
Copyright (C) 2013 The R Foundation for Statistical
Computing Platform: x86_64-apple-darwin10.8.0 (64-
bit)

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contributi esterni. Scrivi 'contributors()' per
maggiori informazioni e 'citation()' per sapere
come citare R o i pacchetti di R nelle
pubblicazioni.

Scrivi 'demo()' per una dimostrazione, 'help()' per la guida in linea, o
'help.start()' per l'help navigabile con browser
HTML. Scrivi 'q()' per uscire da R.

[R.app GUI 1.62 (6558) x86_64-apple-darwin10.8.0]

```
> library(Benchmarking)
Carico il pacchetto richiesto: lpSolveAPI
Carico il pacchetto richiesto: ucminf
> library(AER)
Carico il pacchetto richiesto: car
Carico il pacchetto richiesto: lmtest
Carico il pacchetto richiesto: zoo
```

Attaching package: 'zoo'

The following objects are masked from 'package:base':

as.Date, as.Date.numeric

```
Carico il pacchetto richiesto: sandwich
Carico il pacchetto richiesto: survival
Carico il pacchetto richiesto: splines
> d<-read.csv("magherinicomplessivo.csv",header=TRUE,sep=";",comment.char="#")
> x<-cbind(d$x1,d$x2,d$x3,d$x4)
> y<-cbind(d$y1,d$y2)
> nrep <- 2000
> if ( "FEAR" %in% .packages(TRUE) ) {
+ b<-boot.fear(x,y,NREP=nrep,RTS="crs",ORIENTATION="in")
+ } else {
+ b<-dea.boot(x,y,NREP=nrep,RTS="crs",ORIENTATION="in")
+ }
> E<-eff(b)
```

Benchmarking
package loaded

File
database

Bootstrap DEA
script
CRS scale
Input oriented
2000 replicas

```

> zz1<-d$z1/1e3
> zz4<-d$z4/1e3
> zz2<-d$z2/1e2
> zz3<-d$z3/1e2
> zz5<-d$z5/1e2
> eTob<-tobit(E ~ zz1 + zz3 + zz4 + zz5,left=-Inf, right=1,data=d)
> summary(eTob)
[1] 0.9593 0.8772 0.8374 0.7152 0.8689 0.9517 0.7797 0.6702 0.9301 0.6958 0.7
0.7978 0.8313 0.8723 0.7959
[19] 0.8336 0.8614 0.7735 0.7405 0.7468 0.9585 0.9209 0.8591 0.9865 0.7863 0.7221 0.9589 0.8409 0.7847
0.7056 0.8809 0.8039 0.8380
[37] 0.8433 0.9562 0.9538 0.9543 0.8200 0.8372 0.7492 0.6718 0.7447 0.6316 0.8813 0.6144 0.9505 0.5510
0.7245 0.8188 0.8524 0.9779
[55] 0.7153 0.8288 0.9730 0.7567 0.8245 0.8892 0.8430 0.8541 0.8104 0.9793 0.6857 0.9464 0.8035 1.0327
0.6855 0.7995 0.7442 0.7508
[73] 0.9039 0.8113 0.9018 0.8385 0.7885 0.7588 0.7784 0.8905 0.8326 0.8488 0.8424 0.7965 0.7681 0.8545
0.9492 0.9108 0.8264 0.8171
[91] 0.8237 0.7680 0.8945 0.8103 0.8465 0.7977 0.8676 0.8681 0.8407 0.7943 0.7132 0.7645 0.8044 0.8179
0.8458 0.7251 0.7314 0.7534
[109] 0.6766 0.6855 0.7912 0.7105 0.5828 0.7167 0.6759 0.5919 1.1111
1.0112 0.6887 0.9727 0.7885
[127] 0.7702 0.9821 0.8117 0.8252 0.6754 0.7385 0.7993 0.7771 0.7648
0.8663 0.8051 0.7340 0.8010
[145] 0.8404 0.7724 0.7304 0.7770 0.8320 0.8594 0.7925 0.8085 0.8808
0.7717 0.7706 0.6574 0.6393
[163] 0.8058 0.7888 0.5729 0.8226 0.6656 0.7079 0.8937 0.806
0.8363 0.8770 0.9042 0.8046
[181] 0.7660 0.9267 0.8736 0.8595 0.8708 0.7876 0.8812 0.6099 0.7978
0.8511 0.8191 0.8621 0.8213
[199] 0.8280 0.8749 0.8189 0.6794 0.8252 0.8644 0.8713 0.9403 0.8368
0.9243 0.8809 0.7531 0.7071
[217] 0.5965 0.7822 0.7352 0.7988 0.6985 0.6742 0.7795 0.6898 0.8675 0.7217 0.7454 0.8014 0.7545 0.7737
0.8626 0.9105 0.8315 1.1032
[235] 0.7154 0.8299 0.7701 0.8342 0.7453 0.9099 0.6251 0.7866 0.8130 1.1063 0.8760 0.7792 0.7093 0.7896
0.9079 0.8859 0.9031 0.8161
[253] 0.8826 0.8234 0.8463 0.7830 0.8580 0.8424 0.8739 0.8188 0.9286 0.9305 0.8268 0.8554 0.5141 0.8439
0.8673 0.7752 0.6486 0.6066
[271] 0.8258 0.5317 0.6122 0.7182 0.7552 0.8357 0.7552 0.8712 0.5791 0.6412 0.6333 0.7564 0.8534 0.7291
0.7938 0.8181 0.5783 0.8808
[289] 0.9170 0.7114 0.8513 0.8626 0.8849 0.9696 0.5955 0.7676 0.9263 0.6731 0.8302 0.7740 0.7098 0.6478
1.0006 0.8666 0.8344 0.9425
[307] 0.7646 0.9177 0.6044 0.9826 0.8460 0.9250 0.8969 0.8303 0.9302 0.8270 0.8623 0.9308 0.7264 0.9327
0.9988 0.6758 0.7933 1.0439
[325] 0.7075 0.7685 0.8037 0.6854 0.9464 1.1050 0.9404 0.8710 0.8078 0.8123 0.6777 0.7224 0.9201 0.5204
0.8130 0.7208 0.4395 0.6023
[343] 0.8426 0.8413 0.8982 0.8229 0.8107 0.9393 0.9301

```

Tobit formulation
zz1-zz4 are dummy
variables
zz5 is normal
variable

DEA I Stage
Results

Call:
 tobit(formula = E ~ zz1 + zz3 + zz4 + zz5 + zz6 + z7,
 left = -Inf, right = 1, data = d)

Observations:

Total	Left-censored	Uncensored	Right-censored
348	0	343	5

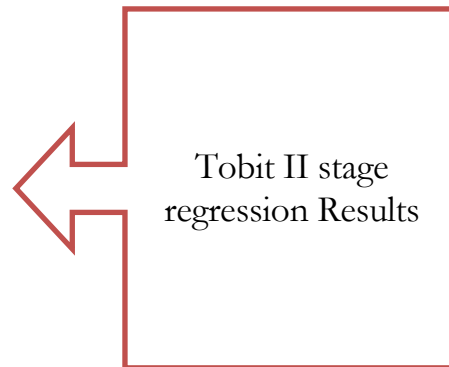
Coefficients:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	0.3465373			
zz1	-0.0247345	0.0086820	-0.045	0.96402
zz3	0.0128418	0.0047848	2.684	
zz4	0.00728	0.0030890		
zz5	0.0086485	0.357	0.72096	
zz6	0.0036877	0.0043974	0.839	0.40169
z7	-0.0115782			
Log(scale)	-2.1970498	0.0284750	-77.157	< 2e-16

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Scale: 0.1111

Gaussian distribution
 Number of Newton-Raphson Iterations: 4
 Log-likelihood: 472.9 on 8 Df
 Wald-statistic: 206.9 on 6 Df, p-value: < 2.22e-16



APPENDIX 4: Technological Innovation In The Management Of The Operating Room - ICT Survey

The management levers of the health structure

In relation to a PhD thesis work, we ask to answer some questions regarding the management aspects of the structures.

These answers will be compared with an analysis of technical efficiency to identify which levers to focus on in order to improve efficiency, including in terms of spending review. Specifically, some questions are open-ended, optional, others multiple-choice to speed up the task and limit the need to find numerical / quantitative data as much as possible.

Introduzione ai parametri gestionali valutati

Le prime domande sono rivolte a capire se e come la struttura si avvalga di protocolli/procedure standard per selezione del personale, sfruttamento R&D, motivazione. Sono domande aperte alle quali in questo caso è facoltativo rispondere.

2. Esistono procedure specifiche per la selezione del personale qualificato? Se sì, quali?

3. Ci sono indicazioni specifiche per gestire l'interazione e la comunicazione con il paziente? *

Contrassegna solo un ovale.

- ☐ Sì
☐ No

4. Quali?

5. Gestione del personale: sono presenti, o sono stati sottoposti di recente questionari di valutazione dell'operato dei dipendenti? Se sì, qual è il sentimento dei dipendenti nei confronti dell'idea di essere valutati?

6. Ruolo di Ricerca e sviluppo:

Seleziona tutte le voci applicabili.

- ☐ Viene destinato un budget specifico per questa voce
- ☐ E' una leva fondamentale per la competitività della struttura
- ☐ Le limitazioni al budget non consentono di stanziare risorse per questa voce
- ☐ La tipologia di struttura non prevede risorse per R&D
- ☐ Altro: _____

Organizzazione dei Reparti

Questa pagina si propone di analizzare se la struttura ha preso provvedimenti per migliorare l'organizzazione tra reparti

7. Collegamento tra reparti

Seleziona tutte le voci applicabili.

- ☐ In fase di progettazione della struttura si è posta particolare attenzione sulla connettività dei reparti
- ☐ I reparti sono stati riprogettati per essere maggiormente funzionali alle esigenze di cura (es. disposizione sale operatorie a ferro di cavallo)
- ☐ I reparti della struttura non sono posizionati secondo un preciso criterio
- ☐ I reparti sono collegati in modo da rendere minime le distanze di percorrenza dei pazienti per emergenza
- ☐ Non è mai stata fatta una verifica sull'utilità di una disposizione razionale dei reparti
- ☐ Altro: _____

8. Disposizione sale operatorie

focus domanda precedente

Seleziona tutte le voci applicabili.

- ☐ Le sale operatorie sono disposte secondo la logica del "minimo spazio percorso dal personale"
- ☐ Ogni chirurgia specialistica ha la sua sala operatoria
- ☐ C'è stata una recente riprogettazione della disposizione delle sale operatorie
- ☐ Non sono stati fatti studi, progetti, discussioni circa la disposizione delle sale operatorie
- ☐ Le sale operatorie hanno una via d'accesso CONTIGUA alla rianimazione
- ☐ la/le sale operatorie hanno un collegamento preferenziale con la rianimazione
- ☐ Altro: _____

9. Il percorso del paziente è tracciato?

Seleziona tutte le voci applicabili.

- ☐ Sono stati implementati strumenti precisi che operano in tempo reale
- ☐ Non è ritenuta importante la tracciatura
- ☐ Ci sono studi per progettare l'implementazione
- ☐ Le risorse economiche non ne consentono l'attivazione
- ☐ E' stata riscontrata opposizione di una parte del personale
- ☐ Altro: _____

10. Percorsi Pre-Ospedalizzazione

Seleziona tutte le voci applicabili.

- ☐ esistono delle linee guida per gli interventi in elezione
- ☐ sono riservati posti per esecuzione di eventuali esami radiologici propedeutici all'intervento in elezione
- ☐ software specifici verificano in tempo reale la programmazione degli esami
- ☐ esistono percorsi specifici per utenti non autosufficienti e/o disabili e/o sordomuti (es. disponibilità interprete)
- ☐ Altro: _____

11. Day Surgery, Day Service, Day Hospital

Esistono percorsi collegati in modo funzionale al Pronto Soccorso (Day Surgery, Day Service, Day Hospital), che permettono di limitare il numero di ricoveri?

Seleziona tutte le voci applicabili.

- ☐ non è presente una unità operativa Day Surgery
- ☐ L'U.O. è in progettazione
- ☐ L'introduzione ha portato benefici alla disponibilità di posti letto
- ☐ DS e/o DH hanno limitato i costi unitari per utente
- ☐ Non hanno portato benefici
- ☐ L'outcome del paziente è migliorato
- ☐ Il gradimento dell'utente è più alto rispetto ad un ricovero ordinario
- ☐ l'utente preferisce il ricovero alla Day Surgery
- ☐ Altro: _____

Spinta all'innovazione tecnologica

In questa parte verranno analizzate alcune possibili implementazioni innovative che sono anche tema di dibattito a livello nazionale e internazionale. L'idea è quella di capire "a che punto siamo" con l'introduzione di queste strumentazioni

12. Introduzione pratica della Telemedicina

La domanda è stata fatta per capire il livello di implementazione di strumenti a favore della Telemedicina

Contrassegna solo un ovale.

	1	2	3	4	5	
Nessuno sviluppo	☐	☐	☐	☐	☐	Stato avanzato

13. Monitoraggio ed archiviazione interventi su supporto informatico

Comprensione del livello di informatizzazione dei servizi sanitari

Contrassegna solo un ovale.

	1	2	3	4	5	
Nessun supporto	☐	☐	☐	☐	☐	Informatizzazione completa

14. Visione online disponibilità letti e accesso ad elenco prenotazioni

Ampliamento della precedente domanda con focus su posti letto e prenotazioni

Contrassegna solo un ovale.

	1	2	3	4	5	
Nessun supporto	☐	☐	☐	☐	☐	Implementazione completa

15. **Protocolli attivi che supportino automatizzazione attività mediche**

Esempio generico: gestione flusso di lavoro, come la previsione domanda di esami
Contrassegna solo un ovale.

	1	2	3	4	5	
Nessun supporto	☐	☐	☐	☐	☐	Sviluppo avanzato

16. **Gestione informatica piani terapeutici**

Contrassegna solo un ovale.

1	2	3	4	5
☐	☐	☐	☐	☐

17. **Standardizzazione piani assistenziali**

Processo volto a costruire degli standard procedurali per terapie ed interventi, in aggiunta alle procedure a livello nazionale
Contrassegna solo un ovale.

1	2	3	4	5
☐	☐	☐	☐	☐

18. **Fascicolo Sanitario Elettronico**

Grado di implementazione di questo supporto
Contrassegna solo un ovale.

1	2	3	4	5
☐	☐	☐	☐	☐

Soddisfazione del paziente

In questa fase sono analizzate tutte le azioni di monitoraggio e non volte a migliorare la customer satisfaction del paziente

19. **Quali azioni sono state intraprese al fine di migliorare la customer satisfaction del paziente?**

Seleziona tutte le voci applicabili.

- ☐ Analisi Fenomeni di Reneging/Balking: pazienti che rinunciano a mettersi in lista d'attesa a causa della lunghezza di questa
- ☐ Somministrazione ai pazienti di questionari di customer satisfaction
- ☐ analisi % liste attesa a rischio superamento obiettivo nazionale
- ☐ Tempestività della risposta per un intervento di emergenza
- ☐ Altro: _____

20. **Gestione attività reparti e sale chirurgiche in specifici periodi dell'anno**

Incidenza della riduzione del personale sulla qualità di cura

Seleziona tutte le voci applicabili.

- ☐ è prevista una riduzione dell'attività interventistica durante il periodo estivo
- ☐ vengono chiusi reparti in specifici periodi dell'anno
- ☐ la struttura lavora a pieno regime tutto l'anno
- ☐ si evidenzia un peggioramento degli esiti di cura durante periodi di riduzione del personale
- ☐ Altro: _____

Misurazione delle performances

In qual misura le seguenti affermazioni descrivono meglio come e tra chi le misure di performance vengono attuate

21. **Coinvolgimento manager nello sviluppo di sistemi di valutazione performances**

Contrassegna solo un ovale.

	1	2	3	4	5	
Mai	☐	☐	☐	☐	☐	Sempre

22. **Coinvolgimento personale medico**

Contrassegna solo un ovale.

	1	2	3	4	5	
Mai	☐	☐	☐	☐	☐	Sempre

23. **Coinvolgimento personale infermieristico**

Contrassegna solo un ovale.

	1	2	3	4	5
	☐	☐	☐	☐	☐

24. **coinvolgimento utenti/pazienti**

Contrassegna solo un ovale.

	1	2	3	4	5
	☐	☐	☐	☐	☐

29. **Gestione del Rischio: cosa è stato fatto?**

queste linee guida derivano dal questionario Mini-HTA danese
Seleziona tutte le voci applicabili.

- ☐ valutazione del rischio e valutazione della frequenza e gravità degli eventi avversi che possono essere collegati al personale infermieristico
- ☐ report specifici su potenziali problemi di personale legati alla sicurezza del paziente almeno trimestralmente.
- ☐ formazione del personale sul mantenimento e il miglioramento delle competenze specifiche relative alla sicurezza del paziente
- ☐ completato una revisione della letteratura e identificato le best practices specifiche per la riprogettazione dei processi
- ☐ risorse a bilancio per programmi di sicurezza del paziente in misura sufficiente a sostenere valutazioni e programmi di rischio e di pericolo
- ☐ fornire ai dirigenti di tutti i livelli strumenti per il monitoraggio del rischio nelle loro aree
- ☐ Altro: _____

30. **Negli ultimi anni sono stati valutati i rischi e i pericoli per i pazienti esaminando:**

Seleziona tutte le voci applicabili.

- ☐ Analisi causa principale per gli eventi avversi
- ☐ indicatori di sicurezza dei pazienti
- ☐ strumenti di trigger
- ☐ Risk Management
- ☐ Nessuna di queste opzioni
- ☐ Definiti gli sforzi di mitigazione del rischio in base al proprio profilo di rischio
- ☐ Altro: _____

EMR Electronic Medical Record/Cartella Clinica elettronica

Le cartelle cliniche elettroniche possono includere dati demografici, storia medica, cure e allergie, stato immunitario, risultati di test di laboratorio, immagini radiologiche, segnali vitali, statistiche personali come età e peso e informazioni di fatturazione.

31. **Nella struttura è stata introdotta la cartella clinica elettronica? ***

Contrassegna solo un ovale.

- ☐ Sì
- ☐ No *Dopo l'ultima domanda in questa sezione, passa alla domanda 42.*
- ☐ In fase di implementazione

APPENDIX 5: Waiting lists and scheduling intervention analysis of case studies – 1st semester 2018

Case 1 - Waiting list analysis										
Classe di priorità	Otorino					Ch. Generale e Bariatrica				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	46	93	9%	30	65%	129	193	12%	109	84%
2 - Ricovero - 60gg	139	202	27%	105	76%	338	240	32%	279	83%
3 - Ricovero - 90gg	338	286	65%	266	79%	591	344	56%	454	77%
Classe di priorità	Ortopedia					Ginecologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	6	21	12%	1	17%	8	40	22%	5	63%
2 - Ricovero - 60gg	10	79	20%	3	30%	20	25	56%	1	5%
3 - Ricovero - 90gg	35	121	69%	10	29%	8	105	22%	2	25%
Case 2 - Waiting list analysis										
Classe di priorità	Senologia					Ginecologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	13	16	36%	1	8%	14	66	8%	7	50%
2 - Ricovero - 60gg	2	91	6%	1	50%	71	204	43%	58	82%
3 - Ricovero - 90gg	21	88	58%	8	38%	82	258	49%	67	82%
Classe di priorità	Ch. Generale					Ortopedia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	69	131	20%	54	78%	54	217	10%	45	83%
2 - Ricovero - 60gg	199	323	57%	170	85%	260	389	46%	244	94%
3 - Ricovero - 90gg	79	511	23%	72	91%	247	368	44%	192	78%
Classe di priorità	Urologia					Ch. Plastica				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	215	266	49%	166	77%	172	71	52%	109	63%
2 - Ricovero - 60gg	69	418	16%	58	84%	63	521	19%	57	90%
3 - Ricovero - 90gg	159	378	36%	125	79%	94	720	29%	86	91%
Classe di priorità	Otorino Pediatrico					Ch. della mano				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	0	0	0%	0	-	0	0	0%	0	-
2 - Ricovero - 60gg	21	57	27%	6	29%	1	682	50%	1	100%
3 - Ricovero - 90gg	58	166	73%	48	83%	1	979	50%	1	100%

Case 3 - Waiting list analysis										
Classe di priorità	Ch. Generale					Oculistica				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	75	125	16%	57	76%	1	40	3%	1	100%
2 - Ricovero - 60gg	256	208	53%	209	82%	17	45	59%	3	18%
3 - Ricovero - 90gg	149	273	31%	102	68%	11	80	38%	4	36%
Classe di priorità	Ortopedia					Ginecologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	20	110	27%	12	60%	19	84	17%	8	42%
2 - Ricovero - 60gg	38	124	51%	16	42%	74	75	67%	33	45%
3 - Ricovero - 90gg	16	79	22%	2	13%	17	64	15%	4	24%
Classe di priorità	Urologia									
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite					
1 - Ricovero - 30gg	25	40	69%	14	56%					
2 - Ricovero - 60gg	7	128	19%	2	29%					
3 - Ricovero - 90gg	4	25	11%	0	-					

Case 4 - Waiting list analysis										
Classe di priorità	NOP-Ch. Generale					NOP-Dermatologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	393	130	27%	302	77%	50	81	91%	35	70%
2 - Ricovero - 60gg	652	316	45%	567	87%	5	64	9%	2	40%
3 - Ricovero - 90gg	406	334	28%	311	77%	0	0	0%	0	-
Classe di priorità	NOP-Odonto					NOP-Ginecologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	3	160	33%	3	100%	51	128	16%	34	67%
2 - Ricovero - 60gg	3	107	33%	2	67%	94	182	30%	65	69%
3 - Ricovero - 90gg	3	3	33%	0	0%	172	208	54%	101	59%
Classe di priorità	NOP-Otorino					NOP-Urologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	82	67	11%	53	65%	98	87	23%	57	58%
2 - Ricovero - 60gg	313	142	43%	235	75%	125	312	29%	99	79%
3 - Ricovero - 90gg	335	254	46%	262	78%	212	392	49%	168	79%
Classe di priorità	NOP-Ortopedia					NOP-Vascolare				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	25	82	16%	19	76%	3	14	13%	1	33%
2 - Ricovero - 60gg	92	119	57%	68	74%	19	167	79%	11	58%
3 - Ricovero - 90gg	44	120	27%	14	32%	2	181	8%	1	50%

Case 5 - Waiting list analysis										
Classe di priorità	Ch. Generale					Ch. Vascolare				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	147	73	19%	89	61%	19	90	15%	17	89%
2 - Ricovero - 60gg	586	170	77%	458	78%	12	218	9%	8	67%
3 - Ricovero - 90gg	25	318	3%	21	84%	100	124	76%	40	40%
Classe di priorità	Ortopedia					Ginecologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	67	62	29%	49	73%	135	54	74%	79	59%
2 - Ricovero - 60gg	145	181	63%	122	84%	41	85	23%	18	44%
3 - Ricovero - 90gg	18	310	8%	16	89%	6	47	3%	1	17%
Classe di priorità	Otorino					Urologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	5	21	5%	1	20%	42	42	40%	12	29%
2 - Ricovero - 60gg	12	88	13%	3	25%	57	52	54%	15	26%
3 - Ricovero - 90gg	74	144	81%	29	39%	7	132	7%	4	57%

Case 6 - Waiting list analysis										
Classe di priorità	Ch. Generale					Ch. Vascolare				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	513	306	28%	459	89%	160	216	40%	153	96%
2 - Ricovero - 60gg	963	452	53%	878	91%	202	274	50%	156	77%
3 - Ricovero - 90gg	331	1.341	18%	253	76%	42	305	10%	16	38%
Classe di priorità	Dermatologia					Oculistica				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	4	48	100%	2	50%	4	27	1%	2	50%
2 - Ricovero - 60gg	0	0	0%	-	-	30	29	10%	0	0%
3 - Ricovero - 90gg	0	0	0%	0	-	270	39	89%	13	5%
Classe di priorità	Ginecologia					Ortopedia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	137	89	54%	106	77%	114	112	22%	89	78%
2 - Ricovero - 60gg	97	109	38%	61	63%	320	187	63%	268	84%
3 - Ricovero - 90gg	22	112	9%	10	45%	74	177	15%	48	65%
Classe di priorità	Otorino					Urologia				
	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite	#	gg medi di attesa	% rispetto al totale	# Oltre data limite	% Oltre data limite
1 - Ricovero - 30gg	45	50	15%	30	67%	70	83	42%	53	76%
2 - Ricovero - 60gg	60	102	20%	39	65%	86	228	52%	76	88%
3 - Ricovero - 90gg	196	162	65%	130	66%	9	73	5%	2	22%

Case 1 - Intervention analysis 1st semester 2018								
NC (non codificati): sono interventi eseguiti in elezione per i quali non è stato possibile rilevare la classe di priorità								
Classe di priorità	Otorino				Ch. Generale e Bariatrica			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	35	4.298	20	57%	59	5.741	37	63%
2 - Ricovero - 60gg	26	2.205	26	100%	46	5.621	43	93%
3 - Ricovero - 90gg	16	1.695	16	100%	37	2.280	33	89%
NC					57			
Classe di priorità	Ginecologia				Ortopedia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	22	2.625	9	41%	11	550	4	36%
2 - Ricovero - 60gg	4	225	1	25%	5	225	2	40%
3 - Ricovero - 90gg	1	60	1	100%	9	320	2	22%
NC								

Case 2 - Intervention analysis 1st semester 2018												
Classe di priorità	Senologia				Ginecologia				Ch. Generale			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	73	3.744	15	21%	16	1.952	13	81%	36	5.216	24	67%
2 - Ricovero - 60gg	1	25	1	100%	11	774	10	91%	7	1.286	7	100%
3 - Ricovero - 90gg	7	745	7	100%	8	830	8	100%	2	1.145	2	100%
Classe di priorità	Ortopedia				Urologia				Ch. Plastica			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	14	1.037	7	50%	61	4.430	47	77%	114	11.060	66	58%
2 - Ricovero - 60gg	5	325	5	100%	10	811	8	80%	5	661	5	100%
3 - Ricovero - 90gg	3	210	3	100%	8	1.382	8	100%	1	0	1	100%
Classe di priorità	Otorino pediatrico				Ch. della Mano							
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite				
1 - Ricovero - 30gg	0	0	0	-	0	0	0	-				
2 - Ricovero - 60gg	0	0	0	-	0	0	0	-				
3 - Ricovero - 90gg	0	0	0	-	0	0	0	-				
NC	18	495										

Case 3 - Intervention analysis 1st semester 2018												
Classe di priorità	Ch. Generale				Oculistica				Ortopedia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	68	5.147	46	68%	6	226	2	33%	24	1.338	5	21%
2 - Ricovero - 60gg	62	3.247	60	97%	18	874	6	33%	13	712	9	69%
3 - Ricovero - 90gg	11	554	11	100%	2	135	0	0%	0	0	-	-
NC	17	1.888	-	-	1	17	-	-	49	2.615	-	-
Classe di priorità	Ginecologia				Urologia							
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite				
1 - Ricovero - 30gg	24	863	8	33%	13	795	11	85%				
2 - Ricovero - 60gg	53	1.542	19	36%	0	0	-	-				
3 - Ricovero - 90gg	5	170	2	-	0	0	-	-				
NC	8	87	-	-	5	177	-	-				

Case 4 - Intervention analysis 1st semester 2018												
Classe di priorità	NOP-Ch. Generale				NOP-Dermatologia				NOP-Odonto			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	155	12664	104	67%	27	1.131	22	81%	0	0	0	-
2 - Ricovero - 60gg	31	1930	24	77%	5	160	3	60%	0	0	0	-
3 - Ricovero - 90gg	7	241	3	43%	0	0	0	-	1	75	0	0%
NC	85	5756	-	-	16	736	-	-	5	147	-	-
Classe di priorità	NOP-Ginecologia				NOP-Otorino				NOP-Urologia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	34	3.973	17	50%	70	4.733	42	60%	82	3.852	45	55%
2 - Ricovero - 60gg	27	2.073	19	70%	29	1.070	21	72%	15	822	4	27%
3 - Ricovero - 90gg	14	1.265	9	64%	16	393	8	50%	22	1.340	17	77%
NC	9	624	-	-	58	2.262	-	-	26	1.556	-	-
Classe di priorità	NOP-Oculistica				NOP-Ch. Pediatrica				NOP-Ch. della mano			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	6	205	1	17%	0	0	0	-	0	0	0	-
2 - Ricovero - 60gg	9	194	1	11%	0	0	0	-	0	0	0	-
3 - Ricovero - 90gg	3	85	0	0%	0	0	0	-	0	0	0	-
NC	20	362	-	-	25	1.125	-	-	32	1.225	-	-
Classe di priorità	NOP-Vascolare				NOP-Ortopedia							
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite				
1 - Ricovero - 30gg	0	0	0	-	15	1.005	4	27%				
2 - Ricovero - 60gg	0	0	0	-	26	2.074	24	92%				
3 - Ricovero - 90gg	0	0	0	-	4	253	1	25%				
NC				-	53	2.803	-	-				

Case 5 - Intervention analysis 1st semester 2018												
Classe di priorità	Ch. Generale				Ch. Vascolare				Ortopedia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	193	11.796	118	61%	17	1.147	12	71%	44	2.921	40	91%
2 - Ricovero - 60gg	124	5.382	108	87%	0	-	-	-	45	2.954	36	80%
3 - Ricovero - 90gg	8	365	7	88%	24	865	21	88%	1	55	1	100%
NC	16	1.197	-	-	27	1.683	-	-	16	727	-	-
Classe di priorità	Ginecologia				Otorino				Urologia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	103	5.639	54	52%	8	626	3	38%	75	3.930	32	43%
2 - Ricovero - 60gg	12	420	10	83%	15	794	1	7%	43	2.067	29	67%
3 - Ricovero - 90gg	1	80	1	100%	63	3.093	7	11%	0	-	-	-
NC	16	921	-	-	2	45	-	-	5	146	-	-

Case 6 - Intervention analysis 1st semester 2018												
Classe di priorità	Ch. Generale				Ch. Vascolare				Dermatologia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	129	18.305	81	63%	35	2.839	29	83%	15	1.227	2	13%
2 - Ricovero - 60gg	51	3.127	50	98%	11	690	11	100%	0	0	0	-
3 - Ricovero - 90gg	8	961	6	75%	4	152	4	100%	0	0	0	-
NC	16	2.362	-	-	3	205	-	-	2	115	-	-
Classe di priorità	Oculistica				Ginecologia				Ortopedia			
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite
1 - Ricovero - 30gg	1	215	0	0%	82	3.323	53	65%	33	1.864	30	91%
2 - Ricovero - 60gg	10	500	6	60%	20	692	20	100%	31	1.499	30	97%
3 - Ricovero - 90gg	5	184	5	100%	4	122	4	100%	6	355	4	67%
NC	0	0	-	-	2	191	-	-	124	5.657	-	-
Classe di priorità	Otorino				Urologia							
	#	Tempo tot (min)	# oltre data limite	% oltre data limite	#	Tempo tot (min)	# oltre data limite	% oltre data limite				
1 - Ricovero - 30gg	44	2.480	28	64%	63	5.041	45	71%				
2 - Ricovero - 60gg	13	630	13	100%	18	893	18	100%				
3 - Ricovero - 90gg	21	576	21	100%	1	35	1	-				
NC	3	289	-	-	1	80	-	-				

PROGRAMMAZIONE BLOCCO OPERATORIO APRILE														
7	m	lun 27	MATT	URG	CHIR		TRAUM	ORT		URO	GINE		OCU	ERCP
1	a		POM	URG							GINE			
6	r	mar 28	MATT	URG	DS CHIR	BAR	TRAUM			URO		ORL	OCU	
2	z		POM	URG				DIABETE						DERM
6	o	mer 29	MATT	URG	CHIR	VASC	ORT				GINE	ORL	OCU	
3			POM	URG	CHIR		TRAUM							ALG
6	2	gio 30	MATT	URG	L SENT		TRAUM	DS ORT		URO			OCU	ERCP
2			POM	URG	CHIR									PORT
7	0	ven 31	MATT	URG	CHIR	DS CHIR	TRAUM	ORT		URO	GINEvg			FAV/RF
1			POM	URG	CHIR									
0	1	sab 01	MATT											
0			POM											

			C	A	B	D	E	F	G	H	I	L	M	N
	a	lun 03	MATT	URG	CHIR	DS CHIR	TRAUM			GINE	ORL	OCU	ERCP	DERM
	p		POM	URG						GINE	ORL			
	r	mar 04	MATT	URG	DS CHIR	BAR	TRAUM	ORT	URO			OCU		
	i		POM	URG					URO				ALG	
	l	mer 05	MATT	URG	CHIR	VASC	ORT		TERM	GINE	ORL	OCU		
	e		POM	URG			TRAUM							
		gio 06	MATT	URG	L SENT		TRAUM	DS ORT	URO		DS VASC	OCU	ERCP	
			POM	URG	CHIR								PORT	
	2	ven 07	MATT	URG	DS CHIR	CHIR	TRAUM	ORT	URO	GINE ivg			FAV/RF	
	0		POM	URG		CHIR								
	1	sab 08	MATT	URG										
	7		POM	URG										

Before

PIANO ASSEGNAZIONE SEDUTE OTTOBRE-DICEMBRE 2017												
Settimana 1			C	A	B	D	E	F	G	H	I	L
	lun	MATT	URG	CHIR	DS CHIR	TRAUM	ORT			GINE	ORL	OCU
		POM	URG	CHIR						GINE		
	mar	MATT	URG	CHIR	BAR	TRAUM			URO	CHIR		OCU
		POM	URG		BAR	DIABETE			URO			
	mer	MATT	URG	CHIR	VASC	ORT			DS CHIR	GINE	ORL	OCU
		POM	URG	CHIR		TRAUM						
	gio	MATT	URG	L SENT	CHIR	TRAUM	ORT		URO		DS VASC	OCU
		POM	URG	CHIR					URO			
	ven	MATT	URG	CHIR	CH-urg di#	TRAUM	DS ORT		URO	DS GINivg	ORL	
		POM	URG	CHIR								
	sab	MATT	URG		CHIR	OST-TR*						
		POM	URG									
Settimana 2			C	A	B	D	E	F	G	H	I	L
	lun	MATT	URG	CHIR		TRAUM	ORT		DS CHIR	GINE	ORL	OCU
		POM	URG	CHIR					GINE			
	mar	MATT	URG	CHIR	BAR	TRAUM	DS ORT		URO	CHIR		OCU
		POM	URG		BAR				URO			
	mer	MATT	URG	CHIR	VASC	ORT			DS CHIR	GINE	ORL	OCU
		POM	URG	CHIR		TRAUM						
	gio	MATT	URG	L SENT	CHIR	TRAUM	ORT		URO	TERM	DS VASC	OCU
		POM	URG	CHIR								
	ven	MATT	URG	CHIR	CH-urg di#	TRAUM	ORT		URO	DS GINivg	ORL	OCU
		POM	URG	CHIR								
	sab	MATT	URG			OST-TR*				GINE		
		POM	URG									

After

Figure 29 – new planning for operating theater