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# Analysis of the quality of hospital care: methodological and empirical issues in the Italian context

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## Abstract

The issue of quality in healthcare has constituted the object of several literature studies during the last decades. Many analyses have been carried out, for the most part in the EU and in the US, with the objective to define quality of hospital care and to identify appropriate indicators to measure it.

This dissertation is aimed at analyzing quality of hospital care, considering aspects related to demand, supply and institutional factors, among which there is the modality of reimbursement. The observed scenario (Italy) is characterised by heterogeneity in the provision of health care; in fact, after the reforms intervened during the last 20 years, the Italian NHS is organised on a regional basis.

Data employed in a cross section analysis, run for the year 2009, are those of the National Program for the Evaluation of health outcomes, carried out by the Ministry of Health with AGENAS. Other information about hospital structures have been extracted from the Ministry of Health database. Five different datasets, one for each outcome indicator, have been built.

A random intercept model and a truncated regression have been applied, considering, as dependent variables, health outcomes related to 30 days mortality and readmission rates for specific conditions (acute myocardial infarction, congestive heart failure, stroke, chronic obstructive pulmonary disease). A positive impact on quality of hospital care due to the reimbursement systems was found: variables related to the extent of DRGs tariff implementation and the choice for a regional tariff were significantly correlated with quality indicators.

Finally, an efficiency analysis at the level of provinces has been run, whose results outlined the role of institutional and "environmental" factors in determining improvements in terms of efficiency.

The positive contribution given by the present dissertation to the literature related to the quality of hospital care is significant. Conclusions that can be drafted confirm the main results obtained in the literature. Moreover, the application to the Italian context allows to obtain relevant policy implications. There is a positive impact on quality due to the choice of reimbursement system; the greater autonomy accorded to the Region might favour competition within hospital sector based on quality.

Il tema della qualità dell'assistenza sanitaria è stato affrontato da numerosi studi di letteratura economica nel corso degli ultimi decenni. La rilevanza dell'argomento è tale che in quasi tutti i Paesi europei e negli Stati Uniti le analisi condotte hanno avuto l'obiettivo di definire, in particolare, la qualità dell'assistenza ospedaliera, e di identificare degli indicatori appropriati per una sua valutazione.

Il presente lavoro ha esaminato la qualità dell'assistenza ospedaliera, considerando fattori relativi alla domanda, all'offerta e allo scenario istituzionale, tra cui la modalità di remunerazione. Lo scenario di riferimento – l'Italia – è caratterizzato da eterogeneità, dato che, a seguito delle riforme intervenute nel corso degli ultimi 20 anni, il sistema sanitario è organizzato su base regionale.

I dati del Programma Nazionale Valutazione Esiti, condotto da AGENAS per conto del Ministero della Salute sono stati impiegati in un'analisi *cross section*, svolta per l'anno 2009. Tali dati sono stati poi combinati con i dati sulle strutture ospedaliere estrapolati dal *database* del Ministero della Salute, costruendo, in questo modo, cinque diversi *dataset,* per ciascun indicatore di risultato.

Sono stati stimati un modello ad intercette *random* e un *truncated regression model*, assumendo, quali variabili dipendenti, i tassi di mortalità e di riammissione a 30 giorni per specifiche condizioni cliniche (infarto del miocardio acuto, scompenso cardiaco, ictus, broncopneumopatie). I risultati delle stime hanno evidenziato un impatto positivo sulla qualità dell'assistenza ospedaliera dovuto ai sistemi di finanziamento: le variabili relative alla misura dell'applicazione dei DRG e alla scelta per una tariffa regionale sono significativamente e positivamente correlate con la riduzione della mortalità e delle riammissioni a 30 giorni.

Da ultimo, è stata condotta un'analisi di efficienza a livello provinciale, che ha evidenziato nuovamente il ruolo di fattori istituzionali e "ambientali" nel determinare delle *performances* positive in termini di efficienza.

Le conclusioni che possono trarsi dall'intero lavoro confermano i principali risultati ottenuti in letteratura. In più, l'applicazione al contesto italiano consente di trarre rilevanti implicazioni di *policy*. L'aver considerato, nell'analisi empirica, delle variabili legate allo scenario istituzionale, sottolinea come vi sia un impatto positivo della scelta di sistemi di finanziamento sulla qualità; la maggiore autonomia attribuita alle Regioni favorisce un modello di concorrenza basata sulla qualità all'interno del mercato sanitario ospedaliero.

*A mia madre*

## Summary

# Introduction

The issue of quality in healthcare has constituted the object of several literature studies during the last decades. The relevance of the topic has determined a large number of analyses, carried out for the most part in the EU and in the US, with the objective to define quality and to identify appropriate measurement tools.

Healthcare outcomes rely mainly on hospital outcomes. Hospitals, both public and private, do often perform similar tasks. However, a comprehensive assessment of hospital outcomes is not an easy task, given the complexity and variety of aspects to take into account. Although hospitals do share the same "mission", protocols and guidelines implemented can lead to dissimilar results. Moreover, there could not be agreement, in the literature or across different health systems, on the definition of some basic notions as hospital admissions, discharges, and on the most appropriate procedures to treat patients, so to make problematical any comparison between different structures. Because of this ambiguity, it could be controversial both to collect data and to develop suitable indicators for measuring quality of care.

Outcomes are generally related to the capacity of obtaining positive results both from a clinical point of view, as well as regarding the level of patients' satisfaction. Hence, quality has to be appraised both within each structure and referring to the whole system. There might be planned specific measures aimed at rewarding those structures promoting, among their main objectives, the achievement of quality: for this reason, in recent years, it is becoming much more frequent the implementation of programs aimed at monitoring the level of care provided on the basis of information provided by patients.

The analyses aimed at measuring the quality of hospital were carried out since the '60s-'70s: the greatest number of studies regarded the assessments of costs and, overall, of the efficiency, as, at that time, quality was thought to coincide with the best possible use of resources.

During the last years, the notion of quality has been widening and now it involves, together with patients' assessments, the evaluation of specific intervention plans and the design of incentives at a normative level.

In this scenario, the Italian *Servizio Sanitario Nazionale* (the National Health System – NHS) is particularly interesting to analyse. The reforms that took place during the last two decades have re-defined substantially the healthcare provision in Italy, which is now organised on a regional basis. The boost toward a regional health system started with the Legislative Decrees no. 502 and 517 of 1992, that made Regions more responsible for the organisation of their own health care systems. Local health authorities experienced a radical change, as vertical integration in services delivery was reduced or eliminated. While still keeping the nature of public organisms, the new local health authorities (that modified their names from *Unità Sanitarie Locali* – USL – to *Aziende Sanitarie Locali* – ASL) were given administrative and financial autonomy and a new governance, with top management appointed by the regional authorities.

The introduction of Diagnosis Related Groups (DRGs) substantially modified the hospitals' activity. While, before the reform, *ex post* payments were adopted to reimburse hospitals of all the actual costs related to the treatments provided, the switch to a prospective payment system (PPS) classified hospital activity into groups, each one including treatments that required similar levels of input.

A fixed rate, the tariff, has to be paid to hospitals, therefore implying that, unlike the previous arrangements, hospitals may not receive a reimbursement that is equal to the true cost level, although the cost structure may not be the same across hospitals.

Hence, the DRG payment system changed the notion of hospital. Hospitals are now seen as productive units, whose objective should be that of maximising production, containing costs and reducing wastes. The need to contain costs might determine a lower quality: therefore, the national legislation on hospital funding takes also into consideration the issue of potential decreases in the level of quality, in order to avoid that the fixed DRG payments may make hospitals showing a more complex case-mix worse-off.

Regions can decide at their discretion whether the same tariffs are appropriate for all hospitals or if a variation is necessary to make per case reimbursement appropriate to the hospitals' costs. Hence, tariffs may diverge across Regions, tough differences can emerge within the regional area too.

The character of a managed NHS was reinforced after the health reform of 1999 with the Legislative Decree no. 229, and successive modifications, that have emphasized the public nature of the Italian NHS and the necessity of coordination and control both by the central and the regional governments.

The issue of equity of access to health care is considered by the legislator, who established the "essential levels of care" (*Livelli Essenziali di Assistenza* – LEA), a minimum amount of health services that must be made available to all citizens under the NHS in all Regions. Efficiency, effectiveness and quality become leading objectives in the health policy design.

The present dissertation is set in this context of institutional change and economic analysis: first of all, it provides several interpretation of the notion of quality of hospital care, together with the identification of a suitable estimation methodology to assess quality of outcomes.

The dissertation is compounded of three chapters: although they can be read separately, as different aspects of the main issue are discussed in each of them, they are organised through a general and well defined line of investigation.

The first chapter presents a wide and detailed review of the economic literature on quality for hospital care. This concept has been differently interpreted across time: initially, scholars focused on costs and efficiency analyses; later, the research stream concentrated on performance analyses and, finally, was centered on cost-utility studies, that allow to take into account patients' perspective; another field of analysis is related to institutional economic studies, that are aimed at assessing the normative system and the incentives provided.

The objective of the chapter was that of identifying a set of indicators that have been frequently and successfully employed in the literature studies to define the quality of hospital care.

The second chapter builds on the conclusions reached by the literature outlined in the first section. The indicators for quality of hospital care are employed as dependent variable in the empirical analysis.

First, a *random intercepts model* is applied. The analysis is carried out at two levels: the performance of each single structure - the "first level" - can be classified within clusters, that constitute the "second level" of analysis and that are the ASLs, the Regions, and the categories of structures within which hospitals can be classified (private structures, *Presidi Ospedalieri*, directly managed by ASLs, *Aziende Ospedaliere*, research institute, etc.). The dependent variable is the outcome for each hospital within each group (i.e., hospitals as elements of ASLs, hospitals as units within the Region, etc.)

An element of novelty is given by the dataset that has been used. For the first time, data collected within the National Program for Outcome Assessment (*Programma Nazionale Valutazione Esiti*), carried out by the Ministry of Health together with the National Agency for Regional Health Services (*Agenzia Nazionale per i Servizi Sanitari Regionali, AGENAS*) are employed. The objective of the program, based on discharge data collected in the time span 2005-2010 is that of evaluating the outcomes of hospital assistance. The project drafted conclusions that can be helpful for Regions, since the latter can identify areas of criticity in the provision of healthcare.

Although 45 indicators were developed within the program, in the present dissertation five risk adjusted indicators, related to mortality and readmissions within 30 days, have been considered. These are: mortality for acute myocardial infarction, mortality for congestive heart failure, mortality for stroke, readmissions for stroke, and readmissions for chronic obstructive pulmonary disease. Explanatory variables, instead, are related to demand and supply (database of the Ministry of Health) and institutional framework.

The objective has been that of evaluating the effect due to demand and supply aspects, together with institutional features, such as the choice for a regional tariff instead of the adherence to the national tariff, on the quality of hospital care. The classification of hospitals within clusters allowed to recognize any difference in quality across Regions, Provinces or types of structures. Overall, there has not been observed any significant variation in the results. Instead, the impact of the reimbursement scheme, whose estimated coefficients showed a positive correlation with the improvement in outcomes, is of interest for the objective of the analysis.

A further profile of analysis consisted in the estimation of a *truncated regression model*, as the dependent variables – risk adjusted mortality and readmission rates – have been calculated only for those structures treating more than 75 cases per year, excluding smaller hospitals.

The analysis based on the truncated model has been carried out at a regional level, and a positive effect due to the institutional scenario has been outlined again as well.

The third chapter presents an efficiency analysis for the hospital care, and has been run at the provincial level (that often coincide with ASLs).

In the first part of the chapter, a brief review on efficiency estimation techniques is presented, considering both parametric and non parametric technique. Then, a non parametric methodology, the Data Envelopment Analysis (DEA) in two steps has been applied to assess the different level of technical efficiency achieved by hospital structures.

Overall, the work present a wide analysis of the issue investigated, and connect normative features with methodological and empirical aspects.

The dissertation suggests an original interpretation of the issue of quality. Through the inclusion of variables related to the institutional framework it is possible to derive some policy implications. One of the main conclusions concerns the role played by the reimbursement system: the preference given by Regions to a regional tariff system together with the extent to which DRG are implemented, can orient hospitals' managerial decisions and determine a higher efficiency and a greater quality.

# CHAPTER I

1.1. Introduction: a framework for analyzing quality.

1.2. Definitions of quality. Evidence from the literature.

1.3. Evolution across years of the analyses on hospitals performances.

1.4. Different perspectives for quality: patients, providers, third-party payers.

1.5. Reimbursement systems and quality of hospital care.

1.6. Quality issues in Italy: a regional matter.

1.7. Conclusions

Appendix

## 1.1. Introduction: a framework for analyzing quality

"*Quality of care is the kind of care which is expected to maximize an inclusive measure of patient welfare, after one has taken account of the balance of expected gains and losses that attend the process of care in all its parts*".

This definition of quality of care is due to Donabedian (1988) and outlines several perspectives through which it is possible to look at this concept.

Quality is referred, first of all, to patients and to the way they can achieve an acceptable level of welfare. The term used by Donabedian, "*inclusive measure of patient welfare*", reveals how this notion refers to individual expectations and is calibrated to individual needs.

However, other subjects are called to define quality: the mention to "*expected gain and losses*" implies that there is an assessment activity as well as the development of economic evaluation techniques, first of all cost-benefit analysis; consequently, there is the need to identify who is obtaining some benefits and who is losing.

Finally, the concept of care itself is not simple, but made of various components: "*the process of care in all its parts*" outlines how several elements contribute to define a complex concept. As in a productive process, inputs are transformed into output, and, when considering health care, into outcomes, that represent the improvements in population health. Donabedian advocates the measurement of structure, process and outcome rather than the use of outcome only to measure quality, on the consideration that "*a good structure increases the likelihood of good process, and good process increases the likelihood of good outcome*" (Donabedian, 1988).

These general considerations, related to health care, may be applied to hospital care.

Hospital activity is extremely various and likely to be classified by looking at some key concepts: first of all outcomes, that denote the health status subsequent to a given treatment or intervention; the procedure of risk adjustment considers the different case mix and identifies the riskier patients; costs, that relate to the resources employed in the production of care; efficiency, that looks at the best possible use of resources; equity, that guarantees the same opportunities to all patients.

Although hospitals have the same mission, protocols and guidelines implemented to treat patients could determine a different bundle of services. The way how the systems respond to different conditions and look at all these aspects contribute to define their characteristics and the overall level of quality itself.

**Outcomes** are the first elements under consideration. According to the first widely accepted Donabedian's model (1966), they are one of the three pillars, beside process and structure that define the quality of health care.

No doubt exists as to the stability and validity of the values of patients' recovery, rehabilitation and survival in most situations. Moreover, outcomes tend to be concrete and can be fairly precisely measured.

However, a number of considerations limit the use of outcomes as exclusive measures of the quality of care. The first one is whether the outcomes of care are, in fact, the "relevant" measure. This is because the same notion of outcomes is twofold, and reflects both 1) the power of medical science to achieve certain results under any given set of conditions, and 2) the degree to which knowledge derived by medical science has been applied in the instances under study.

Outcomes are in the central interest of patients and payers. In relation to provider level, outcome measures are able to "catch" observable as well as unobservable to the payer aspects of care (physicians' involvement, effort, which, instead, is observed by patients, results in overall better health inpatient conditions, higher satisfaction, etc.). Sometimes, a particular outcome may be irrelevant, as when survival is chosen as a criterion of success in a situation which is not fatal but is likely to produce suboptimal health. Outcomes are usually defined in terms of mortality, survival, morbidity and the patient's functional status. Nevertheless, a more comprehensive notion of outcomes should not neglect perceived health status, the patient's mental attitude to the disease, his/her experience of healthcare, which may be influenced by communication with medical staff.

There are some advantages derived by **process** measures, instead of outcome measures: they are quicker to measure and easier to attribute value to health service efforts (Brook *et al.,* 1996). In addition, they are considered a better measure for quality as they examine the aspect of compliance that determines the attitude by physicians and medical staff to perceive the best practice and to follow it.

On the other hand, the use of process measures instead of outcomes, although in many cases justified, entails a risk for the provider of care, that is to focus excessively on such indicators. For example, complying with the execution of certain biomedical tests, the prescription of recommended medicines, etc., could not have in every case a positive impact on the overall pattern of care, as medical or pharmacological treatments might not be beneficial to patients. Moreover, process measures might not have the same value for patients as they have for physicians and providers: patients will be interested in clinical outcomes, rather than to a medical procedure or a surgical intervention that is correctly executed.

Process measures may be too specific when they focus on particular interventions or conditions, once again being of interest only for physicians.

Finally, process measures may ignore the effectiveness or the normative concept of appropriateness of medical interventions, that has been recently re-defined in Italy, and has to be monitored by commissions that are often instituted at medical centres. Process measures pre-judge the nature of the response to a health problem, which may not be identical, even in similar conditions. Patients may often present multiple co-morbidities or have different expectations about the desired level of care: these factors justify the adoption of various procedures, making more difficult the application of process measures.

A possible correction to an evaluation method based on process as related to patients' need and expectations, that reconcile both outcomes and process, is that of employing patient reported outcome measures. These types of measures typically ask patients to assess their current health status and to declare the level of satisfaction about the care received.

Clinical outcome measures are those carrying the most weight in the evaluation process of quality of care, as they are often the most meaningful for stakeholders and providers and represent the main objectives of the health system more clearly. Donabedian (1988) himself concluded how "*outcomes, by and large, remain the ultimate validation of the effectiveness and quality of medical care*".

As measures of health outcome are increasingly used to help designing health policies, researchers' efforts have been concentrated to address some technical issues as well.

A relevant issue is based on the consideration that a patient's outcome will be influenced by the severity of his medical condition and, in a broader perspective, by the socio-economic status, as well as the resources made available for a given treatment. In this perspective, **risk adjustment methods** must be applied to account for the differences in the case-mix of patients treated by individual providers. Such methods are based on statistical modelling of the relationship between an outcome and a set of risk factors. The risk factors include the patient's individual risk characteristics: the provider's quality of care, that is unique and specific to that provider, will be differentiated for all patients treated for a given condition with diverse individual risk.

The patient-specific risk factors may relate to demographic characteristics (age, sex, ethnicity), clinical factors (principal diagnosis, severity of principal diagnosis, extent and severity of co-morbidities, physical functional status, cognitive status and mental health), socioeconomic factors (household composition, educational attainment, economic resources, employment and occupation, health-related behaviours and lifestyle – for example, tobacco use, alcohol use, nutrition habits, obesity, etc.-, perceptions about health status and quality of life, preferences and expectations for health care services).

Risk-adjusting factors facilitate providers who undertake the care of high-risk patients and may eliminate the cream skimming of patients.

The usefulness of such approach is, however, limited by the difficulty to estimate a parameter that should reflect risk. The reliability of estimation depends on the quality and availability of data as well as on the choice of the statistical methods used that should, ideally, take into account risk factors that characterize the provider and that are often omitted.

Indeed, measures of risk may not be uniformly related to patient outcomes across all providers: patterns of use of emergency service may indicate higher degrees of illness in some areas, but poor availability of alternative services in other (Wright and Shojania, 2009). The mistaking of such errors for differences in quality is known as the "case mix fallacy", and leads to erroneous conclusions concerning the true value of some health services. Focusing on certain conditions could be considered an extreme form of risk adjustment: for example, surgical mortality rates for specific conditions or procedures have become more popular in recent years, as they are able to identify key areas where health system quality is more likely to influence outcomes and where medical progress has allowed an improvement in outcomes. This is the case of acute myocardial infarction (AMI) or stroke; better treatments for these conditions may lead to reductions in mortality. As it will described later, this is a case where improved technology determines better outcomes and, overall, an increase in patients' welfare[1].

Full economic evaluations consist of a comparison of both **costs**, linked to the use of resources and **consequences** of alternative strategies. The choice of which costs and consequences have to be included in an economic evaluation is influenced by the perspective taken (patients, providers, third-party payers).

The individuation of costs allows to identify the relevant cost-items and attributes them the correct value. Costs can be distinguished into *direct health care costs* (the money value of health care resources employed in the provision of a treatment and in dealing with the side effects or other current and future consequences associated with it), *direct medical costs*

[1] That is why AMI and stroke have been selected among diagnoses studied in the empirical analysis to test the reliability of mortality rates and readmissions as quality indicators.

(fixed and variable costs associated directly with a medical treatment), *direct non-medical cost* (all additional but non-medical cost connected with the treatment), *indirect health costs* (changes in productivity resulting from illnesses or deaths), *indirect non-health costs* (the money value of resources consumed outside the health sector in the provision of treatment, and in treating the side effects or other current and future consequences associated with it), *intangible cost* (the cost of pain and anxiety because of the disease).

Costs are the common element to all economic evaluation techniques: *cost-effectiveness analysis* calculates the ratio between costs and an index of effectiveness of the treatment considered compared with a set of health programs. Again, costs are the numerator of the ratio to be calculated within *cost-utility* analysis and *cost-benefit* analysis.

*Cost-of-illness studies* apply a wider perspective and estimate the total costs incurred by the community due to a specific disease or health condition. Such approach has been used to calculate the social and economic costs, in terms of loss of productivity, caused by a disease that only in the most serious cases results in the death of an individual: this is the case, for example, of chronic conditions or other pathologies treated at hospitals or requiring long term care.

The concept of **efficiency** concerns the degree of achievement of the objective in relation to the amount of resources employed (ratio between output obtained and inputs employed)

Efficiency in health care determines how well health care resources are employed to improve health status. The main approaches to the problem of health care efficiency concern *technical efficiency* and *allocative efficiency*. Technical efficiency is connected with the use of the least amount of inputs to achieve health outcomes that represent improvements in health status. Allocative efficiency implies the choice between a set of treatment available methods, to produce the greatest possible health increase for the whole society[2].

Finally, the concept of health **equity** poses attention on the distribution of resources and other processes that might cause a systematic inequality in health between more and less advantaged social groups. Equity of care is different from "equality", that is, instead, characterized by homogeneity or similarity among individuals or social groups; equality constitutes a "comparative" concept, judged on the basis of factors such as income, utility, resources employed. In this sense, health care spending is one of the most common causes of health inequalities. Inequalities can be assessed against different health parameters, such as access to general practitioners, access to specialists/hospital care, etc.

[2] According to microeconomic analysis, technical efficiency is measured as the distance from the productivity frontier, while allocative efficiency is measured by comparing different points along the same frontier.

To sum up, from these preliminary considerations it clearly emerges the difficulty to reach a widespread consensus on the quality of care definition, as well as on the key features related to care that should be taken into account.

The aspects that have been mentioned (outcomes, process, risk-adjustment, costs, equity), may only provide a framework within which quality has to be included and specified.

Quality can be described in different ways, using various models and terms. Initially, a definition of quality was of interest only to health professionals and scientists; evaluation methods focused on the use of resources or on clinical results. Nowadays, it is widely accepted that views and preferences of patients should also be taken into account.

The development of quality indicators has become a relevant task for health authorities: quality of care has to be monitored in a single institution as well as across the health care system; quality improvement activities have to be promoted; comparisons over time between institutions and health programs should be done; patients should be assisted when choosing healthcare providers, so to select those ones guaranteeing the optimal quality according to patients' health conditions (Mainz, 2003). Moreover, indicators should be developed, tested and implemented with scientific rigor, instead of being selected by looking at availability of data and ease of measurement.

In this way, the implementation of quality indicators should lead to significant improvements in quality itself.

The definition of a notion of quality has to be considered as one of the objectives of this work: it will be made an attempt to select some quality indicators for hospital assistance, based on the most relevant literature. Indicators will be tested considering three levels of analysis: the regional level, where the most relevant role is played the reimbursement system for hospitals, the local health unit level, and the single structure level.

A lot of information can be obtained by the results of analysis. The same information are of great interest for health authorities. By isolating the characteristics of each structure within a local health authority or a Region, it is possible to identify which structures are more efficient/effective. Moreover, through a comparison of the results, looking at institutional factors and at the reimbursement method, it will be possible to see if the latter can influence the quality of care. What should be clear at the end of this dissertation, is which aspects have the greatest impact on quality and should be modified in order to obtain improvements in quality of care itself.

## 1.2. Definitions of quality. Evidence from the literature: looking at structure, process, outcome.

Performing a comprehensive literature review is essential to clarify the object of the research - quality of care -, to see how this issue has been interpreted, both in theoretical and empirical contributions, and which critical aspects emerged.

Many studies and reports focused on the review of quality indicators, without reaching, however, some definitive conclusions.

Studies and reports, that have been appraised for the present analysis, have in common some characteristics: 1) each review has been performed by looking at the most recent publications, without consider those ones older than 10 years; 2) analyses are more frequent for Europe and US, with the exception of some recent contributions carried out for Eastern Asian countries; 3) more than one variable as a proxy for quality has been considered; 4) data about mortality and morbidity have often been combined to obtain composite indexes.

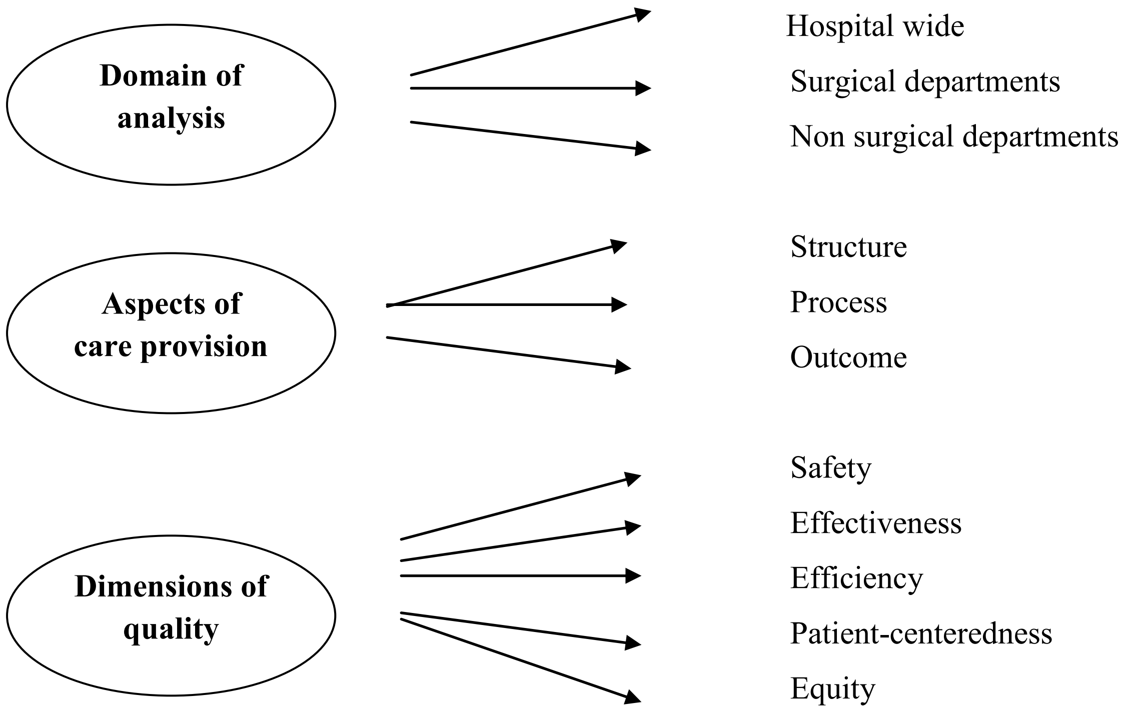
The main databases surveyed by literature studies were PUBMED, MEDLINE, and EMBASE. The algorithms of research used were: [quality of health care; safety management; medical indicators; performance indicators; safety indicators; clinical indicators].

Despite the large number of indicators identified by the relevant literature, some aspects of care lacked coverage and were not well measured.

While it is acknowledged that quality cannot be measured using only a few indicators, there are no standards to determine a fair number of them. For example, the necessity to exploit several quality indicators comes up especially when healthcare for conditions that impose a considerable burden in terms of resources is considered: here, indicators related to the inputs, to the process of producing care, and to the outcomes obtained have to be considered.

Hence, the evaluation process has to look at different aspects. The most relevant have been summarized by Copnell *et al.*, 2009: the domain of analysis (hospital-wide, surgical and non-surgical clinical specialities and departments); the aspects of care provision (structure, process and outcome, recalling the distinction made by Donabedian); and the dimensions of quality (distinguished into safety, effectiveness, efficiency, timeliness, patient-centeredness and equity).

**Figure 1. Aspects of the quality evaluation process.**




Source: Classification made according to criteria identified by Copnell *et al.*, 2009.

Copnell *et al.* (2009) revised the most common medical databases PUBMED, EMBASE and MEDLINE, finding 383 discrete indicators from 22 source organisations and projects.

Concerning the **domain of analysis**, 104 indicators were relevant at a hospital-wide level; they either assessed institutional performance generally (such as evaluating the existence of a clinical risk management system), or were related to specific conditions, therapies or procedures that might occur anywhere in the hospital.

Medications and adverse events were identified as the themes with greatest coverage, accounting for 19.2% and 17,.3% of all indicators respectively. 22 of the indicators categorized as hospital-wide (21.2%) had been developed as part of a clinically-specific set (such as mental health, maternity or cardiology) or were originally defined as relating to specific locations, such as Intensive Care Units, hence indicating the degree o specialization of each structure.

Almost half of the indicators (46.7%) were related to non-surgical specialties ($n$ = 132), individual departments or specific conditions ($n$ = 47). 100 indicators (26.1%) were specific to surgical patients, with 52 relevant to 11 surgical specialties, 18 to anaesthetics and 30 covering other issues such as adverse events, complications, mortality, pain management, prevalence, treatment protocols and access. Almost half (46.2%) of the specialty indicators addressed cardiothoracic surgery.

Looking at **aspects of care**, structural data involve characteristics of physicians and hospitals (such as a physician's specialty or the ownership of a hospital); they concern the potential to guarantee quality of health care and include both measurable factors (number of physicians, technical equipment, etc.), as well as non measurable elements (the physician's skills in surgery room, medical staff background, the geographical area where the hospital is located, etc.). Structural data are employed less frequently than process of care and outcome data to define quality. In fact, the majority of indicators (54%) measured processes of care, with 38.9% relating to outcomes.

Process data have been defined as "*the components of the encounter between a physician or another health care professional and a patient*" (Brook *et al.*, 1996). Process of care often includes preventive care and management of treatment. Process indicators are often preferred because of their ease of measurement: it is easy to verify if a given procedure has been followed or if a patient is receiving the care prescribed by guidelines and protocols of assistance. However, the use of process data could be problematic when scientific evidence of their relationship to health outcomes is limited: they are more sensitive measures of quality comparing to outcome data, because a poor outcome do not occur every time there is a fault in the provision of care. Hence, there could be a correct procedure that is not followed by adequate results: in this case, in order to confirm the validity of process data, it should be demonstrated how outcome would be different if the process of care was modified.

More than half of hospital-wide and non-surgical indicators (51.9% and 65.4% respectively) concerned processes as well, with 34.6% of hospital-wide and 29% of non-surgical indicators were related to outcomes. In contrast, 61% of surgical indicators assessed outcomes, with 36% relating to process. Structural indicators accounted for 7% overall, and 13.5% of hospital-wide indicators.

Outcome data refer to the patient's subsequent health status. Outcome measures are the most credible measures of quality of care; they look at safety of care, patient satisfaction and pain management, and are mainly based on indicators like mortality rate, unexpected effects of treatment and the relief of symptoms.

The centrality of patients characterizes this kind of information, especially when clinical data are considered together with patients' opinions. Patients are often asked to report their health and eventual limitations in performing daily activities that are both physical, mental and social.

Although outcome measures are arguably the most credible measures of quality of care, they must be used with discretion (Donabedian, 2005). Obstacles in measuring outcomes might be the long time necessary for some outcomes to develop, or the difficulties in identifying the changes in health status attributed to health care, instead that to a change in lifestyle. Other problems may be underestimated: for example, the trend to shorter hospital stays means that postoperative infections may not manifest until after discharge.

Brook *et al.* (1996) identified five methods by which quality can be evaluated on the basis of process data, outcome data or both.

The first three methods are defined as *implicit*. This means that there are no prior standards or agreements about what reflects good or poor quality. The objective is that of answering the following questions: 1) was the process of care adequate? 2) could better care have improved the outcome? 3) was the overall quality of care acceptable?

Instead, evaluation based on *explicit* process methods looks at each case, checking if medical protocols and guidelines have been observed. What was done is compared with what should have been done, and the results are expressed as the proportion of criteria that were met.

Another explicit method uses a priori criteria to determine whether the observed results of care are consistent with the outcome predicted by a model validated on the basis of scientific evidence and clinical judgment. In other words, do the observed outcomes differ significantly from expected outcomes?

The results of the assessment will vary according to the method used: explicit process methods are the most restrictive, since they imply an accurate monitoring of each case; on the other hand, implicit methods are less restraining and require that an adequate level of assistance has been overall provided.

Many patients may improve their conditions even when they do not receive all the care they need: according to implicit criteria, the assessment of hospital performance would be positive in this case, while, when considering explicit process criteria, the judgment would not be positive.

Moreover, for many chronic conditions there could be a long time between the performance of the key processes and the outcome of care (for example, a patient with diabetes and poorly controlled level of blood sugar may not present any worsening before 10 or 20 years; a constant monitoring may improve the level of care received increasing the likelihood that an adverse outcome may be identified earlier)[3].

Safety and effectiveness were the dimensions most frequently represented when looking at the **dimensions of quality**. Safety was measured by 57.2% and effectiveness by 32.1% of indicators (Copnell *et al.,* 2009).

The ideal balance between structural, process and outcome indicators in quality measurement has still to be clarified (Lilford *et al.*, 2004). The dominance of safety indicators is probably both due to the history of quality measurement, based initially on the achievement of positive outcomes for patients as well as a reflection of stakeholders' priorities (Kazandjian *et al.*, 2005).

The large number of effectiveness and efficiency indicators reflects widespread implementation of evidence-based guidelines and greater need for accountability in resource use, in the framework of economic evaluation of health care.

Relatively few indicators measured the other dimensions. Patient-centeredness was evaluated mainly by process indicators, such as evaluation of pain or overall patient satisfaction, and measured by 12 outcome indicators: some examples concerned the attainment of patient-specified goals, for example, after rehabilitation programs (Elwyn *et al.*, 2007).

A few indicators addressed continuity of care, communication and patient education, but with the exception of one mental health indicator (support for caregivers) none of the studies surveyed addressed emotional support or involvement of family and friends. Hence, finding ways to measure patient-centeredness continues to present a challenge.

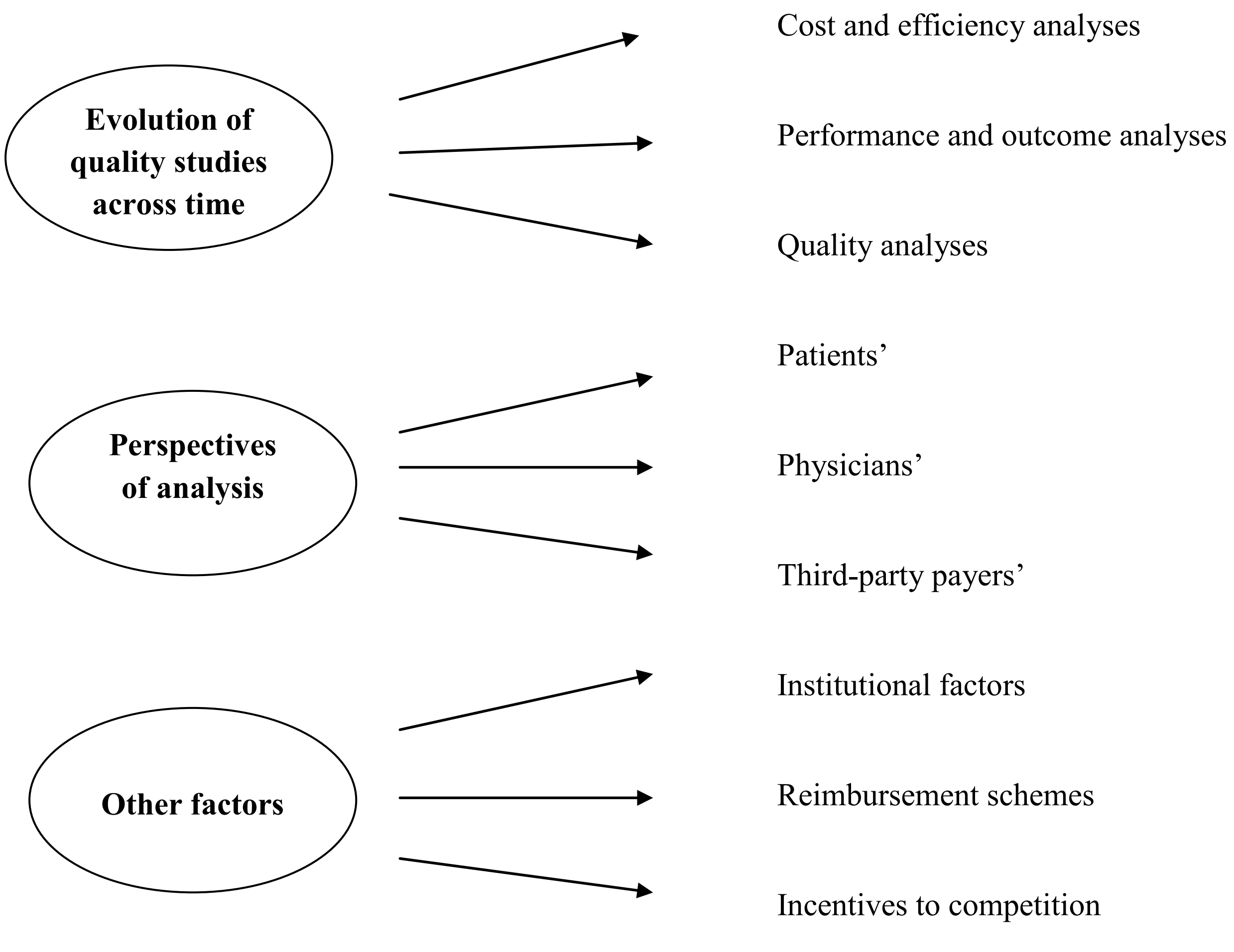
The dimension of equity was similarly underrepresented and measured only in association with other dimensions, mainly in broad indicators judged to assess all dimensions, such as accreditation of hospitals or data quality measures. Inequalities in health care due to age, sex, ethnicity, geography or socioeconomic status may be assessed within more general indicator data (Coffey, Andrews and Moy, 2005). However, some scholars have argued for more specific equity indicators (Lin *et al.*, 2007), looking at some age groups, such as children or the elderly; however, where indicators do exist, it is unclear whether or to what extent they have been implemented.

[3] For these reasons, the assessment of quality meant as continuous assistance for patients should depend more on process data than on outcome data.

The aspects and the dimensions of quality of care will guide the present review. What is not outlined by the studies presented so far, is the flexibility of the concept of quality of care: it has been said how it poses continuous challenges. Quality has been evolving along time, going from the consideration of the use of resources (hence, cost and efficiency analyses) to process and outcome measures, centered on patients and physicians.

Another classification of the studies that have investigated quality may rely on: 1) time; 2) perspective adopted (patients', physicians', third-party payers); 3) other factors (mainly institutional).

**Figure 2. Criteria adopted for the classification of studies on quality.**




At the end of this review it should be easier to identify which factors to employ for the empirical analysis.

Keeping into account the indications provided by the literature, the selection of quality indicators will look at the variables that have been employed to define quality in the last five years.

### 1.3. Evolution across years of the analyses on hospitals performances

The first step to examine quality in hospital care has been that of looking at the evolution of the relevant literature along time, going from studies that initially were based only on costs and efficiency to quality of care analyses.

This evolution can be seen together with the growing importance gained by economic evaluation studies, that, in the last years, are focusing mainly on cost-utility analyses: patients' satisfaction and improvements in quality of life are now the main objectives to achieve, together with clinical outcomes.

In a first phase, quality coincided with the best possible use of resources, given the level of costs and the value of final output: hence, more than quality analyses it is more correct to talk about efficiency analysis.

There is efficiency when health care resources are used to get the best value for money. Efficiency has been meant as well as a measure of the relationship between cost of care and a specific level of performance: the goal is that of providing a level of services sufficient to meet patients' health care needs, given a patient's health status, or to use fewer inputs to get the same or better outcomes (Agency for Healthcare Research and Quality, 2000).

According to a more general definition, efficiency is given by the ratio output/input. This definition is likely to include different types of outputs and inputs as well as different methods for describing the relationship between these two critical components. Since economic efficiency looks at the cost of inputs and the value of final output, the specification of cost function for hospitals is preliminary to the analysis of efficiency.

*Ad hoc* specifications employed, as regressors for the cost equation, elements such as: the capacity of the hospital (represented by the number of beds or by the physicians' density or the hospital beds' density) and other global indicators of hospital activity, such as the case-flow rate, the average occupancy rate, the average length of stay, some case mix indicators – that might be measured by the proportions of patients in various diagnostic categories -; work and education programs have to be seen in this perspective too: for example, indicators of hospitals' activity might be the wage level of hospital employees, dummy variables for teaching status, the existence of a educational and training programs for nurses and, overall, for the staff; other institutional characteristics concern the ownership type, hospital facilities and services and the characteristics of the market for inpatient services like the regional income level (Breyer, 1987).

Given the heterogeneity of factors that could be employed as explanatory variables in the cost equation, there is no accepted theory on the structure of the 'true' functional relationship to costs[4].

During the '90s, studies based on costs have been focusing on specific measures of inefficiency, by employing frontier analysis.

Zuckerman *et al.* (1994) derived hospital specific measures of inefficiency using a stochastic frontier multiproduct cost function. In their study, patient and hospital level data were employed: at the hospital level, variations in output characteristics were measured by the percentage of beds in intensive care units, the percentage of outpatient visits that do not involve surgery, the percentage of long-term admissions, the ratio of births to admissions, the average Medicare case-mix based on DRGs, an index of high technology services and the number of inpatient surgical operations per admission. Other data proposed for the analysis regarded the share of admissions on weekends, to evaluate the degree and timing of hospitals activity; the share of admissions for psychiatric, rehabilitation, or alcohol related problems, that are areas where patients require continuous assistance and monitoring; the share of admissions from other States/Regions; the percentage of discharges to a home health agency and the percentage of patients that were transferred from another hospital or a long-term care facility, that constitute indicators for patients' mobility. The results of that study outlined how inefficiency accounted for 13.6% of total hospital costs, therefore signalling that there was room for intervention to make the provision of hospital care more efficient and to improve overall quality of care.

A recent application of frontier analysis was due to Farsi and Filippini (2006), in a study aimed at examining the productive efficiency of the Swiss general hospitals. The financial data of 214 general hospitals over four years were used. Variables employed included the number of admissions, the number of patients' days, the hospitals' outpatients revenues, the price for labor and capital, the number of nurses per bed, the average length of stay, the presence of emergency rooms, and geriatrics divisions. Several specifications were considered and the results were compared. The efficiency estimates for each hospital were then analyzed to test whether hospitals with different ownership and subsidization types were significantly different regarding efficiency. The conclusions were that considerable savings could be achieved through improvement of hospitals' efficiency. On average, university hospitals and large regional facilities spent more in the provision of health services, with cost differences

[4] Most studies apply the simplest possible functional specification, the additive-linear form. A flexible functional form, proposed as alternative, would require, in fact, a higher number of parameters to be estimated (Vita, 1990).

due to higher expenses resulting from teaching and research activities. In small hospitals, one of the main sources of excessive costs was related to lengthy hospital stays. Instead, the inefficiency estimates did not provide any evidence of significant differences among hospitals with different ownership/subsidy types.

Together with costs, output represents another variable that needs to be specified: in a recent work, Yu and Ariste (2009), focused on quantities, distinguishing between costs, activities and cases. The authors pointed out the ambiguity, in the health care sector, of the units of measurement that define quantities of services: hence, their objective was to discuss various approaches in direct output measurement and to develop an episode-based approach with quality adjustment, using some peculiar quality indicators. The episode-based approach considers the case mix as the basis for output. Changes in quality, instead, are taken into account both at the product stage (*i.e.* an unplanned readmission) and in the outcome stage (*i.e.* by applying a utility-based measure such as the Health-Adjusted Life Expectancy – HALE).

However, this approach was not feasible when considering different national accounts and classification schemes. Frequent measurement of health outcome for the whole country could be impracticable, as well as aggregating output measures, because of differences in case mix and type of services and activity required for each episode.

Dawson *et al.* (2001) considered whether English hospitals have incentives to respond appropriately to comparative cost information. They provided a review of cost indices in the UK, with emphasis on case mix cost indexes as well as, from an institutional perspective, a review of the theory of yardstick competition as a successful regulatory device. The authors conclude that cost improvements may not be realised in England, where there are insufficient incentives to respond to the provision of comparative cost information.

Some problems in measurement and comparison of unit costs have been outlined by Daidone and D'Amico (2009): costs could be highly dependent on the measurement technique adopted. Moreover, technical efficiency could be affected by the productive structure and the level of specialization of a hospital[5]. A stochastic frontier analysis was implemented to assess the level of technical efficiency and to take into account the case mix of hospitals, but neither parametric nor non-parametric classical methodologies revealed adequate for examining hospital production efficiency. In fact, the number of discharged patients gives a rough measure of overall hospital production, if other aspects of treatment,

[5] The authors define the productive structure is the degree of capitalization of the hospital, while the degree of specialization refers to the number of different types of cases treated within the organisation.

such as the type and the severity of illness, the presence of other factors of co-morbidity, the overall characteristics of the patient, etc., are not taken into account.

Overall, analyses based on costs can describe inefficiency, but the problem that is still open is if such inefficiency can be used as a measure of quality.

In the last decade, cost-analyses have been focused on some specific themes, linking the issue of quality not only to cost-savings and improvements in outcomes, but to productivity and performance of structures. In this sense, indicators that have been developed can be interpreted as the application of Donabedian's scheme of hospitals activity, that distinguish structure, process and outcome.

The best practice frontier of total factor productivity can be constructed by enveloping input and output data. Data Envelopment Analysis (DEA) was developed by Charnes, Cooper and Rhodes (1978) and handles settings with multiple inputs and outputs more easily than other efficiency models (see Hagen, Veenstra and Stavem, 2005, Mutter, Valdmanis and Rosko, 2010, Hadad, Hadad and Simon-Tuval, 2011, for recent applications). The main advantage of such approach is flexibility, as it does not require a specific functional form for the technology or specific distributional assumptions on the efficiency measure.

Performance measures have been developed starting from Farrell (1957), who compared the total factor productivity of individual establishments to the best practice frontier total factor productivity and have been then applied to evaluate hospital care.

Performance measures consider a broader notion of hospitals' activity and achievements, as they look at the overall performance of the staff and the structure. However, from the patients' perspectives, the level of activities, measured as the number of diagnostic tests conducted, the surgery intervention performed, or the length of hospital stay, is not the main concern. It is, instead, whether or not an acute disease or injury can be cured as quick as possible, or a chronic illness can be under control with minimum impacts on their quality of life.

Cost-efficiency and productivity analyses are often carried out together. Grosskopf and Valdmanis (1987) compare levels of efficiency of a sample of 66 urban hospitals in California and consider hospital outputs and inputs to sketch a productivity frontier according to Farrell (1957). Ehreth (1994), in a study aimed at developing and evaluating performance measures, considered hospitals' behaviour instead of profit margins. The sample consisted of all hospitals for which Medicare Cost Report and balance data were available. The reliability and validity of measures employed to describe hospital behaviour were assessed using descriptive statistics and factor analysis for a 3-year period. 33 measures were evaluated, five of which represented the critical aspects of hospital performance: a technical efficiency measure was obtained through DEA techniques; the short-term financial performance; the ratio of long term debt-to-net fixed assets, representing long-term viability; total margin, that portrays profitability; and Medicare margin, that characterizes Medicare's contribution to hospital financial position. Each measure represents different aspects of hospital efficiency and financial viability. The results showed how technical efficiency was the most dominant dimension of hospital performance, although a comparison across hospitals was not possible, since there was no theoretically or empirically based best value.

Hence, should efficiency analyses be regarded as the most adequate tools to describe hospital activity and quality of their services?

The production function has been criticized for not recognizing the important time lags that exist in producing health outcomes (Anand *et al.*, 2003), a circumstance that could be relevant especially for hospital outcomes. Some of these criticisms have been addressed by Murray and Evans (2003). Anand *et al*., (2003) proposed to include a second-stage analysis, which explores whether exogenous factors, such as institutional quality, income distribution, population density, etc., had an impact on effectiveness.

An alternative method to monitor quality level was used by Romano *et al.* (1999), in a study aimed at verifying the usefulness of information related to hospitals' characteristics and collected through report cards rather than administrative data. Hospitals were categorized according to ownership, size, occupancy, risk adjusted mortality, teaching status, patient volume and surgical capability. Reports based on clinical data were rated superior, understood better and disseminated more often than administrative data. There could be barriers to a constructive use of outcomes data, especially for high mortality hospitals. In this case, hospital leaders may tend to blame the structures when their facilities are rated poorly and argue that the risk adjustment methods are inadequate. Hence, a careful examination of outcomes should be necessary.

Quality scores were employed also in Freund and Lichtenberg (2000), who analyzed the cross sectional relationship between hospital quality scores and risk adjusted indicators of outcomes and quality. The latter were relating to mortality rates, rates of surgical/medical misadventures, adverse drug reactions, length of stay. The database employed considered almost one thousand of US hospitals. The hypothesis to test was that the higher the overall accreditation summary score, the lower the mortality rate; similarly, the shorter the length of stay, the lower the probability of a patient experiencing any of the adverse outcomes. It was found that adherence to accreditation standard did not lead to increased survival. More severity and more control were necessary to reduce physicians errors. Although preliminary, the study was interesting since, for the first time, variables related to misadventures at hospitals (accidental poisonings, surgical/medical misadventures, and adverse affects of drugs) were considered. The study itself could be classified as a quality investigation rather than a performance analysis.

The issue of information about performance was treated in other studies: Marshall *et al.* (2000) summarized the empirical evidence concerning public disclosure of performance. A literature review identified descriptive, observational, or experimental evaluations of US reporting systems. The selected studies were organised on the basis of the use of public data by consumers, purchasers, physicians, and hospitals. Results showed how there were several potential gains from the public disclosure of performance data and on impact on quality of care outcomes. In a limited number of studies, the publication of performance data had been associated with an improvement in health outcomes. The most of times, however, consumers and purchasers rarely searched out information and did not understand or trusted it; also physicians were skeptical about such data and only a small proportion made use of it.

Jarlier and Charvet-Protat (2000) tried to determine whether the concept of cost of quality, used for the industrial sector, was applicable to hospitals as well, by doing a systematic review of the literature published between 1992 and 2000 and related to quality and costs.

The papers selected for the review related quality to increases in patients' satisfaction – measured through questionnaires -, low rates of unplanned hospital readmissions, post-operative care – represented by the number of infections –, reduced length of stay, mortality rates and management characteristics as well. It was demonstrated how increasing quality led to financial savings and that positive results in overall quality were obtained when considering just the role of management.

Nowadays, there is an increasing number of detailed studies on costs performance and quality: the economic literature on hospitals activity is oriented at reconciling all these aspects.

Magee (2003) aimed at developing a methodology for improved comparability of hospital inpatient and day case activity data across Europe, and produced a pilot common data set. All EU members, Iceland and the WHO were the participants. Data on inpatients and day cases were classified by age, gender, diagnosis and type of admission; number of hospital discharges, mean and median lengths of stay and population rates were reported as well. The full data set included approximately 500.000 records. This “Hospital Data Project” was a first step aimed at making comparable hospital activities and results across Europe.

Soberman Ginsburg (2003) designed and tested a model of the factors that influence managers’ perceptions of usefulness of comparative reports of hospital performance. 344 frontline and midlevel managers with responsibility for stroke and medical cardiac patients in almost 90 acute care hospitals in the Canadian province of Ontario were involved in the analysis. 59% of managers responded to a mail survey regarding managers’ familiarity with a comparative report of hospital performance, ratings of the report’s data quality, relevance and complexity, improvement culture of the organisation, and perceptions of usefulness of the report. Variables included in a factorial analysis related to past experience, organisational tenure, performance achieved, dissemination intensity, teaching hospital status, total revenue, improvement culture.

The studied revealed how organisational context played an important role in determining line managers’ response. However, as in Romano *et al.* (1999), defensive reactions to performance data may cause those who are the subjects of performance reports to question the quality or usefulness of the data, leaving some questions open, such as how to mitigate negative assessments of data quality.

Studies based on benchmark analysis can be interpreted under this perspective.

Häkkinen and Joumard (2007) identified some methods to perform benchmarking and best practices analysis for OECD countries at three different levels: health systems, patients, providers.

Looking at the system level analysis, health outcomes may be defined as those changes in health status of the population that can be attributed to public spending on health care. These outcomes are best measured by indicators such as effects of health care on quality-adjusted life-years (QALYs). Instead, when considering more specifically individuals’ welfare, health outcomes correspond to the changes in health status attributable to health care and, once again, can be measured by QALYs, this time looking at mortality for specific diseases. Only at a professional level, measurement can be based on outputs – bed days, discharges, DRG classification. This “system approach” is suitable for relating outcomes to institutional frameworks, but require data on QALYs added by the overall health care system, data that still do not exist. An alternative measure could be represented by the number of avoidable deaths; however, it is incomplete by definition, as it does not reflect the quality of life and the type of assistance received.

The second approach reduces the interference of non-policy factors, concentrating on individuals, but is necessarily selective. Moreover, it does not allow to assess the impact of specific services (outpatient care and pharmaceutical in particular) on outcomes since data are often unavailable once the patient has been discharged.

The approach focusing on providers gives useful insights on efficiency in delivering a given set of outputs but it presents difficulty to control for case mix and quality of care: neither risk adjustment factors nor patients' assessments are considered.

Overall, the various approaches could be seen as complementary rather than exclusive and applied in comprehensive quality analyses.

Hagen *et al.* (2006) analyze the effects of a reimbursement reform, that replaced a capitation-based block grant system by an activity-based system, on hospitals' efficiency and quality, measured as patient experiences. A mixed model approach was applied to data on efficiency and patient satisfaction from 213 hospital departments before (1996) and after (1998, 2000 and 2003) the reform. While the efficiency ratings were developed at the level of the hospital using DEA, the patient satisfaction scores were obtained at department level data and were then calculated from patient surveys. The paper focuses on four dimensions of patient experiences: general satisfaction, that is the patient's overall confidence and satisfaction with hospital stays); information provided by hospital staff; nursing services, that summarizes experiences with nurses' care and professional competence; doctor service, that concerns patients' experiences with doctors' care and their competence. Higher efficiency was found in local and county hospitals, probably explained by differences in teaching load, research activities, and differences in the volume of acute services. Only five hospitals collected data for the four year of the analysis, whereas complete panel data should be used.

The variation in patient satisfaction (as well as other patient outcomes) seems related to respondents' characteristics than to the resources available for treatment: this circumstance would imply how the use of individual data instead of department level data should be preferred.

In a paper of 2010, Aiura and Sanjo analyzed a duopolistic health care market in which a rural public hospital competed against an urban public hospital on medical quality.

The theoretical framework is based on a Hotelling-type spatial competition model, extended into a two-region model. A definition for quality of service provided by hospitals developed by the authors, employed a multidimensional vector including various aspects of medical and non-medical quality. Although quality indicators were not specified in details, quality was recalled as one of the arguments of a welfare function and drives the competition between rural and urban hospitals.

In a broader perspective, measures of health outcomes are used to inform health policies, to produce indicators of performance for hospitals or to evaluate health care reforms (Farrar *et al.*, 2009). Use of outcomes to compare quality of care assumes that variation due to other factors can be properly accounted for, so that any residual variation in outcomes, such as observed mortality and morbidity, is indicative of variation in quality of care. However, definitions of outcomes can vary considerably across institutions, influencing the comparability of data.

More recently, Papanicolas and McGuire (2011a and 2011b) focused on quality aspects in two papers; while the first one calculates latent outcome measures, the second one apply such measures within Vector Autoregressions (VARs) estimations.

In their works, the authors applied the method developed by McClellan and Staiger (1999) to measure quality: the estimates reflect different dimensions of quality, and relate to structure (type of hospital), process (type of intervention), and outcome (mortality). Current and past quality of care within and across NHS Acute Trusts was considered, using the Hospital Episode Statistics for a period of 13 years for specific clinical conditions (AMI and Hip Replacement). By using hospital-specific intercepts derived from a patient level equation which maps quality of outcome (mortality and readmission rates at different time intervals) against patient characteristics, latent measures of quality are created. Latent outcome measures filter out much of the estimation error that is otherwise present due to systematic differences in patient mix across hospitals rather than differences in care. A latent variable approach represents an improvement comparing to other methods, as it provides a composite measure of quality for each provider.

Latent outcome estimates of hospital quality have a number of attractive features. They can incorporate information on quality measures in a systematic manner, are relatively easy to compute from available data and overcome the risk of over-estimation which is common when aggregate data are combined with individual observations. Hospital intercepts, which estimate the mean value of quality measure holding patient characteristics constant, are less noisy and less likely to be inconsistent estimates than crudely observed aggregate measures of hospital quality.

The results of both papers indicate which dimensions of hospital performance are persistent across different conditions, how much they vary across hospitals and over time, and provide insights as to their relationship with each other.

When managing data about mortality and readmissions related to single structures and some specific conditions, the approach based on latent variables appears to be consistent and likely to identify which factors (including institutional factors or information linked to the reimbursement system for hospitals) have a positive impact on quality.

The next objective of the review will be that of identifying which elements have been considered when defining quality, adopting several perspectives (patients', providers', regulators') and which results have been achieved.

### 1.4. Different perspectives for quality: patients, providers, third-party payers.

It has been seen, so far, how quality is a complex notion, that cannot be defined by using only one or few indicators: analyses of quality followed a pattern along years, going from efficiency analyses to structure-outcome-performance studies, to patients' satisfaction works.

This evolution is accompanied by a change in the perspective adopted in establishing the objectives of each project or to comment the results of the same studies.

There are different perspectives in evaluating quality: analyses focused mainly on patients' satisfaction have been spreading during the last five years.

Quality can be also defined by looking at hospitals' performances and the role of providers, as in studies based on structure-process-outcome: in this context, the main elements to consider are the clinical staff, the amount of hospitals' inputs, etc..

Analyses based on the effect of institutional factors on quality consider the leading role of third party-payers (i.e. NHS, Regions) and of reimbursement schemes as well.

Indicators of quality vary, of course, accordingly to the perspective considered.

On the basis of these considerations, another short survey has been carried out, with the objective of identifying the indicators more frequently used in defining quality. This time, criteria to select appropriate indicators for quality have been based on the frequency of use in the last five years and on their reliability. The literature research differs from that carried out in the previous section, that was aimed, instead, at summarizing conclusions of studies focusing on quality. Here, the aim is to verify how selected indicators have been employed in quality analysis, looking at different perspectives: third-party payers' perspective and the role of reimbursement systems have been especially considered.

The literature research has been done on www.pubmed.org, first by using the algorithm [indicators of quality, hospital care] and limiting the research to studies published in the last five years. More than 2600 studies were found. Successive researches were done using the PICOTS criteria[6] outlined in INTERQUALITY WP1 - Description of the Lit Review, carried

[6] The PICOTS criteria (**p**opulation, **i**ntervention, **c**omparator, **o**utcomes, **t**ime, **s**etting) were defined as follows: **P**opulation: any human population, anywhere in the world, that received care under provider payment system(s) that were the subject of study; **I**ntervention: studies must compare two or more payment systems for hospitals; physicians; non-hospital, short-term facilities; **C**omparator: the comparator was an alternative provider payment system or a major variant on a system; **O**utcomes: one or more of the three broad outcomes of interest to the InterQuality project: Quality, cost/utilization, and access. Specific categories within the broad outcome of quality include, but are not limited to: health outcomes, such as morbidity, mortality, and quality adjusted life years (QALYs); intermediate physiological outcomes, such as blood pressure or cholesterol levels; clinical care processes, such as following guidelines; process outcomes, such as readmission rates or adverse patient safety events; structures, such as accreditation and certification; patient experience; and disparities in quality; **T**ime:

out by the Urban Institute of Washington. The results of the research, focusing on indicators of mortality, morbidity, intermediate physiologic outcomes, clinical care process, patients' satisfaction, disparities in access to health care, and to the impact of payment systems on quality of care provided, were compared with the results of the INTERQUALITY bibliographic review.

The indicators that were identified have been distinguished as follows:

- indicators of quality according to patients' perspective: hospitalization rates; mortality rates for some clinical conditions; satisfaction from hospital care;

- indicators of quality according to provider's perspective: average length of stay weighted according to the case mix; percentage of discharges from surgical units with medical DRG over the total discharges from surgical units; quota of home care assistance over the total volume of services; percentage of admissions at emergencies; percentage of admissions presenting DRGs likely to be inappropriate; professional knowledge; access to health care and equity; quality of hospital management;

- indicators of quality of care related to third-party payers, such as the ownership of hospitals, the level of private and public funding including out-of-pocket payments, PPS related funding comparing with other typologies of funding or territorial differences in the characteristics and composition of hospital care funding

In the following table, the indicators related to each perspective of analysis, are summarized.

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Studies had to have been published in 1986 or later, a long period that should capture studies of the first nationally prominent change in payment systems, the adoption of diagnosis-related group (DRG) case payment for hospitals in the U.S; **S**etting: studies had to deal with care by hospitals.

**Table 1. Quality indicators according to the perspective of analysis.**

| Perspective of analysis | Quality indicators |
|---|---|
| Patients | 1) hospitalization rates;<br><br>2) mortality rates for pathologies representing the most frequent causes of death: cancer and cardiovascular diseases;<br><br>3) satisfaction from hospital care:<br>- responsiveness,<br>- good patient care (clear explanation and communication)<br>- good reputation<br>- good doctors<br>- cleanliness<br>- up-to-date equipment,<br>- limited noise,<br>- adequateness of food. |
| Providers | 1) Average length of stay weighted according to the case mix;<br><br>2) % discharges from surgical units with medical DRG over the total discharges from surgical units;<br><br>3) home care quota;<br><br>4) % admissions at emergencies;<br><br>5) % admissions presenting DRGs likely to be inappropriate;<br><br>6) professional knowledge;<br><br>7) access to health care – equity;<br><br>8) quality of hospital management. |
| Third-party payers | 1) ownership of hospitals;<br><br>2) level of private and public funding including out-of-pocket payments;<br><br>3) PPS related funding comparing with other typologies of funding;<br><br>4) territorial differences in the characteristics and composition of hospital care funding. |

Another literature research has been done again on www.pubmed.org for each of the above mentioned quality indicators. This time the algorithm of research used has been [*selected indicator* AND quality of care AND hospitals]; as before, the research has been limited to studies published in the last five years.

**Patients' indicators**

About hospitalization rates, 130 records were found. Hospitalization rate is, the most of time, the main indicator for quality of hospitals outcome (Chang and Troyer, 2011; Jackson *et al.*, 2011; Liotta *et al.*, 2011; in Berchialla *et al.*, 2010, hospitalization rate is a proxy for a more comprehensive quality of life evaluation; Billett *et al.*, 2008). Information on hospitalization rates derive mainly from administrative data submitted by acute-care hospitals (Chang and Troyer, 2011), number of discharges of county residents divided by county-level population estimates (Jackson *et al.*, 2011), or, for specific countries, data sources as the Italian Hospital-Discharge Registries (Liotta *et al*., 2011) and the Hospital Episodes Statistics for England (Billett *et al.*, 2008).

Mortality rates were considered for cancer and cardiovascular diseases, that represents the most frequent causes of death. 303 records were found (109 for cancer mortality and 194 for cardiovascular diseases). Among the latest studies employing mortality rates as measure of hospitals quality there are Goossens-Laan *et al.*, 2011; Eapen *et al*., 2011; Lau and Litman, 2011; Osler *et al.*, 2011; Elferink *et al.*, 2010; Gasper *et al.*, 2009; Chua, Palangkaraya and Yong, 2009.

Information on mortality rates were retrieved from National Cancer Registries (Goossens-Laan *et al.*, 2011; van Westreenen *et al.*, 2011, Osler *et al.*, 2011). National Registries and data collected by patients' associations allow to consider several thousands of patients. Wider health information databases – Medicare – were used by Osler *et al.*, 2011; Joynt *et al.*, 2011; Girotra *et al.*, 2010). Other studies considered administrative data on hospitalizations and discharges, linked with National Registries data (Friese and Aiken, 2008). Finally, there are observational studies, as Eapen *et al.* (2011), which developed composite indices of health care performance for acute myocardial infarction from 334 hospitals participating in a quality improvement program; Lau and Litman, 2011, which conducted mortality reviews of the 50 most recent inpatient deaths at 11 hospitals in Southern California region, or Seccareccia *et al.* (2011), which observed patients undergoing a coronary artery bypass graft (CABG) procedures at 26 Italian cardiac surgery centers, within a national prospective study on short-term outcomes carried out in Italy.

For cancer, mortality rates are mainly evaluated at 30 days (when a surgery occurred) or one year, whereas for cardiovascular diseases, mortality rates are mainly considered at 30 days.

Satisfaction from hospital care consists of several elements to be exploited through surveys. Some key elements through which patients may evaluate hospitals quality are: responsiveness (that is the capacity to respond to patients' needs), good patient care (that should be based on clear explanation and communication), good reputation of the hospital, doctors' competence, and some factors related to the same structure, as cleanliness, up-to-date equipment, limited noise, adequate food.

327 records were found. Among the elements most frequently examined there were the hospital environment and nurse-physician relationships and satisfaction with waiting time, comfort, physicians' technical skills, and the level of collaboration between physicians and nursing staff (as in Shen *et al.*, 2011).

Data about patients' satisfaction were mainly retrieved through questionnaires based on EQ-5D, SF-36 and other internationally validated scales (Gifford *et al.*, 2010) or *ad hoc* questionnaires (as in Bjertnaes, Sjetne and Iversen, 2011; Schoenfelder, Klewer and Kugler, 2011; Shen *et al.*, 2011).

Questionnaires were administered by external investigators through individual interviews (Pitrou *et al.*, 2009; Nakano, Main and Lomborg *et al.*, 2008) or posted questionnaires (Bjertnaes, Sjetne and Iversen, 2011; Schoenfelder *et al.*, 2010), and the observed rate of response was relatively high.

Overall, safety indicators were dominant when assessing quality by looking at patients' perspective. However, other aspects emerged, as the patient-centeredness, the coordination or continuity of care, especially for chronic conditions. Recently the emphasis has been posed on communication and patient education, on the assumption that a higher patients' involvement could improve their compliance as well (Gitto, 2010); nonetheless, there is still a limited number of studies focusing on emotional support or involvement of caregivers.

**Providers**

One of the indicators of quality most frequently used in the literature was the average length of stay weighted according to the case-mix, followed by the percentage of discharges from surgical units with medical DRG over the total discharges from surgical units.

These variables are not employed exclusively, but are often used together with other variables to define quality. In Morikawa (2010), average length of stay, obtained through administrative data, was specifically used as a measure of quality for hospitals.

Data about discharges (obtained by looking at hospital records) are employed together with patients' satisfaction (data retrieved through questionnaires) and rate of medical errors as measures of patient safety.

44 records were found when the algorithm of research [integrated home care quality analysis hospital] was considered. Home care has been evaluated both from a quantitative (amount of resources employed) as well as a qualitative (satisfaction about home care assistance) perspective.

Administrative data concerning resources necessary for guaranteeing home care per year were: the number of physicians, the number of patients, number of activities/million inhabitants/year (including, within these activities home visits, consultations, advising services, coordination meetings, educational meetings) (Herrera-Kiengelher *et al.*, 2007); other questionnaires administered to patients and their family were aimed at assessing the coordination between the community service and the hospital (Monterosso *et al.*, 2007).

173 records were found by using as algorithm of research [admission emergencies quality analysis hospital]. This indicator was employed in retrospective analyses (as in Studnicki, Platonova and Silver, 2011; Venkatesh *et al.*, 2011; Boyle *et al.*, 2011).

The effectiveness of emergency departments in managing urgent cases was considered in some qualitative studies (Weber *et al.*, 2011) that looked at surveys and questionnaires administered both to patients and staff: patients were asked to evaluate waiting times and communication with medical staff while physicians assessed aspects as workload and hospitals medical equipments.

Admissions at emergencies have been considered together with length of stay at emergencies (Tsai *et al.*, 2010). Cost opportunity of time at emergencies has been meant as indicator of quality as well (Lucas *et al.*, 2009)

Data related to admissions at emergencies have been mainly retrieved through National databases. Some studies carried out in the US used the National Hospital Ambulatory Medical Care Survey (NHAMCS) (Venkatesh *et al.*, 2011; Pham *et al.*, 2011); a study carried out in the UK used the Hospital Episode Statistics (HES), together with population data (Purdy *et al.*, 2011); other works considered semi-structured interviews (as Weber *et al.*, 2011); the Emergency Department Quality Study (EDQS) survey in a 6-months prospective study

(Downey and Zun, 2010); Sartini *et al.* (2007) used a questionnaire posted on the Italian Society of Emergency Medicine web page based on 18 questions.

A small number of studies employing inappropriateness – i. e. the percentage of admissions presenting DRGs likely to be inappropriate as measure of (low) quality -, was found on www.pubmed.org. The inappropriateness of care received by patients during hospital stay was evaluated as well, in terms of higher costs. A study carried out for Italy considered as indicator for inappropriateness of care the incidence of caesarean deliveries (Francese *et al.*, 2010).

Qualitative analyses, based on surveys and questionnaires, related to physicians' professional commitment and professional knowledge as perceived by patients. Professional knowledge was meant not only as medical staff's competence, but as managerial skills too (Groene *et al.*, 2010).

Data have been retrieved mainly through questionnaires and internationally validated scales (such as the Service Quality Scale and Professional Commitment Questionnaire, Teng *et al.*, 2009), semi-structured interviews (Leach *et al.*, 2009), *ad hoc* questionnaires administered to clinicians, nurses and managers (Kunkel, Rosernqvist and Westerling, 2007), or internet report cards, based on publicly disclosed data, through which consumers can review grades on physicians, hospitals, nursing homes, home health agencies, and insurance plans (Carlisle, 2007).

About equity and access to health care, 325 records were found. The greatest number of existing contribution related to the set out of a general theoretical framework within which equity of access can be examined.

Although published in 2001, a relevant contribution is that of Goddard and Smith, that considered, among areas of intervention, acute hospital care (percentage of admissions and surgeries), waiting time (Zineldin, Camgöz-Akdağ and Vasicheva, 2011; Cremonesi, Di Bella and Montefiori, 2010), or, more specifically, waiting time for medical analysis and time to process results (see, for example, Tokur *et al.*, 2011, who examined the case of MRI, whose delay in results may cause negative consequences on patients' health).

62 records were found by using the research algorithm "accreditation, organisation hospital management quality analysis".

Overall, quality of hospital management related to organisational quality as well as those factors that may influence managers' perceptions about hospital performance.

Some of the papers reviewed considered a normative approach and proceeded examining laws and regulations aimed at managing conflicts, especially between patients and physicians (such as Scott and Gerardi, 2011). Other aspects concerned the analysis of the relationship between the "organisational knowledge sharing structure and hospital coding performance" (Rangachari, 2008); analysis of accreditation and ISO certifications (looking at scores reported, as Shaw *et al.,* 2010, or Fong *et al.*, 2008).

Quality of management was detected though interviews administered to health executives, managers and clinicians who take part in the accreditation processes (Greenfield, Pawsey and Braithwaite, 2011), or by the review of laws and regulations aimed at managing conflicts within hospitals (Scott and Gerardi, 2011).

It is possible to observe patients' empowerment in quality improvement, as indications of a growing organisational culture. Although these indicators relate to providers of care, however, patients' safety and their involvement are central to each analysis.

**Third party payers**

From this perspective, indicators about quality might refer to the level of private and public funding including out-of-pocket payments; PPS related funding comparing with other typologies of funding, and territorial differences in the characteristics and composition of hospital care funding.

About these aspects, no records were found when searching on medical databases, given the policy relevance of such indicators, that are peculiar to the different countries and Regions and that have been mainly investigated by reports and specific projects.

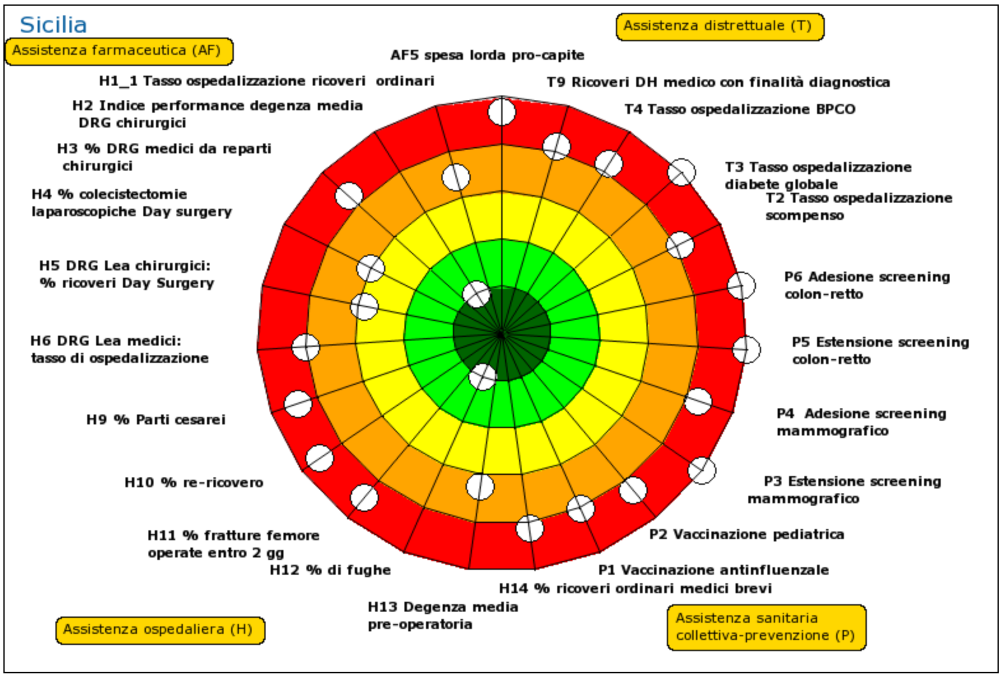
Territorial differences in the provision of health care have been measured, in Italy, through Regional analyses focusing on performances. For example a "target method" (*metodo dei bersagli)* has been considered when choosing the most appropriate weights for performance indicators of Regional Health Systems (Spandonaro and d'Angela, 2011).

Levels of utility connected to each possible performance are defined by a multi–attribute utility model: performance indicators are the attributes and are characterized by completeness, importance, measurability, independence.

The evaluation for the type and quality of health care provided by each Region is the result of a ranking process computed on the basis of a "quintile logic": Regions are ranked according to the increasing value of a given indicator and dividing their distribution into five equally large classes. Better performing Regions are those in the first quintile class while those with the worst performance are placed in the fifth quintile class. The reporting system is visually represented by a ‘‘target’’ diagram (*diagramma a bersaglio*) which is divided into five colour evaluation bands. Every year, each Region receives its own target and the more the Region is able to reach objectives and high performance levels during the year, the closer the performance indicators are to the center; on the contrary, bad performance results are represented by indicators which are positioned far from the centre.

This diagram system favors inter-regional benchmarking.

**Figure 3. Example of target diagram for the Region Sicily.**




Source: Preliminary report for InterQuality Project, WP4 (2012).

However, the role of third-party payers and the impact on quality should be looked in a different way, as it will attempted by the last part of the review, carried out in the next section. Quality cannot be defined by institutional indicators, as the type of reimbursement system. Rather, these factors are likely to influence quality, that, in turn, is defined according to patients’ and providers’ perspective.

Indicators of quality, such as hospital technical efficiency or mortality rates, can be influenced by the remuneration scheme. Hence, the institutional and financial framework should be considered as regressors in a model where the dependent variable is an indicator of quality defined according to patients’ and providers’ perspectives.

Some studies adopted mixed criteria, that combine more than one perspective to identify indicators for quality: for example, concerning the regulation for accessing hospital care, the report by Hagen, Veenstrab and Stavemc (2006) is aimed at analyzing the effects of a reimbursement reform on hospitals' efficiency and quality, measured as patient experiences. By the reform, in Norway, a capitation-based block grant system was replaced by an activity-based system. Among the main objectives, there were the increase in hospital production and the shortening of waiting lists, that determined a better access to hospital care. Data on efficiency and patient satisfaction from 213 hospital departments before and after the reform were analyzed using a mixed model approach. The efficiency ratings were developed at the level of the hospital employing a DEA, while the patient satisfaction scores were at department level data from recent patient surveys. Variations in efficiency and patient experiences with hospital care have been interpreted as a function of type of reimbursement system and other relevant variables[7].

The next step will be that of performing a literature review aimed at outlining the effects of changes in institutional framework as well in the reimbursement system on quality of hospital care. The issue of competition will be examined as well.

At the end of the survey, the importance of including institutional variables in the model and to consider several elements to study quality should be clear.

The impact of each of these factor on overall quality o hospital care will then be the objective of the empirical analysis.

[7] Another mixed indicator is represented by the autonomy of hospital management. The paper by Soberman Ginsburg (2003), already mentioned, designed and tested a model of the factors that influence managers' perceptions of usefulness of comparative reports of hospital performance. The study was not directly related to hospitals performance, but it shed light on the role of managers and their perceptions about which factors might lead to an improvement. Variables included in a factorial analysis relate to past experience, organisational tenure, performance achieved, dissemination intensity, teaching hospital status, total revenue, improvement culture. Qualitative variables have been created by considering the mean of multiple items' responses to specific questionnaires submitted to 344 managers in 89 acute care hospitals in Ontario.

## 1.5. Reimbursement systems and quality of hospital care

Incentives for quality may come from the reimbursement scheme.

Usually, hospitals payment scheme consists of some mix of different payment mechanisms, incorporating particular design features aimed at increasing or diminishing incentives provided by a base payment system (Langenbrunner, Cashin an O'Dougherty, 2009, Robinson *et al.*, 2004). Therefore, the healthcare outcomes are not the result of the particular base payment system used, but, indeed, they may depend on how that system has been implemented in a given country/Region.

The majority of OECD countries finance hospital activity by employing DRG-based prospective payment systems (PPS) (Busse *et al.*, 2011). In European countries the share of hospitals revenue related to DRGs ranges approximately from 20% in Spain to 90% in Austria. This circumstance should provide incentives to increase the quality of services, comparing to other mechanisms, as global budget systems.

The development of DRGs in the hospital sector has significantly improved the scope for adjusting aggregate output measures for case severity. An increasing number of hospital efficiency analyses were based on the concept of DRGs, with output measures typically defined as the number of discharges or the number of patient days for each group. However, as the cross-country comparability of aggregate output measures based on DRGs is limited, whereas within-country analyses dominate the literature. Even the same payment system might lead to potentially very different results according to the specific context. In fact, though payment systems (and DRG) provide high-powered incentives, the analysis of their actual realization cannot abstract from the broader institutional context which, in turn, involves a complex interaction among the cultural, political and socioeconomic landscape (Custers *et al.*, 2008).

The assumption of higher quality induced by reimbursement system as DRG can be verified by identifying appropriate indicators for quality and its variations. Effects on quality might result by looking at health outcomes, such as morbidity and mortality, adherence to guidelines and quality standards established at a national level, equity issues, or, according to the main stream of literature focused on patients' assessment – mentioned in the previous section -, patient experience.

A first indication coming from some reviews of the literature on payment schemes and quality outcomes is that there is little or no significant correlation between these aspects.

Rather, payment systems appear to impact more on costs and levels of utilization. Case payment reduces costs by approximately 6-10% relative to fee for service (Mc Cue and Thompson, 2006), although it may take many years for this effect on costs to become visible, depending on how high payment levels are initially set under a newly-introduced case payment system (Rosko and Mutter, 2010).

The first analyses based on the correlation between quality and reimbursement schemes used, as quality indicator, variations in mortality rate.

Mortality was studied especially in some US studies since the end of '80s. Payment methods and systems compared included fee for service, case payments, global budgets, capitation, pay for performance, all-payer rate setting, and competitive bidding. The datasets ranged in sample size from hundreds to millions of patients. The largest sample sizes were from analyses in which national discharge or outcome rates were collected.

Mayer-Oakes *et al.* (1988), for example, analysed outcomes for patients in the medical intensive care units of three hospitals in California, USA, after the payment change from fee-for-service to case payments. The study concerned 400 patients; 200 were admitted before the PPS and 200 were admitted after the PPS. While both groups experienced a decreased hospital length of stay, there were no significant changes in in-hospital or six-months mortality.

A wide analysis has been done by Moreno-Serra and Wagstaff (2009), who compared the effect on mortality of payment system changes in 28 Central and Eastern European and Central Asian nations. The authors considered 28 countries during a fifteen-year period (1990-2004), when many former Soviet republics and satellites changed from global budgets to case payments or fee for service, and found that switching from global budgets to case payments resulted in national standardized death rates (not inpatient mortality). This effect was due to heart disease mortality rate, that decreased approximately by 4%, and to stroke mortality, that decreased by 5% over the study period. Moving from global budgets to case payments, there was no significant impact on mortality (as measured by national standardized death rates) for five other causes of death: diabetes, breast cancer, appendicitis, intestinal disease, and adverse events.

A significant effect on mortality rate was, instead, identified in Volpp *et al.* (2003), although their analysis was limited to payment system changes in only one US state, New Jersey, during the 1990s. The change in the payment system was related to competitive bidding for per diem rates instead of to a subsidy for care of uninsured patients. It was observed an increase in inpatient heart attack mortality from 3.7% to 5.2% for uninsured patients. Another later study on the same dataset, carried out by the same authors (Volpp *et al.*, 2005) measured differences in inpatient mortality for more conditions (heart attack, heart failure, stroke, hip fracture, pulmonary embolism, or pneumonia) and found no significant changes in mortality due to the change in payment methods.

Funding levels and quality outcomes, especially for the elderly, were considered by Byrne *et al.* (2007), who observed a significant cross-sectional effect on mortality due to different funding levels that, however, did not appear when longitudinal data were used.

The measurement of quality through mortality measures is often combined with morbidity measures, such as hospitalization for specific events (heart attack, pneumonia, stroke), emergency readmission rate after inpatient treatment for hip fracture. Although some readmissions cannot be avoided, low readmission rates are often used as a proxy measure for good inpatient care quality (Ashton *et al.*, 1997).

Measurement of quality based on mortality and morbidity data was the object of the US Medicare – Premiere Inc. pay for performance demonstration, implemented in 2003. Premiere Inc. is a U.S. nationwide organisation of non-profit hospitals; more than 200 hospitals adherent to Premiere Inc. agreed to participate in the demonstration, which involved sharing quality data, mostly on process measures, and an incentive/disincentive program for Medicare patients. The baseline payment method for these patients was Medicare's DRG case payment system[8].

Findings from studies of the Medicare-Premiere demonstration are that pay for performance's overall impact on quality was little to modest.

Glickman *et al.* (2007) studied heart attack care processes in 54 hospitals from 2003 to 2006, without finding significant incremental improvement in quality of care or outcomes for acute myocardial infarction attributable to the pay for performance program. In both intervention, hospitals and control hospitals, processes improved and mortality decreased, but the amount of change did not differ between the two groups. Grossbart (2006) observed only 10 hospitals and a one-year post-intervention period, detecting 8% improvement in heart failure care quality processes, but no improvement in pneumonia or heart attack care. However, the positive effect could be due to the very small sample size and the short time period of this study.

[8] The demonstration rewarded top performing hospitals with 1 to 2% bonuses during the first years of the demonstration and took away 1 to 2% of revenues from low performing hospitals that failed to improve by the third year of the demonstration.

Jha *et al.* (2010) concentrated their attention on 251 control hospitals that collected data on 33 quality measures. The hospitals included in the sample served a disproportionate share of poor or uninsured patients: improvements in mortality rates due to a pay for performance program were less than 1% for heart attack and pneumonia care and there was no significant change for heart failure care.

Farrar *et al.* (2009) studied the effects on mortality and morbidity of English hospitals' change from global budgets to case payments with the objective to examine whether the introduction of payment by results (a fixed tariff case mix based payment system) was associated with changes in key outcome variables measuring volume, costs, and quality of care between 2003/2004 and 2005/2006. All patients admitted to hospitals in England and Scotland during the study period (10.4 million admissions to 248 hospitals), with Scottish hospitals being used as the control group (1.06 million admissions to 49 hospitals), were considered in the study. The authors examined proxy measures for output and quality. Concerning quality of care, inpatient hospital mortality, 30 day post-surgical mortality and Emergency Room (ER) admissions after hip fractures did not change significantly over the study period.

Ljunggren and Sjoden (2001 and 2003) considered morbidity as parameter to measure quality outcomes: they compared outcomes from two surgical clinics (that is, two hospital orthopaedic surgery departments) in Sweden, one of which was paid by DRGs and the other one operating under a global budget. They studied the impact of the payment system differences on self-reported quality of life after surgery. Both studies did not found any effect, although, with only one intervention hospital and one control hospital, generalization of findings is questionable.

Financial difficulties for hospitals may question the quality of care. Bazzoli *et al.* (2008) concentrated on the relationship between financial performance and quality of care: as financial pressure increases, there might be a decline in staff levels of infrastructure investments. Their analysis showed a relationship between operating margins, profitability and in-hospital mortality, but not so strong as evidenced by other studies.

In a recent work, Peabody *et al.* (2011) considered an experiment in the Phillipines to improve child health: randomly selected districts were assigned to one of three categories, "*Expanded Insurance intervention*", where hospitals were eligible for 100% of the cost of covering common infections, such as pneumonia and diarrhea, "*Bonus intervention*", where physician salary increased by 5% for reaching quality benchmarks and a "control group".

Rather than the usual pay for performance model of making bonus payments afterwards, o recompense performance achieved, this was an arrangement characterized by an anticipated payment, aimed at improving performance on the basis of increased funding. The measurement of doctors' performance was done through on standardized clinical vignettes, although this was a very indirect measure of hospital quality. It was found a 3.5% improvement in scores attributable to the intervention at three year follow up.

Looking at the Italian situation, the institutional framework is fragmented, because of Regional differences. There are no many studies for Italy investigating the role that payment systems might have on hospital outcomes (Louis *et al.*, 1999).

Berta *et al.* (2010) carried out a study for the Lombardy Region. The authors started from the consideration that case payment systems often have pairs of DRGs differing only in the circumstances that one DRG of the pair is for patients with complications or co-morbidities, and that the payment for that DRG is higher. This situation might lead to an "upcoding", in which hospitals record all complications and co-morbidities and obtain the higher payment rate for many patients who should not be included in the DRG "with complications". The Lombardy Region in Italy addressed this problem by adding a condition to its DRG system and admitting higher payments for patients with a length of stay of at least a specified minimum duration. Hospital stays affected by the minimum length of stay rule decreased by 4%: this result demonstrates that patterns of discharges are affected by financial incentives.

Other effects induced by DRG system related to the degree of competition in the hospital market. Hospital revenues depend on the number of patients hospitals actually serve. Therefore, this funding scheme brings in the system a clear element of competition for patients and, consequently, a boost toward higher hospital quality (see, for a review of the effects of competition in health care, Propper, Burgess and Gossage, 2008 and Propper, 2012. Positive results in terms of lower mortality rates have been examined by Cooper *et al.*, 2011).

Indeed, the theoretical literature on this topic shows that, as long as there is competition in the market for attracting more patients, PPS provide incentives to increase the quality of services (Beitia, 2003; Brekke, Siciliani and Straume, 2008, 2011). However, the degree of competition in this market is strongly related to the demand responsiveness to quality differentials: if the demand is not elastic, the stimulus of competition might be more theoretical than real (Brekke, Siciliani and Straume, 2011; Tay, 2003; Howard, 2006).

Another feature of the context potentially relevant in influencing the actual realization of the incentives provided by PPS is the hospital type (private and public hospitals, for-profit and not-for-profit hospitals) and their interaction within the same environment (Milcent, 2005; Palangkaraya and Yong, 2012).

Indeed, it could be expected a difference in performance when considering hospital ownership types, since they have different objective functions. In particular, authentic not-for-profit hospitals should assign more weight to non-financial motivations respect to for-profit hospitals, which might induce not-for-profit hospitals to care more about the quality of treatment, regardless the economic convenience of a particular treatment, as well as the type of patient. On the other hand, not-for-profit hospitals should act under a softer budget constraint, both in terms of profit confiscation and in terms of bailout, which might significantly weaken the incentive to compete in quality provided by PPS (Brekke, Siciliani and Straume, 2011).

Therefore, the interaction among different types of hospitals should be evaluated: there might be different hospital types relative weights for every country. For example, in the US only one-quarter of hospitals are government owned, whereas in France one hospital out of three is public owned and in Italy even about 45% are public hospitals. On the other hand, whereas in the US the majority of privately owned hospitals are not-for-profit, in Italy almost all the privately owned hospitals are for-profit.

The next section will review the normative reforms that have regarded Italy together with the specific programs that have been developed mainly at a central level to assess quality of care and, especially, hospital care.

### 1.6. Quality issues in Italy: a regional matter

Although modified by legislative decrees and constitutional laws, which devolved responsibilities for the effective provision of health care services to Regions (such as the legislative decree 19/06/1999 n. 229 and the Constitutional Law 21/10/2001, n. 3), the Italian central government still keeps the crucial role to establish the main guidelines and to identify the Essential Levels of Care (*Livelli Essenziali di Assistenza,* LEA), that is, the minimum level of health care services the Italian Regions have to guarantee to all individuals in their territory.

Indeed, the National Health Plan, a three-year document (the last is the *Piano Sanitario Nazionale 2011-2013*), not only defines those health services to be guaranteed, but also identifies the main critical aspects, states the strategic lines for the development of the system and, in particular, fixes the objectives to be achieved in the triennium. Since these objectives are often chosen so as to be measurable, to some extent the institutional monitoring of the actual realization of these objectives can be considered as a first tool in the Italian National Health Service (NHS) allowing for some evaluation of the appropriateness, quality and outcome of health care.

Although in recent years Italy has experienced an increasing interest toward the issue of assessing the quality of health care, national projects and initiatives are still very few.

Indeed, at a national level the monitoring of LEA should represent one of the most structured systems of multidimensional evaluation, aimed at improving the efficacy of the quality of care assessment procedures.

At the moment, only other two programs of performance evaluation have been experimentally tested using empirical national data: they are the National Program for Outcome Assessment (*Programma Nazionale Valutazione Esiti, PNE*, that constitute the informative basis for the empirical analysis, that will be carried out in the next section) and, at a regional level, the system of performance evaluation carried out by one Italian Region, Tuscany.

Other quality evaluation experiences are either national-based, or regional-based. Compared to national initiatives, the number of regional projects is very large, albeit information on these researches are quite lacking.

Some specific tools designed for quality assessment, that are predetermined at a central level, are the LEA monitoring and the accreditation procedures. Regions have seen an increasing competence in the monitoring procedure, but their role is still merely operative, as normative rules are defined at a central level.

The monitoring of the LEAs by the Italian Regions takes place through a large set of data which try to capture important aspects of the health care in the national territory, included those concerning the quality as well as the efficiency of the health care provision.

The legislative decree n. 56/2000 has designed a **Guarantee System** (***Sistema di Garanzia***), accompanied by a process of *Verifica Adempimenti* (Fulfilment Verification), that is carried out by a Permanent Committee for LEA Verification (*Comitato Permanente per la Verifica dei LEA*).

The Guarantee System follows the legislative provisions of the Ministerial Decree 12 December 2001, with the aim of collecting, elaborating and, then, publishing a set of indicators relevant for monitoring the actual provision of LEA. The same decree establishes that such a set of indicators has to be revised and updated annually, in order to consider the potential evolution of the healthcare system. For this purpose, a permanent mixed working group was established, with members from the Ministry of Health, the Ministry of Treasury, the National Institute of Statistics, the Italian Regions and other experts. From 2001, the results of the monitoring activity are published in an annual report widely diffused, available on the Ministry of Health website.

The other monitoring system is constituted by a set of indicators, called **LEA Grid** (***Griglia LEA***), used for the synthetic evaluation of objectives and performances established by the National Health Plan. The selection of indicators, made by the Permanent Committee for LEA Verification, reflects the distribution of resources among the levels of care as well as the main strategic guidelines indicated by the National Health Plan. As for the Guarantee System, the set of indicators used is annually revised by an established panel of experts. This group operates on three different levels evaluating the reliability, significance and relevance of each indicator and, in accordance, decides on the confirmation, modification or substitution of them. Moreover, the panel of experts also deals with problems related to calculations, sources of data and data gathering for all indicators.

The main aim of this process is the identification of a general evaluation scheme, including weights and thresholds for each indicator and assigning a score for the level of each indicator in a Region respect to the national standard. Then, in accordance to the final regional score, the Ministry of Health gives the certification of "*fulfillment*", "*fulfillment with* *commitment*" or "*non fulfilment*". Those Regions getting "fulfilment" in all items gain access to rewarding funds.

The statistical data source collected through these procedures are shared nationwide and constitute the *Nuovo Sistema Informativo Sanitario* (*NSIS*, New Health Information System). Into the NSIS flows the detailed data on all health services, detected through telematic channels, made available to Regions and local health units. This comprehensive database is the main reference for the Ministries of Health and Treasury. While, on one hand, NSIS supports the former in the national health planning, the guiding and monitoring of quality in reference to LEA, on the other hand, it supports the latter for the coordination and verification of health care spending.

Another data source for the evaluation of the Italian NHS is the *Annuario Statistico Nazionale* (National Statistical Yearbook), that detects accurately data on the supply system, the number of beds and the number of private accredited providers, therefore allowing to check if the Regions have satisfied the national parameters settled about hospital beds endowment, development of the district health assistance and NHS staff.

The second normative pre-determined procedure for guaranteeing a certain level of quality in the NHS healthcare provision is the **accreditation procedure**. It has been settled with the legislative decree n. 502/1992 and later modified with the so-called "third health reform" (legislative decree n. 229/1999).

The provision of LEA competes to hospitals which may be directly managed by the *Aziende Sanitarie Locali* (ASL, the local health units), called *Presidi Ospedalieri*, as well as other providers, either public trust (*Aziende Ospedaliere*) or private accredited. The institutional accreditation signals the reliability of each structure involved in the health care provision: any provider (either private hospitals, nursing homes, general practitioners, etc.) has to comply with the established requirements in order to be accredited.

There are two levels to pass in order to be accredited.

The first level is established by the central government through the *Atto di Indirizzo e Coordinamento* (Guiding and Coordinating Act), that is enacted according to some guiding principles related to quality. Each provider must guarantee, first of all, structural and technological equipments appropriate for quantity and quality; moreover, forms of citizens empowerment have to be considered as well.

In the second level of qualifications, there is a broader role of Regions, that carry out the administrative procedure leading to the accreditation.

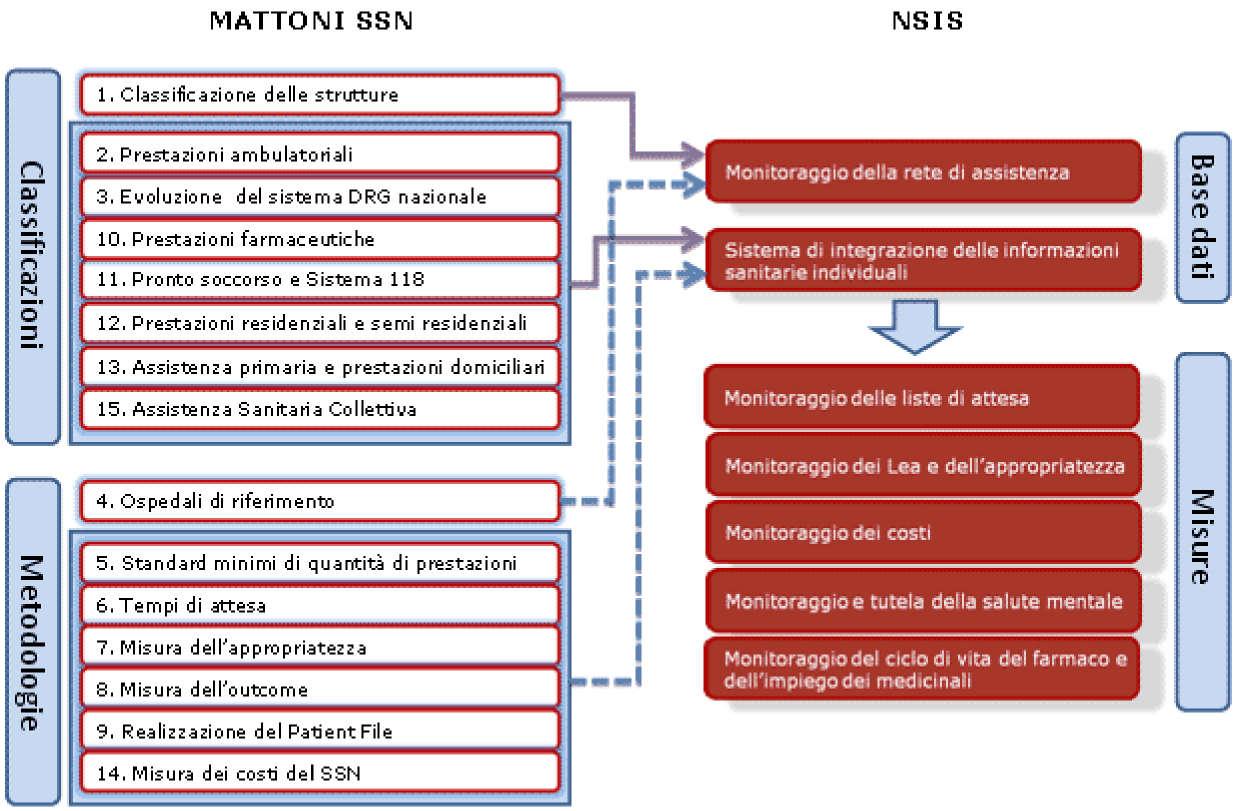
The same act which regulates the accreditation procedure also explicitly provides for a deep control system, especially related to the quality of medical care. In particular, the article 8-octies of the law provides that "*with the aim of guaranteeing the quality of health care to all citizens, Regions and ASLs activate a universal monitoring and control system on the quality of health care and the appropriateness of health services*".

The main operating utilizations of the quality monitoring and control system should be essentially two. The former utilization, managed directly by Regions, is to check periodically the full compliance of providers with the minimum quality standards required for getting the accreditation. Therefore, this first application of quality indicators tries to approach the quality issue from a micro perspective. The second use of the monitoring system is to provide the Ministry of Health with a powerful instrument to evaluate the attainment of the macro objectives established in the PSN and, more generally, to appraise quality trends and differences across Regions. In particular, the Ministry of Health should state every year about these macro evaluations in the Report on the State of the Health care System.

In the vision of the Italian NHS, together these two applications of the quality monitoring and control system are expected to be part of the national quality implementation strategy and, to some extent, should be able to guarantee a certain level of quality in the health care for all citizens (InterQuality Project, 2012).

Another project settled out with the objective of quality measurement was the *Progetto Mattoni* (*Bricks Project*), approved by the by the "Conferenza Stato-Regioni", a discussion table involving both the national and the regional level of Government in 2003. The "Mattoni" Project aims at defining a common strategy to compare data and information collected through the already mentioned NSIS. The latter constitutes the basis to develop indicators for quality analysis.

**Figure 4. Main contents of the *Progetto Mattoni*.**



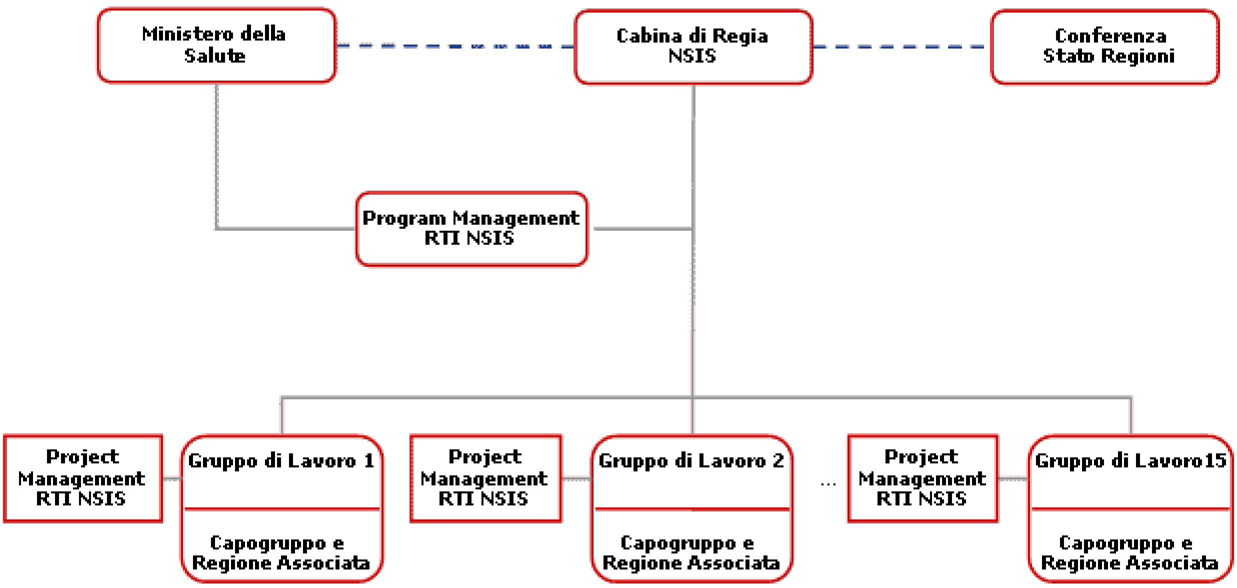

Source: Progetto Mattoni, Ministero della Salute.

Fifteen different issues have been considered for the *Progetto Mattoni*; several working groups have been appointed with the task to analyze each issue. Each working group was compounded by a "leading" Region, an "associated" Region, and other Regions, together with research institutes an institutional subjects.

While the leading Region had the task to define the activities to follow, and to allocate the available budget or the project, the associated Regions gave a contribution in terms of know-how.

The governance of the project was attributed to the Ministry of Health and to a "production room" (*Cabina di Regia*), created in June 2002 with the aim of coordinating and monitoring the implementation of the NSIS. The Ministry of Health could be supported by a group of private enterprises (such as, Kpmg Advisory – leading enterprise -, Price WaterhouseCoopers, Sin&rgetica and Nolan Norton Italia).

**Figure 5. Organisational structure of the *Progetto Mattoni*.**




Source: Progetto Mattoni, Ministero della Salute.

The main objective of the *Progetto Mattoni* has been the development of a "common language" to compare available information on costs and effectiveness of health programs in quality analyses.

The 15 "bricks" identified for the project are classified as follows:

01 – Classification of structures: it is aimed at mapping each structure, public or private, providing health care in the national territory.

02 – Classification of outpatient services: the aim is that of defining a new national list of outpatient services in accordance with the LEAs, so as to update the current LEA list that traced back to the Ministerial Decree of 1996 and to make it consistent with the requirements of the NSIS.

03 – Evolution of National DRG system: a common informative basis for hospital care is set out, by employing, as classification system, the International classification for diseases and traumatism ICD 9 CM 2002. The contents of the discharge forms (*schede di dimissione ospedaliera, SDO*) is revised too.

04 – Reference Hospitals: the aims is that of defining a methodology suitable to identify reference centers for highly specialized care and for the treatment of rare diseases. Such "excellence" centers are grouped into a network both at national and regional level, so to

guarantee uniformity of treatment to all patients on the basis of common protocols and guidelines. Assessment of structures is based on organisational and structural elements.

05 – Minimum standards for quantity of services: it is aimed at monitoring the LEAs by applying quantitative analysis. A common definition of standards helps to collect information useful both at national and regional level for planning new investments and keeping high the level of quality.

06 – Waiting times: long waiting times are often seen as a signal of inequity of access. Waiting times are distinguished into "expected" and "effective" and concern both hospital and outpatients services. A methodology for the systematic analysis of these two categories of waiting times is developed. Guidelines for setting out the Unified Booking Centres (*Centri Unificati di Prenotazione*, CUP) are established, in order to stratify the demand according to priority criteria and to measure waiting times for single diagnostic therapeutic pathways.

07 – Measurement of appropriateness: the aim is that of refining the tools already available to evaluate appropriateness of hospital care as well as of other essential levels of care (pharmaceutical, outpatient, day hospital, day surgery, etc.) and to favour integration at a conceptual and operational level, between the organisation (care settings) and clinical appropriateness dimensions.

08 – Outcome measurement: the outcome of health interventions is systematically evaluated at a level of both providers (supply) and population (demand). In particular, the aim is that of identifying and experimenting appropriate methodologies to define, measure and evaluate health care outcomes, not only using existing but still not systematically applied tools but also defining new ones.

09 – Implementation of a "Patient File": it consists in the collection of information useful to build a report for each patient and in the developing of common guidelines to organise each file.

10 – Pharmaceutical care: the aim is that of defining a system for monitoring consumption of drugs distribution in the behalf of the NHS through either pharmacies or the so-called direct distribution (according to Law n. 405/2001) or hospitals. Pharmaceutical consumptions are monitored through a network connecting the general practitioner, the hospital, home and residential care to the patient.

11 – Emergencies: a common methodology referring to the system of emergencies is developed in order to allow the exchange of information between the national level of NSIS and regional health systems. Common classification systems are especially focused on the

triage system and the telephone number 118 for emergencies; methodologies to evaluate activities, appropriateness and outcomes are developed as well.

12 – Residential and semi-residential care: a common base of analysis to evaluate residential and semi-residential care for the elderly and disabled people is developed. Such classification system regards long term and rehabilitation care as well.

13 – Primary and home care: once again, a common base of analysis is developed for identifying which health services to include into primary and home care.

14 – Measurement of NHS costs: methodology to calculate costs is revised so as to standardize budgets both at a intraregional and interregional level. Costs are distinguished according to each structure and each essential level of care, based on analytical accountability data; the new EU accounting methods are used.

15 – Collective health care: it is focused mainly on collective health care, once again by looking at those services included in the LEA Collective Health Care (Ministerial Decree 29 November 2001), in order to make easier the evaluation of performance in this field both for Regions and at a national level. In this brick, it is included as well the aim of proceeding with specific pharmacovigilance programs for chronic diseases (such as vaccines and screening for oncologic diseases).

Information collected have been used to improve the allocation of resources within ASLs, at a regional level and to favour the national monitoring of the LEAs provided by the Ministry of Health at a central level.

Overall, the system based on the *Progetto Mattoni* is coherent with the consideration that health care performance has a multidimensional nature: all dimensions of performance should be made clear and represented by the selected indicators. Efficiency, effectiveness and quality are different dimensions of the whole performance.

There are two perspectives that is possible to identify in the *Progetto Mattoni*: the first one concerns the NHS. Issues specifically related to a national/regional perspective are 1), 2), 3), 10), 11), 12), 13), 14), 15). Then, the perspective of providers has been considered, with issues 4), 5), 6), 7), 8), 9).

The National Program for Outcome Assessment (*Programma Nazionale Valutazione Esiti, PNE*) has been carried out by the National Agency for Regional Health Services (*Agenzia Nazionale per i Servizi Sanitari Regionali, AGENAS),* appointed by the Ministry of Health. It was partly based on the results of the *Progetto Mattoni* and the Regional Outcome

Evaluation Program of Health Care in Region Lazio (*Programma Regionale di Valutazione degli Esiti degli Interventi Sanitari del Lazio, P.Re.Val.E.*.

The PNE program is intended to assess the health care activity of all Italian hospitals, either public or private accredited, which provide services on behalf of the SSN. The observation units are both the hospitals and the ASLs.

The project draws conclusions that can be helpful for Regions which can hence identify areas of criticisms in the provision of their health care. However, it does not allow to perform any comparison between Regional health systems.

Its specific objectives are:

- the assessment of the “efficacy” (theoretical efficacy) of health interventions for which it is not possible to do randomized trials;

- the assessment of the “effectiveness” (operational efficacy) of health programs for which experimental analyses can be done. In this case, the analysis considers the difference between the effectiveness tested experimentally and the effectiveness observed in real conditions;

- the assessment of the performance of providers, physicians, local health units concerning accreditation, remuneration and information procedures. Outcome results have to be published, stressing the aspects of citizens’ empowerment and quality assessment;

- the assessment of quality across population groups, assuming as main objective the equity of access to health care services, according to the area of residence and the socioeconomic level;

- the assessment of the factors that are likely to determine better health outcomes: for example, which is the minimum level of activity that maximizes results in terms of health improvement for the population? Can the minimum level of activity be used as a criterion for accreditation of structures?

- the monitoring of the levels of assistance provided.

The assessment of health programs has been carried out through observational studies, focusing on the outcomes of health interventions and treatments.

The outcome assessment is based on discharge data collected in the time span 2005-2010 and the study population is represented by all the Italian residents at the date of January 1st, 2010. Trends about the implementation of health programs have been estimated for all areas and for all structures whose level of activity is higher than a threshold, determined for the year 2010.

Data employed in the project are those collected within the Informative Hospital System (*Sistema Informativo Ospedaliero*, *SIO*) that regards all hospitalizations for acute and post-acute conditions in Italy, and, where available, from the Informative Systems for Regional Mortality (*Sistemi Informativi di Mortalità Regionali*).

The main instrument for data collection is the hospital discharge form (*scheda di dimissione ospedaliera, SDO*) which contains information related to all patients discharged from public and private structures. It has been instituted by the decree of the Ministry of Health 28th December 1991 and has been revised in 2000.

The decree of the Ministry of Health no. 380/2000 established general rules for the codification of clinical data (diagnosis, surgical interventions, therapeutic procedures), that has to employ the system ICD 9 CM. Data contained in the discharge form relate to patients' age, gender, residence, hospitalization date, code for the structure, other information related to the hospitalization, main diagnosis and other five secondary diagnoses, main intervention and other secondary interventions, date of discharge, information about DRG, etc..

Outcome measures considered by PNE project include mortality data, readmissions, hospitalizations for specific conditions, surgical procedures, complications following surgical interventions, waiting times.

Overall, 45 performance indicators (32 related to hospital services and 13 to hospitalization) were computed.

At present, there are no mechanism of incentives/penalties associated with the program, whose results, therefore, have only an informative value for Regions. Although the analysis is based on a comparison across hospitals and ASLs, Regions are primarily interested in the results of the project.

Information obtained can be used for further assessment programs, clinical and organisational auditing. Indeed, AGENAS identifies the less efficient structures and those ASLs that require an immediate intervention, and signal these cases to the Regions.

## 1.7. Conclusions

The review carried out in this first chapter has explored the relevant literature on the quality of hospital care, following three different lines of research, that can be summarized as follows:

1. First, it has been evaluated how quality has been studied across time.

2. Second, it has been appraised which indicators have been used more frequently and the results achieved

3. Third, the impact of "institutional" indicators has been assessed. Instead of constituting autonomous measures for quality, these indicators have to be regarded as explanatory variables. There are not many contributions based on the impact of reimbursement systems on quality of care; for this reason, an empirical analysis that would include these factors among the covariates would be innovative and likely to provide relevant policy implications.

The selection of the studies mentioned in the review has been done by considering several algorithms of research. Although the concept of quality started to be developed from the mid '60s on, the greatest part of the studies reviewed is relatively recent; it is possible to foresee how the future tendency of studies focusing on quality will certainly be based on patients' perspectives and on their preferences and evaluations.

Looking at the methodology applied in all the studies and at the variables selected, some proxies can be identified as best indicators for hospital quality. Mortality rates for acute conditions represent the sum of professional knowledge and technical skills likely to determine tangible improvements (= number of lives that can be saved) in population's health. Analogously, readmissions few days/weeks after the discharge may constitute the signal of a low quality for the assistance received.

In the light of these considerations, data about mortality and readmissions will be considered as proxies - dependent variables in the empirical analyses performed in the next chapters.

## Appendix

### Quality in international databases. Reports and research projects

International databases containing indicators relating to hospitals' activities and use of resources are available and constantly updated. Many international organisations do perform studies related to quality of hospital assistance based on the same databases.

Some of these databases and reports are listed below:

- the **Organisation for Economic Co-operation and Development (OECD)** – www.oecd.org – publishes every year a report on health topics. ***OECD Health Data 2011*** *has been* released on 30 June 2011 and offers a comprehensive source of statistics on health and health systems across OECD countries. The information relate mainly to structural indicators (number of beds, technical equipments, data about personnel, etc.); there are also data about length of stay, % of beds occupancy, discharges, complexity of some interventions, such as transplantations, etc., that allow to take into account process and outcome measures as well and to carry out comparative analyses;

- the **Agency for Healthcare Research and Quality (AHRQ)** – www.ahrq.org is a part of the United States Department of Health and Human Services, whose objectives are to improve the outcomes and quality of health care, to reduce its costs, to address patient safety and medical errors, and to broaden access to effective services. It also acts as the regulator for Patient Safety Organisations.

The Agency defines Quality Indicators (QIs) to measure health care quality based upon hospital inpatient administrative data. These indicators consist of four modules measuring various aspects of quality:

1) the *Prevention Quality Indicators* (PQI) identify hospital admissions that could have been avoided, at least in part, through high-quality outpatient care;

2) the *In-patient Quality Indicators* (IQI) reflect quality of care inside hospitals including inpatient mortality for medical conditions and surgical procedures;

3) the *Patient Safety Indicators* (PSI) also reflect quality of care inside hospitals, but focus on potentially avoidable complications and iatrogenic events;

4) the same indicators but related to pediatric population are included in the *Pediatric Quality Indicators* (PQI).

In 2000, the Agency identified seven operations for which they recommended surgical mortality as a quality indicator: Coronary Artery Bypass Graft (CABG) surgery, Repair of Abdominal Aortic Aneurysm, Pancreatic Resection, Esophageal Resection, Pediatric Heart Surgery, Craniotomy and Hip Replacement. However, the list of quality factors to be accounted for was not exhaustive, as there was no internationally agreed framework to define what factors should be included and how to measure quality changes.

In 2004, AHRQ has created a National Resource Center for Health Information Technology with the aim of enhancing the quality, safety, efficiency and effectiveness of health care through the use of technology;

- the **International Society for Quality in Health Care (ISQua)** – www.isqua.org is constituted by a group of health professionals, set out in 1985 in Northern Italy to discuss the assurance of quality of medicine. ISQua's Secretariat was established in Australia in 1995 and then moved to Ireland in 2008. The Society is a non-profit, independent organisation;

- the **European Society for Quality in Healthcare (ESQH)** – www.esqh.net is a not-for-profit organisation dedicated to the improvement of quality in European healthcare. It consists of 21 members, all of whom are National Societies for Quality in Healthcare;

- the **International Society For Pharmacoeconomics and Outcomes Research (ISPOR)** – www.ispor.org – has as objective to increase the efficiency, effectiveness, and fairness of health care resource use to improve health outcomes. Hence, in its activities both process – through efficiency analyses – and outcomes – through effectiveness and utility analyses – do matter.

ISPOR activities focus especially on pharmaceutical care, although outcomes assessment of more comprehensive health programs are considered as well;

- **Health Technology Assessment International (HTAi)** – www.htai.org - is a scientific and professional society for those subjects who produce or need Health Technology Assessment. The relevance of technology in the production of hospital care can be appreciated especially in process analyses. Health technology includes pharmaceuticals, devices, diagnostics and treatments, and other clinical, public health, and organisational interventions.

The scope and methods of HTA may be adapted to respond to the policy needs of a particular health system. In health systems throughout the world, HTA plays a role in supporting decision-making about access to technology, its diffusion, and innovation. Within the activities performer by HTA, it can be mentioned the **European network for Health Technology Assessment (EUnetHTA)** – www.eunehta.net - launched in November 2008 in order to implement a sustainable and permanent collaboration for HTA in Europe. The EUnetHTA Collaboration focuses on HTA in Europe to facilitate efficient use of resources available for HTA and to promote good practice in HTA methods and processes;

- the **National Institute for Health and Clinical Excellence (NICE/NHS)** – www.nice.org.uk - sets quality standards and manages a national database for UK to improve people's health and prevent and treat illnesses. NICE makes recommendations to the NHS on new and existing medicines, treatments and procedures, care for people with specific diseases and conditions.

The activity of NICE is aimed at developing and defining the standards of healthcare that people expect to receive. These standards will indicate when a clinical treatment (or set of clinical procedures) is considered highly effective, cost effective and safe, as well as being viewed as a positive experience by patients;

- the **National Quality Forum (NQF)** – www.qualityforum.org - is a nonprofit organisation set in the USA aimed, among other things, at endorsing national consensus standards for measuring and publicly reporting on performance. It comprises both private and public subjects (purchasers, physicians, nurses, researchers, etc.). Its relevance is, however, limited to the American health care market.

Some of these organisations, together with their activities of collecting data and developing reports publish periodicals to disseminate knowledge on the issues of quality. For example, the **National Association for Healthcare Quality (NAHQ),** a professional association dedicated to the advancement of healthcare quality and patient safety, publishes every two months the *Journal for Healthcare Quality* that focuses on quality in evidenced-based practices.

A consistent number of indicators employed in the literature and in common practice have been derived by data collected. Moreover, several projects aimed at measuring quality have been developed within the activities performed by the above listed organisations:

- **OECD: Health at a Glance 2011** [http://www.oecd.org/health/healthataglance];

- **WHO,** ***The World Health Report. Health Systems: Improving Performance***, World Health Organisation, Geneva;

- ***The Hospital Data Project*** (Magee, 2003), aimed at creating common data sets and to unify information system. Although useful, the database is incomplete when considering a more detailed level and does not take into account the case mix.

- the **OECD Health Care Quality Indicators (HCQI) project** (2002), that was aimed at measuring and comparing the quality of health service provision in the different countries and identified key quality variables that can be used at the acute care level.

- **PATH (Performance Assessment Tool for quality improvement in Hospitals** www.pathqualityprojects.eu) project founded by WHO, that see the cooperation of European and non European hospitals. It started in 2004 and is still ongoing. It is aimed at constituting a quality assessment network for hospitals. Quality is assessed in six dimensions: clinical effectiveness, safety, patient centeredness, efficiency, staff orientation, responsive governance against selected quality objectives.

- **HCQI (Health Care Quality Indicators Project** www.oecd.org/health/hcqi), is promoted by OECD and involves 32 OECD countries. It started in 2001 and is still ongoing. It has the objectives to establish a set of internationally comparable health care quality indicators and a framework for collecting data. Quality of health care systems are periodically assessed against developed indicators, that are systematically improved.

- **SIMPATIE** (Safety Improvements for Patients in Europe) www.simpatie.org, developed within the EU during the period 2005-2007. It uses a network of organisations, experts, professionals and other stakeholders to establish a common European set of vocabulary, indicators, internal and external instruments for improvement of safety in health care.

- **EuNetPas** (European Network for Patient Safety) www.eunetpas.eu, developed in 2008, established a network of all 27 EU Member States and EU stakeholders to encourage and enhance collaboration in the field of Patient Safety.

- **EuroDRG** (*Diagnosis-Related Groups in Europe: towards Efficiency and Quality*), www.eurodrg.eu, assessed the determinants of hospital costs and DRG-based payments in the inpatient sector, together with their impact on quality of inpatient care. The final results on patient classification, payment rates, system performance and quality of care across 12 countries were presented at the European Conference on Health Economics (ECHE), held in Zurich, Switzerland, on 20 July 2012.

- **INTERQUALITY** (International Research Project on Financing Quality in Healthcare InterQuality) is currently being carried out as a part of the Seventh Framework Programme (FP7) of the European Union. The research aims to examine financing systems' effects on quality of healthcare, using administrative and survey data. Areas of investigation are: hospital care, outpatient care, pharmaceutical care, integrated care. The research is being conducted in Poland, Italy, Denmark, Germany, United Kingdom and United States. Knowledge gained from the project should provide support for Member States to choose the right financing mechanisms in the different areas of the health care system, according to their needs.

# CHAPTER 2

2.1. Introduction: motivations for the empirical analysis

2.2. Description of the methodology. The random intercept model.

2.3. Description of the units of analysis.

2.4. Description of the variables employed

2.5. The random intercept model and the truncated regression model.

2.6. Conclusions.

## 2.1. Introduction: motivations for the empirical analysis.

The survey in the previous section has outlined how quality of hospital care has been interpreted by the relevant literature across years, and has stressed the difficulty to identify appropriate indicators for measuring it. Overall, there is a widespread use of indicators related to mortality rates, mainly related to some clinical conditions.

This section will focus on the empirical analysis, that will be carried out through different estimation strategies.

First, a brief overview of the estimation techniques used to model the issue of quality will be presented. The suitability of each indicator to employ in the analysis will be assessed especially by looking at the Italian scenario.

In fact, the Italian context is characterized by differences in the epidemiological conditions of the population, fragmentation in the application of financing schemes and a great degree of autonomy left to Regions, that, during the last 20 years, have contributed to create "*21 health systems, together with the Sistema Sanitario Nazionale – the Italian National Health System*" (Mapelli, 2000).

Moreover, different types of hospitals can be identified within the same framework. They are distinguished by ownership (public vs. private), organisational model (e.g., *Aziende Ospedaliere*, more autonomous, vs. *Presidi Ospedalieri*, directly controlled by ASLs), degree of dependence from the NHS.

Classification schemes for structures that provide hospital care have been attempted, especially in the Italian literature on health policy (for example, Cantù and Carbone, 2007; Carbone, Jommi and Salvatore, 2007; Jommi, Cantù and Anessi Pessina, 2001): the great variety of organisational schemes is often determined by the degree of autonomy claimed by Regions after the devolution and regionalization process started from the '90s on, as well as by the role played by ASLs.

The empirical analysis is aimed at examining the correlation between quality outcomes and some characteristics of health market (factors related to demand and supply) as well as health policy choices (higher/lower presence of private and public structures, choice of a regional DRG instead of adherence to national payment schemes).

While the dependent variable concerns quality in providing hospital care, and its choice has been guided by the indications obtained by the literature, the other explanatory factors used for the empirical analysis, referred to the aspects of demand and supply, as well a to institutional and reimbursement factors.

The main source of data was the database of the Italian Ministry of Health, with regard to the information for hospitals and their classification.

Moreover, some data extracted by the database of the National Program for Outcome Assessment (*Programma Nazionale Valutazione Esiti, PNE*) have been used. The whole database, that constitutes the output of the project, is not fully accessible yet, so that the present dissertation, together with very other few studies (Cavalieri, Gitto and Guccio, 2012, InterQuality Project, 2012), is using these data for the first time.

A descriptive analysis allows to depict a scenario of Italian context and to see the differences in the provision of health care across Regions. There are differences both at the hospital level, at the Local Health Unit (*Azienda Sanitaria Locale - ASL*) level and at the Regional level.

The empirical analysis has the objective of outlining the relationship between quality indicators and some selected explanatory variables, looking especially at the adoption and the extent of regional payment schemes.

A random intercept and a truncated regression model have been applied; the dependent variable is represented by selected quality indicators.

However, quality for hospital care might also be investigated by running an efficiency analysis that correlates inputs with outcome indicators. Such analysis will be considered in the next chapter.

## 2.2. Description of methodology

As it has been seen in the first chapter, studies focusing on the quality of hospital care have mostly employed patients' and providers' perspective of analysis in defining quality.

Data used for empirical analyses come mainly from national and international databases (for example, Magee, 2003, within the *Hospital Data Project*, or Farrar *et al.*, 2009), or selected samples of hospitals (for example, as in Farsi and Filippini, 2006, in a cost-efficiency analysis focused on 156 Swiss hospitals, or as in Hagen, Veenstrab and Stavemc, 2006, who employed data on 213 Norwegian hospitals to assess quality).

Each study has been developed over a time span of at least 3-4 years, though the length of the analysis is often conditioned by the availability of data. While the optimal choice would be that of observing the efficiency-performance-quality patterns of hospitals for at least 10-12 years, in order to appreciate any modification that can derive from institutional reforms, the most of time such analyses are constrained by time of data collection and/or by the merging of two or more databases.

A common problem to all studies focusing on quality is the selection of a suitable methodology of analysis.

As it has been seen in the previous section, quality of hospital care is often conceptualized with regards to the performance in different domains; its measurement indicators range beyond clinical outcomes, such as clinical process and resource utilization measures.

Many studies have been concerned with methodological techniques that can be used to create suitable "profiles" of provider quality (see, for example, Landrum, Bronskill and Normand, 2000). Different statistical tools have been used to this purpose, although they often investigated only one dimension of care, as, for example, in some Bayesian hierarchical regression models (Normand, Glickman and Gatsonis, 1997; Christiansen and Morris, 1997) and maximum likelihood estimates (Silber, Rosenbaum and Ross, 1995).

In the literature on quality of healthcare, it is quite frequent to use composite measures: they combine information across several dimensions of care, have more statistical power and allow to detect differences among providers.

A "composite performance measure" is a combination of two or more related indicators, e.g. process measures and outcome measures, and it is useful for summarizing a large number of indicators, since it can distill a large amount of information into a summary variable.

Examples of composites indices set up at a provider-level are: a) mortality for selected procedures, that could be meant as a weighted average of the *reliability-adjusted ratios* for the mortality indicators for patients who undergo given medical procedures; b) the mortality for selected conditions, instead, is a weighted average of the reliability-adjusted ratios for the mortality indicators for patients admitted to hospitals for treating selected conditions.

However, problems may arise from using composite measures, as measures describing different aspects of quality have to be combined together, leading to potential loss of information.

In creating a composite score, moreover, there is the question of how much weight to give to individual items, as there is no single widely accepted approach to choose weights.

The inferences that is possible to make about a provider's performance will depend on the way the composite score is defined: every time composite measures are used in the context of public reporting and pay for performance schemes, the choice of methodology used to obtain composites can have relevant implications for providers.

In spite of this criticism, composite measures are becoming increasingly important tools to support decision making by consumers, payers, and providers. In fact, observed variations across providers in outcomes, such as mortality, patient functioning, and satisfaction; in utilization of therapeutic procedures; in processes of care such as length of stay, appropriateness rates, and readmissions; and in costs of care, have induced policy makers to question whether the quality of health care is a feasible objective for the health policy maker.

Composite measures are used as well within latent variable models to define quality. Latent variable models are based on the assumption that an unobservable (latent) trait, such as quality, contributes to the attainment of an ultimate outcome for hospitals. Such latent trait represents the summary of the overall quality of services that hospitals are able to deliver (Landrum, Bronskill and Normand, 2000).

Originally these types of models were used in psychology research (Bentler, 1980; van der Linden and Hambleton, 1997) or in the social sciences (Eye and Clogg, 1994)[9].

One of the advantages of this methodology is that it can deal with multidimensionality of data, as in the case of hospitals, where more aspects contribute to define the underlying concept of quality.

The variability present in latent measures is determined both by a systematic component and a random component. While the systematic component can be explained by provider

[9] This is the case, for example, of educational testing setting, where subjects are asked to answer a series of questions from which investigators must infer their underlying ability.

specific covariates, including hospital characteristics such a number of beds, hospital specialization, medical staff, number of surgeries and discharges, the latter is due to chance[10].

The key feature of the latent variable model approach to modelling multivariate performance measures is the ability to estimate the composite measure of quality for each provider.

Latent variable models have been applied in health economic evaluation and, especially, in cost-utility analyses to measure subjective dimensions that otherwise would not been directly observable, such as quality of life (Theunissen *et al.*,1998).

Landrum, Bronskill and Normand (2000) propose the use of latent variable models for comparing health care providers in the cross-sectional setting when each provider is measured on more than one dimension of care[11].

Papanicolas and McGuire (2011a) used the latent variables approach to measure the quality of different English NHS hospitals in providing services over the period 1996 –2008 for seven different conditions (Acute Myocardial Infarction – AMI -, Myocardial Infarction – MI -, Ischemic Heart Disease – IHD-, Congestive Cardiac Failure – CCF-, Stroke, Transient Ischemic Attack – TIA - and Hip Replacement). The authors concentrated especially on two conditions, AMI and Hip Replacement, building on the methods used in another work (Papanicolas and McGuire, 2011b), where individual patient mortality rates and readmission rates were employed at different intervals to represent latent outcome measures at the hospital level.

It is assumed a latent "hospital level" variable that includes all of the unobserved factors influencing hospital quality. The latter is captured by vectors of "hospital level" intercepts estimated from "individual patient level" equations that measure determinants of outcomes for different conditions across hospitals. The intercepts estimated in the first part of the model, or "latent outcome measures" exclude confounding "patient level" variables, and reflect environmental and organisational characteristics as well as random error and data

[10] The systematic components may also include measures of quality that contribute to outcome, such as severity of cases (Mohammed *et al.*, 2009).

[11] In their work, they examined a cohort of 4,628 Medicare patients aged between 65 and 89 years, discharged with a principal diagnosis of acute myocardial infarction (AMI) from 73 hospitals located in one US state during 1994-1995), the authors present, first, a univariate approach, based on hierarchical models with the aim of estimating provider specific profiles; then, they apply a multivariate approach, based on latent variable models, that is utilized to estimate a composite measure of quality.

imperfections. The authors used these measures to explain how much unobserved hospital effects contribute to changes in mortality and readmission in any given year[12].

Another alternative is that of running the estimations after having grouped the observed units into clusters (for example, Regions or other geographical areas or, as in our case, ASLs) to catch any differences due to geographical and institutional variations. In this case, a linear mixed model allows for more levels of analysis.

The term "mixed model" was used for the first time by Eisenhart (1947) to indicate models with both random and fixed effects. Swamy (1971) introduced the linear mixed model under the name 'random coefficient model'. Later on, Goldstein (1987) and Bryk and Raudenbush (1992) applied these models under the names "multilevel" or "hierarchical" models.

The linear mixed model takes into account the between-cluster variability, both in the overall level of the response and in the effects of covariates.

Let $I = 1, \ldots, n_j$ be the number of units nested in cluster $j = 1, \ldots, N$.

A linear mixed model can be written as

$$Y_j = X_j \alpha + Z_j a_j + \varepsilon_j$$

where $Y_j$ is an nj-dimensional vector of continuous responses $y_{ij}$ for cluster j, $X_j$ is an $n_j \times p$ matrix of covariates with fixed effects $\beta$, $Z_j$ is an $n_j \times q$ matrix of covariates with random effects, $b_j$, and $\varepsilon_j$ constitute a vector of residual errors.

The random effects and the residuals are assumed to have normal distributions and are independent across clusters. The covariates are assumed to be independent of the random effects and residuals[13]. The marginal expectation of the responses for cluster *j*, given the observed covariates but not the random effects, is

$$\mu_j = E(Y_j \mid X_j , Z_j ) = X_j \beta$$

The most common linear mixed model is the **random intercept model** where there is only one random effect: a normally distributed random intercept. This model can be represented as follows:

$$Y_{ij} = \beta_{0j} + X_{ij} \beta_1 + \varepsilon_{ij}$$

[12] Implications for health policy come from the consideration that, observing the trend of the latent outcome measures over time – as the authors do in Papanicolas and McGuire (2011b), based on Vector AutoRegressions (VARs) model -, allows for a better examination of the rate of change in hospital quality, rather than the examination of raw outcome measures.

[13] The linear mixed model can be viewed as a two-levels model. Higher level models arise when the clusters *j* are themselves nested in superclusters *k*, etc., and when random effects are included at the corresponding levels (Skrondal and Rabe-Hesketh, 2007; Rabe-Hesketh S., Skrondal A., Pickles A, 2010).

In the above equation, $\beta_{0j}$ the random effect due to the cluster, has mean 0 and variance $\sigma^2_b$. The error term $\varepsilon_{ij}$ is assumed to be normally distributed as well, with mean 0 and variance $\sigma^2$ and represents the "within-subject" measurement errors. $\beta_{0j}$ and $\varepsilon_{ij}$ are independent of each other.

The equation refers to each unit of observation. The elements $\beta_{0j}$ and $\beta_1$ instead, refer to the clusters and concern the "second level" of the analysis. They can be expressed as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} z_j + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} z_j + u_{1j}$$

The error terms $u_{0j}$ and $u_{1j}$ have mean 0 and constant variance $\tau^2_0$ and $\tau^2_1$ and are independent among them, so that the error term is not correlated with the coefficients; they are independent from the error term in the first level, $\varepsilon_{ij}$, as well.

In the random intercept model only $\beta_{0j}$ assumes different values accordingly to the cluster within which each unit is grouped.

The random intercept model can be seen as a series of regressions (one for each cluster): the differences among groups can be seen by examining the differences in the values of estimated intercepts.

The random intercept model describes the conditional mean of $Y_{ij}$ given the cluster specific effect

$$E(Y_{ij} \mid \beta_{0j}) = \beta_{0j} + X_{ij} \beta_{11}$$

The mean response profile in the population, instead, is the marginal mean of $Y_{ij}$ :

$$E(Y_{ij}) = X_{ij} \beta_1$$

The parameter β describes patterns of change in the mean response in the population of interest, while $\beta_{0j}$ represents the individual's deviation from the population mean intercept, after having taken into account the effect of covariates.

The marginal variance of each response is given by

$$\begin{aligned} Var(Y_{ij}) &= Var(X_{ij} \beta_1 + \beta_{0j} + \varepsilon_{ij}) \\ &= Var(\beta_{0j} + \varepsilon_{ij}) \\ &= \tau^2 + \sigma^2 \end{aligned}$$

This equation includes the variance at two different levels.

A random intercept model has been considered for the present analysis. Here, the levels of analysis are represented by: 1) the single structures, that register average outcomes in terms of mortality rates and readmission rates for each hospital ("individual level"), and 2) the cluster within which each structure has been grouped (ASLs, Regions or type of structure).

Overall, the identification of a suitable framework of analysis is determined by the necessity to take into account several levels of analysis in the Italian scenario of hospital care (ASLs, Regions or even different types of structures). Such variability is the result of several institutional reforms that will be briefly described in the next paragraph.

### 2.3. Description of the units of analysis

The actual organisational structure of the *Servizio Sanitario Nazionale* (Italian National Health Service - NHS –) derives from the reforms undertaken since the early 1990s, at first with the legislative decree no. 502/92 and the legislative decree no. 517/93, and refined at the end of 1990s, with the legislative decree no. 229/99. The reform process implemented during the last two decades aimed at introducing a more managerial culture and quasi-market mechanisms into the health care system, as well as to devolve to Regions new responsibilities and powers for both the financing and delivering of health care.

The Italian NHS has the nature of a complex multi-tier system, involving three different levels of government: central (Ministry of Health), regional (*Assessorati alla Salute*) and *Aziende Sanitarie Locali* (ASLs), that are Local Health Units.

The Ministry of Health is responsible for the national planning and for the coordination of regional activities, in order to guarantee the same essential levels of care (LEA) in all the areas of the country, whereas Regions are competent to define their own health plans so as to organise services delivery within their own territory in accordance to central government's planning.

ASLs have administrative and financial autonomy, although at different levels, and are directly involved in the production and provision of services in the geographical area under their responsibility.

All hospitals, either public or private, have to be paid according to a fee for service system: the DRG-based reimbursement model was implemented since the reforms of 1992/1993, that were aimed at introducing incentives to efficiency and ensure the accountability of both ASLs and providers. While reducing the degree of vertical integration in the Italian NHS, these interventions were also sought to establish transparent funding rules, as public funds should be allocated to public and private providers in line with the services actually delivered.

ASLs have been meant as the only organisms entitled to purchase services for all residents in their district. Furthermore, regional governments could also decide to make arrangements with independent providers without the intervention of the ASLs. Provision of the reforms of 1992 and 1993 were then reinforced with the reform of 1999, that stressed the regional character of the Italian NHS and, at the same time, called for coordination and control by the central and regional governments, in order to guarantee the LEA to all citizens in all Regions.

As a result of all the reform waves, provision of hospital care today is made by public structures, that include independent *Aziende Ospedaliere* (AOs), hospitals that are still directly controlled by the ASLs (*Presidi Ospedalieri* - POs) and private accredited[14] hospitals[15].

The AOs are the main independent providers: they deliver highly specialized, intensive and emergency care. Their top management is appointed by the regional health authorities and their services are financed through a prospective payment system (PPS); DRGs tariffs are defined at the central and regional level. Payments outside PPS are also recognized for specific activities, such as emergency care services and teaching and research activities.

POs, or *Ospedali a gestione diretta* (Directly managed hospitals) are not independent from ASLs and provide a range of services, from inpatient and outpatient care to rehabilitation treatments. They are funded out of the financial endowment of ASLs, generally through a unit's budget adjusted for historical spending and mobility inside and outside the Region.

Private structures are split into *private not for profit independent hospitals*, that have the status of independent hospitals and are often research oriented (as in the case of *Policlinici universitari privati*), in which case they are able to get additional funding outside PPS; *private for profit hospitals* (so called "*case di cura private*") are meant to supplement the treatments delivered by public providers. Central to the definition of the number and activity of private providers is the regional market entry regulation, so that the contribution of these hospitals to healthcare supply is defined at a regional level.

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[14] In Italy, the accreditation process of public and private providers has been systematically addressed with the Legislative Decree 299/1999. The issue is ultimately a regional responsibility and requires two standard top-down procedures: 1) an authorization for delivering health care services which is granted by the regional departments of health once a minimum set of structural, technological and organisational requirements has been satisfied; 2) an institutional accreditation for accessing the market of publicly funded services which requires the compliance with quality standards and the objectives of the regional plan.

[15] Within this legislative framework, Regions are, however, free to decide the number of hospitals to make independent, the extent to which the commissioning power has to be attributed to ASLs and the nature of providers with which to negotiate.

The Legislative Decree 229/99 does not specifies clearly what should be the ASL's involvement in the negotiation process. Therefore, regions have differently interpreted the role played by ASLs and their interrelations with regional authorities and providers. At one extreme, ASLs can carry out the purchasing activity autonomously (ASL-based model). At another extreme, regional authorities are directly involved in purchasing services and no role is delegated to ASLs. Sometimes, ASLs do not play any negotiation role but are only required to remunerate providers according to regional tariffs and to comply with regional budget constrains (third-party payer model). (See, Cantù and Carbone, 2004; France, Taroni and Donatini, 2005). Recently, a classification scheme for the role of ASLs and hospital structures has been done in a background paper for the InterQuality Project (Mangano, 2011).

As a result, there is a highly differentiated composition of hospital care supply across Regions, in terms of both public-private mix and status of public providers, which influence the degree of competition within the hospital care market.

The Italian NHS reforms determined the switch from cost-reimbursement mechanisms (bed-day rates and *ex-post* payments) in the financing of hospital care to PPSs for both inpatient procedures and outpatient ambulatory care. Under the new arrangements, hospitals receive a pre-determined fixed amount, which may not necessarily reflect true production costs. This change did not however affect hospitals directly managed by local health authorities which continue to be mainly remunerated on the basis of historical spending.

For inpatient care provided by public independent hospitals and private accredited ones, the reimbursement is made up of two components:

1) the first component is made of activity based payments, where patients are classified according to the DRG classification of discharges. Starting from January 1$^{st}$ 2009, Italy has adopted the version 24.0 of the Diagnosis Related Group system and the corresponding International Classification of Diseases ICD 9 CM;

2) another component is made by block assignments, that are based on average production costs for specific health services, such as integrated care and management of chronic illnesses, prevention activities, programs for rare diseases, emergencies and, more generally, care activities with high waiting costs, experimental programs and organ transplants, according to the provisions of the legislative decree no. 502/1992, article 8-sexies. The rationale for the use of an established component lies in the fact that all these services are thought to be inadequate to be properly funded through a per case payment system. The Regions have, however, the power to autonomously decide the specific areas of hospital activity which should be remunerated through non-tariff allocations, the type of hospitals that are entitled to receive this source of funds (only public hospitals or also private ones) and the related funding levels. Several aspects of the adoption of the tariff-based system vary extensively among Regions. Tariffs can play different roles towards hospital care providers. While for private hospitals they represent the “real price” paid by Regions for the services provided on behalf of the Italian NHS, for public hospitals, Regions can decide to use tariffs just as a device to assess hospital activity and to determine the global hospital budget (Morandi *et al.*, 2008). In the latter case, losing their original character of per case payment, tariffs are no more expected to generate positive incentives (such as improved efficiency).

As for the way tariffs are determined, some Regions have decided to apply national tariffs, set in accordance with either the Ministry of Health decree of 30.06.1997 (Piemonte, Valle d'Aosta, Provinces of Trento and Bolzano) or the Ministry of Health decree of 12.09.2006 - Lazio, Campania, Molise, Puglia, Sicilia, Abruzzo and Sardegna[16] - (Morandi, 2009, 2010).

On the other hand, five Regions (Lombardia, Veneto, Emilia Romagna, Toscana and Umbria) have developed their own fee schedules on the basis of some kind of cost assessment.

Furthermore, all Regions are free to discriminate tariffs across providers to make them closer to their actual costs and the specificities of their regional context. In general, a more generous financial treatment is applied to public hospitals, under the assumption that these structures provide more complex services and treat patients in worse health conditions, as well as those structures providing highly specialized services (such as emergency, blood banks, etc.) or carrying out teaching and research activities[17]. The range of variation in regional hospital tariff classes is quite large, moving from a minimum of 3% in Sicily and a maximum of 25% in the Province of Trento, with the only exception of Campania, where it reaches 57% (Morandi and Arcangeli, 2009).

Regions may also decide to modulate tariff fees not just to secure adequate funding to hospitals but also to orient hospital activity towards the achievement of the regional planning objectives. In this case, tariffs of single hospitals' activities are used as tools to encourage or discourage certain delivery patterns (Cantù and Carbone, 2007). While a high level of tariffs may push providers to increase the production of health services, on the other hand, low tariffs may induce to restrain health care provision.

Overall, a few Regions have recognized the same payments to all hospitals irrespective of their public or private ownership. It has been outlined how that private providers are generally worse off in terms of DRG-related reimbursement. These hospitals do not generally get other non-PPS related funding: hence, the greatest part of their financial allocation is

[16] According to the criteria established by the Ministry of Health Decree of 15.04.1994, tariffs were to be set using a full costing approach. National tariffs, defined in 1994, were updated in 1997 (Ministry of Health Decree of 30.06.1997) and, more recently, in the 2006 (Ministry of Health Decree of 12.09.2006). National tariffs are not differentiated by hospital categories, nor do they entail additional reimbursements for costly items such as drugs and medical devices (Morandi, 2009).

[17] According to the Legislative Decree no. 517/99, teaching hospitals are also entitled of additional financial resources, regionally defined in an amount between 3% and 8% of the overall budget allocated through the DRG system.

given by the tariff-based remuneration, so that the incentive to increase the output level is substantial.

In this sense, tariffs reductions for private providers might have the effect to reduce the provision of health services, might contain costs, and allow, as well, a more appropriate delivery as requested by the regional planning.

Nevertheless, often tariff discrimination has taken place also amongst public hospitals. For example, AOs have taken advantage of higher tariffs compared to other public hospitals; again, this arrangement relies on the assumption that these hospitals deliver more complex care and, for this reason, show higher costs. Less frequently, higher tariffs have been recognized to some of the regional private hospitals showing a more complex case mix[18].

To sum up, the analysis of the impact of tariffs on hospital care is not easy as tariff systems are regionally differentiated in Italy and, often, variations can be observed even within the same Region.

The differences in tariffs come together with higher or lower autonomy of ASLs.

National legislation allows Regions to autonomously decide the main characteristics of their own tariff rates (level, classes of providers, tariff reductions, etc.), the extent to which the overall hospital funding should be tariff-based as well as various other aspects of the hospital care market structure (public-private mix; relationships among regional authorities, ASLs and providers; etc.).

All these regulatory arrangements are expected to have an effect on the incentives provided by the PPS on quality of care, but cannot easily represented and quantifiable in the empirical analysis. A simplification adopted in this analysis, as it will be seen, is that of employing a dummy variable assuming value = 1 for those Regions that opted for their own tariffs instead of national DRGs.

The extent to which the DRG tariffs are adopted in each Region will be proxied by the share of total hospital beds owned by AOs and private accredited hospitals: these ones are the only two classes of hospitals for which the DRG financing mechanism is actually in use, even if at different degrees (Finocchiaro Castro *et al.*, 2011)

[18] In the Region Campania all independent public hospitals have been paid the highest reimbursement, corresponding to the whole amount of the ministerial tariffs. In the Region Friuli-Venezia Giulia, hospitals have been grouped together in two different categories. The first category included all main public hospitals offering emergency care services that are paid a tariff greater by 20.3%, while the second included all other hospitals, either the public or private ones, which are paid the same ministerial tariff reduced by 5.3%. A much more complicated remunerating approach has been adopted in Piemonte, where private hospitals have been treated differently than the public ones. In Emilia Romagna two groups of hospitals have been defined according to the characteristics of the services provided (Mangano, 2011).

The empirical analysis will be focused on the following levels of analysis:

1) Regions: 21 Regions, including the autonomous Provinces of Trento and Bolzano and the *Regioni a statuto speciale* Valle d'Aosta, Friuli-Venezia Giulia, Sicilia and Sardegna.

2) ASLs, whose number varies according to the clinical conditions considered for the empirical analysis.

3) Hospitals, that, according to the classification given by the Ministry of Health can be distinguished into:

- private ("*case di cura accreditate*");

- public, that are further classified into:

A) Aziende Ospedaliere

B1) Aziende ospedaliere integrate con università

B2) Aziende ospedaliere integrate con SSN

B3) Policlinico universitario privato

C) Ospedale a gestione diretta – Presidio ASL

D) Ospedale classificato o assimilato

E) Istituto qualificato

F) IRCCS

G) Enti di ricerca

The last two types of structures are mainly devoted to research activity[19]. In 2009 – the year considered in the analysis - there were, moreover, 13 qualified institutes, 26 "classified hospitals" (*ospedale classificato o assimilato*), 143 AOs and 40 *Policlinici Universitari*.

Modality of reimbursement are different for each structure and for each Region (Rapporto AGENAS, 2010).

This circumstance complicates the framework of analysis. It will be seen how the choice of dummy variables to overcome the problem is not fully satisfactory.

[19] In the sample of health structures considered for the present research, the research institutes are only three, located in Central and Southern Italy: the Fondazione CNR Monasterio is located in Pisa, the Centro di Ricerca Biomed is in Molise, while the ISMETT (Istituto Mediterraneo Trapianti) is located in Palermo. These structures have been considered together with the *Istituti di Ricovero e Cura a Carattere Scientifico* (IRCCS).

### 2.4. Description of the variables to employ in the analysis

The main sources of data are the National Program for Outcome Assessment (*Programma Nazionale Valutazione Esiti* – PNE), and the database of the Ministry of Health.

The PNE consider specific outcome measures such as short-term mortality, short-term readmissions, hospitalization for specific clinic conditions, surgical procedures, short-term complications after specific treatments, waiting lists. Overall, 45 performance indicators (32 related to hospital services and 13 to hospitalization) were computed within the project.

Although in the PNE database the information were collected at a hospital level for the period 2005-2010, the present analysis has been limited to a cross sectional framework, so to merge the information from the PNE together with data extracted from the database of the Ministry of Health related to each structure.

The database of the Ministry of Health presents, for many variables, 2008 as the last year of observation.

The choice of the dependent variables, that should represent the latent trait for quality, has been determined by the indications from the prevalent literature, as well as by data availability.

The variables most frequently employed in international studies on quality, related to mortality, are:

1) 30-day mortality rates in patients with Acute Myocardial Infarction (AMI);

2) 30-day mortality rates in patient experiencing Congestive Heart Failure (CHF);

3) 30-day mortality rates in patients with stroke.

Two indicators are related to readmission rate:

4) 30-day readmission rates after stroke;

5) 30-day in-hospital readmission rate after Chronic Obstructive Pulmonary Disease (COPD).

Mortality rate is the most common used outcome for hospital quality, although some studies have stressed how it is not a meaningful indicator in some clinical contexts, such as those involving outpatient treatments, or younger patients[20].

Readmission rates as measure for quality have become increasingly popular despite the fact that they cannot always be attributed to the quality of care delivered by the hospital.

[20] Moreover, it might be difficult to control for unobserved patient severity and to account for patients' preferences: as a result, using mortality rates for all conditions might lead to biased results (Sari, 2002).

McClellan and Staiger (1999) note that high readmissions may be easily misinterpreted as indicators of poor quality when in some cases they may indicate good quality treatment of severe patients. Readmissions may be the result of poor quality care of other parts of the health system (primary care), behavioural factors (poor adherence to therapies), or even the result of good quality care; in fact, as hospital technology improves, patients may survive, but with worsened morbidity and subsequent episodes of hospital readmission[21].

Hence, investigating mortality and readmission rates by looking at different condition may allow a clearer relationship between outcome and quality of care

Within the PNE database both the gross rate and the adjusted rates of risk for these clinical conditions are calculated.

The gross rate measures the probability for a given outcome to occur. The adjusted rate of risk is aimed at reducing systematic errors, improving the validity of estimations. While gross rates are provided for almost all hospital structures, risk adjusted mortality and readmission rates are reported by the PNE only for high-volume hospitals (that are those structures treating more than 75 cases per year). These indicators are composite measures for quality and include many aspects of hospital care.

The risk adjustment methodology used by the PNE had to take into account the variability that is related both to structures and potential users, and is based on multivariate regressions: specifically, odds ratios have been calculated to adjust for higher risks that certain groups of patients might present. A predictive model has been implemented by considering all factors (patients' age, sex, seriousness of clinical conditions, presence of chronic co-morbidity factors, etc.) which could be potentially associated to the outcome considered.

Datasets for the analysis have been built for each clinical condition considered, by employing data from the Italian Ministry of Health related to either characteristics of supply (number, type of hospitals, medical staff, etc.) and demand (such as number of admissions, length of stay, etc.).

The five datasets do not contain of course the same number of hospitals, as not all the structures deal with the same conditions.

Although the PNE collected data on overall 1575 hospitals, here we have:

1) AMI 30 day mortality – 1021 structures;

[21] After their initial use in some studies carried out for the US, there is now a growing number of European countries that measure readmission rates more systematically as a health service outcome (Klazinga, 2011). A recent literature review on the use of readmission rate has been conducted by Fischer, Anema and Klazinga (2011), who reviewed 360 studies.

2) CHF 30 day mortality – 1127 structures;

3) STROKE 30 day mortality – 1018 structures;

4) STROKE readmissions – 1007 structures;

5) COPD readmissions – 1108 structures.

Table 1 present some statistics related to the characteristics of supply (number of public, directly managed hospitals, and other structures, bed per 1,000 inhabitants, ASLs) and their regional distribution. The table summarizes information included in Mangano (2011) and reports the situation in Italy as it was in the last two years. However, the framework of analysis is not significantly different from 2009, the year that is considered in the present analysis.

**Table 1. Market structure in Italy.**

| | ASL | Directly managed hospitals | Public Hospital trusts | Other hospitals (private profit and not for profit) | Beds per 1,000 residents in all publicly funded hospitals, either publicly or privately owned |
|---|---|---|---|---|---|
| **Piemonte** | 22 | 53 | 7 | 45 | 3.8 |
| **Friuli Venezia Giulia** | 6 | 11 | 6 | 6 | 3.5 |
| **Liguria** | 5 | 10 | 5 | 5 | 3.7 |
| **Marche** | 13 | 31 | 7 | 13 | 3.6 |
| **Lazio** | 12 | 52 | 12 | 109 | 4.4 |
| **Abruzzo** | 6 | 23 | | 15 | 4.1 |
| **Campania** | 13 | 51 | 11 | 78 | 3.1 |
| **Puglia** | 12 | 27 | 4 | 29 | 3.6 |
| **Calabria** | 11 | 33 | 5 | 37 | 3.7 |
| **Sardegna** | 8 | 39 | 4 | 14 | 3.9 |
| **Lombardia** | 44 | 2 | 34 | 76 | 3.9 |
| **Veneto** | 22 | 67 | 2 | 23 | 3.6 |
| **Emilia Romagna** | 13 | 38 | 6 | 41 | 4.2 |
| **Toscana** | 12 | 34 | 5 | 28 | 3.4 |
| **Umbria** | 5 | 9 | 2 | 5 | 3.1 |
| **Sicilia** | 9 | 48 | 20 | 61 | 3.2 |
| | | | | | |
| **Min** | | | | | 3.1 |
| **Max** | | | | | 4.4 |
| **Coefficient of variation** | | | | | 0.10 |

**Source: A. Mangano, *Background paper for the InterQuality Project*, 2011.**

The structures are differently distributed across Regions. The table looks at geographical criteria, and organisational structure, distinguishing into private and public structures.

In the following tables, instead, the number of structures, both private and public, as well as number of ASLs, are considered separately for each clinical condition.

Care for AMI has changed considerably in recent decades, with the introduction of coronary care units in the 1960s and with the advent of treatment aimed at rapidly restoring coronary blood flow in the 1980s. Although there have been improvements in the availability of emergency treatments, numerous studies have shown that a considerable proportion of AMI patients still do not receive evidence-based care.

AMI mortality rate is a good measure of acute care quality because it reflects the processes of care for AMI, such as effective medical interventions including thrombolysis, early treatment with aspirin and beta-blockers, and co-ordinated and timely transport of patients.

In Italy, the greatest number of AMI (75.42%) is treated at public structures and, especially, at POs.

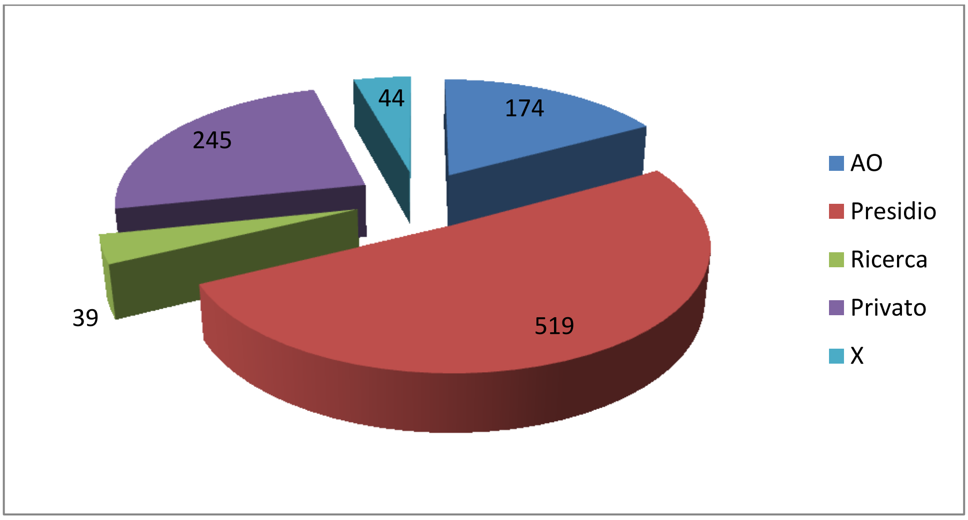
**Table 2.A. Hospitals treating AMI.**

| Regions | No. of structures | Private | Public | No. of ASLs |
|---|---|---|---|---|
| Piemonte | 72 | 15 | 57 | 13 |
| Valle d'Aosta | 1 | 0 | 1 | 1 |
| Lombardia | 159 | 46 | 113 | 15 |
| Prov. Trento /Bolzano | 18 | 4 | 14 | 2 |
| Veneto | 68 | 9 | 59 | 21 |
| Friuli-Venezia Giulia | 18 | 3 | 15 | 6 |
| Liguria | 25 | 2 | 23 | 5 |
| Emilia-Romagna | 78 | 21 | 57 | 11 |
| Toscana | 55 | 9 | 46 | 12 |
| Umbria | 15 | 0 | 15 | 4 |
| Marche | 36 | 5 | 31 | 1 |
| Lazio | 94 | 33 | 61 | 12 |
| Abruzzo | 27 | 6 | 21 | 6 |
| Molise | 10 | 2 | 8 | 1 |
| Campania | 97 | 32 | 65 | 14 |
| Puglia | 53 | 17 | 36 | 6 |
| Basilicata | 13 | 1 | 12 | 4 |
| Calabria | 45 | 10 | 35 | 5 |
| Sicilia | 101 | 29 | 72 | 9 |
| Sardegna | 36 | 7 | 29 | 8 |
| **TOTAL** | **1021** | **251 (24.58%)** | **770 (75.42%)** | **156** |

**Table 2.B. Type of hospitals treating AMI.**

| Regions/Type of hospital | Structures within each Azienda Ospedaliera | Presidio Ospedaliero (managed by ASL) | Azienda Ospedaliera – Teaching hospital | IRCCS | Ospedale assimilato | Private structure | Qualified institute | Research trust | Not specified |
|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 5 | 42 | 5 | 2 | - | 15 | 3 | - | - |
| Valle d'Aosta | - | 1 | - | - | - | - | - | - | - |
| Lombardia | 88 | 2 | - | 16 | 5 | 46 | - | - | 2 |
| Prov. Trento /Bolzano | - | 14 | - | - | 4 | - | - | - | - |
| Veneto | 2 | 46 | 1 | - | 4 | 9 | 5 | 1 | - |
| Friuli-Venezia Giulia | 1 | 8 | 2 | 1 | - | 3 | - | - | 3 |
| Liguria | - | 17 | - | 1 | 3 | 2 | - | - | 2 |
| Emilia-Romagna | - | 52 | 4 | 1 | - | 21 | - | - | - |
| Toscana | - | 40 | 3 | - | - | 9 | 1 | 2 | - |
| Umbria | 2 | 13 | - | - | - | - | - | - | - |
| Marche | 4 | 24 | - | 2 | - | 5 | - | - | 1 |
| Lazio | 3 | 37 | 6 | 3 | 5 | 32 | 2 | - | 6 |
| Abruzzo | - | 17 | - | - | - | 6 | - | - | 4 |
| Molise | - | 5 | - | 1 | - | 2 | - | 1 | 1 |
| Campania | 7 | 41 | 7 | 2 | 3 | 31 | 1 | - | 5 |
| Puglia | - | 26 | 2 | 3 | 2 | 17 | - | - | 3 |
| Basilicata | 1 | 11 | - | - | - | 1 | - | - | - |
| Calabria | 6 | 23 | - | 1 | - | 10 | - | - | 5 |
| Sicilia | 16 | 39 | 5 | 1 | 1 | 29 | - | 1 | 9 |
| Sardegna | 1 | 22 | 3 | - | - | 7 | - | - | |
| Total | 136 | 480 | 38 | 34 | 27 | 245 | 12 | 5 | 44 |

**Figure 1. AMI: type of structure.**



Heart failure may be caused by myocardial failure but may also occur in the presence of near-normal cardiac function under conditions of high demand. Heart failure always causes circulatory failure and requires emergency treatments for patients.

In Italy, about 30% of the private structures are equipped to treat CHF, that is, therefore, the condition with the highest percentage of private hospitals involved in its treatment. There is, as well, a slightly higher number of AOs treating CHF, comparing to other conditions.

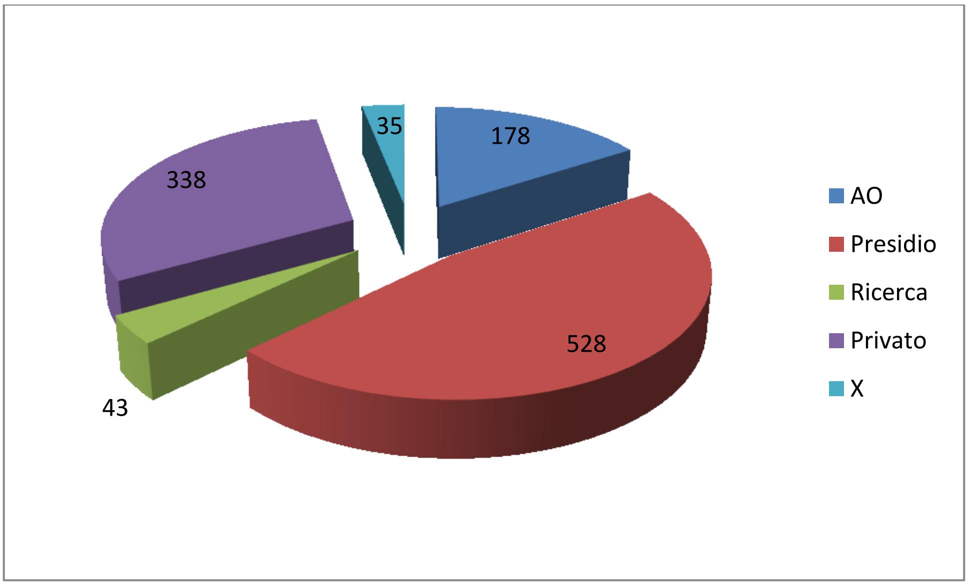
**Table 3.A. Hospitals treating CHF.**

| Regions | No. of structures | Private | Public | No. of ASLs |
|---|---|---|---|---|
| Piemonte | 77 | 24 | 53 | 13 |
| Valle d'Aosta | 1 | 0 | 1 | 1 |
| Lombardia | 171 | 55 | 116 | 15 |
| Prov. Trento /Bolzano | 25 | 10 | 15 | 2 |
| Veneto | 67 | 8 | 59 | 22 |
| Friuli-Venezia Giulia | 17 | 4 | 13 | 6 |
| Liguria | 27 | 3 | 24 | 5 |
| Emilia-Romagna | 87 | 31 | 56 | 11 |
| Toscana | 56 | 9 | 47 | 12 |
| Umbria | 17 | 1 | 16 | 4 |
| Marche | 42 | 8 | 34 | 1 |
| Lazio | 122 | 56 | 66 | 12 |
| Abruzzo | 29 | 8 | 21 | 5 |
| Molise | 10 | 2 | 8 | 1 |
| Campania | 106 | 38 | 68 | 14 |
| Puglia | 60 | 24 | 36 | 6 |
| Basilicata | 14 | 1 | 13 | 4 |
| Calabria | 53 | 16 | 37 | 5 |
| Sicilia | 104 | 31 | 73 | 9 |
| Sardegna | 41 | 9 | 32 | 8 |
| **TOTAL** | **1126** | **339 (30.02%)** | **788 (69.98%)** | **156** |

## Table 3.B. Type of hospitals treating CHF.

| Regions/Type of hospital | Structures within each Azienda Ospedaliera | Presidio Ospedaliero (managed by ASL) | Azienda Ospedaliera – Teaching hospital | IRCCS | Ospedale assimilato | Private structure | Qualified institute | Research trust | Not specified |
|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 5 | 41 | 4 | - | - | 24 | 2 | - | - |
| Valle d'Aosta | - | 1 | - | - | - | - | - | - | - |
| Lombardia | 90 | 2 | - | 17 | 5 | 55 | - | - | 2 |
| Prov. Trento /Bolzano | - | 13 | - | - | 1 | 10 | - | - | - |
| Veneto | 2 | 44 | 1 | 1 | 4 | 8 | - | 5 | - |
| Friuli-Venezia Giulia | 1 | 7 | 2 | - | - | 4 | - | - | - |
| Liguria | - | 18 | - | 1 | 4 | 3 | - | - | - |
| Emilia-Romagna | - | 52 | 4 | - | - | 31 | - | - | - |
| Toscana | - | 40 | 4 | - | - | 9 | - | 1 | 2 |
| Umbria | 2 | 14 | - | - | - | 1 | - | - | - |
| Marche | 4 | 26 | - | - | 2 | 8 | - | - | - |
| Lazio | 5 | 37 | 6 | 5 | 6 | 56 | - | - | 6 |
| Abruzzo | - | 17 | - | - | - | 8 | - | - | 4 |
| Molise | - | 5 | - | 1 | - | 2 | - | 1 | 1 |
| Campania | 8 | 44 | 7 | 2 | 3 | 38 | 2 | - | 2 |
| Puglia | - | 26 | 2 | 3 | 2 | 24 | - | - | 3 |
| Basilicata | 1 | 12 | - | - | - | 1 | - | - | - |
| Calabria | 6 | 24 | - | 1 | - | 16 | - | - | 6 |
| Sicilia | 18 | 41 | 5 | 1 | 1 | 31 | 9 | - | 9 |
| Sardegna | 1 | 22 | - | 4 | 1 | 9 | - | - | 4 |
| Total | 143 | 486 | 35 | 36 | 29 | 338 | 13 | 7 | 35 |

## Figure 2. CHF: type of structure.



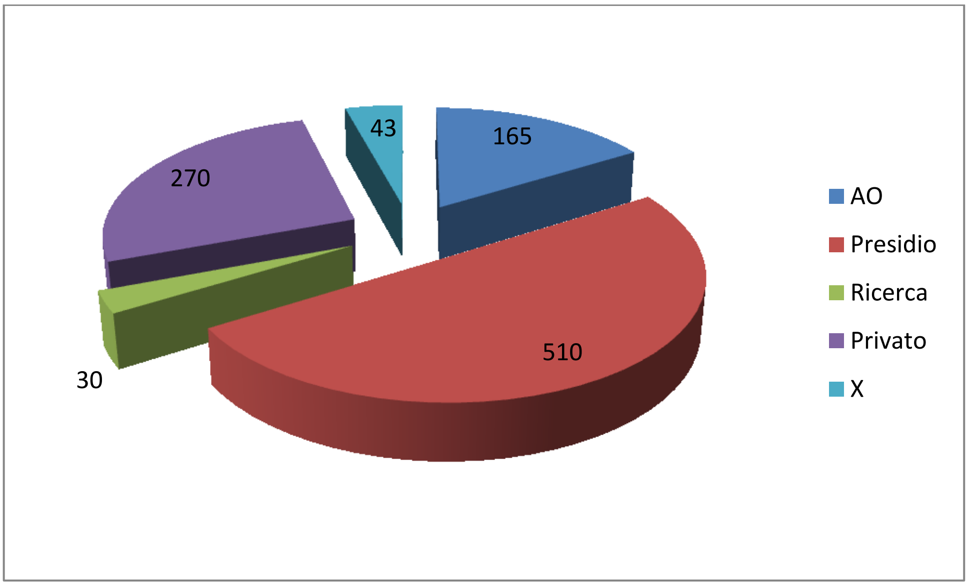
## Table 4.A. Hospitals treating STROKE.

| Regions | No. of structures | Private | Public | No. of ASLs |
|---|---|---|---|---|
| Piemonte | 69 | 16 | 53 | 13 |
| Valle d'Aosta | 1 | 0 | 1 | 1 |
| Lombardia | 141 | 42 | 99 | 15 |
| Prov. Trento /Bolzano | 20 | 6 | 14 | 2 |
| Veneto | 62 | 6 | 56 | 21 |
| Friuli-Venezia Giulia | 13 | 2 | 11 | 6 |
| Liguria | 23 | 0 | 23 | 5 |
| Emilia-Romagna | 81 | 23 | 58 | 11 |
| Toscana | 48 | 5 | 43 | 11 |
| Umbria | 16 | 1 | 15 | 3 |
| Marche | 40 | 6 | 34 | 1 |
| Lazio | 121 | 55 | 66 | 12 |
| Abruzzo | 28 | 7 | 21 | 5 |
| Molise | 11 | 2 | 9 | 1 |
| Campania | 93 | 29 | 64 | 14 |
| Puglia | 53 | 18 | 35 | 6 |
| Basilicata | 12 | 1 | 11 | 4 |
| Calabria | 45 | 12 | 33 | 5 |
| Sicilia | 104 | 33 | 71 | 9 |
| Sardegna | 37 | 10 | 27 | 8 |
| **TOTAL** | 1018 | 274 (26.92%) | 744 (73.08%) | 153 |

**Table 4.B. Type of hospitals treating STROKE.**

| Regions/Type of hospital | Structures within each Azienda Ospedaliera | Presidio Ospedaliero (managed by ASL) | Azienda Ospedaliera – Teaching hospital | IRCCS | Ospedale assimilato | Private structure | Qualified institute | Research trust | Not specified |
|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 4 | 41 | 4 | 1 | - | 16 | 2 | - | 1 |
| Valle d'Aosta | - | 1 | - | - | - | - | - | - | - |
| Lombardia | 80 | 2 | - | 10 | 5 | 42 | - | - | 2 |
| Prov. Trento /Bolzano | - | 13 | - | - | - | 6 | - | - | 1 |
| Veneto | 2 | 43 | 1 | 1 | 3 | 6 | 5 | - | 1 |
| Friuli-Venezia Giulia | 1 | 8 | - | 2 | - | 2 | - | - | 3 |
| Liguria | - | 18 | - | 1 | 4 | - | - | - | - |
| Emilia-Romagna | - | 53 | 4 | 1 | - | 23 | - | - | - |
| Toscana | - | 39 | 3 | - | - | 5 | - | - | 1 |
| Umbria | 2 | 13 | - | - | - | 1 | - | - | - |
| Marche | 5 | 26 | - | 3 | - | 6 | - | - | 6 |
| Lazio | 5 | 39 | 6 | 2 | 6 | 55 | - | 2 | 6 |
| Abruzzo | - | 17 | - | - | - | 7 | - | - | - |
| Molise | - | 5 | - | 2 | - | 2 | - | 1 | 1 |
| Campania | 7 | 43 | 7 | - | 3 | 29 | 2 | - | 4 |
| Puglia | - | 26 | 2 | 1 | 2 | 18 | - | - | 4 |
| Basilicata | 1 | 11 | - | - | - | - | - | - | - |
| Calabria | 5 | 22 | - | 1 | - | 12 | - | - | - |
| Sicilia | 16 | 39 | 5 | 1 | 1 | 33 | - | 1 | 9 |
| Sardegna | 1 | 18 | 4 | - | - | 7 | - | - | 4 |
| Total | 129 | 477 | 36 | 26 | 24 | 270 | 9 | 4 | 43 |

**Figure 3. STROKE: type of structure.**




A patient experiencing stroke has to undergo immediate medical treatment, and must reach a hospital within three hours after symptoms begin. The treatment received at the hospital will depend on how severe the stroke was and what caused it, and may involve pharmacotherapy, instrumental exams, surgery. An accurate follow up is needed as well, so to prevent the probability of an early readmission.

It has been stressed, in the medical literature, how hospital-level readmission rates in case of stroke is a valid tool to assess quality of care, but it needs to be appropriately risk-adjusted for differences in patient characteristics.

In Italy, the number of hospitals dealing with stroke is of 1018, comparing to 1007 structures that registered stroke early readmissions.

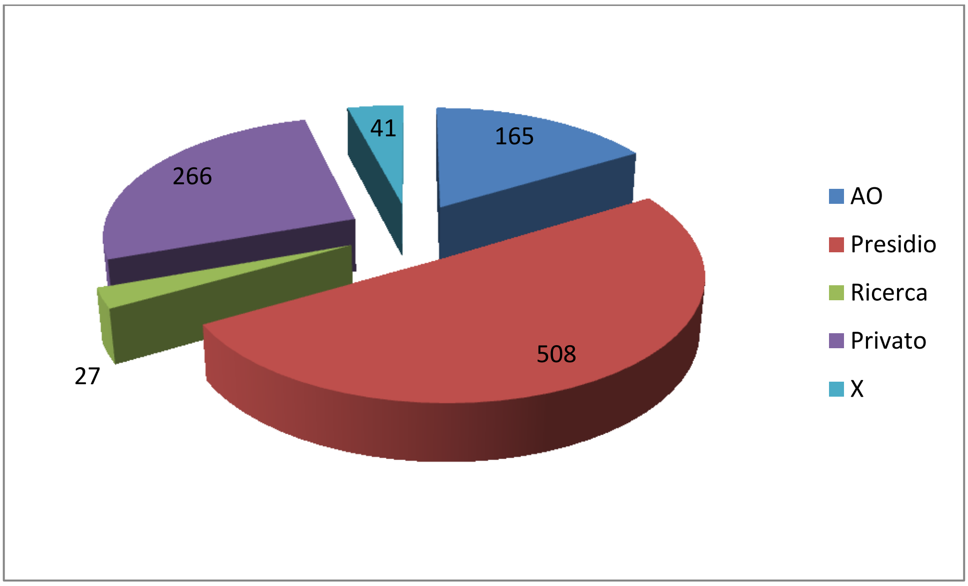
**Table 5.A. Hospitals treating STROKE_READMISSIONS.**

| **Regions** | **No. of structures** | **Private** | **Public** | **No. of ASLs** |
|---|---|---|---|---|
| Piemonte | 68 | 15 | 53 | 13 |
| Valle d'Aosta | 1 | 0 | 1 | 1 |
| Lombardia | 140 | 41 | 99 | 15 |
| Prov. Trento /Bolzano | 20 | 6 | 14 | 2 |
| Veneto | 62 | 6 | 56 | 21 |
| Friuli-Venezia Giulia | 16 | 2 | 14 | 6 |
| Liguria | 23 | 0 | 23 | 5 |
| Emilia-Romagna | 81 | 23 | 58 | 12 |
| Toscana | 48 | 10 | 38 | 10 |
| Umbria | 16 | 1 | 15 | 3 |
| Marche | 40 | 6 | 34 | 1 |
| Lazio | 116 | 50 | 66 | 12 |
| Abruzzo | 28 | 7 | 21 | 5 |
| Molise | 11 | 2 | 9 | 1 |
| Campania | 93 | 29 | 64 | 13 |
| Puglia | 53 | 19 | 44 | 6 |
| Basilicata | 12 | 0 | 12 | 4 |
| Calabria | 44 | 11 | 33 | 5 |
| Sicilia | 102 | 32 | 70 | 9 |
| Sardegna | 33 | 6 | 27 | 8 |
| **TOTAL** | 1007 | 266 (26.42%) | 751 (74.58%) | 152 |

## Table 5.B. Type of hospitals treating STROKE_READMISSIONS.

| Regions/Type of hospital | Structures within each Azienda Ospedaliera | Presidio Ospedaliero (managed by ASL) | Azienda Ospedaliera – Teaching hospital | IRCCS | Ospedale assimilato | Private structure | Qualified institute | Research trust | Not specified |
|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 4 | 41 | 4 | 1 | - | 15 | 2 | - | 1 |
| Valle d'Aosta | - | 1 | - | - | - | - | - | - | - |
| Lombardia | 80 | 2 | - | 10 | 5 | 41 | - | - | 2 |
| Prov. Trento /Bolzano | - | 13 | - | - | - | 6 | - | - | 1 |
| Veneto | 1 | 43 | 2 | 1 | 3 | 6 | 5 | - | 1 |
| Friuli-Venezia Giulia | 1 | 8 | 2 | - | - | 2 | - | - | 3 |
| Liguria | - | 18 | - | 1 | 4 | - | - | - | - |
| Emilia-Romagna | - | 54 | 4 | - | - | 23 | - | - | - |
| Toscana | - | 33 | 2 | - | - | 10 | - | 1 | 2 |
| Umbria | 1 | 13 | 1 | - | - | 1 | - | - | - |
| Marche | 5 | 27 | - | 2 | - | 6 | - | - | - |
| Lazio | 5 | 40 | 6 | 2 | 6 | 50 | - | 2 | 5 |
| Abruzzo | - | 17 | - | - | - | 7 | - | - | 4 |
| Molise | - | 5 | - | 2 | - | 2 | - | 1 | 1 |
| Campania | 7 | 43 | 7 | - | 3 | 29 | 2 | - | 2 |
| Puglia | - | 26 | 2 | 1 | 2 | 19 | - | - | 3 |
| Basilicata | 1 | 11 | - | - | - | - | - | - | - |
| Calabria | 5 | 22 | - | 1 | - | 11 | - | - | 5 |
| Sicilia | 16 | 39 | 4 | 1 | 1 | 32 | - | 1 | 8 |
| Sardegna | 1 | 19 | 4 | - | - | 6 | - | - | 3 |
| **Total** | **127** | **475** | **38** | **22** | **24** | **266** | **9** | **5** | **41** |

## Figure 5 – STROKE_READMISSIONS: type of structure



Finally, COPD is a progressive disease. Higher rates of hospital readmissions and unexplained variations of the latter may indicate problems in transitions of care and outpatient management following the first discharge. Many studies in the medical and economic literature have concentrated on causes of readmissions, especially for some groups of patients (marked differences due to age and race). Hence, as for stroke readmissions, COPD readmissions need to be risk-adjusted for differences in patient characteristics.

Another stream of literature has focused on costs of readmissions for COPD, since they have been found to be significantly higher than for the original hospital stay.

In Italy, in 2009, more than 1,100 structures had to deal with earlier readmission for COPD. Almost 30% of patients were admitted at private structures.

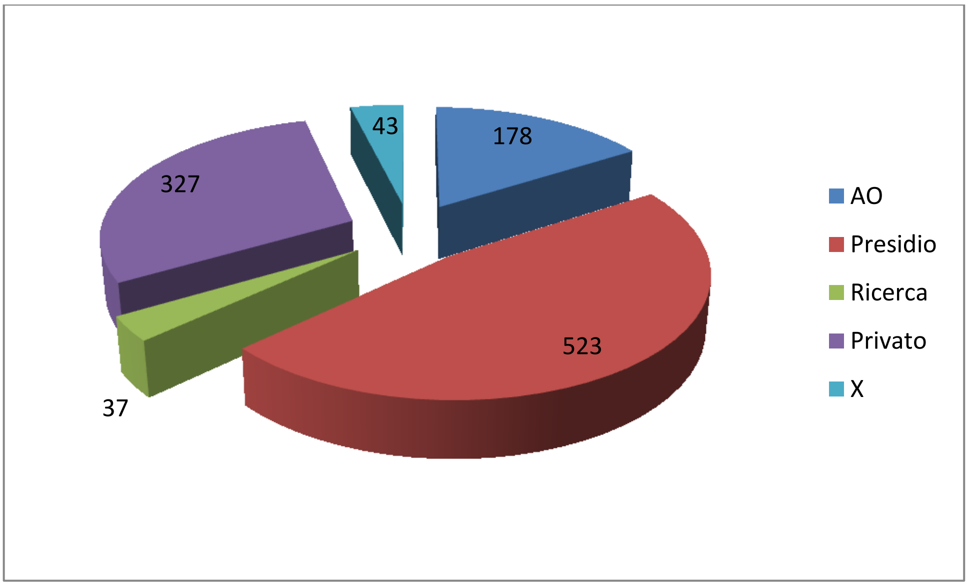
**Table 6.A. Hospitals treating COPD_READMISSIONS.**

| Regions | No. of structures | Private | Public | No. of ASLs |
|---|---|---|---|---|
| Piemonte | 79 | 25 | 54 | 13 |
| Valle d'Aosta | 1 | 0 | 1 | 1 |
| Lombardia | 169 | 55 | 114 | 15 |
| Prov. Trento /Bolzano | 24 | 9 | 15 | 2 |
| Veneto | 66 | 9 | 57 | 21 |
| Friuli-Venezia Giulia | 19 | 5 | 14 | 6 |
| Liguria | 23 | 0 | 23 | 5 |
| Emilia-Romagna | 83 | 27 | 56 | 10 |
| Toscana | 54 | 9 | 45 | 11 |
| Umbria | 16 | 1 | 15 | 4 |
| Marche | 42 | 8 | 34 | 1 |
| Lazio | 118 | 51 | 67 | 12 |
| Abruzzo | 31 | 9 | 22 | 6 |
| Molise | 10 | 2 | 8 | 1 |
| Campania | 108 | 40 | 68 | 13 |
| Puglia | 56 | 19 | 37 | 6 |
| Basilicata | 14 | 1 | 13 | 4 |
| Calabria | 53 | 14 | 39 | 5 |
| Sicilia | 103 | 30 | 73 | 9 |
| Sardegna | 39 | 9 | 30 | 8 |
| **TOTAL** | 1108 | 323 (29.15%) | 785 (70.85%) | 153 |

## Table 6.B. Type of hospitals treating COPD_READMISSIONS.

| Regions/Type of hospital | Structures within each Azienda Ospedaliera | Presidio Ospedaliero (managed by ASL) | Azienda Ospedaliera – Teaching hospital | IRCCS | Ospedale assimilato | Private structure | Qualified institute | Research trust | Not specified |
|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 4 | 41 | 4 | 1 | - | 25 | 3 | - | 1 |
| Valle d'Aosta | - | 1 | - | - | - | - | - | - | - |
| Lombardia | 87 | 2 | - | 16 | 6 | 55 | - | - | 2 |
| Prov. Trento /Bolzano | - | 13 | - | - | 1 | 9 | - | - | 1 |
| Veneto | 2 | 44 | 1 | - | 4 | 9 | 5 | - | 1 |
| Friuli-Venezia Giulia | 1 | 8 | 2 | - | - | 5 | - | - | 3 |
| Liguria | - | 18 | - | 1 | 4 | - | - | - | - |
| Emilia-Romagna | - | 52 | 4 | - | - | 27 | - | - | - |
| Toscana | - | 40 | 3 | 1 | - | 9 | - | - | 1 |
| Umbria | 2 | 13 | - | - | - | 1 | - | - | - |
| Marche | 4 | 27 | - | 2 | - | 10 | - | - | 6 |
| Lazio | 5 | 38 | 6 | 4 | 6 | 51 | - | - | 6 |
| Abruzzo | - | 18 | - | - | - | 9 | - | - | - |
| Molise | - | 5 | - | 1 | - | 2 | - | 1 | 1 |
| Campania | 8 | 44 | 7 | 2 | 3 | 40 | 2 | - | 4 |
| Puglia | - | 26 | 2 | 4 | 2 | 19 | - | - | 4 |
| Basilicata | 1 | 12 | - | - | - | 1 | - | - | - |
| Calabria | 7 | 25 | - | 1 | - | 14 | - | - | - |
| Sicilia | 18 | 40 | 5 | 1 | 1 | 32 | - | 1 | 9 |
| Sardegna | 1 | 19 | 4 | 1 | - | 9 | - | - | 4 |
| **Total** | 140 | 486 | 38 | 35 | 27 | 327 | 10 | 2 | 43 |

## Figure 5. COPD_READMISSIONS: type of structure.



The picture that has been represented so far for each clinical condition outlines how many public or private structures have dealt with that condition in the year of analysis.

Tables 7a-7e present more detailed information, summarizing the main characteristics of hospitals, both private and public, located in each Region, that treated each given condition.

For each variable, mean and standard deviation have been reported.

Information concerning private structures relate to number of beds, beds occupancy rate, medical staff (physicians and nurses); information for public structures relate to number of beds, utilization rate for each structure, index of case mix, index of entropy, medical staff (physicians and nurses).

Beds occupancy and utilization rates should be regarded as indicators for demand, while the other factors, such as medical staff, or number of beds, constitute the inputs in the process of providing hospital care and are, therefore, supply indicators.

The last two columns represent those variables, employed as well in the empirical analysis, that are linked to the institutional scenario described in the second paragraph, such as the choice for a regional DRG, the share of beds in AOs and private structures.

## Table 7a. AMI - Characteristics of hospitals per Region.

| Regions | Public | Private | Beds | Beds occupancy rate | Physicians | Nurses | Beds | % utilization of the structure | Physicians | Health professionists (= nurses) | Index of case mix | Index of entropy | Number of AMI | DRG Regional | % beds for AOs and private structures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 0.79 | 0.21 | 104 | 0.95 | 50 | 59.26 | 405 | 81.13 | 238.30 | 568.63 | 1.09 | 2.07 | 99.97 | 1 | 0.50 |
| Valle d'Aosta* | 1 | 0 | - | - | - | - | 408 | 77.24 | 258 | 513 | 1.03 | 2.29 | 251 | 0 | 0 |
| Lombardia | 0.71 | 0.29 | 141.3 | 0.93 | 83.16 | 106.35 | 697.40 | 78.3 | 349.45 | 1000.14 | 0.99 | 2.15 | 98.93 | 1 | 0.76 |
| Trentino A.A. | 0.76 | 0.24 | 98.5 | 0.95 | 18 | 30 | 245.92 | 74.34 | 113.69 | 338.84 | 0.90 | 2.26 | 71.39 | 0 | 0.18 |
| Veneto | 0.87 | 0.13 | 99.12 | 0.92 | 30.25 | 50.87 | 531.09 | 81.46 | 249.37 | 750.46 | 0.99 | 2.18 | 96.70 | 1 | 0.23 |
| Friuli V. Giulia | 0.8 | 0.2 | 123.5 | 0.83 | 69 | 75.5 | 357.44 | 81.39 | 200.66 | 535.22 | 1.00 | 2.23 | 120.05 | 0 | 0.24 |
| Liguria | 0.95 | 0.5 | 67 | 1 | 18 | 19 | 494.35 | 81.46 | 309.9 | 792.2 | 1.00 | 2.23 | 130.6 | 0 | 0.37 |
| Emilia Romagna | 0.73 | 0.27 | 98.45 | 0.91 | 55.85 | 64.2 | 827.11 | 75.22 | 420.57 | 1126.8 | 1.03 | 2.11 | 114.44 | 1 | 0.24 |
| Toscana | 0.84 | 0.16 | 112.77 | 0.81 | 31.88 | 51.22 | 306.02 | 77.29 | 195.76 | 490.52 | 1.07 | 2.07 | 123.27 | 1 | 0.14 |
| Umbria ** | 1 | 0 | - | - | - | - | 251.33 | 79.97 | 170.07 | 354.13 | 0.86 | 2.14 | 83.8 | 1 | 0.54 |
| Marche | 0.86 | 0.14 | 81 | 0.91 | 32.3 | 31.2 | 359.62 | 84.79 | 218 | 568.25 | 1.04 | 2.04 | 81.42 | 0 | 0.37 |
| Lazio | 0.64 | 0.36 | 142.32 | 0.88 | 61.76 | 71.12 | 337.87 | 78.90 | 225.58 | 498.04 | 0.94 | 2.10 | 87.16 | 1 | 0.40 |
| Abruzzo | 0.74 | 0.26 | 147.17 | 0.92 | 71.66 | 131.83 | 211.35 | 78.26 | 119.35 | 298.88 | 0.88 | 2.09 | 69.07 | 0 | 0.24 |
| Molise | 0.78 | 0.22 | 67 | 0.91 | 37 | 23 | 235 | 88.22 | 98.71 | 202.14 | 0.98 | 2.00 | 33.7 | 0 | 0.14 |
| Puglia | 0.66 | 0.34 | 115.87 | 0.89 | 45.26 | 60.71 | 308.82 | 81.40 | 249.23 | 504.77 | 0.91 | 2.07 | 89.64 | 0 | 0.55 |
| Campania | 0.66 | 0.34 | 89.59 | 0.98 | 30.12 | 83.24 | 403.56 | 80.66 | 201.90 | 411.5 | 0.88 | 2.12 | 92.74 | 0 | 0.18 |
| Basilicata | 0.92 | 0.08 | - | - | 10 | 19 | 184.42 | 77.50 | 106.83 | 268.17 | 0.87 | 2.03 | 62 | 0 | 0.44 |
| Calabria | 0.75 | 0.25 | 100 | 0.93 | 29.2 | 40.4 | 190.86 | 84.63 | 138.82 | 270.68 | 0.81 | 1.92 | 63.49 | 0 | 0.64 |
| Sicilia | 0.68 | 0.32 | 89.41 | 0.93 | 38.97 | 42.38 | 191.01 | 74.26 | 147.80 | 260.80 | 0.85 | 2.03 | 80.73 | 1 | 0.57 |
| Sardegna | 0.79 | 0.21 | 139.71 | 0.92 | 48.57 | 53.28 | 195.88 | 68.14 | 124.85 | 253.65 | 0.84 | 1.98 | 59.14 | 0 | 0.26 |

*** data are related only to one structure**
**** data are related only to public structures**

## Table 7b. CHF - Characteristics of hospitals per Region.

| Regions | Public | Private | Beds | Beds occupancy rate | Physicians | Nurses | Beds | % utilization of the structure | Physicians | Health professionists (= nurses) | Index of case mix | Index of entropy | Number of AMI | DRG Regional | % beds for AOs and private structures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 0.69 | 0.31 | 101.9 | 0.96 | 45.09 | 57.4 | 401.22 | 80.37 | 243.49 | 594.82 | 1.09 | 2.16 | 99.07 | 1 | 0.51 |
| Valle d'Aosta* | 1 | - | - | - | - | - | 408 | 77.24 | 258 | 513 | 1.03 | 2.29 | 231 | 1 | 1 |
| Lombardia | 0.67 | 0.33 | 138.60 | 0.94 | 75.90 | 97.60 | 691.32 | 78.62 | 344.60 | 990.30 | 0.97 | 2.14 | 167.83 | 1 | 0.76 |
| Trentino A.A. | 0.58 | 0.42 | 70 | 0.99 | 11.25 | 24.5 | 236.78 | 72.80 | 106.93 | 321.5 | 0.90 | 2.21 | 107.72 | 0 | 0.18 |
| Veneto | 0.88 | 0.12 | 96 | 0.88 | 32.71 | 53.43 | 521.96 | 81.19 | 245.46 | 734.05 | 1.00 | 2.16 | 203.90 | 1 | 0.23 |
| Friuli V. Giulia | 0.71 | 0.29 | 130.5 | 0.90 | 56 | 70.25 | 429.71 | 81.36 | 236.86 | 649.86 | 1.00 | 2.23 | 253.33 | 0 | 0.24 |
| Liguria | 0.88 | 0.12 | 59 | 0.87 | 15.33 | 25 | 488.32 | 80.03 | 310.64 | 788.18 | 0.99 | 2.20 | 214.52 | 0 | 0.37 |
| Emilia Romagna | 0.64 | 0.36 | 90.72 | 0.91 | 54.69 | 56.38 | 836.44 | 75.10 | 425.15 | 1140.33 | 1.03 | 2.10 | 172.66 | 1 | 0.24 |
| Toscana | 0.84 | 0.16 | 74.62 | 0.84 | 21 | 24.5 | 299.36 | 78.04 | 195.96 | 490.83 | 1.07 | 2.07 | 159.57 | 1 | 0.14 |
| Umbria | 0.94 | 0.06 | 65 | 0.91 | 22 | 20 | 244.5 | 79.53 | 165.5 | 346.81 | 0.87 | 2.14 | 164.88 | 1 | 0.54 |
| Marche | 0.8 | 0.2 | 76.87 | 0.91 | 26.62 | 29.62 | 359.62 | 84.79 | 218 | 568.25 | 1.04 | 2.04 | 130.02 | 0 | 0.37 |
| Lazio | 0.52 | 0.48 | 142.05 | 0.90 | 54.21 | 67.29 | 350.38 | 79.82 | 232.53 | 509.4 | 0.94 | 2.08 | 119.29 | 1 | 0.40 |
| Abruzzo | 0.68 | 0.32 | 123.62 | 0.89 | 61.25 | 105.5 | 211.35 | 78.26 | 119.35 | 298.88 | 0.88 | 2.09 | 166.55 | 0 | 0.24 |
| Molise | 0.78 | 0.22 | 67 | 0.91 | 37 | 23 | 235 | 88.22 | 98.71 | 202.14 | 0.98 | 2.00 | 120.1 | 0 | 0.14 |
| Puglia | 0.65 | 0.35 | 113.54 | 0.89 | 41.86 | 54.73 | 302.12 | 81.45 | 241.26 | 490.54 | 0.91 | 2.07 | 124.68 | 0 | 0.55 |
| Campania | 0.58 | 0.42 | 82.87 | 0.97 | 29.67 | 67.83 | 403.56 | 80.66 | 201.91 | 411.5 | 0.88 | 2.12 | 191.7 | 0 | 0.18 |
| Basilicata | 0.93 | 0.07 | - | - | 10 | 19 | 179.92 | 76.75 | 102.85 | 260.07 | 0.87 | 2.03 | 130.71 | 0 | 0.44 |
| Calabria | 0.66 | 0.34 | 90.87 | 0.91 | 29.44 | 38.75 | 186.34 | 83.30 | 135.41 | 263.65 | 0.81 | 1.91 | 123.87 | 0 | 0.64 |
| Sicilia | 0.68 | 0.32 | 86.45 | 0.93 | 37.29 | 41.97 | 191.01 | 74.26 | 147.80 | 260.80 | 0.85 | 2.03 | 156.60 | 1 | 0.57 |
| Sardegna | 0.76 | 0.24 | 128.78 | 0.89 | 45.11 | 56.11 | 199.75 | 65.95 | 130.29 | 257.79 | 0.85 | 1.94 | 87.22 | 0 | 0.26 |

*** data are related only to one structure**

## Table 7c. STROKE – Characteristics of hospitals per Region.

| Regions | Public | Private | Beds | Beds occupancy rate | Physicians | Nurses | Beds | % utilization of the structure | Physicians | Health professionists (= nurses) | Index of case mix | Index of entropy | Number of AMI | DRG Regional | % beds for AOs and private structures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 0.76 | 0.24 | 109 | 0.94 | 46.12 | 59.81 | 396.82 | 81.10 | 234.51 | 573.15 | 1.08 | 2.14 | 94.86 | 1 | 0.51 |
| Valle d'Aosta * | 1 | 0 | - | - | - | - | 408 | 77.24 | 258 | 513 | 1.03 | 2.29 | 208 | 0 | 0 |
| Lombardia | 0.70 | 0.30 | 144.24 | 0.94 | 83.93 | 109.88 | 728.71 | 77.80 | 363.44 | 1044.39 | 0.99 | 2.19 | 84.94 | 1 | 0.765 |
| Trentino A.A. | 0.68 | 0.32 | 55.8 | 0.98 | 11.2 | 18.8 | 245.92 | 74.34 | 113.69 | 338.85 | 0.90 | 2.26 | 63.4 | 0 | 0.18 |
| Veneto | 0.90 | 0.10 | 90.4 | 0.88 | 30.2 | 45.8 | 532.83 | 81.17 | 252.96 | 756.02 | 1.00 | 2.16 | 105 | 1 | 0.23 |
| Friuli V. Giulia | 0.85 | 0.15 | 123.5 | 0.83 | 69 | 75.5 | 388.62 | 81.37 | 212.5 | 580.12 | 1.00 | 2.23 | 105.62 | 0 | 0.24 |
| Liguria ** | 1 | 0 | - | - | - | - | 488.32 | 80.03 | 310.63 | 788.18 | 0.99 | 2.20 | 134.43 | 0 | 0.37 |
| Emilia Romagna | 0.72 | 0.28 | 94.04 | 0.91 | 62.09 | 60.86 | 817.40 | 75.32 | 408.21 | 1094.57 | 1.03 | 2.13 | 87.65 | 1 | 0.24 |
| Toscana | 0.90 | 0.10 | 75.2 | 0.88 | 16 | 31 | 310.88 | 77.02 | 201.65 | 503.30 | 1.04 | 2.10 | 136.56 | 1 | 0.14 |
| Umbria | 0.94 | 0.06 | 65 | 0.91 | 22 | 20 | 251.33 | 79.97 | 170.06 | 354.13 | 0.87 | 2.14 | 87.62 | 1 | 0.54 |
| Marche | 0.85 | 0.15 | 75.83 | 0.93 | 29.67 | 29.33 | 329.7 | 86.1 | 195.2 | 512.1 | 1.02 | 1.99 | 72.05 | 0 | 0.37 |
| Lazio | 0.52 | 0.48 | 126.51 | 0.89 | 49.90 | 61.46 | 347.37 | 80.25 | 226.80 | 501.37 | 0.93 | 2.07 | 54.19 | 1 | 0.40 |
| Abruzzo | 0.71 | 0.29 | 132 | 0.91 | 64.86 | 116.86 | 211.35 | 78.25 | 119.35 | 298.88 | 0.88 | 2.09 | 71.43 | 0 | 0.24 |
| Molise | 0.8 | 0.2 | 67 | 0.91 | 37 | 23 | 242.62 | 88.60 | 97 | 189.25 | 1.00 | 1.91 | 39.64 | 0 | 0.14 |
| Puglia | 0.70 | 0.30 | 101.78 | 0.88 | 44.86 | 52.03 | 2408.27 | 81.07 | 248.39 | 501.35 | 0.90 | 2.09 | 64.20 | 0 | 0.55 |
| Campania | 0.63 | 0.37 | 81.61 | 0.99 | 29.89 | 76.28 | 419.8 | 79.42 | 212.43 | 432.7 | 0.87 | 2.18 | 72.49 | 0 | 0.18 |
| Basilicata ** | 1 | 0 | - | - | - | - | 184.42 | 77.50 | 106.83 | 268.17 | 0.87 | 2.03 | 73.75 | 0 | 0.44 |
| Calabria | 0.70 | 0.30 | 103.83 | 0.92 | 29.92 | 40.83 | 181.88 | 84.98 | 131.81 | 261.08 | 0.80 | 1.91 | 50.91 | 0 | 0.64 |
| Sicilia | 0.66 | 0.34 | 88.88 | 0.93 | 36.76 | 39.45 | 187.18 | 74.36 | 147.16 | 259.54 | 0.86 | 2.01 | 71.87 | 1 | 0.57 |
| Sardegna | 0.77 | 0.23 | 139.71 | 0.92 | 48.57 | 53.28 | 222.09 | 68.61 | 144.13 | 283.87 | 0.82 | 2.06 | 50.79 | 0 | 0.26 |

*** data are related only to one structure**
**** data are related only to public structures**

**Table 7d. STROKE readmissions - Characteristics of hospitals per Region.**

| Regions | Public | Private | Beds | Beds occupancy rate | Physicians | Nurses | Beds | % utilization of the structure | Physicians | Health professionists (= nurses) | Index of case mix | Index of entropy | Number of AMI | DRG Regional | % beds for AOs and private structures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 0.78 | 0.22 | 112 | 0.94 | 40.87 | 56.8 | 396.82 | 81.10 | 234.51 | 573.15 | 1.082 | 2.14 | 82.90 | 1 | 0.51 |
| Valle d'Aosta * | 1 | 0 | - | - | - | - | 408 | 77.24 | 258 | 513 | 1.03 | 2.29 | 182 | 0 | 0 |
| Lombardia | 0.70 | 0.30 | 144.24 | 0.94 | 83.93 | 109.88 | 714.36 | 77.80 | 356.14 | 1027.33 | 0.99 | 2.19 | 76.41 | 1 | 0.76 |
| Trentino A.A. | 0.68 | 0.32 | 55.8 | 0.98 | 11.2 | 18.8 | 245.92 | 74.34 | 113.69 | 338.84 | 0.90 | 2.26 | 57.1 | 0 | 0.18 |
| Veneto | 0.90 | 0.10 | 90.4 | 0.88 | 30.2 | 45.8 | 532.83 | 81.17 | 252.96 | 756.02 | 1.00 | 2.16 | 92.82 | 1 | 0.23 |
| Friuli V. Giulia | 0.85 | 0.15 | 123.5 | 0.83 | 69 | 75.5 | 388.62 | 81.37 | 212.5 | 580.12 | 1.00 | 2.23 | 86.44 | 0 | 0.24 |
| Liguria ** | 1 | 0 | - | - | - | - | 488.32 | 80.03 | 310.64 | 788.18 | 0.99 | 2.20 | 113.60 | 0 | 0.37 |
| Emilia Romagna | 0.72 | 0.28 | 94.04 | 0.91 | 62.09 | 60.86 | 814.74 | 75.53 | 414.23 | 1112.55 | 1.029 | 2.095 | 75.89 | 1 | 0.24 |
| Toscana | 0.79 | 0.21 | 102 | 0.83 | 29.7 | 47.4 | 307.36 | 77.81 | 195.54 | 499.82 | 1.07 | 2.06 | 120.54 | 1 | 0.14 |
| Umbria | 0.94 | 0.06 | 65 | 0.91 | 22 | 20 | 298.25 | 79.76 | 202.94 | 427.44 | 0.92 | 2.14 | 79.62 | 1 | 0.54 |
| Marche | 0.85 | 0.15 | 75.83 | 0.93 | 29.67 | 29.33 | 316.92 | 81.28 | 194.54 | 484 | 0.99 | 2.10 | 59.27 | 0 | 0.37 |
| Lazio | 0.55 | 0.45 | 128.02 | 0.90 | 51.81 | 62.10 | 342.64 | 80.40 | 223.25 | 493.72 | 0.93 | 2.07 | 47.91 | 1 | 0.40 |
| Abruzzo | 0.71 | 0.29 | 132 | 0.91 | 64.86 | 116.86 | 211.35 | 78.26 | 119.35 | 298.88 | 0.88 | 2.09 | 62.39 | 0 | 0.24 |
| Molise | 0.8 | 0.2 | 67 | 0.91 | 37 | 23 | 242.62 | 88.60 | 97 | 189.25 | 1.00 | 1.91 | 33.27 | 0 | 0.14 |
| Puglia | 0.70 | 0.30 | 101.78 | 0.88 | 44.86 | 52.03 | 301.76 | 81.07 | 248.38 | 501.35 | 0.90 | 2.009 | 57.49 | 0 | 0.55 |
| Campania | 0.62 | 0.38 | 83.63 | 0.98 | 29.95 | 76.68 | 419.8 | 79.41 | 212.43 | 432.7 | 0.87 | 2.17 | 64.30 | 0 | 0.18 |
| Basilicata ** | 1 | 0 | - | - | - | - | 184.42 | 77.50 | 106.83 | 268.17 | 0.87 | 2.03 | 66.25 | 0 | 0.44 |
| Calabria | 0.72 | 0.28 | 104.18 | 0.91 | 30.81 | 42.09 | 181.88 | 84.98 | 131.80 | 261.07 | 0.80 | 1.91 | 45.61 | 0 | 0.64 |
| Sicilia | 0.66 | 0.34 | 89.16 | 0.93 | 36.12 | 38.97 | 180.80 | 74.19 | 139.15 | 244.78 | 0.85 | 2.01 | 66.88 | 1 | 0.57 |
| Sardegna | 0.79 | 0.21 | 151.67 | 0.91 | 47.17 | 54.67 | 222.09 | 68.60 | 144.13 | 283.87 | 0.82 | 2.05 | 45.27 | 0 | 0.26 |

*** data are related only to one structure**
**** data are related only to public structures**

## Table 7e. COPD readmissions - Characteristics of hospitals per Region.

| Regions | Public | Private | Beds | Beds occupancy rate | Physicians | Nurses | Beds | % utilization of the structure | Physicians | Health professionists (= nurses) | Index of case mix | Index of entropy | Number of AMI | DRG Regional | % beds for AOs and private structures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piemonte | 0.68 | 0.32 | 101.22 | 0.97 | 45.04 | 54.56 | 397.71 | 81.23 | 235.25 | 574.63 | 1.09 | 2.14 | 73.11 | 1 | 0.50 |
| Valle d'Aosta * | 1 | 0 | - | - | - | - | 408 | 77.24 | 258 | 513 | 1.03 | 2.29 | 208 | 0 | 0 |
| Lombardia | 0.67 | 0.33 | 134.79 | 0.94 | 75.07 | 95.17 | 687.56 | 78.47 | 343.46 | 989.13 | 0.98 | 2.15 | 85.73 | 1 | 0.76 |
| Trentino A.A. | 0.61 | 0.39 | 68.75 | 0.98 | 10.87 | 23.62 | 236.79 | 72.80 | 106.93 | 321.5 | 0.89 | 2.21 | 52.70 | 0 | 0.18 |
| Veneto | 0.87 | 0.13 | 96 | 0.88 | 32.71 | 53.43 | 534.87 | 81.62 | 252.31 | 753.84 | 0.99 | 2.16 | 82.89 | 1 | 0.23 |
| Friuli V. Giulia | 0.69 | 0.31 | 130.5 | 0.90 | 56 | 70.25 | 388.62 | 81.37 | 212.5 | 580.12 | 1.00 | 2.23 | 105.74 | 0 | 0.24 |
| Liguria ** | 1 | 0 | - | - | - | - | 488.32 | 80.03 | 310.63 | 788.18 | 0.99 | 2.20 | 140.13 | 0 | 0.37 |
| Emilia Romagna | 0.67 | 0.33 | 88.04 | 0.93 | 52.84 | 52.6 | 836.45 | 75.10 | 425.15 | 1140.33 | 1.03 | 2.10 | 114.14 | 1 | 0.24 |
| Toscana | 0.83 | 0.17 | 70.25 | 1.79 | 36.12 | 203 | 306.7 | 77.52 | 200.58 | 499.82 | 1.030 | 2.08 | 104.33 | 1 | 0.14 |
| Umbria | 0.94 | 0.06 | 65 | 0.91 | 22 | 20 | 251.33 | 79.97 | 170.06 | 354.13 | 0.87 | 2.14 | 94.25 | 1 | 0.54 |
| Marche | 0.80 | 0.20 | 76.87 | 0.91 | 26.62 | 29.62 | 359.62 | 84.79 | 218 | 568.25 | 1.04 | 2.04 | 57.09 | 0 | 0.37 |
| Lazio | 0.54 | 0.46 | 133.33 | 0.90 | 54.15 | 66.06 | 342.54 | 78.89 | 225.88 | 496.25 | 0.94 | 2.08 | 68.63 | 1 | 0.40 |
| Abruzzo | 0.67 | 0.34 | 113.22 | 0.90 | 55.22 | 95 | 221.28 | 79 | 127 | 316.5 | 0.89 | 2.10 | 88.19 | 0 | 0.24 |
| Molise | 0.78 | 0.22 | 67 | 0.91 | 37 | 23 | 235 | 88.22 | 898.71 | 202.14 | 0.98 | 2.00 | 66.7 | 0 | 0.14 |
| Puglia | 0.63 | 0.37 | 108.12 | 0.90 | 40.77 | 53.85 | 302.12 | 81.45 | 241.26 | 490.54 | 0.91 | 2.06 | 112.36 | 0 | 0.55 |
| Campania | 0.64 | 0.36 | 79.63 | 0.97 | 26.74 | 62.79 | 394.09 | 80.07 | 198.18 | 402.70 | 0.89 | 2.11 | 236.93 | 0 | 0.18 |
| Basilicata | 0.93 | 0.07 | - | - | 10 | 19 | 179.92 | 76.75 | 102.85 | 260.07 | 0.87 | 2.03 | 109.57 | 0 | 0.44 |
| Calabria | 0.70 | 0.30 | 96 | 0.93 | 25.86 | 30.71 | 198.45 | 82.83 | 144.26 | 282 | 0.81 | 1.93 | 87.17 | 0 | 0.64 |
| Sicilia | 0.69 | 0.31 | 86.4 | 0.93 | 37.97 | 38.73 | 191.01 | 74.26 | 147.80 | 260.80 | 0.85 | 2.03 | 82.45 | 1 | 0.57 |
| Sardegna | 0.74 | 0.26 | 128.77 | 0.89 | 45.11 | 56.11 | 215.64 | 66.78 | 139.08 | 270.72 | 0.84 | 1.96 | 67.46 | 0 | 0.26 |

*** data are related only to one structure**
**** data are related only to public structures**

Table 8 presents the gross and risk adjusted mortality and the readmission rates, that are the dependent variables, obtained by the PNE database.

Although data are available on a regional basis, here they have been aggregated at a national level.

**Table 8. Gross and risk adjusted rates for given conditions.**

| | AMI | CHF | STROKE | STROKE readmission | COPD readmission |
|---|---|---|---|---|---|
| **Gross index %** [a] | 16.16 (20.53) | 9.39 (10.6 ) | 13.00 (14.96) | 13.29 (16.23) | 14.78 (12.85) |
| *Number of cases* | *94,221* | *169,046* | *80,231* | *70,532* | *104,400* |
| *Number of hospitals* | *1,021* | *1,127* | *1,018* | *1,007* | *1,108* |
| **Risk adj. index %** [a] | 11.16 (4.05) | 9.00 (4.71 ) | 13.36 (6.03) | 11.46 (4.15) | 14.34 (4.82) |
| *Number of cases* | *85,742* | *151,892* | *71,080* | *60,713* | *94,159* |
| *Number of hospitals* | *393* | *650* | *435* | *395* | *605* |

*Source:* elaborations on data provided by the PNE.
[a] Mean value (SDs)

The number of hospitals treating the clinical conditions selected for this analysis ranges from 1007 to 1127. At first sight, gross values reveal great variability; however, the same variability decreases considerably as far as risk adjusted indicators are used. The number of structures decreases as well, as only hospitals treating a high number of cases have been considered for risk adjusted rates. However, even if the number of hospitals for which risk adjusted indicators are provided is limited, these ones cover almost the totality of hospital cases. As for AMI, risk adjusted mortality rates in 2009 were provided for 393 hospitals (about 38% of all the hospitals dealing with this diagnosis); however, they treated 91% of the overall cases (85,742 patients out of a total of 94,221).

Similar conclusions can be drawn also with regard to the other indicators. This circumstance implies, overall, a high degree of hospitals' specialization for the selected medical conditions.

The empirical analysis has been run through different stages.

In a first stage, an exploratory analysis aimed at outlining the potential effect of the reimbursement system on the quality indicators has been carried out.

Here, risk-adjusted indicators have been considered. A preliminary distinction has been done between those Regions that have established their own DRG tariffs and those ones that have opted for the national DRG rates, though with some modifications. By splitting Regions into two groups, it is be possible to disentangle regional decision-making over the use of the DRG system. Regions that implemented their own tariff system are expected to be more active in managing their health care market and this would result in a better ability to control expenditure levels.

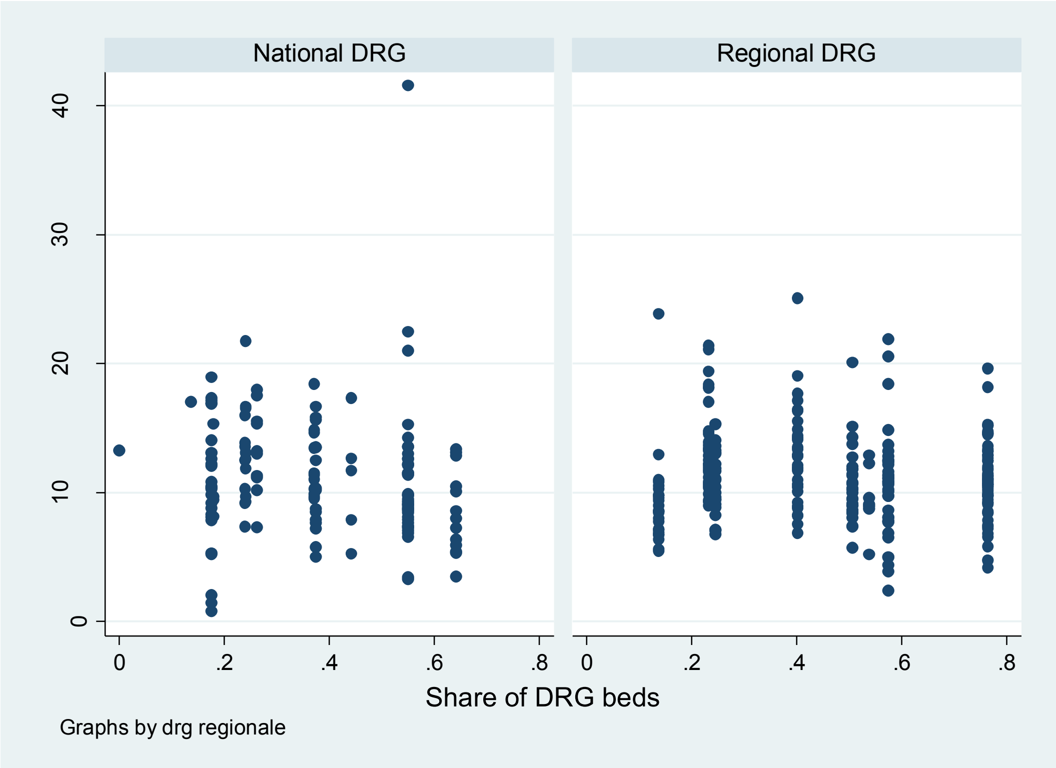
The empirical analysis has seen the estimation of a random intercept model, related to several clusters (ASLs, Regions and type of hospital), to identify possible “group effects”, and of a truncated regression model.

The next figures show scatter (Figures 6a-10a) and box plots (Figures 6b-10b) for mortality and readmission rates, correlated with the choice of a regional DRG or adherence to national tariffs.

Scatter plots show some common trends: as for AMI and STROKE, for example, it would seem that the higher the share of beds financed through DRG within each Region, the better the outcome result, though the increases are very small.

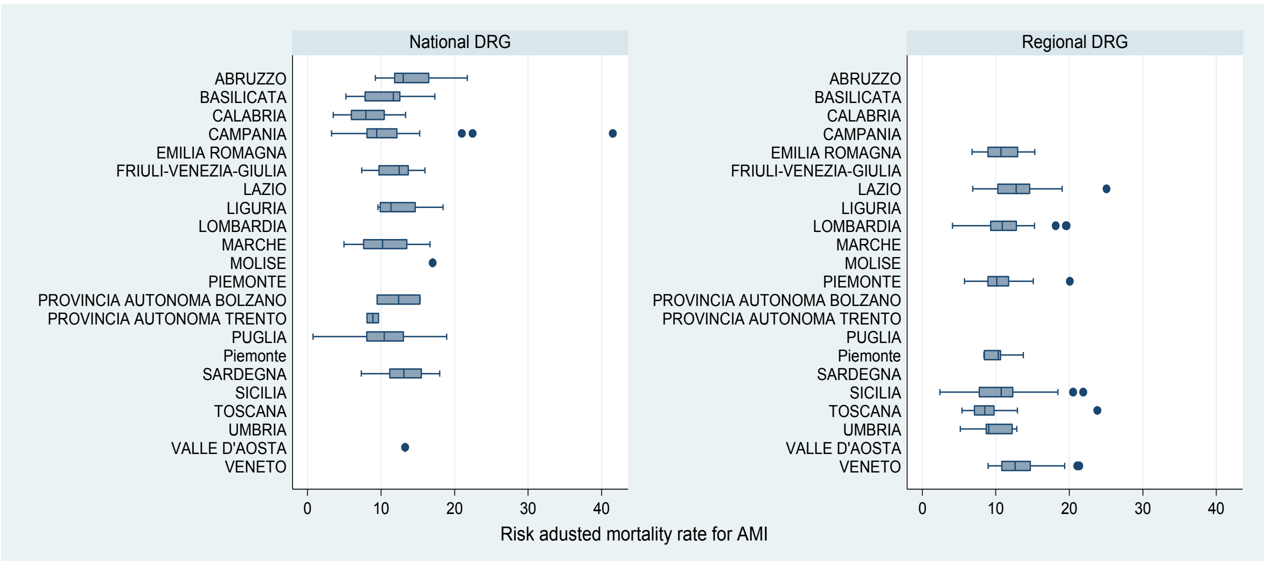
In contrast, box plots reveal less marked irregularities, especially for readmissions. A greater variability can be seen for acute conditions (especially CHF and STROKE).

**Figure 6a. Scatter plots of hospital risk adjusted mortality rates for AMI by DRG system.**



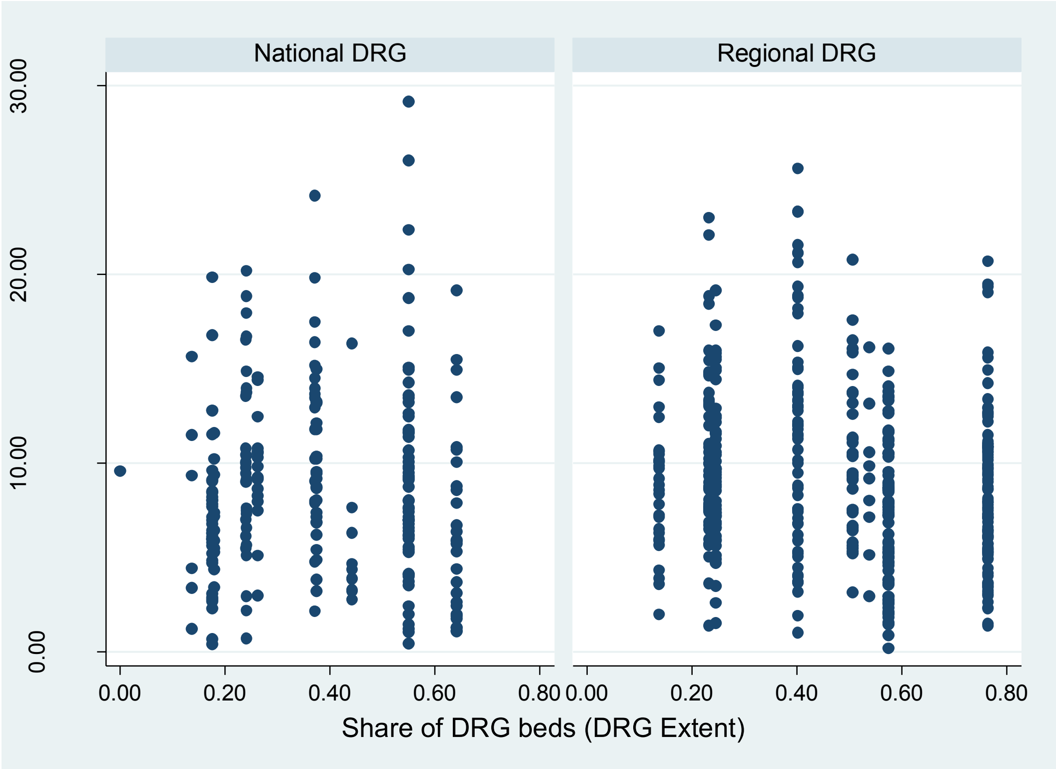

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 6b. Box plots of hospital risk adjusted mortality rates for AMI by DRG system.**



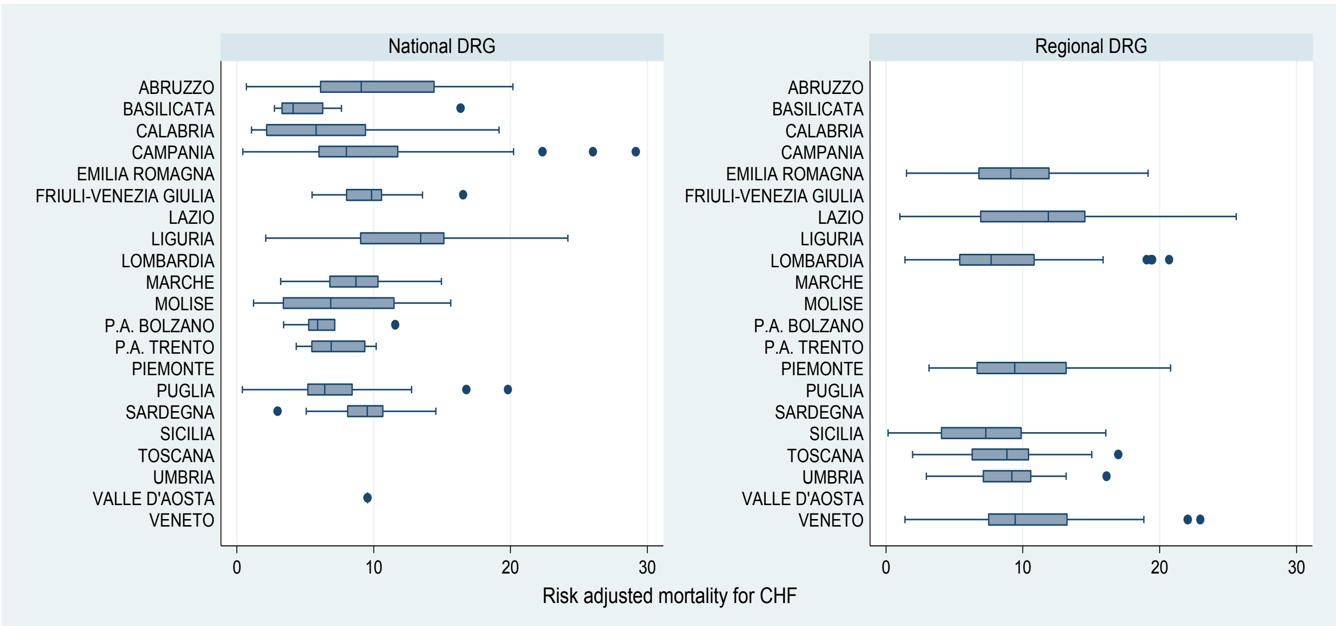

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 7a. Scatter plots of hospital risk adjusted mortality rates for CHF by DRG system.**



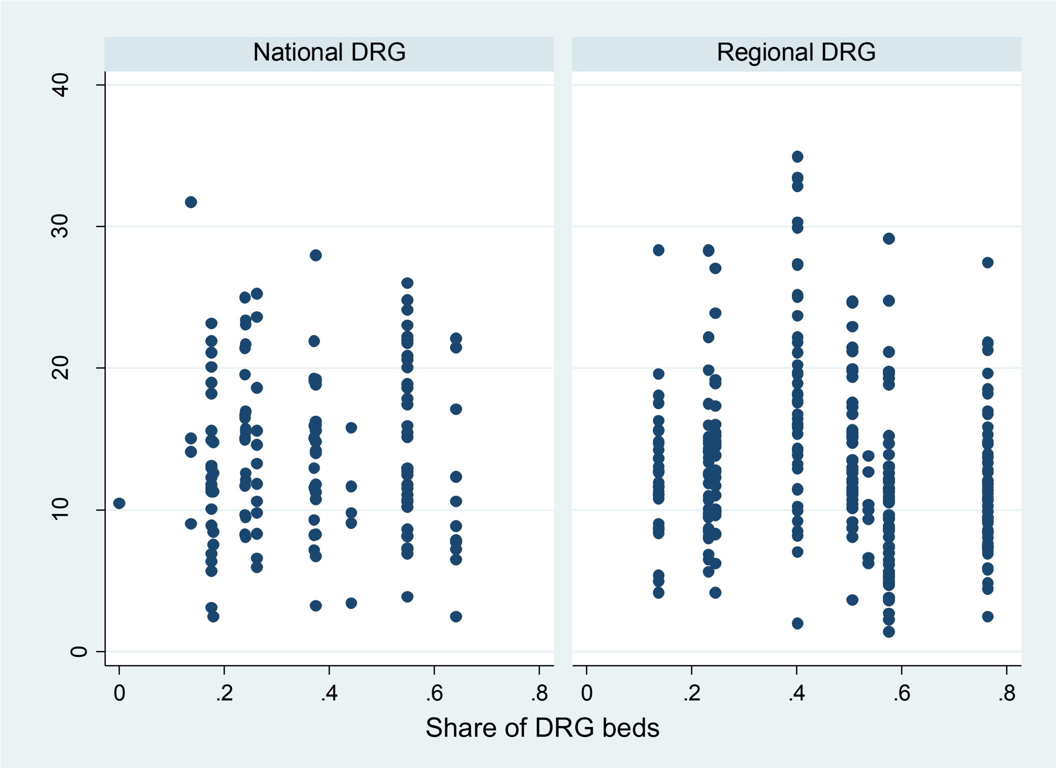

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 7b. Box plots of hospital risk adjusted mortality rates for CHF by DRG system.**



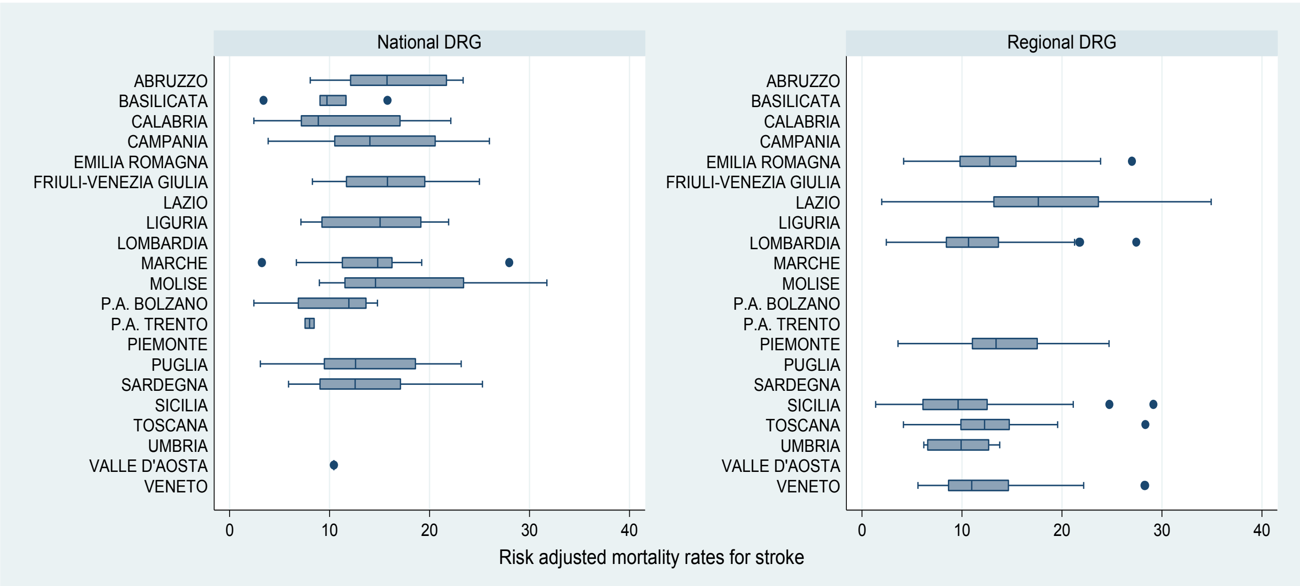

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 8a. Scatter plots of hospital risk adjusted mortality rates for STROKE by DRG system.**



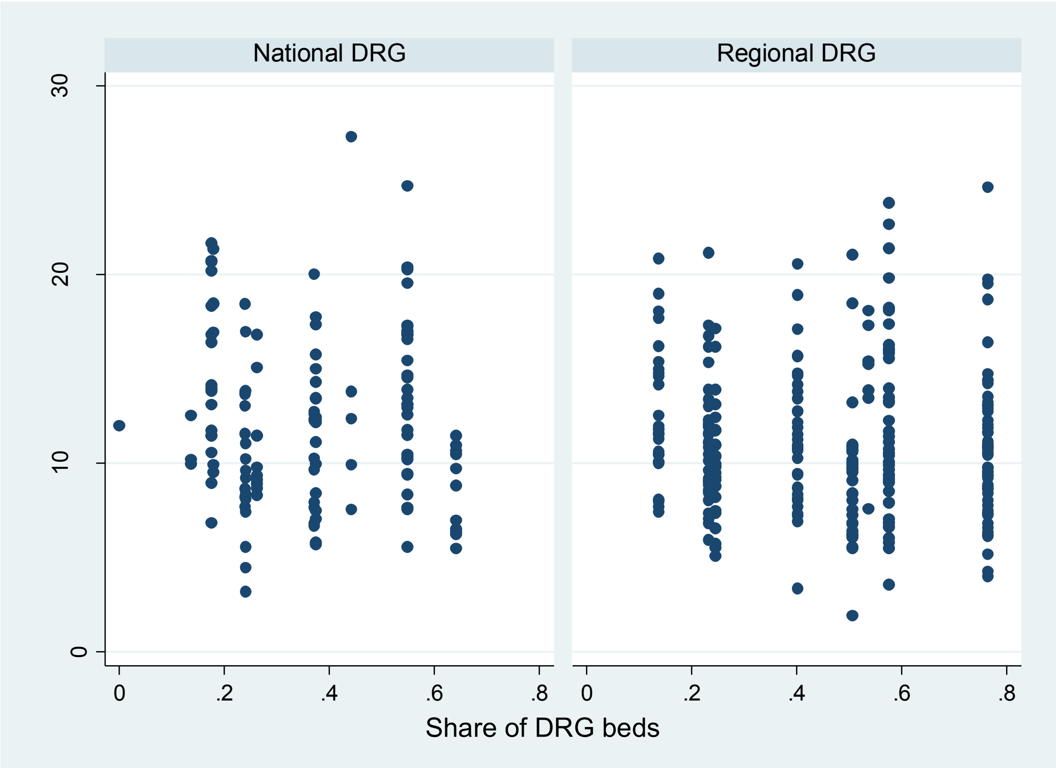

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 8b. Box plots of risk adjusted mortality rates for STROKE by DRG system.**



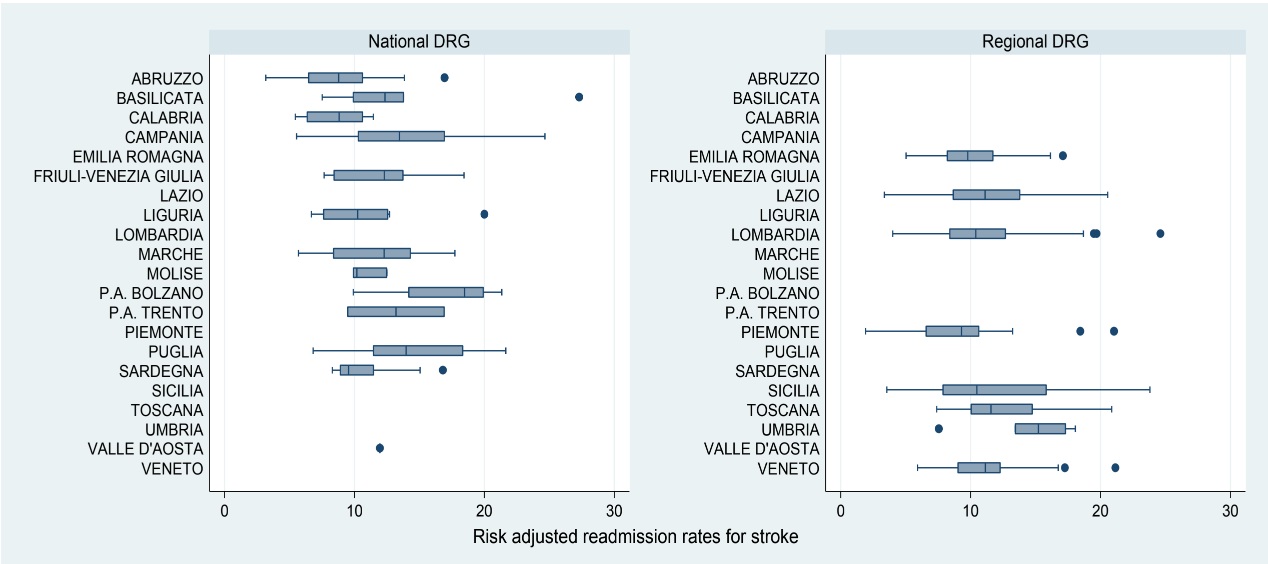

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 9a. Scatter plots of hospital risk adjusted readmission rates for STROKE by DRG system.**



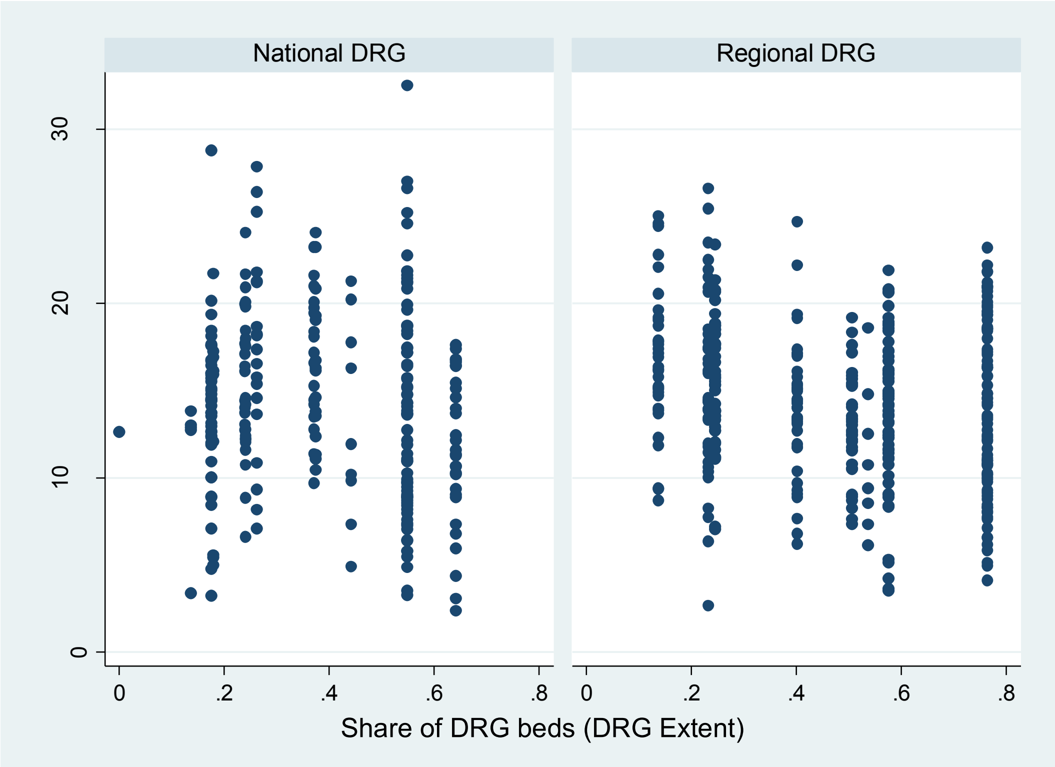

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 9b. Box plots of hospital risk adjusted readmission rates for STROKE by DRG system.**



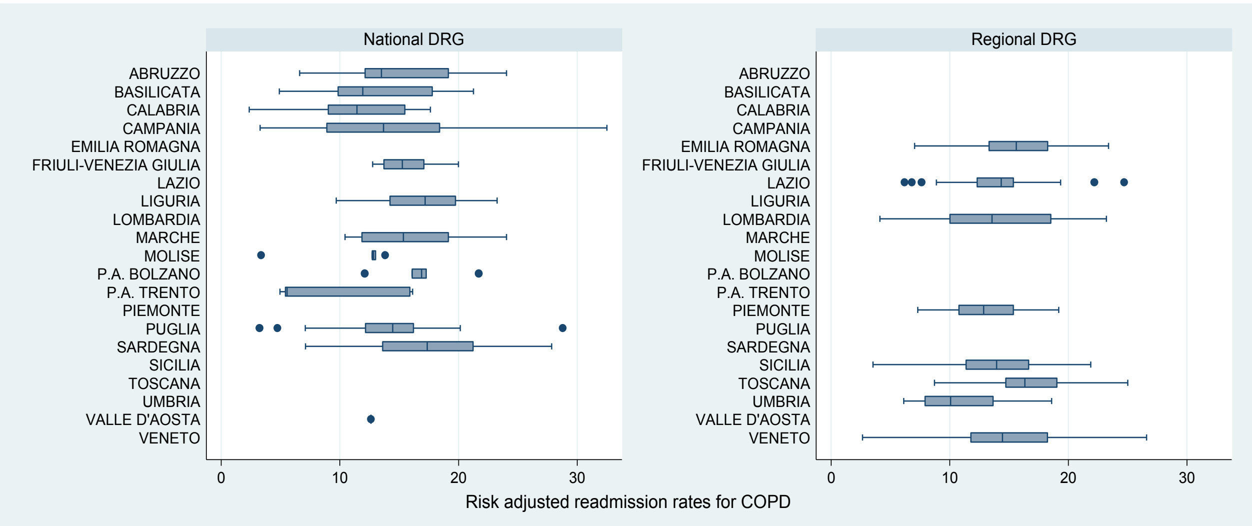

*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 10a. Scatter plots of risk adjusted readmission rates for COPD by DRG system.**




*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

**Figure 10b. Box plot of risk adjusted readmission rates for COPD by DRG system.**




*Source:* elaborations on data provided by the PNE and by the Ministry of Health.

### 2.5. The random intercept model and the truncated regression model. Estimations and discussion of results.

The econometric analysis has been carried out by applying, at first, a random intercept model.

For each clinical condition, the model has been estimated three times, considering different hierarchical clusters j that are: ASLs, Regions, typology of structures.

$$Y_{ij} = \beta_{0j} + X_{ij}\,\beta_1 + \varepsilon_{ij}$$

In the above equation, Y is the dependent variable and is represented by the clinical outcome (adjusted rate of mortality/readmissions for AMI, CHF, Stroke and COPD) for the hospital i within the cluster j (ASL, Region or typology of structure), $\varepsilon_{ij}$ is the error term.

$X_{ij}$ is a matrix which includes the following covariates:

- the number of cases (CASE) related to each condition and treated at each structure;
- the % of structure utilization for public hospitals (UTILIZATION RATE);
- the index of case mix for public hospitals (ICM);
- the index of entropy for public structures (ENTROPY);
- two Regional dummies for different areas of Italy (NORTH, CENTRE): according to ISTAT classification, NORTH includes Piemonte, Valle d'Aosta, Lombardia, Trentino Alto Adige, Veneto, Friuli Venezia Giulia, Liguria, Emilia Romagna; CENTRE comprises Toscana, Umbria, Marche, Lazio, Abruzzo, Molise);
- a dummy variable related to the implementation of regional DRG (DRG_Regional);
- the % of beds in AOs and private structures, financed by DRGs (DRG_Extent).

This last variable is employed as index for the "potential use" of DRGs in Cantù, Carbone and Anessi Pessina (2011). DRGs based funding only applies when patients look for care outside their own ASLs of residence. If a Region would decide to establish no AOs and to accredit no private providers, most patients would be treated by their ASL of residence. In this case, the relevant expenses would be covered by the capitated funding that ASLs receive from their Regions and not by DRGs tariffs. Hence, the share of beds in AOs and private structures measure the extent of DRG application in each Region.

Besides the variables "DRG_Extent" and "DRG_Regional", the number of cases treated by hospitals for each selected indicator ($CASE_j$) is employed to evaluate whether hospitals treating a higher number of cases show better outcomes.

The relationship between volume and outcome has been studied by a large empirical literature (see Gaynor, Seder and Vogt, 2005, for a review). Two leading explanations are provided for the positive correlation which, nonetheless, imply a different direction of causality: the first one is the “practice makes perfect” hypothesis; the second one is the “selective referral” assumption. Under the first hypothesis, either learning-by-doing or quality-enhancing scale economies cause large hospitals to provide better quality care and thus to improve outcomes. The other assumption suggests how hospitals with higher quality attract a greater volume of patients. Although both explanations are plausible, the literature has largely relied on the learning-by-doing interpretation.

Another factor that could, in theory, influence hospital performance, is the different size of the hospital system at a regional or local level. To control for the effects of differences in the regional supply of hospital beds, the total number of regional hospital beds in 2008 (BEDS) has been used.

Some studies have indicated that the performance of the Italian regional health systems across different country areas are marked by relevant efficiency differentials (see, for example, France, Taroni and Donatini, 2005): hence, two macro-area dummies (NORTH and CENTRE) are also considered, although in the equations with single Regions as cluster, regional fixed effects are considered as well.

The Index of Case Mix (ICM) represents the complexity of cases treated at each hospital considering the mean complexity at a reference group of hospitals. Together with the utilization rate, this variable, that is calculated both for public and private structures, should be a proxy of the capability of hospitals to attract more complex cases, *i.e.*, likely to be included in a higher DRG. This should signal a higher level of specialization for each structure.

The index of entropy (ENTROPY) measures, instead, the heterogeneity of care provided by hospitals. The entropy is minimum in a situation where all discharges are included in the same DRG; on the other hand, the highest heterogeneity occurs when all discharges are equally split among DRGs. Both ENTROPY and ICM represent the type of care provided and can be meant as related to the demand for health care satisfied by each structure.

Table 9 provides summary statistics for the variables employed in the empirical analysis.

**Table 9. Summary statistics.**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| *SAMPLE FOR AMI* | | | | | |
| **MORTALITY – GROSS RATE** | 1020 | 16.18 | 20.53 | 0 | 100 |
| **MORTALITY – ADJ RATE** | 393 | 11.16 | 4.04 | 0.74 | 41.54 |
| **$CASE_{AMI}$** | 1020 | 92.37 | 127.48 | 1 | 908 |
| **BEDS** | 1021 | 17820.82 | 10198.23 | 415 | 37406 |
| **UTILIZATION RATE** | 687 | 78.64 | 13.22 | 1.37 | 174 |
| **INDEX CASE MIX** | 687 | 0.956 | 0.17 | 0.61 | 2.57 |
| **ENTROPY** | 687 | 2.10 | 0.26 | 0.2 | 2.42 |
| **NORTH** | 1021 | 0.43 | 0.49 | 0 | 1 |
| **CENTRE** | 1021 | 0.23 | 0.42 | 0 | 1 |
| **SOUTH** | 1021 | 0.34 | 0.47 | 0 | 1 |
| **DRG_REGIONAL** | 1021 | 0.63 | 0.48 | 0 | 1 |
| **DRG_EXTENT** | 1021 | 0.44 | 0.20 | 0 | 0.76 |
| *SAMPLE FOR CHF* | | | | | |
| **MORTALITY – GROSS RATE** | 1127 | 9.39 | 10.60 | 0 | 100 |
| **MORTALITY – ADJ RATE** | 650 | 9 | 4.71 | 0.16 | 29.14 |
| **$CASE_{CHF}$** | 1127 | 150 | 162.65 | 1 | 1080 |
| **BEDS** | 1127 | 17805.11 | 10192.68 | 415 | 37406 |
| **UTILIZATION RATE** | 701 | 78.48 | 13.41 | 1.37 | 174 |
| **INDEX CASE MIX** | 701 | 0.953 | 0.171 | 0.61 | 2.57 |
| **ENTROPY** | 701 | 2.09 | 0.26 | 0.2 | 2.42 |
| **NORTH** | 1127 | 0.42 | 0.49 | 0 | 1 |
| **CENTRE** | 1127 | 0.24 | 0.43 | 0 | 1 |
| **SOUTH** | 1127 | 0.34 | 0.47 | 0 | 1 |
| **DRG_REGIONAL** | 1127 | 0.62 | 0.48 | 0 | 1 |
| **DRG_EXTENT** | 1127 | 0.44 | 0.20 | 0 | 0.76 |
| *SAMPLE FOR STROKE* | | | | | |
| **MORTALITY – GROSS RATE** | 1018 | 13.50 | 22.17 | 0 | 535 |
| **MORTALITY – ADJ RATE** | 435 | 13.36 | 6.03 | 1.38 | 34.93 |
| **$CASE_{STROKE}$** | 1018 | 78.99 | 103.58 | 1 | 632 |
| **BEDS** | 1018 | 17654.47 | 9945.29 | 415 | 37406 |
| **UTILIZATION RATE** | 666 | 78.63 | 13.33 | 1.37 | 174 |
| **INDEX CASE MIX** | 666 | 1.51 | 6.50 | 0.61 | 2.57 |
| **ENTROPY** | 666 | 2.11 | 0.25 | 0.2 | 2.42 |
| **NORTH** | 1018 | 0.41 | 0.49 | 0 | 1 |
| **CENTRE** | 1018 | 0.26 | 0.44 | 0 | 1 |
| **SOUTH** | 1018 | 0.33 | 0.47 | 0 | 1 |
| **DRG_REGIONAL** | 1018 | 0.63 | 0.48 | 0 | 1 |
| **DRG_EXTENT** | 1018 | 0.44 | 0.20 | 0 | 0.765 |
| *SAMPLE FOR STROKE_R* | | | | | |
| **MORTALITY – GROSS RATE** | 1007 | 13.29 | 16.23 | 0 | 100 |
| **MORTALITY – ADJ RATE** | 395 | 11.46 | 4.15 | 1.91 | 27.3 |
| **$CASE_{STROKE}$** | 1007 | 70.04 | 91.92 | 1 | 584 |
| **BEDS** | 1007 | 17626.23 | 9957.20 | 415 | 37406 |

| | | | | | |
|---|---|---|---|---|---|
| **UTILIZATION RATE** | 665 | 78.65 | 13.36 | 1.37 | 174 |
| **INDEX CASE MIX** | 665 | 1.52 | 6.50 | 0.61 | 2.57 |
| **ENTROPY** | 665 | 2.10 | 0.26 | 0.2 | 2.42 |
| **NORTH** | 1007 | 0.41 | 0.49 | 0 | 1 |
| **CENTRE** | 1007 | 0.26 | 0.44 | 0 | 1 |
| **SOUTH** | 1007 | 0.33 | 0.47 | 0 | 1 |
| **DRG_REGIONAL** | 1007 | 0.63 | 0.48 | 0 | 1 |
| **DRG_EXTENT** | 1007 | 0.43 | 0.20 | 0 | 0.76 |
| *SAMPLE FOR COPD_R* | | | | | |
| **MORTALITY – GROSS RATE** | 1108 | 15.48 | 21.95 | 0 | 554 |
| **MORTALITY – ADJ RATE** | 605 | 14.34 | 4.82 | 2.36 | 32.51 |
| **$CASE_{COPD}$** | 1106 | 95.39 | 123.73 | 1 | 1186 |
| **BEDS** | 1108 | 17820.68 | 10201.97 | 415 | 37406 |
| **UTILIZATION RATE** | 694 | 78.51 | 13.35 | 1.37 | 174 |
| **INDEX CASE MIX** | 694 | 1.49 | 6.37 | 0.61 | 2.57 |
| **ENTROPY** | 694 | 2.10 | 0.26 | 0.2 | 2.42 |
| **NORTH** | 1108 | 0.42 | 0.49 | 0 | 1 |
| **CENTRE** | 1108 | 0.24 | 0.43 | 0 | 1 |
| **SOUTH** | 1108 | 0.34 | 0.47 | 0 | 1 |
| **DRG_REGIONAL** | 1108 | 0.62 | 0.49 | 0 | 1 |
| **DRG_EXTENT** | 1108 | 0.44 | 0.20 | 0 | 0.76 |

The dependent variable is the mortality/readmission risk rates, both gross and adjusted.

Gross rates have been calculated for all structures in the sample, whereas adjusted rates are calculated only for those structures treating more than 75 cases per year. In the random intercept regressions, risk adjusted indicators have been considered for all conditions examined, although this determines a lower number of observations.

The other covariates are related to demand (as the utilization rate), supply (as the number of beds, or the index of entropy) and the institutional scenario, focusing on DRG application.

Three models have been estimated:

1) $Outcome_{ij} = \beta_{0j} + \varepsilon_{ij}$ – **model with intercept only**;

2) $Outcome_{ij} = \beta_{0j} + [CASE_{ij}\ \beta_1 + BEDS_{im,\ t-1}\ \beta_2 + UTILIZATION\ RATE_{ij,\ t-1}\ \beta_3 ICM_{ij,\ t-1}\ \beta_4 + ENTROPY_{ij,\ t-1}\ \beta_5 + NORTH\ \beta_6 + CENTRE\ \beta_7] + \varepsilon_{ij}$ – **model with supply and demand factors**;

3) $Outcome_{ij} = \beta_{0j} + [CASE_{ij}\ \beta_1 + BEDS_{im,\ t-1}\ \beta_2 + UTILIZATION\ RATE_{ij,\ t-1}\ \beta_3\ ICM_{ij,\ t-1}\ \beta_4 + ENTROPY_{ij,\ t-1}\ \beta_5 + NORTH\ \beta_6 + CENTRE\ \beta_7 + DRG\_Regional_{m}\ \beta_8 + DRG\_Extent_{m,\ t-1}\ \beta_8] + \varepsilon_{ij}$ - **model with demand, supply, geographical and reimbursement factors**.

j, as it has been specified, is the cluster considered, and M = 1,…,20 are the Regions.

The subscript $_{ij}$ refers to the average outcome in hospital i within the cluster j.

As explained earlier, $DRG\_Extent_{m, t-1}$ is a proxy aimed at capturing regional differences in the adoption of financing mechanisms in region m at time t-1, as the last information about beds are available till 2008, so at time $_{t-1}$, since the present analysis refers to 2009; $e_{ij}$ is the error term.

Results of the model, that are robust, are shown in Tables 10-14. Overall, in the estimations, almost all the covariates are significant, although not for all the conditions considered.

Estimations have been run with Stata 10.0.

## Table 10a. Random intercept model. AMI - estimations by ASL.

| **Risk adjusted** | **I (constant term only)** | **II (demand and supply factors)** | **III (I+II+geographical dummies and reimbursement factors)** |
|---|---|---|---|
| **Constant** | 11.197*** (0.221) | 0.189 (4.524) | 2.179 (4.722) |
| **CASE** | | -0.002 (0.001) | -0.001 (0.001) |
| **BEDS** | | 0.00001 (0.00001) | 0.00004 (0.00003) |
| **UTILIZATION RATE** | | 0.043 (0.032) | 0.041 (0.032) |
| **ICM** | | -1.216 (1.418) | -1.365 (1.561) |
| **ENTROPY** | | 4.028*** (1.568) | 3.319** (1.563) |
| **NORTH** | | | 0.792 (0.746) |
| **CENTRE** | | | 0.713 (0.870) |
| **DRG_Regional** | | | -1.061 (0.750) |
| **DRG_Extent** | | | -1.350 (1.477) |
| **No. of level 1 units**<br>**No. of level 2 units** | 389<br>134 | 335<br>128 | 335<br>128 |
| **Variance at level 1**<br>**Variance at level 2** | 15.527 (3.050)<br>0.961 (0.943) | 14.764 (2.886)<br>0.856 (0.684) | 14.475 (2.915)<br>0.981 (0.740) |
| **Log likelihood** | -1096.062 | -932.319 | -930.345 |

Standard errors in brackets
*** significant at 99%; ** significant at 95%; * significant at 90%

**Table 10b. Random intercept model. AMI - estimations by Regions.**

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 11.209***<br>(0.353) | 2.460<br>(3.148) | 3.826<br>(3.181) |
| **CASE** | | -0.001<br>(0.001) | -0.001<br>(0.001) |
| **BEDS** | | 9.18e-06<br>(0.00002) | 0.00005<br>(0.00003) |
| **UTILIZATION RATE** | | 0.032<br>(0.022) | 0.031<br>(0.022) |
| **ICM** | | -1.134<br>(1.429) | -1.283<br>(1.457) |
| **ENTROPY** | | 3.343***<br>(0.999) | 2.843***<br>(0.896) |
| **NORTH** | | | 0.786<br>(0.631) |
| **CENTRE** | | | 0.802<br>(0.906) |
| **DRG_Regional** | | | -1.111<br>(0.730) |
| **DRG_Extent** | | | -1.419<br>(2.132) |
| **No. of level 1 units**<br>**No. of level 2 units** | 393<br>20 | 338<br>20 | 338<br>20 |
| **Variance at level 1**<br>**Variance at level 2** | 15.342 (2.819)<br>1.118 (0.654) | 14.969 (3.025)<br>0.586 (0.440) | 14.873 (3.017)<br>0.505 (0.350) |
| **Log likelihood** | -1102.039 | -941.493 | -939.949 |

Standard errors in brackets
*** significant at 99%; ** significant at 95%; * significant at 90%

**Table 10c. Random intercept model. AMI - estimations by typology of structure.**

| Risk adjusted | I (constant term only) | II (demand and supply factors) | III (I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 11.110***<br>(0.091) | 1.353<br>(2.995) | 3.406<br>(2.378) |
| **CASE** | | -0.001***<br>(0.0004) | -0.002***<br>(0.0006) |
| **BEDS** | | 0.00001<br>(0.00002) | 0.00003<br>(000002) |
| **UTILIZATION RATE** | | 0.0398**<br>(0.020) | 0.037*<br>(0.020) |
| **ICM** | | -1.227<br>(1.023) | -1-393<br>(1.006) |
| **ENTROPY** | | 3.635***<br>(0.474) | 2.921***<br>(0.720) |
| **NORTH** | | | 0.663<br>(0.572) |
| **CENTRE** | | | 0.613<br>(0.735) |
| **DRG_Regional** | | | -0.885<br>(0.589) |
| **DRG_Extent** | | | -1.194*<br>(0.707) |
| **No. of level 1 units**<br>**No. of level 2 units** | 379<br>7 | 338<br>6 | 338<br>6 |
| **Variance at level 1**<br>**Variance at level 2** | 16.282 (2.730)<br>5.417e-14 (6.123e-13) | 15.517 (2.931)<br>3.368e-20 (3.666e-15) | 15.366 (2.832)<br>7.352e-08 (3.986e-08) |
| **Log likelihood** | -1066.499 | -942.997 | -941.318 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

In the equation estimated for **AMI**, only ENTROPY is significant and positively correlated with mortality rates (the more heterogeneous the discharges the lower the quality: this circumstance may represent a not efficient allocation of resources).

Variables related to the reimbursement system do not show any effect on quality/outcomes.

As expected, the variance is higher in the estimations for the first level of analysis.

From the analysis of residuals (empirical Bayes predictions) it emerges how there is not normality. The sample is not homogenous, and a possible explanation could be the presence of several outliers: as a result, coefficients could be over-estimated and hypothesis tests might not be reliable, especially in small samples. The observed sample here should be sufficiently large to deal with this problem, although results are not convincing. A correction should be done, for example, dropping outliers in the equation or including some dummy variables for all those observed units for which the residuals exceed a given threshold.

Estimates for the second clinical conditions considered (CHF) can be seen in the Tables 11a – 11c.

**Table 11a. Random intercept model. CHF - estimations by ASL.**

| Risk adjusted | I (constant term only) | II (demand and supply factors) | III (I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 9.192*** (0.237) | -3.112 (3.563) | -1.717 (3.889) |
| **CASE** | | -0.001 (0.001) | -0.001 (0.001) |
| **BEDS** | | 0.00008 (0.00002) | 0.00005 (0.00003) |
| **UTILIZATION RATE** | | 0.064** (0.025) | 0.062** (0.026) |
| **ICM** | | -2.398* (1.302) | -3.484*** (1.271) |
| **ENTROPY** | | 4.594*** (1.412) | 4.161*** (1.466) |
| **NORTH** | | | 1.143 (0.781) |
| **CENTRE** | | | 1.849** (0.741) |
| **DRG_Regional** | | | 0.013 (0.636) |
| **DRG_Extent** | | | -0.399 (1.405) |
| **No. of level 1 units**<br>**No. of level 2 units** | 648<br>154 | 507<br>151 | 507<br>151 |
| **Variance at level 1**<br>**Variance at level 2** | 19.088 (1.699)<br>2.958 (0.777) | 16.894 (1.507)<br>2.120 (0.750) | 16.829 (1.491)<br>1.736 (0.665) |
| **Log likelihood** | -1920.385 | -1461.180 | -1456.451 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

## Table 11b. Random intercept model. CHF - estimations by Region.

| Risk adjusted | I (constant term only) | II (demand and supply factors) | III (I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| Constant | 8.986*** (0.4) | -1.838 (3.513) | -1.619 (3.479) |
| CASE | | -0.001 (0.0009) | -0.001 (0.0009) |
| BEDS | | 0.00002 (0.00004) | 0.00002 (0.00004) |
| UTILIZATION RATE | | 0.061** (0.026) | 0.060** (0.027) |
| ICM | | -3.473** (1.613) | -3.913*** (1.465) |
| ENTROPY | | 4.396*** (1.359) | 4.134*** (1.342) |
| NORTH | | | 1.359 (1.020) |
| CENTRE | | | 1.914** (0.858) |
| DRG_Regional | | | -0.148** (0.793) |
| DRG_Extent | | | 0.040 (1.698) |
| No. of level 1 units<br>No. of level 2 units | 650<br>20 | 507<br>20 | 507<br>20 |
| Variance at level 1<br>Variance at level 2 | 20.205 (2.373)<br>2.013 (0.721) | 17.917 (1.452)<br>1.398(0.614) | 17.941 (1.467)<br>0.803 (0.435) |
| Log likelihood | -1911.922 | -1460.523 | -1458.047 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

**Table 11c. Random intercept model. CHF - estimations by typology of structure.**

| Risk adjusted | I (constant term only) | II (I+II+geographical dummies and reimbursement factors) |
|---|---|---|
| **Constant** | 8.110*** (0.638) | -4.358*** (1.370) |
| **CASE** | | -0.0007 (0.0006) |
| **BEDS** | | 0.00001 (0.00004) |
| **UTILIZATION RATE** | | 0.071*** (0.038) |
| **ICM** | | -2.485** (1.162) |
| **ENTROPY** | | 4.049*** (0.846) |
| **NORTH** | | 0.893 (0.584) |
| **CENTRE** | | 1.852*** (0.498) |
| **DRG_Regional** | | -0.157 (0.279) |
| **DRG_Extent** | | 0.413 (0.618) |
| **No. of level 1 units**<br>**No. of level 2 units** | 626<br>8 | 507<br>20 |
| **Variance at level 1**<br>**Variance at level 2** | 20.463 (1.598)<br>1.687 (0.608) | 18.326 (1.393)<br>0.658 (0.758) |
| **Log likelihood** | -1838.705 | -1459.657 |

The sample for **CHF** included originally 1127 units. Since only those units for which adjusted rates have been calculated are considered, the final sample if made of 626 structures.

CASE, inversely correlated with the dependent variable in all the regressions, is never significant. Variables related to demand and supply, as UTILIZATION RATE, ICM and ENTROPY are always significant and represent the factors with the higher impact on quality. The coefficients estimated are similar in all the specifications in spite of the cluster considered. However, the convergence is not reached in one of the specifications of the model, signalling how the latter should be better specified or reconsidered.

## Table 12a. Random intercept model. STROKE - estimations by ASL.

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 13.450***<br>(0.355) | 12.811**<br>(5.163) | 13.784***<br>(5.370) |
| **CASE** | | -0.001<br>(0.00003) | -0.001<br>(0.002) |
| **BEDS** | | -0.00004<br>(0.00003) | 0.00009*<br>(0.00005) |
| **UTILIZATION RATE** | | 0.058<br>(0.038) | 0.051<br>(0.035) |
| **ICM** | | -3.712<br>(2.524) | -4.045<br>(2.719) |
| **ENTROPY** | | -0.099<br>(2.541) | -0.569<br>(2.698) |
| **NORTH** | | | 1.192<br>(1.015) |
| **CENTRE** | | | 4.076***<br>(1.168) |
| **DRG_Regional** | | | -2.517***<br>(0.896) |
| **DRG_Extent** | | | -1.742<br>(2.301) |
| **No. of level 1 units**<br>**No. of level 2 units** | 434<br>151 | 380<br>149 | 380<br>149 |
| **Variance at level 1**<br>**Variance at level 2** | 30.552 (2.668)<br>5.923 (2.237) | 26.305 (2.780)<br>7.422 (2.327) | 26.454 (2.794)<br>4.824 (1.924) |
| **Log likelihood** | -1388.867 | -1198.168 | -1188.398 |

Standard errors in brackets
*** significant at 99%; ** significant at 95%; * significant at 90%

**Table 12b. Random intercept model. STROKE - estimations by Regions.**

| Risk adjusted | I<br>(constant term only) | II<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|
| **Constant** | 13.407***<br>(0.556) | 14.973***<br>(4.425) |
| **CASE** | | -0.001<br>(0.002) |
| **BEDS** | | 0.0001<br>(0.00009) |
| **UTILIZATION RATE** | | 0.034<br>(0.021) |
| **ICM** | | -4.541<br>(3.571) |
| **ENTROPY** | | -0.573<br>(2.029) |
| **NORTH** | | 1.409<br>(1.172) |
| **CENTRE** | | 4.033***<br>(1.403) |
| **DRG_Regional** | | -2.747**<br>(1.153) |
| **DRG_Extent** | | -1.966<br>(2.844) |
| **No. of level 1 units**<br>**No. of level 2 units** | 435<br>20 | 380<br>20 |
| **Variance at level 1**<br>**Variance at level 2** | 31.898 (3.828)<br>3.683 (1.765) | 28.637 (3.345)<br>2.351 (1.041) |
| **Log likelihood** | -1381.368 | -1184.804 |

**Table 12c. Random intercept model. STROKE - estimations by typology of structure.**

| Risk adjusted | I (constant term only) | II (demand and supply factors) | III (I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 13.020***<br>(0.541) | 9.770***<br>(2.377) | 13.455***<br>(4.075) |
| **CASE** | | -0.003*<br>(0.001) | -0.002**<br>(0.001) |
| **BEDS** | | 0.00003<br>(0.00009) | 0.00008<br>(0.0001) |
| **UTILIZATION RATE** | | 0.074***<br>(0.010) | 0.059***<br>(0.011) |
| **ICM** | | -2.394<br>(1.569) | -3.461**<br>(1.511) |
| **ENTROPY** | | 0.560<br>(1.465) | -0.781<br>(2.576) |
| **NORTH** | | | 1.026<br>(1.017) |
| **CENTRE** | | | 4.024***<br>(1.404) |
| **DRG_Regional** | | | -2.475***<br>(0.989) |
| **DRG_Extent** | | | -1.782<br>(1.593) |
| **No. of level 1 units**<br>**No. of level 2 units** | 422<br>7 | 380<br>6 | 380<br>6 |
| **Variance at level 1**<br>**Variance at level 2** | 35.374 (4.486)<br>0.465 (0.225) | 33.401 (4.447)<br>0.222 (0.502) | 31.106 (3.085)<br>7.455e-09 (1.237e-07 |
| **Log likelihood** | -1352.778 | -1206.704 | -1192.307 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

In the estimations carried out for **STROKE**, 434 units over 1018 have been considered after the risk adjustment. For the first time it is possible to see a high significance of the variable related to DRG_Regional. The dummy variable for Central Regions is highly significant as well. Although it is not significant, DRG_Extent show an inverse correlation with the dependent variable, signalling a positive effect on quality, confirmed by the estimations carried out for STROKE readmissions.

However, for this clinical condition as well as for the previous one, convergence is not reached in the estimations where the clusters are represented by Regions.

### Table 13a. Random intercept model. STROKE readmissions - estimations by ASL.

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 11.417***<br>(0.264) | 8.028***<br>(3.053) | 7.831***<br>(3.141) |
| **CASE** | | -0.005***<br>(0.000042) | -0.004***<br>(0.001) |
| **BEDS** | | -0.00004*<br>(0.00002) | 0.00003<br>(0.00004) |
| **UTILIZATION RATE** | | 0.001<br>(0.023) | -0.003<br>(0.022) |
| **ICM** | | 1.254<br>(0.908) | 2.087**<br>(0.932) |
| **ENTROPY** | | 1.715**<br>(0.749) | 2.270***<br>(0.818) |
| **NORTH** | | | -2.240***<br>(0.738) |
| **CENTRE** | | | -0.927<br>(0.861) |
| **DRG_Regional** | | | -0.649<br>(0.792) |
| **DRG_Extent** | | | -2.711<br>(1.930) |
| **No. of level 1 units**<br>**No. of level 2 units** | 393<br>144 | 342<br>142 | 342<br>142 |
| **Variance at level 1**<br>**Variance at level 2** | 13.386 (1.467)<br>4.001 (0.946) | 13.421 (1.637)<br>2.985 (0.871) | 13.352 (1.658)<br>2.158 (0.9348) |
| **Log likelihood** | -1107.014 | -952.526 | -945.150 |

Standard errors in brackets
*** significant at 99%; ** significant at 95%; * significant at 90%

## Table 13b. Random intercept model. STROKE readmissions - estimations by Region.

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 11.635***<br>(0.433) | 5.885**<br>(2.816) | 6.561**<br>(3.049) |
| **CASE** | | -0.005**<br>(0.001) | -0.004***<br>(0.001) |
| **BEDS** | | -0.00005**<br>(0.00003) | 0.000001<br>(0.00007) |
| **UTILIZATION RATE** | | -0.001<br>(0.015) | -0.003<br>(0.017) |
| **ICM** | | 1.917**<br>(0.834) | 2.149**<br>(0.877) |
| **ENTROPY** | | 2.631***<br>(0.810) | 2.802***<br>(0.748) |
| **NORTH** | | | -1.887**<br>(0.958) |
| **CENTRE** | | | -0.699<br>(0.930) |
| **DRG_Regional** | | | -0.448<br>(0.992) |
| **DRG_Extent** | | | -1.933<br>(2.478) |
| **No. of level 1 units**<br>**No. of level 2 units** | 395<br>20 | 341<br>20 | 341<br>20 |
| **Variance at level 1**<br>**Variance at level 2** | 15.351 (1.424)<br>2.286 (0.952) | 14.596 (1.751)<br>2.022 (0.799) | 14.775 (1.853)<br>0.916 (1.123) |
| **Log likelihood** | -1111.982 | -951.562 | -949.451 |

Standard errors in brackets
*** significant at 99%; ** significant at 95%; * significant at 90%

**Table 13c. Random intercept model. STROKE readmissions – estimations by typology of structure.**

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 11.397***<br>(0.212) | 8.072***<br>(1.962) | 7.286***<br>(2.600) |
| **CASE** | | -0.004***<br>(0.00001) | -0.004***<br>(0.001) |
| **BEDS** | | -0.00005***<br>(0.00001) | 0.00003<br>(0.00002) |
| **UTILIZATION RATE** | | 0.001<br>(0.014) | -0.008<br>(0.010) |
| **ICM** | | 0.971<br>(0.721) | 2.150**<br>(1.093) |
| **ENTROPY** | | 1.933***<br>(0.595) | 2.652***<br>(0.858) |
| **NORTH** | | | -2.244***<br>(0.493) |
| **CENTRE** | | | -0.833***<br>(0.278) |
| **DRG_Regional** | | | -2.281**<br>(1.159)<br>(0.600) |
| **DRG_Extent** | | | -2.507**<br>(0.600) |
| **No. of level 1 units**<br>**No. of level 2 units** | 385<br>8 | 341<br>7 | 341<br>7 |
| **Variance at level 1**<br>**Variance at level 2** | 17.026 (1.503)<br>0.00002 (0.00001) | 16.372 (1.457)<br>2.458e-13 (5.670e-12) | 15.445 (1.091)<br>3.372e-21 (3.888e-15) |
| **Log likelihood** | -1091.979 | -960.503 | -950.572 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

About **STROKE readmissions**, the estimations have been carried out on 385 structures over 1007.

The coefficients related to the number of cases treated (first and second model), ENTROPY and ICM are significant and show the expected sign. The effect due to the localization in Northern Regions is higher comparing to CENTRE. Surprisingly, the dummy variable related to DRG_Regional is not significant in the first two specifications, whereas it is significant when considering the type of structure as clusters.

**Table 14a. Random intercept model. COPD readmissions - estimations by ASL.**

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 14.416***<br>(0.244) | 7.845***<br>(2.958) | 9.317**<br>(3.014) |
| **CASE** | | -0.001<br>(0.0009) | -0.002**<br>(0.001) |
| **BEDS** | | -0.00001<br>(0.00002) | 0.00008**<br>(0.00003) |
| **UTILIZATION RATE** | | 0.013<br>(0.026) | 0.016<br>(0.026) |
| **ICM** | | -4.627***<br>(1.664) | -4.199***<br>(1.619) |
| **ENTROPY** | | 5.053***<br>(1.162) | 4.791***<br>(1.206) |
| **NORTH** | | | -0.584<br>(0.710) |
| **CENTRE** | | | -0.126<br>(0.760) |
| **DRG_Regional** | | | -0.836<br>(0.671) |
| **DRG_Extent** | | | -5.541***<br>(1.560) |
| **No. of level 1 units**<br>**No. of level 2 units** | 601<br>153 | 471<br>151 | 471<br>151 |
| **Variance at level 1**<br>**Variance at level 2** | 20.101(1.367)<br>2.888 (0.918) | 16.573 (1.299)<br>2.500 (0.978) | 16.348 (1.274)<br>2.041 (0.887) |
| **Log likelihood** | -1786.161 | .1356.908 | -1349.801 |

Standard errors in brackets
*** significant at 99%; ** significant at 95%; * significant at 90%

## Table 14b. Random intercept model. COPD readmissions - estimations by Region.

| Risk adjusted | I (constant term only) | II (demand and supply factors) | III (I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 14.392*** (0.363) | 6.926** (3.151) | 8.791** (3.313) |
| **CASE** | | -0.001 (0.0003) | -0.002** (0.001) |
| **BEDS** | | -0.000006 (0.00003) | 0.00009** (0.00003) |
| **UTILIZATION RATE** | | 0.027 (0.023) | 0.024 (0.024) |
| **ICM** | | -5.210*** (1.388) | -4.244*** (1.614) |
| **ENTROPY** | | 5.041*** (1.029) | 4.680*** (1.035) |
| **NORTH** | | | -0.394 (0.742) |
| **CENTRE** | | | -0.052 (0.769) |
| **DRG_Regional** | | | -0.896** (0.592) |
| **DRG_Extent** | | | -5.322*** (1.873) |
| **No. of level 1 units**<br>**No. of level 2 units** | 605<br>20 | 471<br>20 | 471<br>20 |
| **Variance at level 1**<br>**Variance at level 2** | 22.091 (2.726)<br>1.437 (0.785) | 18.213 (1.993)<br>1.151 (0.832) | 18.328 (2.057)<br>0.109 (0.402) |
| **Log likelihood** | -1804.407 | -1359.89 | -1354.536 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

**Table 14c. Random intercept model. COPD readmissions – estimations by typology of structure.**

| Risk adjusted | I<br>(constant term only) | II<br>(demand and supply factors) | III<br>(I+II+geographical dummies and reimbursement factors) |
|---|---|---|---|
| **Constant** | 13.597***<br>(0.829) | 7.045**<br>(2.826) | 8.835***<br>(3.282) |
| **CASE** | | -0.001<br>(0.0007) | -0.002***<br>(0.00003) |
| **BEDS** | | -0.00001<br>(0.00001) | 0.00008***<br>(0.00003) |
| **UTILIZATION RATE** | | 0.021**<br>(0.010) | 0.022**<br>(0.011) |
| **ICM** | | -4.547***<br>(1.208) | -4.077***<br>(1.417) |
| **ENTROPY** | | 5.061***<br>(1.479) | 4.644***<br>(1.799) |
| **NORTH** | | | -0.423*<br>(0.268) |
| **CENTRE** | | | -0.061<br>(0.204) |
| **DRG_Regional** | | | -0.878***<br>(0.411) |
| **DRG_Extent** | | | -5.255***<br>(0.880) |
| **No. of level 1 units**<br>**No. of level 2 units** | 577<br>7 | 471<br>6 | 471<br>6 |
| **Variance at level 1**<br>**Variance at level 2** | 20.396 (1.035)<br>3.188 (1.291) | 19.122 (1.651)<br>1.224e-6 (1-67e-6) | 18.432 (1.332)<br>1.80e-6 (4.659e-9) |
| **Log likelihood** | -1695.823 | -1363.246 | -1354.590 |
| Standard errors in brackets<br>*** significant at 99%; ** significant at 95%; * significant at 90% | | | |

About **COPD readmissions**, the initial sample, including 1018 structures reduced to about 500 observed units when risk adjusted indicators were considered

Almost all variables are significant, but for utilization rate and geographical dummies. In the specification where Regions are the clusters both DRG_Extent and DRG_Regional are significant: both of them show an inverse correlation with the dependent variable, that means a positive effect on quality due to the reimbursement scheme. DRG_Extent has the greater impact comparing to variables related to demand and supply. As for the previous estimations where readmission rates was the dependent variable, NORTH and CENTRE are not significant here. A stronger effect of variables related to the reimbursement scheme can be appreciated when readmissions are considered.

The results from the random intercepts models can be summarized as follows:

- CASE is inversely and significantly correlated, when readmissions are considered, with the dependent variable: hospitals treating a higher number of cases should report better outcomes and the probability of a new hospitalization should be lower.

- the coefficients of geographical dummies vary according to the indicator of outcome considered (higher and more significant per AMI e STROKE, rather than for readmissions);

- although positively correlated with quality, DRG_Regional is not significant when mortality rates are considered. In the case of COPD readmission, the variable DRG_Extent is significant as well. The same variable is significant and positively correlated with quality indicators when mortality rates are considered.

Because of some differences between the results for mortality rates and readmission rates, it would seem that a diverse type of assistance is required by acute conditions, so that inputs for producing health care could be employed to a different extent. An analysis based on efficiency might allow to stress such peculiarities.

Some considerations can be raised with regard to the model selected. By running several estimations, each related to a different cluster, it was expected to observe variability in the level of significance of coefficients and, overall, of the regression, so to identify the most appropriate level of analysis (ASL, Region of type of structure). This was not the case, as the estimated coefficients do not differ significantly. Moreover, residuals are not normally distributed because of many outliers in the sample, so that some corrections should be employed (for example, by dropping outliers).

Alternatively,  another estimation strategy could be considered.

As it has been said earlier, adjusted risk rates, employed as dependent variables in all regressions, are available only for those structures treating more than 75 cases per year. Since data are truncated from below, an alternative method to apply could be that of running a truncated regression model.

The equation to estimate should be written as follows:

$$\text{Outcome}_{ki} = \gamma_1 + \text{CASE}_{ki}\,\gamma_2 + \text{BEDS}_{mi\,t-1}\,\gamma_3 + \text{UTILIZATION RATE}_{mi\,t-1}\,\gamma_4 + \text{ICM}_{mit-1}\,\gamma_5 + \text{ENTROPY}_{mi,\,t-1}\,\gamma_6 + \text{NORTH}\,\gamma_7 + \text{CENTRE}\,\gamma_8 + \text{DRG\_Regional}_{m}\,\gamma_9 + \text{DRG\_Extent}_{m,\,t-1}\,\gamma_{10} + \text{AZIENDAOSP}\,\gamma_{11} + \text{PRESIDIO}\,\gamma_{12} + \mu + \varepsilon_{it}$$

where the subscript $_{ki}$ refers to outcome k in hospital i, $\mu$ is the fixed effect and $\varepsilon_{it}$ is the disturbance term.

The analysis is carried out at regional level. Some dummy variables are employed to define AOs (AO) and POs (PRESIDI OSP). The dummies AONorth or PresidiNorth assume value = 1 if a structure such as AO or PO is located in Northern Regions and = 0 otherwise.

The results can be seen in Table 15.

**Table 15. Estimation results for risk adjusted mortality and readmission rates. Truncated regression models.**

| Variable | AMI | CHF | STROKE | Stroke (Readmissions) | COPD (readmission) |
|---|---|---|---|---|---|
| **Intercept** | 0.588<br>(5.065) | -5.10<br>(3.414) | 10.741<br>(5.301) | 5.449<br>(3.984) | 11.847***<br>(2.209) |
| **CASE** | -0.0008<br>(0.001) | -0.0002<br>(0.001) | -0.001<br>(0.003) | -0.004*<br>(0.002) | -0.002*<br>(0.001) |
| **BEDS** | 0.00004<br>(0.00003) | 0.00006*<br>(0.00003) | 0.0001***<br>(0.00005) | 0.00001<br>(0.00003) | 0.001***<br>(0.00003) |
| **UTILIZATION RATE** | 0.032<br>(0.023) | 0.065***<br>(0.019) | 0.054*<br>(0.029) | -0.0029<br>(0.022) | -0.137<br>(0.017) |
| **ICM** | -1.567<br>(1.836) | -2.618***<br>(1.498) | -2.732<br>(2.577) | 2.629<br>(1.375) | 0.127***<br>(0.038) |
| **ENTROPY** | 3.728*<br>(2.259) | 3.322***<br>(1.248) | -1.234<br>(2.015) | 3.028**<br>(1.399) | 2.379***<br>(0.965) |
| **NORTH** | 0.816<br>(0.799) | 1.777**<br>(0.685) | 1.895*<br>(1.036) | -1.314<br>(0.599) | -0.334<br>(0.651) |
| **CENTRE** | 0.681<br>(0.754) | 2.288***<br>(0.650) | 4.512***<br>(0.981) | -1.175*<br>0.726 | -0.095<br>(0.691) |
| **DRG_Regional** | -0.896<br>(0.639) | -0.643<br>(0.576) | -3.158***<br>(0.849) | -0.574<br>(0.627) | -1.176**<br>(0.601) |
| **DRG_Extent** | -0.661<br>(1.597) | 1.403<br>(1.459) | -0.156<br>(2.237) | -2.560**<br>(1.651) | -5.501***<br>(1.506) |
| **AO** | -0.653<br>(1.209) | 2.340**<br>(1.084) | 1.693<br>(1.604) | 0.016<br>(0.979) | 0.851<br>(1.095) |
| **PRESIDI OSP** | -0.479<br>(0.989) | 2.795**<br>(0.876) | 2.005*<br>(1.277) | 0.799<br>(0.988) | 0.996<br>(0.856) |
| **AO North (Presidi North)** | -0.687<br>(1.095) | -2.438**<br>(1.060) | -2.819**<br>(1.512) | -1.736*^^<br>(1.061) | -0.224^^<br>(1.064) |
| σ | 3.910 (0.150) | 4.252 (0.133) | 5.523 (0.200) | 3.914 (0.149) | 4.343 (0.140) |
| *Observations* | 338 | 507 | 380 | 341 | 475 |
| *Log likelihood* | -940.5056 | -1453.2913 | -1188.6061 | -949.209 | -1371.608 |
| Wald (Prob > chi2) | 0.3888 | 0.0000 | 0.0000 | 0.0007 | 0.0002 |

*Source:* elaborations on data provided by the PNE and the Ministry of Health.
Standard errors in parentheses *** significant at 99%; ** significant at 95%; * significant at 90%
^^ in this equation the variable refers to *presidi* instead of *aziende ospedaliere*.

Several considerations can be raised by looking at the results and the comments are done by considering each clinical condition.

As for AMI, the results are not significant but for ENTROPY, as it was in the previous estimations carried out by applying the random intercepts model. The sign and the size of the estimated coefficients is almost the same as before.

Although the results of the estimations carried out for AMI follow a similar pattern, they do not allow to state a clear correlation between factors related to supply and demand and the dependent variable; neither they allow to define the role of reimbursement mechanisms and the extent of DRG implementation.

The estimated coefficients for the dummies related to the type of structure (AO, PRESIDI OSP and AO North) are inversely correlated with the mortality rate. This is the only regression where this correlation can be appreciated. Probably, with reference to AMI, more information about medical equipment and specific training for medical staff should be considered among the explanatory variables.

On the other hand, in the estimation carried out for CHF, many of the coefficients are significant, show the expected sign and confirm the results of the previous analysis. The only difference occur for the variable related to hospitals' capacity (BEDS) that is now slightly significant (90%) and positively correlated with the dependent variable. The utilization rate coefficient is positively and significantly correlated as well.

The geographical dummies are positively correlated, with NORTH showing a positive but lower impact on the mortality rate. The type of structure appears to be positively correlated with mortality, with a higher coefficient estimated for PRESIDI OSP rather than for AOs. AOs located in Northern Italy show an inverse pattern: the effect on quality is positive and the value of the estimated coefficient almost counterbalances the coefficient estimated for the variable related to the type of structure. It could be inferred a higher efficiency/effectiveness for the treatment of CHF, deriving by the decision to hive off AOs from ASL directly managed hospitals in Northern Regions.

The degree of specialization of hospitals, represented by the index of case mix (ICM) has an inverse correlation with the dependent variable, showing, therefore, a positive effect on quality. This circumstance may signify the effort by hospitals to improve their performances and to save resources. The positive coefficient for the number of beds and their utilization rates can be interpreted in the same sense: structures providing a higher quality service tend not to increase the number of beds and to avoid admissions that are not necessary (however, the result should be checked for emergency admissions within the same structure, that are not considered in this estimation). On the other hand, ENTROPY is positive: hence, the higher the heterogeneity of discharges within each DRG, the higher the mortality rates for the conditions considered[22].

It could be concluded how there is a positive effect on quality if hospitals are equipped to treat very complex cases, unless the cases treated do not show a high heterogeneity. The index of entropy, in fact, is the factor likely to influence quality more consistently (conclusions that hold both for CHF and STROKE).

The number of cases treated does not show a significant impact on hospital performance for CHF and STROKE, but the coefficients present the expected negative signs and are significant when considering readmission rates.

The regional dummy variables show the same positive correlation and their estimated coefficients are significant as they were in the previous analysis. Here, however, these results have to be seen together with the significant correlation for the type of structures and their localization in Northern Italy.

Instead, the choice for a regional DRG as well as the extent of DRG implementation are not significant; the latter shows a positive correlation with outcome, as it was in the estimation with random intercepts carried out at a regional level.

Such dummy variables should characterize the institutional framework by comparing, on one hand the adherence to DRG scheme settled at a national level and, on the other hand, the choice made by each Region for its own reimbursement scheme.

However, summarizing these two alternative scenarios only by employing one dummy variable leaves many issues open. An observation that could be raised concerns how a Region has to be classified if it applied national tariffs to some types of hospitals, but different tariffs to other types of hospitals. Moreover, it should be reminded that, even if regional governments decided to apply national tariffs, tariff rates could be modified, so to adjust the amount due for each episode of care to the peculiarities of the regional context: in this case it would be problematic to establish if the variable DRG_Regional would be 0 or 1 (in the estimations carried out here, the choice has been for 1, although with some *caveats*).

The variable DRG_Regional is especially significant for STROKE and for COPD readmissions. A first, broad conclusion is that improvements in quality indicators can be achieved by setting tariff fees at a regional level: this result might be accounted as an element of flexibility allowed by the Italian NHS, that leads to positive outcomes as regarding quality

[22] Although the correlation is inverse for STROKE, for which, however, the estimated coefficient is not significant.

of hospital care. However, for the reasons specified just above, these conclusions need to be reinforced by futher analyses or a more detailed specification of tariffs.

DRG_Regional has to be seen interpreted together with DRG_Extent, that is significant for readmissions and shows always an inverse correlation with the dependent variable but for CHF: DRG_ Extent signals the role of Regions in deciding the composition of supply (more autonomous or private hospitals instead of structures that depend on ASLs), that might lead to a higher degree of competition within the hospital market and a higher flexibility.

In the already mentioned study, Cantù, Carbone and Anessi Pessina (2011), measure with this variable the "potential use" of DRG: the authors meant with this expression the degree of purchaser-provider split, in terms of the percentage of hospital beds in AOs and accredited private hospitals[23].

Overall, the results of the estimations allows to trace a picture of the characteristics of DRG systems, although it might be completed by considering the actual use of DRGs. This consideration could, moreover, identify a positive role for Regions, that may use their regulatory power and modulate the DRG-based payment in order to orient hospitals' activity towards its own health policy objectives. As a consequence, there could be the enhancement of specific activities and changes in the delivery pattern, aimed at encouraging modalities of provision or type of services[24].

The negative correlation between quality outcomes and DRG_Extent would imply a positive effect of this payment system on quality itself. Normally, fixed case-payments might reduce costs as well as quality; however, where many providers compete on the same market, the diminution in quality may be offset by the higher degree of competition (in this case, a competition based on quality rather than on price)[25].

However, as specified in the previous sections, the funding allocated through the PPS is not the only type of funding available to hospitals in Italy, but accounts for part of it. Its composition and amount are up to the regional policy: the analysis of regional payment schemes for hospitals should, therefore, take into account the role of block assignments together with DRG-based payments.

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[23] On the other hand, the "actual use" of DRG is the share of regional health funding that effectively ends up being allocated to public and private providers on a DRG basis.

[24] Such as, for example, day hospital and day surgery.

[25] With regard to the relationship between DRG–based allocations and the overall funding, an important issue is that regional authorities could decide not to consider tariffs as the fixed payment due for the single episode of care aimed at encouraging efficiency in the provision of care. In this case, losing their original character of per case payment, tariffs would be considered as a device to appraise hospital's activity and determine the overall hospital budget: the use of tariff rates becomes part of a wider process resulting in the definition of the budget.

The results for STROKE show a high value of the estimated coefficients, whereas some of them, that are almost always significant in the other regressions, as ICM or the index entropy are not significant for this condition. There is a marked effects of the geographical dummy CENTRE, while Stroke_readmissions rates tend to be lower in Northern Regions. However, this result could signal a different epidemiological pattern across Regions, rather than a diverse quality of care.

When considering Stroke_readmissions, ENTROPY is significant, the estimated coefficients are smaller, and, for the first time, DRG_Extent is significant (while, in the analysis considering random intercepts, these coefficients were significant in the regressions carried out only considering the ASLs level). The same variable is significant and has a positive effect on quality when COPD readmissions are considered.

It appears that the reimbursement based on DRGs is likely to be an effective policy choice for those conditions for which a follow up of patients could be necessary. In this sense, it could be interpreted the number of beds (BEDS), that is positively and significantly correlated with mortality for stroke and readmissions for COPD. Rather than being determined by a higher/lower level of quality of care, this result may signal a different pattern across Regions regarding demand and supply.

In the equations related to readmissions, the sign of the coefficients for the dummy variables related to the type of structure (AO or PRESIDI OSP) confirm the trend seen for acute clinical conditions, although the same coefficients are not significant but for AO North for Stroke readmissions.

To sum up, the results of the truncated regression model estimations confirm the pattern already seen in the random intercept model.

It has been clearly defined that the reimbursement mechanisms may play a role in defining the level of quality. There are differences in Regional patterns that have been sketched only marginally by the inclusion of the dummy variable "DRG_Regional".

In this perspective, a correction for the analysis could be that of considering to which extent each Region has invested on the implementation of DRG, as done by Cantù, Carbone and Anessi Pessina, 2011: the investment on DRG might be evaluated by looking, for example, at the number of revisions of tariffs, the existence of sanctions, etc..

Another possibility might be that of calculating if the Regional DRG for given conditions is higher comparing to the national average, in order to verify the degree of autonomy exerted by Regions in managing this mechanism.

## 2.6. Conclusions

The focus of this chapter has been, first of all, that of presenting the organisation of hospital care in Italy, in order to describe the framework of analysis. An extensive descriptive analysis has been aimed at illustrating how the treatment of clinical conditions whose mortality and readmission rates have been employed as quality indicators, is characterised by a high degree of heterogeneity. Heterogeneity is related to the composition of hospital care: together with the distinction among private accredited and public structures, the latter are further distinguished into *Presidi ospedalieri*, research institutes, *Aziende Ospedaliere*, etc.). The situation is made more complex by the choices related to the mechanisms of reimbursements (DRG set at a national/regional level).

The choice of explanatory variables, especially those ones related to the institutional framework, has been reinforced by a preliminary analysis based on scatter plots and box plots correlating quality indicators with the selection of national/regional tariffs and the share of beds financed through DRGs.

The empirical analysis has seen, first, the application of a random intercepts model. Regressors employed related to demand factors (utilization rates of beds, number of cases treated for each clinical condition, index of entropy etc.), supply factors (such as the number of beds), geographical dummy variables and reimbursement choices. Several specifications of the model have been estimated, by modifying the clusters within which the structures have been grouped and the explanatory variables.

In spite of the different clusters considered, the sign of the estimated coefficients and the level of significance did not vary consistently for each condition. Differences could be appreciated when comparing mortality rates and readmission rates.

An alternative estimation strategy has then been considered, because the residuals did not always comply with the assumption of normality, that the random intercept model would require. Truncated regressions have been estimated employing, as dependent variable, the adjusted rate of mortality and readmissions, that is truncated, since it has been calculated only for those structures treating more tha 75 cases per year. The same explanatory variables have been employed, by adding, however, some dummies related to the type of structure (PRESIDI OSP or AOs and the localization in Northern Italy).

Overall, the comments that can be raised are similar to those formulated for the random intercept model.

Effects on mortality and readmission rates are due mainly to demand and supply factors, although a positive effect of reimbursement choices on the level of quality can be noticed. The role of DRGs at a regional level in determining a higher level of quality can be seen especially by looking at readmissions rates.

Quality has been analysed so far by investigating the effect of given factors on some outcome indicators. The analysis can now be completed by considering the aspect of efficiency.

# CHAPTER III

## 3.1 Introduction: motivations for an efficiency analysis of hospital care

## 3.2 Data and methodology applied

## 3.3 Results and discussion

## 3.4 Conclusions

## 3.1. Introduction: motivations for an efficiency analysis of hospital care

The previous chapter has presented the framework of analysis, describing its peculiarities, the differences existing among hospitals (private, public and other organisational schemes) and the impact of reimbursement schemes (national vs. regional DRG) on the overall level of quality.

The cross section study referred to the year 2009.

A preliminary analysis on scatter plots and box plots has tried to assess, at a regional level, the effect of the implementation of DRG on outcome indicators.

The econometric analysis has been based, first, on a random intercept model in two levels: the dependent variables were some outcome indicators; the explanatory variables regarded factors related to demand and supply and to some "institutional" factors, among which there was the modality of reimbursement. The consideration of different clusters – ASL, Regions and type of structures – as second level of analysis did not outline any relevant difference in the results. However, because of some drawbacks in the analysis of residuals, an alternative estimation strategy was considered, applying a truncated regression model. The results of this other model showed a positive impact on quality due to reimbursement mechanisms, the type of structure and its localization.

In this last section a different perspective of analysis will be adopted.

The economic literature focusing on the activity of hospitals has gone through different phases, starting from efficiency analyses of production and getting to wider investigations about effectiveness, quality and customers' satisfaction (see chapter 1).

Recent developments in methodology for efficiency analysis suggest to complete the investigation on quality and outcomes in hospital care carrying out an analysis based on inputs/outputs/outcomes and to test the suitability of techniques like Data Envelopment Analysis as complementary tools to econometric analysis to assess the quality of hospital care.

There is a variety of definitions of efficiency that are currently in use: that is why the same word, efficiency, has often determined confusion about what is the object of study.

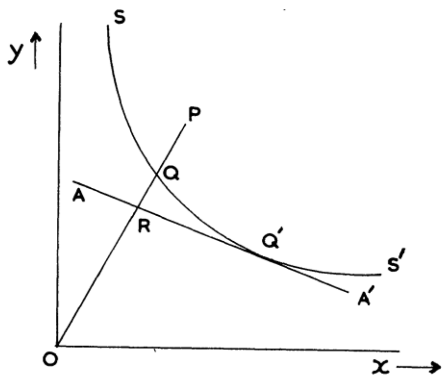
According to a more general definition, efficiency is given by the ratio output/input. This definition is likely to include different types of outputs and inputs as well as different methods for describing the relationship between these ones.

The concept of efficiency of production needs to be separated from productivity: in fact, while "*productivity is the ratio of a measure of output to a measure of input*" (Street and Hakkinen, 2009), efficiency implies a "*comparison between observed and optimal values of output and input*" (Fried, Lovell and Schmidt, 2008).

Another distinction exists between *technical efficiency*, that occurs when the same level of the output cannot be produced with fewer of the inputs and has, as objective, that of reducing waste; *productive efficiency*, that refers to the maximization of output for a given cost, or minimization of costs for a given output, and whose objective is that of saving money; *social (or Pareto) efficiency*, whose purpose is the maximization of social welfare, that exists when no one can be made better off without making someone else worse off (Farrell, 1957).

A definition of the three concepts can be provided, with respect to the diagram used by Farrell (1957).

**Figure 1. Productive efficiency**




Source: Farrell (1957).

In the above diagram, the isoquant SS' represents the efficient production function, relative to the production of a given amount of output. AA' is an isocost, whose slope represents the relative prices of the two inputs, x and y.

While 1) technical efficiency includes the inputs needed at best practice to produce given outputs relative to observed input quantities, keeping observed input ratios and is given by OQ/OP in the figure, 2) allocative efficiency concerns the costs of producing the observed output at observed factor prices, assuming technical efficiency, relative to minimized costs at the frontier, and is represented by OR/OQ in the figure. Finally, 3) overall efficiency comprises the costs of producing observed output if both technical efficiency and price efficiency are assumed relative to observed costs, and is given by OR/OP = (OQ/OP) (OR/OQ) (Filippini and Farsi, 2008).

The issue of efficiency becomes more problematic when healthcare is concerned.

The Definition of efficiency in health sector is specific and differs from the definition of efficiency used in other economic sectors: in fact, the product in health care sector are health consequences, as the improvement in health status, while, in other sectors of the economy, final goods are produced. In this context, efficiency is meant as a measure of the relationship between costs of care and a specific level of performance that is the objective of health policies, and the provision of a level of services that is sufficient to meet patients' health care needs, but which is not excessive, given a patient's health status (Agency for Healthcare Research and Quality, 2008).

According to the definition of allocative efficiency, efficiency in health care should emerge from the comparison of consequences on health status of different treatment methods. As regard to technical efficiency, instead, it is connected with objectives faced by providers, that are either to provide treatment minimizing the budget employed, and to achieve health outcomes representing improvements in health status. Hence, efficiency is realized when health care resources are being used to get the best value for money (Palmer and Torgerson, 1999).

From an operational perspective, the measurement of efficiency involves three stages:

- to isolate relevant model variables, which depends on understanding of the production process and the identification of the decision making unit;

- to formulate an efficiency measure using chosen variables and to select an appropriate evaluation technique that can generate robust efficiency measures;

- to obtain data for variables included in the model, so to calculate the efficiency scores.

Efficiency is a relative concept, since its definition, in health care, depends on the perspective adopted, given that each stakeholder may behave differently.

Jacobs, Smith and Street (2006) underline the importance of defining the exact boundaries of the analysis of efficiency, above all with respect to the entity whose behavior is under exam. The unit of analysis should be that subject encompassing the whole, or, at least the greatest part of the production process of the healthcare services, and should have control of the decisions regarding the utilization of inputs[26].

However, it is difficult to make these criteria operational in such a way to define exactly the sphere of activity of decision-making units. In fact, if the boundaries were too large, as it

[26] This is the reason why the units of analysis are generally called decision-making units (DMUs).

would be if the whole healthcare system was considered as a unit, then it would be difficult to identify the relevant decision-makers. The analysis should preferably be run from another perspective, choosing subjects or groups of subjects as the relevant unit of analysis, albeit, when the analysis goes down to a disaggregated level, the risk is to overlook the interdependency in production among the different units.

Moreover, the choice of the unit of analysis needs to consider the issue of comparability of different units. The measurement of efficiency can be carried out, for example, through the benchmarking of different structure. The latter can be instrumental to policy decisions, wherever their comparative performance is of interest for some decision-maker; in this respect, "*the units being compared are seeking to deliver the same set of health care outputs*" (Jacobs, Smith and Street, 2006).

Finally, the financial aspect of delivering health care, together with health improvements have to be considered (InterQuality, WP2, 2012).While calculating costs in monetary terms is an easy task, the real, more stimulating – and problematic - issues, are connected with evaluating risks and benefits in health care, *i.e.* to select suitable output/outcome indicators.

There are many surveys that examine the issues of selecting appropriate indicators and methodology for efficiency analysis (Coelli, Rao and Battese, 1998; Murillo-Zamorano, 2004; Jacobs, Smith and Street, 2006; Fried, Lovell and Schmidt, 2008).

The modern efficiency measurement involves a comparison of actual performance with optimal performance located on the relevant frontier, or best practice frontier.

Since the technically feasible production frontier is unknown, empirical approximations are needed. Literature studies have been aimed at determining an efficient frontier function or "envelopment" surface in order to evaluate the relative performance of different units of analysis.

The methodology of analysis relies on the estimation of an empirical frontier based on observed behaviour.

Overall, it is possible to distinguish two principal approaches to measure efficiency:

- the economic (parametric) approach and
- the linear programming (non parametric) approach.

A further distinction is made between deterministic and stochastic models.

This classification looks at the different treatment of measurement error and statistical noise: while in parametric methods the functional form is pre-defined, in non-parametric methods no functional form is pre-established.

Although Table 1 summarizes the characteristics of all the mentioned approaches to measure efficiency, the focus, in the present research, will be on DEA.

**Table 1. Methods to evaluate efficiency**

| | **Deterministic** | **Stochastic** |
|---|---|---|
| **Parametric** | Corrected OLS (COLS) | Stochastic frontier analysis (SFA) |
| **Non-Parametric** | Data envelopment analysis (DEA)<br>Free disposal hull (FDH) | Stochastic Data envelopment analysis (SDEA) |

Within deterministic methods of analysis, the production and cost frontiers measure inefficiency as the distance between a best practice frontier and actual performance, and are based on efficiency indicators proposed by Koopmans (1951) and Debreu (1951). These indicators have been empirically applied by Farrell (1957), who suggested to estimate productive efficiency using linear programming.

The deterministic models assume that all the deviations from the efficient frontier, defined by the available technology, are a measure of inefficiency. The deterministic frontier functions can be solved either by using econometric techniques or by means of mathematical programming.

The earlier econometric approach applied Farrell's definitions in empirical frameworks in which the inefficiency is identified with disturbances in a regression model. Aigner and Chu (1968) built on Farrell's work by measuring a deterministic model of production assuming that all deviations from the frontier are one-sided.

Later on, Greene (1980) showed that OLS with a correction to the intercept of the largest residual provides an estimate of the production frontier. This technique, deterministic and parametric is referred to as corrected OLS (COLS).

In general terms, a cost function can be defined as:

$$y_i = \alpha + x_i\, b_i + \varepsilon$$

where $y_i$ is the total cost of production of the ith unit (in the case considered for the present analysis, for example, the unit considered are the provinces or Regions where the hospitals are located); $x_i$ is a vector of factors explaining costs; b is a vector of unknown parameters to be estimated, and ε is the error term. Under this formulation, the difference (residual) between observed costs and those predicted by the model should be due to inefficient behaviour. If the residual term is interpreted as an inefficiency measure, it is possible to calculate the efficiency of each observation based on its distance from a relative cost frontier. The frontier is located after making the assumption that the observation with the minimum residual value is fully efficient and is operating on the cost frontier with all the other observations lying above the frontier. Hence, the OLS line is shifted down, so that it passes through the data point for the efficient observation: this procedure leads to corrected OLS, and in the model there will be a corrected constant term, $\alpha\hat{}_i = \alpha + \min(\varepsilon_i)$.

Another deterministic approach for the measurement of the efficiency has been developed by Charnes, Cooper and Rhodes (1978), which generalized Farrell's single input/output measure to a multiple-input/multiple-output technique. The aim of their approach is the measurement of productive efficiency by definition of a frontier envelopment surface for all sample observations using linear programming techniques.

Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) are, nowadays, among the most known and applied nonparametric techniques for the measurement of efficiency. These approaches have received a considerable amount of interest, both from a theoretical and from an applied perspective.

The DEA is a non-parametric data analytic technique whose domain of inquiry is a group of entities, the decision making units (DMUs), which receive multiple inputs and produce multiple outputs. Given a sample of the DMUs, the purpose of the DEA is to establish the relative efficiency of each DMU within the sample.

Efficiency by DEA is defined in the three forms of technical, allocative and overall efficiency.

Since the work by Charnes, Cooper, and Rhodes, DEA has rapidly grown and is now extensively used in evaluating efficiency for a many industries and institutions. Along years, DEA has been validated through a variety of means such as observation, simulations, and hypothetical data sets with known efficiencies and inefficiencies.

The specification of DEA can be described as follows:

$$\max_{u,v} h_0(u,v) = \frac{\sum_r y_{r0}}{\sum x_{i0}}$$

under the constraint

$$\frac{\sum_r u_r y_{rj}}{\sum_i c_i y_{ij}} \qquad u_r, v_i \geq 0 \qquad j = 0, 1, \ldots, n$$

In the maximisation problem above, it is assumed that there are n DMU, each one employing different quantities of inputs to produce different outputs. More specifically, each $DMU_j$ uses the quantity $x_{ji}$ of the ith input to produce the amount $y_{jr}$ of the rth output.

$u$r and $v$i are the weights attached to output r, $u$r > 0, $r = 1,\ldots, p$ and to input $i$, $v$i > 0, $i = 1,\ldots, m$. The weights are specific to each unit so that $0 \leq h0 \leq 1$. A value of 1 implies complete technical efficiency relative to the sample of units under examination. Since the weights are not known initially, they are calculated from the efficiency frontier by comparing a given unit with other ones producing similar outputs and using similar inputs. DEA computes all possible sets of weights which satisfy all constraints and chooses those ones which give the highest efficiency score (Jacobs, 2000).

The advantage of DEA is that it considers the multiple output/multiple input ratio as a ratio between a single output/single input. For each unit, this ratio provides a measure of the technical efficiency.

Several studies have proven the powerful and the superiority of DEA compared with other techniques. Nyhan and Cruise (2000), for example, studied the comparative performance assessment in managing care. They reviewed three comparative performance methodologies with a comprehensive explanation of DEA, a ratio analysis and a regression analysis. Although ratio and regression analysis provided interesting results, DEA showed superior in that, as the authors stressed, it incorporates an optimizing principle rather than an averaging principle, and produces improvement targets for inefficient providers identifying best practice providers, that can be used as benchmark for operational improvement.

Interesting applications of DEA can be found in less recent economic literature: Bowlin *et al.* (1985) developed a hypothetical data set for hospital units with known efficiencies and inefficiencies and compared DEA against ratio and regression analyses. DEA outperformed both ratio analysis and least squares regression in identifying sources and amounts of inefficiencies.

Banker, Conrad and Strauss (1986) used empirical data from a sample of North Carolina hospitals to identify inefficiencies and return to scale possibilities in individual hospitals that were not evident in the trans-log model. Sustainers of the use of DEA in evaluating physicians' performance are Chillingerian and Sherman (1997) who explored the use of DEA to identify best practice primary care physicians, and calculated the potential savings if inefficient physicians were to adopt best practice patterns.

However, some drawbacks of this method have limited its use in the last decade.

Although the methodology is quick and straightforward to implement as no assumptions are required about the technology or the specification of the cost/production function[27], a weakness relies on the impossibility to distinguish between inefficiency and statistical noise.

In fact, the residual term is interpreted as due to inefficiency alone, with no recognition of statistical error. Hence, results may be influenced by noise and outliers, traditional hypothesis testing is not possible and the efficiency scores calculated tend to be sensitive to the choice of input and output variable.

An alternative to DEA might be the application of a stochastic frontier analysis (SFA), that presents considerable advantages[28]: it attempts to account for noise and allows for traditional statistical tests of hypothesis. Moreover, SFA makes it possible to identify outliers and allows to control for unobserved heterogeneity.

Stochastic cost and production functions measure deviations from the ideal production frontier with an additional error term which denotes the inefficiency in the production[29].

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[27] Moreover, DEA does not assume a functional form for the frontier, neither a distributional form for the inefficiency term.

[28] The foundation for the stochastic frontier models are provided by Aigner, Lovell, and Schmidt (1977), which assumed that the error term can be partitioned into two component, one of which represents inefficiency and the other random noise.

[29] An example of the application of a SFA is a study carried out by Linna (1998). The analysis focuses on the development of hospital cost-efficiency and productivity in Finland in 1988-1994. A comparative application of parametric and non-parametric panel model is performed: a stochastic frontier model with a time-varying inefficiency component is employed as parametric method. In particular, the author assumes that the duality between cost and production transformation processes is ensured by imposing certain regularity conditions such as non-decreasing function with linear homogeneity and concavity in input prices on the production possibility set. Hence the model for the cost frontier can be written as:

$$C_{it} = C\ (y_{it}, z_{it}, w_{it}) + \varepsilon_{it}$$

$$\varepsilon_{it} = |u_i| + v_{it}$$

where C stands for total costs, $y_{it}$ refers to the output vector; $z_{it}$ is related to some non-output control variables and $w_{it}$ is the vector of input prices; v is the normally distributed random term, while u is a one-sided inefficiency term.

The term $u_i$ characterize the inefficiency of the ith unit; overall, the $u_i$s are positive and iid random variables independent of v. Other assumptions of the model are: (1) $v_{it}$ iid for all t and i; (2) $y_{it}$ and $v_{it}$ are independent for all t and i; (3) $y_{it}$, $v_{it}$, $u_i$ are independent for all t and i. Under these assumptions, the model is estimated by maximum likelihood.

However, such methodology requires large sample size to obtain robust estimates, which may not always be available; then, the decomposition of the error term into noise and efficiency component may be affected by the particular distributional form specified.

However DEA technical efficiency estimate may be affected by others exogenous variables or environmental factors that should be taken into account.

In the literature, two main approaches were suggested to consider such “environmental” or exogenous variables. The first approach includes environmental variables as inputs when estimating the efficiency frontier (Banker and Morey, 1986). The second approach performs a two-stage analysis (Coelli et al., 1998): in the first stage, DEA technique is used to evaluate the relative DMU efficiency and in the second stage the DEA efficiency scores are regressed on a set of appropriate environmental covariates. When using the two-stage approach, researchers typically adopt censored regression techniques (Tobit model) or, in a few cases, OLS estimates, given the censored nature of the dependent variable. In fact, a fundamental criticism of the two-stage DEA analysis is that standard approaches to statistical inference are invalid for limited dependent variable models.

Simar and Wilson (2007) showed that the Tobit estimates are biased from the serial correlation of efficiency scores and proposed application of the semi-parametric two-stage technique. More recently, Banker and Natarajan (2008) proposed a statistically consistent estimators for the two-stage procedure, which involve nonparametric estimation of productivity in the first stage followed by OLS regression. In this sense, Banker and Natarajan argued that their statistical model requires less restrictive assumptions than the Simar and Wilson model (2007)

### 3.2. Data and methodology applied

An empirical analysis of efficiency for Italian provinces has been run. The analysis builds on the consideration that quality can depend on the best possible use of inputs. However, the presence of some “environmental factors” may have an impact on the efficiency scores.

Environmental factors such as composition of population, or income, or the “attractivity” of some hospital structures located in other Regions/provinces may affect organisational capacity, influence the organisation’s production frontier and constrain the amount of output that can be obtained for a given level of input. That is why a second step for the efficiency analysis has been developed.

Comparing to the econometric analysis carried out in the chapter 2 that was mainly centred on Regions and ASLs, the present efficiency analysis focuses on territorial areas (provinces).

DMUs for the DEA are provinces, that mostly coincide with the territory covered by ASLs healthcare provisions. Since DMUs may utilize any combination of inputs and outputs in order to maximize their own efficiency score, DEA allows to identify the most efficient provinces and, thereby, can determine their rankings.

First of all, appropriate inputs and output measures have to be chosen. Among inputs frequently employed in efficiency analyses there are the number of hospital beds, pharmaceuticals consumption, the total salary for physicians and for nurses. Hadad, Hadad and Simon-Tuval (2001) distinguish into inputs that can be discretionally controlled by the SSN and exogenous inputs, related to individuals’ life style and habits.

Indicators for output usually comprise the number of in-patients and outpatients, the number of emergency visits, the total number of scheduled and follow up visits, DRG weighted number of total admissions, bed productivity, life expectancy[30], low birth weight infant mortality, age-standardised self reported health status, potential years of life lost.

Mortality and survival indicators are considered the best available proxies for health output, likely to represent the population’s health status, although they might present some drawbacks[31].

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[30] Life expectancy reflects not just health spending but also choices of lifestyles, such as some kinds of consumption and education levels. These factors might be taken into account in a policy perspective when assessing the efficiency of health care spending programs.

[31] For example, some deaths are unrelated to the quality of health care interventions (as those related to accidents). Moreover, indicators of health status should reflect the prevalence and severity of sickness and functional disability. Mortality data adjusted for these dimensions are available only sparsely but tend to be

In this analysis, two efficiency estimates have been run, considering as outputs the standardized survival/10,000 (first estimation) and standardized survival/10,000 together with infant survival/10,000 (second estimation).

To improve the estimates scores, following the methodology suggested by Afonso and Aubyn (2005), survival rate has been considered, instead of mortality rate, since it treats the life year saved - rather than life lost - as the unit of output.

Mortality rate is equal to:

(number of deaths/population) *10,000.

Analogously, infant mortality rate, considered as a second measure for output, is equal to:

(number of children who died before 12 months/number of born children) * 10,000.

Survival rate for both indicators is calculated as follows:

Survival rate = (10,000-Mortality rate)/Mortality rate

Infant survival rate = (10,000-Mortality rate)/Mortality rate

The inputs selected represent the availability of resources on the territory: number of hospital beds, number of paediatricians (that has been chosen as proxy for the health assistance available on the territory, given the unavailability of data about general practitioners or medical guards for the years of analysis), number of physicians at hospitals, including in this definition, both private and public structures.

Since other "environmental" factor may have an impact on health outcomes, these ones are taken into account in a second step, where dependent variables are the efficiency scores estimated in the first step. Felder and Tauchmann (2011) apply the same estimation strategy, but stress how such two-step analysis requires some caution: efficiency scores obtained from DEA in the first step might be sensitive to outliers and measurement errors; moreover, DEA generates a correlation pattern among estimated efficiency scores, which might result in misleading inference in the subsequent regression analysis; estimated scores are bounded from above at one, and would require a generalized regression model.

Other authors (as Simar and Wilson, 2007) develop a truncated regression-based bootstrap that considers the latter two problems. In the spatial regression analysis carried out by Felder and Tauchmann (2011), instead, efficiency estimates are obtained from a partial frontier that does not envelop all data point. In particular, some subsamples are randomly

highly correlated with raw mortality/longevity data. Other indicators, such as survival rates after specific diagnoses, public satisfaction with the health care system and sick leave, may provide complementary information.

drawn from the original data to attenuate the impact of extreme observations on the estimated efficiency scores. The correlation among them is, therefore, reduced.

The present analysis employs data extracted from the Health for All database.

Data are available from 1996 on, although not for all variables. It has been considered the time interval 2000-2004 (five years); the observed sample includes 103 provinces.

Some descriptive statistics about selected indicators, both at national and regional level can be seen in the following tables/figures.

**Table 2.**
**Survival rate (average) per 10,000 inhabitants – 2000-2004**
**(Northern, Central and Southern Regions)**

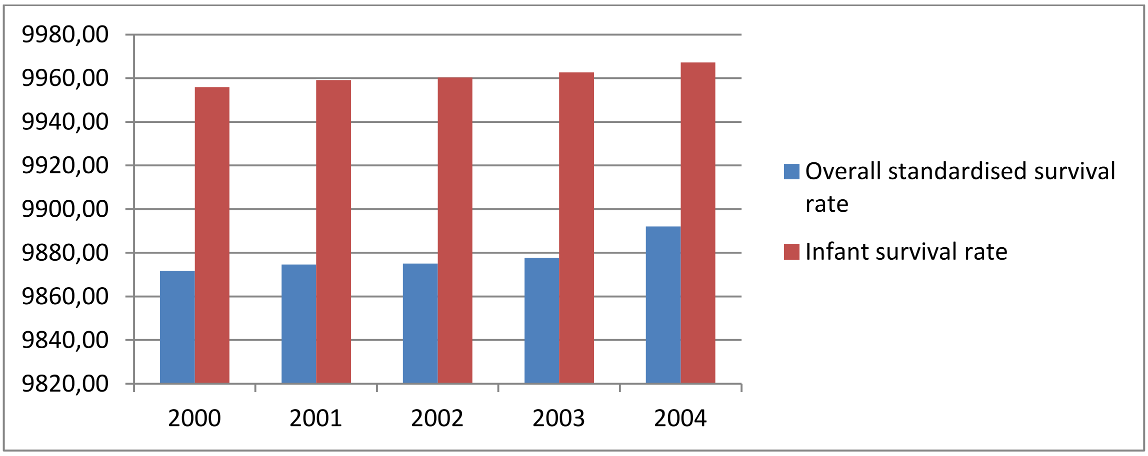
| Region | Standardised population survival | Standardised infant survival |
|---|---|---|
| | | |
| **Valle d'Aosta** | 9,858.81 | 9,954,56 |
| **Emilia Romagna** | 9,880.90 | 9,965,02 |
| **Friuli Venezia Giulia** | 9,869.87 | 9,974.79 |
| **Liguria** | 9,875.08 | 9,961.59 |
| **Lombardia** | 9,893.57 | 9,970.38 |
| **PA Bolzano** | 9,879.70 | 9,965.91 |
| **PA Trento** | 9,874.23 | 9,967.12 |
| **Piemonte** | 9,867.26 | 9,963.44 |
| **Veneto** | 9,874.74 | 9,970.39 |
| **NORTHERN REGIONS** | **9,874.91** | **9,965.91** |
| **Abruzzo** | 9,880.89 | 9,957.85 |
| **Lazio** | 9,874.72 | 9,957.57 |
| **Marche** | 9,887.57 | 9,964.67 |
| **Molise** | 9,882.82 | 9,959.60 |
| **Toscana** | 9,879.97 | 9,969.55 |
| **Umbria** | 9,882.08 | 9,964.13 |
| **CENTRAL REGIONS** | **9,881.34** | **9,962.22** |
| **Basilicata** | 9,880.66 | 9,948.78 |
| **Calabria** | 9,880.79 | 9,946.30 |
| **Campania** | 9,866.23 | 9,953.87 |
| **Puglia** | 9,880.78 | 9,946.86 |
| **Sardegna** | 9,874.96 | 9,961.36 |
| **Sicilia** | 9,874.52 | 9,943.61 |
| **SOUTHERN REGIONS** | **9,876.32** | **9,950.13** |
| **ITALY** | **9,878.24** | **9,961.01** |

Source: elaborations on Health for All data.

Central Regions have registered, in the period 2000-2004, the highest average survival in Italy. Lombardia shows the highest standardized survival rate (9,893.57 per 10,000 inhabitants) while Friuli Venezia Giulia presents the highest infant survival (9,974.79). Overall, survival is lower for Southern Regions (Sicilia shows, for example, the lowest infant survival rate – 9,943.61 per 10,000 inhabitants -). The poorer results for Valle d'Aosta (for which, however, a dimensional effect has to be considered) determine an average survival for Northern Regions of 9,874.91, a value that is below the national average of 9,878.24, during the period considered.

Figure 2 shows a variation in overall standardized survival rate from the year 2000 to the year 2004, that goes from an increase of 0.03% from 2000 to 2001, has a zero growth in the following years and rises to 0.15% from 2003 to 2004. Variation in infant survival rate, instead, is smaller, going from 0.03% to 0.05%.

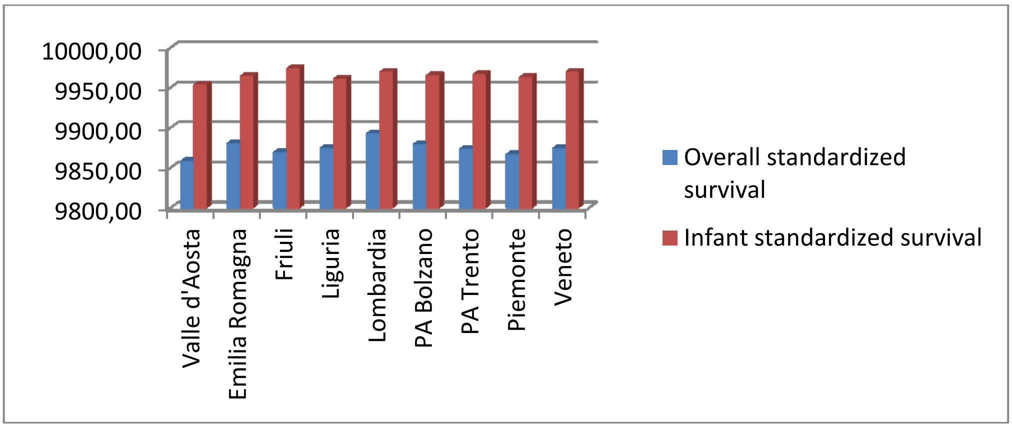
**Figure 2.**
**Survival data – Italy 2000-2004**




Source: elaborations on Health for All data.

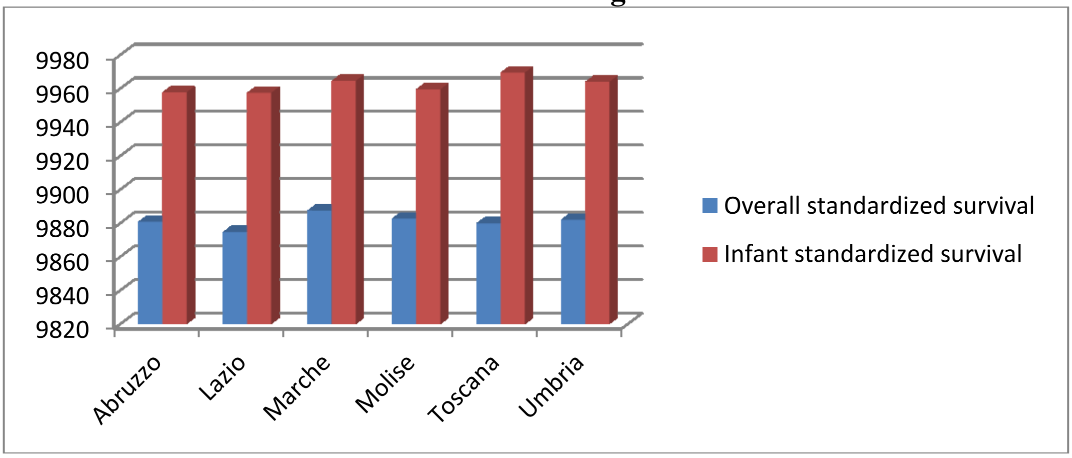
Figures 3a-3b-3c present overall and infant survival distinguished for groups of Regions. Differences among Northern Regions might be explained by characteristics of population (higher percentage of elderly people living in these Regions) or prevalence of some diseases. In Liguria, for example, the percentage of people over 65 years old is of 25.76%. This pattern is completely different in Southern Italy, where the average shares of people over 65 and over 80 years old are, respectively of 17.10% and 1.74%. In Southern Italy all Regions show a share of population over 65 years old that is below 20%.

**Figure 3a.**
**Survival data – Northern Regions 2000-2004**



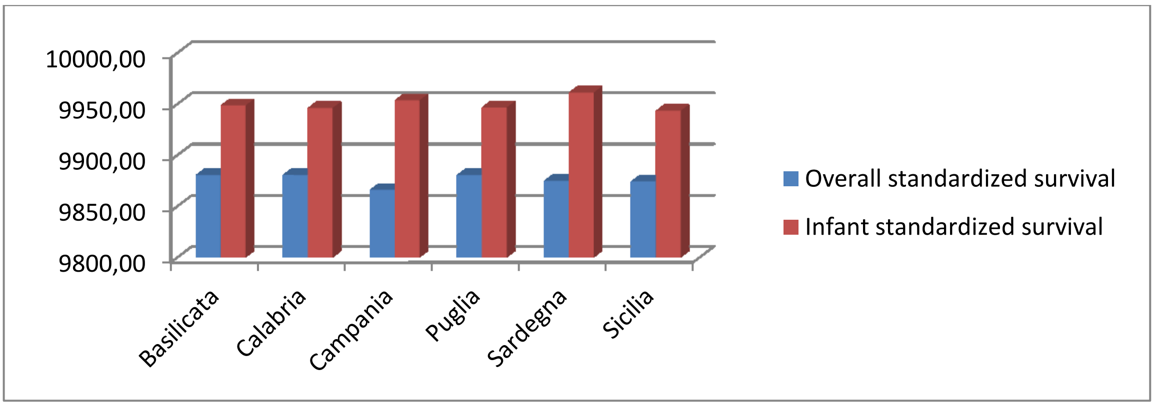

Source: elaborations on Health for All data.

**Figure 3b.**
**Survival data – Central Regions 2000-2004**




Source: elaborations on Health for All data.

**Figure 3c.**
**Survival data – Southern Regions 2000-2004**

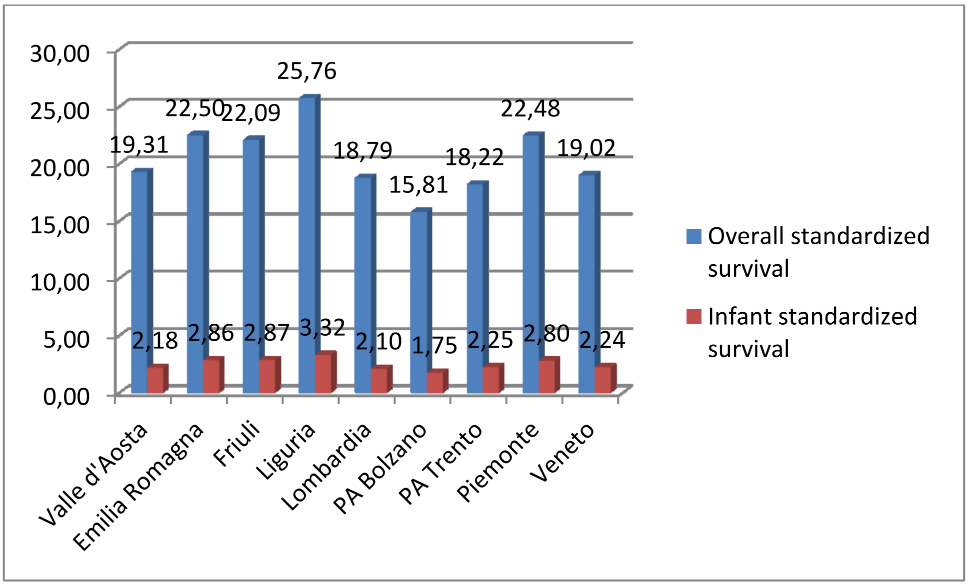



Source: elaborations on Health for All data.

Figures 4a-4b-4c show the share of population over 65 years old and over 85 years old living in Northern, Central and Southern Regions (average values for the time interval 2000-2004).

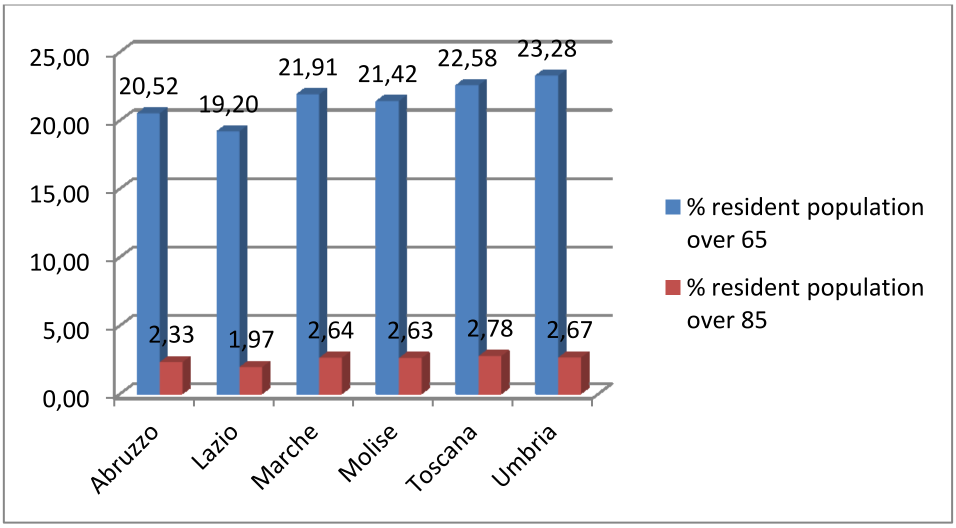
Autonomous province of Bolzano, Puglia and Campania are the "youngest" Regions, while Liguria, Friuli Venezia Giulia and Emilia Romagna present the highest percentage of resident over 85 years old.

**Figure 4a.**
**% of people over 65 and over 80 – Northern Italy**



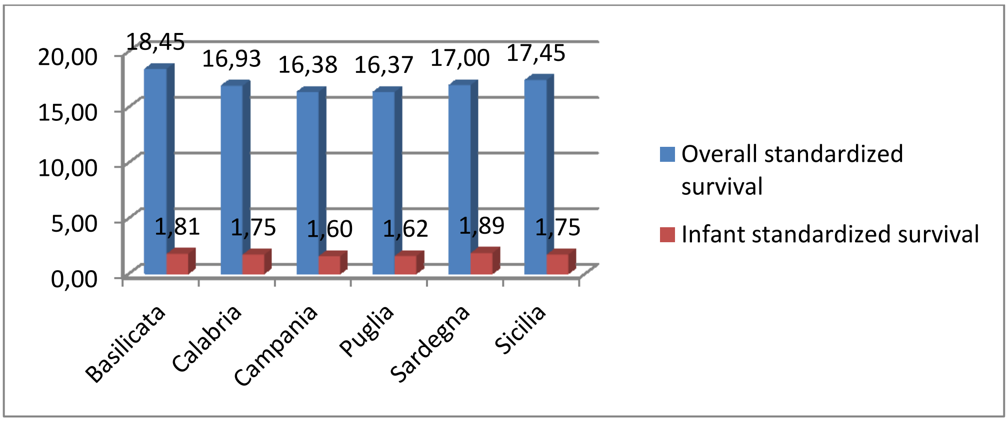

Source: elaborations on Health for All data.

**Figure 4b.**
**% of people over 65 and over 80 – Central Italy**




Source: elaborations on Health for All data.

**Figure 4c.**
**% of people over 65 and over 80 – Southern Italy**




Source: elaborations on Health for All data.

Summary statistics about inputs data are reported in Table 3 and Figures 5a-5b-5c.

**Table 3.**
**Input variables. Summary statistics.**

| Regione | Hospital beds/10,000 (standard deviation in brackets) | Average number of paediatricians_10000 (standard deviation in brackets) | Average number of physicians at hospitals _10000 (standard deviation in brackets) |
|---|---|---|---|
| **Valle d'Aosta** | 36.26 (1.65) | 7.01 (1.26) | 17.45 (0.69) |
| **Emilia Romagna** | 45.64 (6.84) | 1.74 (0.62) | 20.14 (3.41) |
| **Friuli** | 43.82 (16.18) | 1.93 (1.01) | 19.27 (2.37) |
| **Liguria** | 39.75 (8.59) | 3.99 (1.69) | 18.21 (6.24) |
| **Lombardia** | 44.99 (10.49) | 1.71 (1.38) | 18.87 (4.74) |
| **PA Bolzano** | 48.11(2.10) | 1.19 (0.37) | 17.09 (2.15) |
| **PA Trento** | 43.38 (6.87) | 1.53 (0.063) | 16.36 (0.22) |
| **Piemonte** | 42.88 (12.16) | 2.12 (1.16) | 17.64 (5.43) |
| **Veneto** | 44.41 (6.70) | 1.36 (1.17) | 17.85 (2.90) |
| **Abruzzo** | 40.71 (7.18) | 3.46 (1.55) | 19.20 (2.90) |
| **Lazio** | 39.49 (11.70) | 1.79 (1.45) | 18.01 (6.50) |
| **Marche** | 41.92 (9.41) | 1.97 (0.54) | 17.90 (5.03) |
| **Molise** | 53.18 (14) | 8.65 (5.88) | 23.79 (5.61) |
| **Toscana** | 38.69 (9.31) | 1.72 (0.53) | 18.88 (7.82) |
| **Umbria** | 37.44 (3.44) | 1.69 (0.79) | 19.11 (0.89) |
| **Basilicata** | 36.40 (8.04) | 2.19 (0.64) | 14.77 (1.54) |
| **Calabria** | 47.75 (27.50) | 2.94 (2.05) | 18.34 (4.55) |
| **Campania** | 35.20 (7.32) | 1.16 (1.03) | 18.32 (2.60) |
| **Puglia** | 38.15 (4.91) | 1.00 (0.40) | 16.00 (3.42) |
| **Sardegna** | 40.90 (9.93) | 1.77 (0.93) | 17.17 (5.31) |
| **Sicilia** | 39.96 (9.70) | 1.82 (1.57) | 17.55 (6.40) |

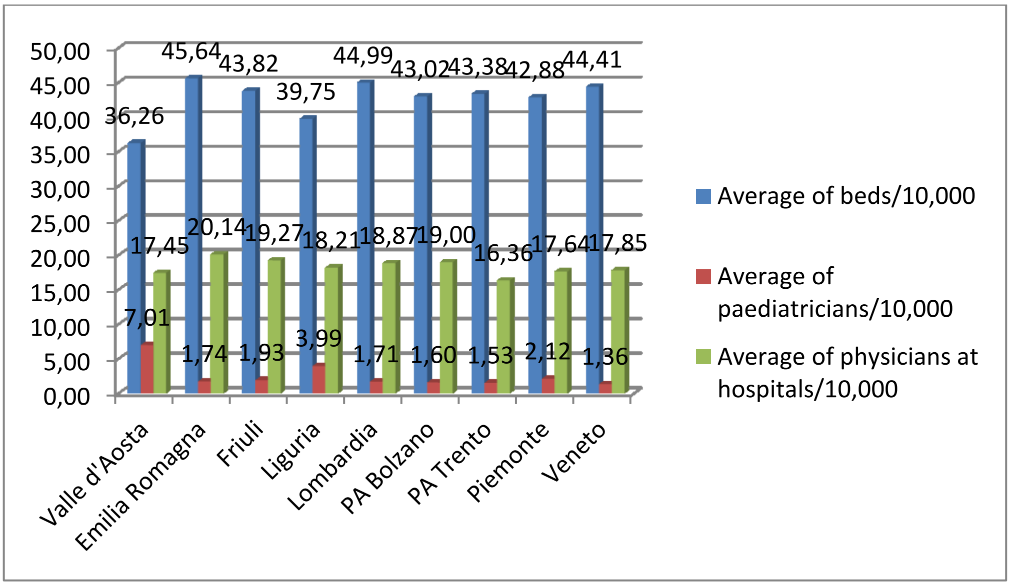
Source: elaborations on Health for All Data.

About hospital beds, it is not possible to individualize a common trend across Regions. A high number of beds/10,000 inhabitants can be found both in larger Regions as Emilia Romagna (45.64/10,000) and in smaller Region as Molise (53.18). Southern Regions comparing to Northern ones show a limited number of beds as in Campania (35.20), Basilicata (36.40) and Sicilia (39.96); on the other hand, Calabria (47.75) present more hospital beds than the average number of beds calculated for Northern Regions.

Number of paediatricians does not follow a distinct pattern according to geographical groups of Regions: their average number goes from 1 per 10,000 inhabitants in Puglia to 8.65 in Molise and 7.01 in Valle d'Aosta. A less irregular distribution belongs to the number of physicians at hospital, with the exception, once again, of Molise, with an average number of 23.79/10,000 physicians.

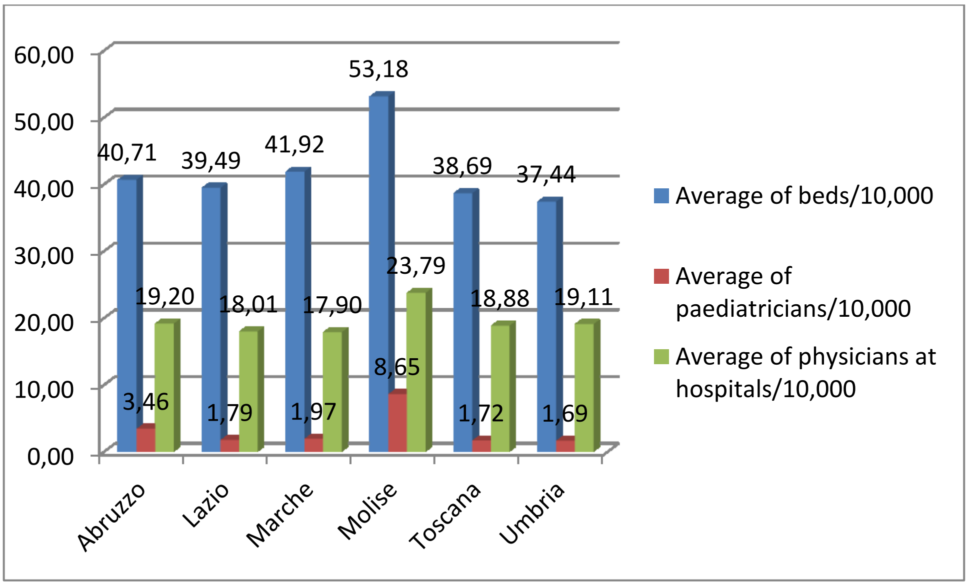
The following figures summarise these results and provide a clearer picture of the framework of analysis:

**Figure 5a.**
**Input variables. Northern Regions – average values 2000-2004**



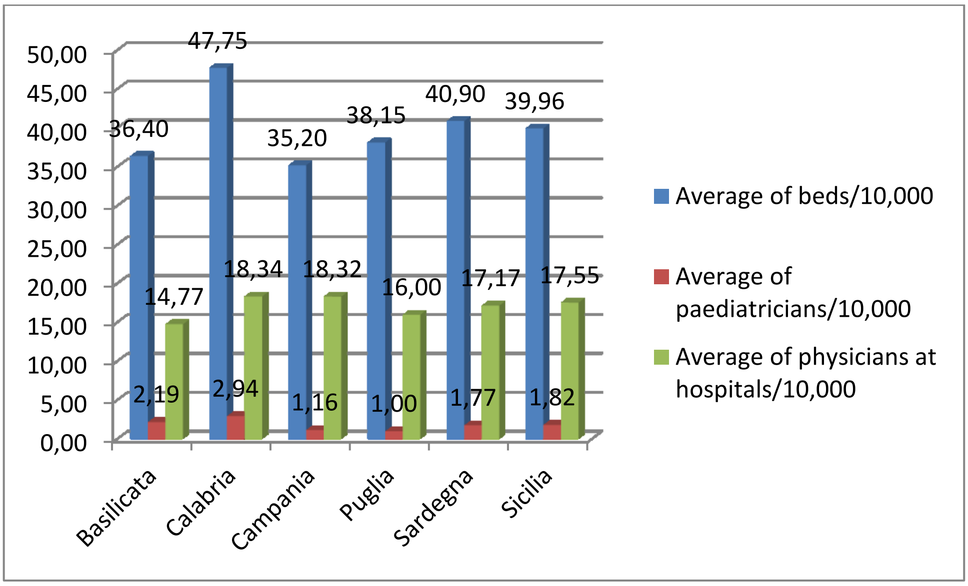

Source: elaborations on Health for All data.

**Figure 5b.**
**Input variables. Central Regions – average values 2000-2004**




Source: elaborations on Health for All data.

**Figure 5c.**
**Input variables. Southern Regions – average values 2000-2004**




Source: elaborations on Health for All data.

Table 4a and 4b report the efficiency scores calculated by applying DEA.

The efficiency analysis has been run both for one-output and two-outputs.

In the tables, the results of technical efficiency are shown for the years 2001 and 2005 (respectively the first and the last year analyzed); moreover, only the provinces in the first and last positions are reported.

**Table 4a.**

**Efficiency scores – 1output model- for Italian provinces (years 2000 and 2004).**

| **2000** | | | **2004** | | |
|---|---|---|---|---|---|
| **Rank** | **Province** | **Efficiency score** | **Rank** | **Province** | **Efficiency score** |
| **1** | Treviso | 0.97 | **1** | Vicenza | 0.89 |
| **2** | Agrigento | 0.91 | **2** | Treviso | 0.88 |
| **3** | Napoli | 0.87 | **3** | Taranto | 0.88 |
| **4** | Taranto | 0.83 | **4** | Agrigento | 0.84 |
| **5** | Milano | 0.82 | **5** | Caserta | 0.78 |
| **6** | Caserta | 0.81 | **6** | Napoli | 0.77 |
| **7** | Vicenza | 0.80 | **7** | Frosinone | 0.74 |
| **8** | Sondrio | 0.78 | **8** | Venezia | 0.74 |
| **9** | Bolzano | 0.77 | **9** | Salerno | 0.73 |
| **10** | Lecce | 0.74 | **10** | Lecce- Reggio-Brindisi-Pisa | 0.72 |
| **94** | Verbano-Ossola | 0.39 | **94** | Arezzo | 0.39 |
| **95** | Ancona | 0.38 | **95** | La Spezia | 0.39 |
| **96** | Aosta | 0.38 | **96** | Teramo | 0.39 |
| **97** | Brescia | 0.37 | **97** | Belluno | 0.39 |
| **98** | Arezzo | 0.35 | **98** | Aosta | 0.38 |
| **99** | Savona | 0.35 | **99** | Brescia | 0.33 |
| **100** | Belluno | 0.35 | **100** | Enna | 0.29 |
| **101** | Teramo | 0.35 | **101** | Lecco | 0.29 |
| **102** | Lecco | 0.28 | **102** | Vibo Valentia | 0.23 |
| **103** | Isernia | 0.25 | **103** | Isernia | 0.19 |
| | **NORTH** | 0.54 (0.15) | | **NORTH** | 0.55 (0.13) |
| | **CENTRE** | 0.51 (0.10) | | **CENTRE** | 0.53 (0.12) |
| | **SOUTH** | 0.60 (0.14) | | **SOUTH** | 0.58 (0.15) |

In 2000, the provinces at the top of the efficiency ranking were alternatively located in Northern and Southern Italy (Treviso, followed by Agrigento and, surprisingly, Napoli and Taranto), while the provinces at the bottom were mainly from Central Italy (Isernia and Teramo for example). After four years the picture has not changed significantly: two provinces from Veneto (Vicenza and Treviso) are at the top of the ranking, although it would seem that the Southern Provinces are performing much better than the Northern and the Central ones. The efficiency score of Southern provinces is of 0.60, that indicates, however, how these provinces are operating with about 40% of relative inefficiency. Provinces with a DEA score of less than 1 could either increase their outputs with the same amount of inputs, or produce the same amount of outputs with fewer inputs, at least compared to the benchmark or technically efficient provinces.

As it has been already stressed when describing statistics about input and output variables, there is not a clear geographical pattern explaining these results: this circumstance demonstrate how it is necessary to take into account other factors that might have an influence on the overall efficiency.

The reasons for such a low efficiency in Central and Northern Province could depend on the composition of population (for example, a higher percentage of elderly people will require a much more articulated network of assistance), on the prevalence of some risk factors in the population or of some diseases, that justify a higher level of expenditure to guarantee an adequate assistance. Not all public health needs may be the same across the various provinces because of population heterogeneity. Therefore, controls for the heterogeneity of the population served by each ASL have to be specified.

In this perspective, also the mobility across Regions and Provinces has to be considered: a high number of patients moving to another province to be treated at a well-renowned structure, for example, might cause congestion and a lower level of technical efficiency. On the other hand, mobility, or attractivity of hospital structures calls for higher efficiency, in order to guarantee an appropriate level of care to a higher number of patients.

**Table 4b.**

**Efficiency scores – 2-outputs model- for Italian provinces (years 2000 and 2004).**

| **2000** | | | **2004** | | |
|---|---|---|---|---|---|
| **Rank** | **Province** | **Efficiency score** | **Rank** | **Province** | **Efficiency score** |
| **1** | Treviso | 0.99 | **1** | Gorizia | 1.00 |
| **2** | Napoli | 0.98 | **2** | Napoli | 1.00 |
| **3** | Agrigento | 0.95 | **3** | Treviso | 0.93 |
| **4** | Sondrio | 0.89 | **4** | Vicenza | 0.92 |
| **5** | Taranto | 0.85 | **5** | Taranto | 0.91 |
| **6** | Milano | 0.84 | **6** | Agrigento | 0.87 |
| **7** | Caserta | 0.83 | **7** | Sondrio | 0.87 |
| **8** | Vicenza | 0.82 | **8** | Milano | 0.87 |
| **9** | Bolzano | 0.79 | **9** | Caserta | 0.87 |
| **10** | Torino | 0.78 | **10** | Bari | 0.80 |
| **94** | Parma | 0.40 | **94** | Crotone | 0.42 |
| **95** | Aosta | 0.40 | **95** | Arezzo | 0.42 |
| **96** | Ancona | 0.40 | **96** | Teramo | 0.42 |
| **97** | Brescia | 0.39 | **97** | Parma | 0.41 |
| **98** | Teramo | 0.38 | **98** | Aosta | 0.41 |
| **99** | Arezzo | 0.38 | **99** | Brescia | 0.41 |
| **100** | Savona | 0.37 | **100** | Belluno | 0.40 |
| **101** | Belluno | 0.36 | **101** | Lecco | 0.39 |
| **102** | Lecco | 0.30 | **102** | Enna | 0.32 |
| **103** | Isernia | 0.27 | **103** | Vibo Valentia | 0.27 |
| | NORTH | 0.54 (0.15) | | NORTH | 0.55 (0.13) |
| | CENTRE | 0.50 (0.10) | | CENTRE | 0.53 (0.12) |
| | SOUTH | 0.60 (0.14) | | SOUTH | 0.58 (0.15) |

The efficiency scores calculated for the 2-outputs model confirm the non systematic pattern of efficiency. Some province that ranked among the top 10 as Treviso (in Northern Italy) or Agrigento (in Southern Italy) confirm their high efficiency score. Other provinces as Gorizia or Pistoia, in Northern and Central Italy, present the highest score, respectively for 2004 and for 2001-2002, although they do not show the same result for the years before (Gorizia) and after their best performance (Pistoia). Average values for geographical areas (North, Centre, South) are similar to those estimated for the 1-output efficiency model.

The first stage of the DEA has helped to determine which provinces are able to provide health services to its population in a relatively efficient way.

The second stage of the DEA, instead, will allow some insights into the external factors shaping the production behavior of provinces.

In the second step of the analysis, the dependent variable is represented by the efficiency scores. Regressors relate to the percentage of population over 65 and over 80 years old; the value added in the sectors of agriculture, industry and tertiary, that is meant as a proxy for the level of income; some geographical dummy variables, assuming value = 1 if the province is in the Northern or Central Italian Regions and = 0 otherwise; a dummy variable related to the population in the province considered, and assuming value = 1 if more than 500,000 inhabitants live within that province; the index of attractivity of hospital structures (ISTAT data), that justify the mobility across Regions and Provinces[32].

First of all a pooled OLS estimation has been run, checking for robustness.

Heteroskedasticity, due to heterogeneity across provinces, however, is not the only problem likely to arise in this context. Like heteroskedasticity, autocorrelation regards the structure of the error term. Autocorrelation is a violation of the assumption that the errors are uncorrelated and independent from each other and it is usually associated with time series data: for example, the efficiency score calculated for time t is the best predictor of the score that will be achieved in time t+1; as a result, scores at time t and t+1 are not anymore independent.

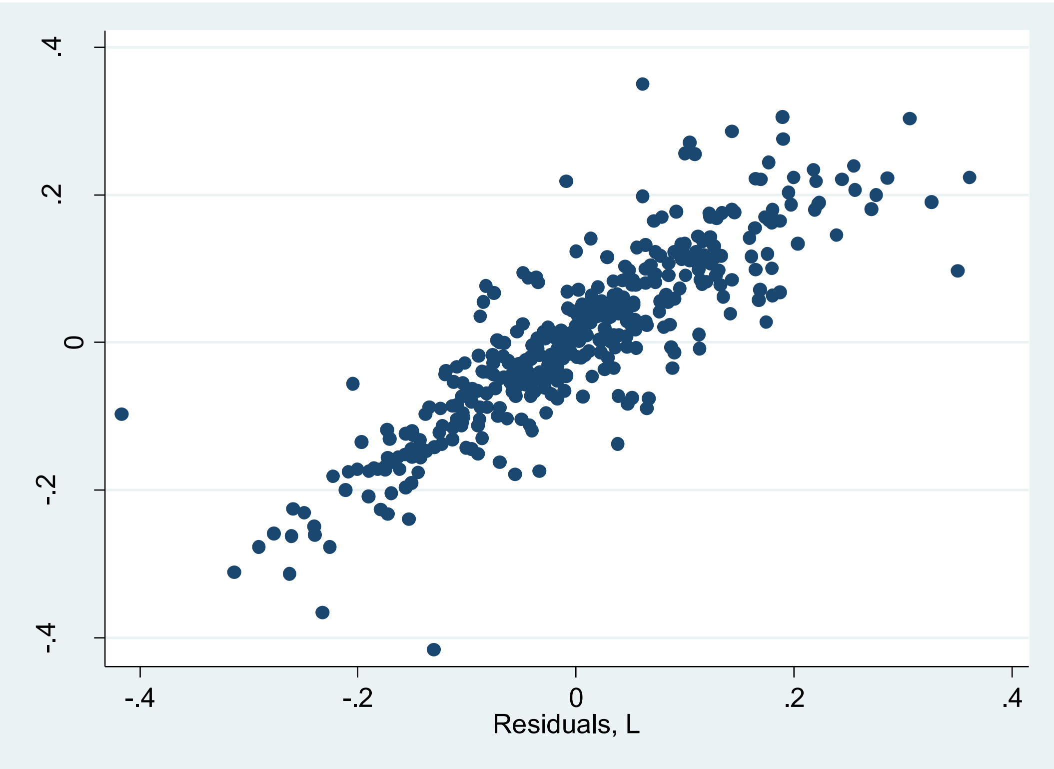
[32] In order to explain patients' mobility, the Tiebout model on decentralization can be recalled. The Tiebout theory argues that decentralization promotes efficiency (Tiebout, 1956). People "shop" for local public goods like public health by "voting with their feet": this Tiebout-type competition forces public decision-makers to operate more efficiently. However, it should not be neglected how centralization could favor coordination and, thereby, enhance the efficiency of public health delivery.

As consequences of autocorrelation, OLS estimators will be still linear and unbiased, but no longer efficient. The estimated variances of OLS estimators will be biased as they tend to underestimate the true variances and standard errors, and thus inflate t values[33].

As an example, autocorrelation of residuals can be noticed by plotting residuals against the lagged residuals. Figure 6 shows residuals obtained after GLS estimation (whose result will be described later).

**Figure 6.**

**Residuals vs. lagged residuals after GLS estimation (presence of autocorrelation).**




In this situation, given the presence of autocorrelation and considering the time interval, that is limited to 5 years, a generalized least-squares (GLS) regression with Prais estimator has been run, within which the errors are assumed to follow a first-order autoregressive process[34].

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[33] When autocorrelation occurs, the usual F and t tests are not reliable anymore. In fact, the formula used to compute error variance ($\sigma^2$) is a biased estimator that underestimates the actual variance in the error, so that the estimated $R^2$ will not be a reliable estimate of the true $R^2$ (Greene, 2007).

[34] Regressing the dependent variable on the regressors in the difference form would imply to lose one observation. Since in this analysis only five years are considered, a generalized difference equation would reduce the time interval. The Prais-Winsten transformation modifies the first observation as follows:

$$Y_1 = \sqrt{1 - \rho^2}\,(Y_1)$$
$$X_1 = \sqrt{1 - \rho^2}\,(X_1)$$

In order to perform this transformation, ρ is estimated simultaneously to the parameters of the model.

Finally, as the regression residuals have a truncated distribution, since the DEA efficiency scores are naturally bounded between 0 and 1, a truncated regression has been estimated as well. As stressed in the previous chapter, this model produces robust regression coefficients and standard errors of the independent variables.

### 3.3. Results and discussion

OLS pooled regression, Prais-Winsten GLS regression and truncated regression model results are reported in Tables 5a and 5b.

Table 5a refers to the regressions carried out by employing DEA efficiency scores with 1 output, while Table 5b reports the results where the dependent variable has been estimated by considering 2 outputs.

**Table 5a.**
**Regression results – Efficiency scores – 1 output DEA.**

| Variables | OLS pooled regression | GLS –Prais Winsten | Truncated regression |
|---|---|---|---|
| % Population 65 + | -0.011** (0.004) | -0.008 (0.006) | -0.012** (0.004) |
| % Population 85 + | -0.049** (0.024) | -0.069*** (0.023) | -0.049** (0.025) |
| Value added agricult. | -0.00002 (0.00002) | -0.0000008 (0.00001) | -0.00002 (0.00002) |
| Value added industry | 0.000006*** (0.000002) | 0.000001 (0.000001) | 0.000006*** (0.000002) |
| Value added tertiary | -0.000001** (0.0000007) | -0.0000006** (0.0000003) | -0.000006** (0.0000008) |
| North | 0.049*** (0.016) | 0.050 (0.033) | 0.049*** (0.016) |
| Centre | 0.051*** (0.017) | 0.046 (0.032) | 0.051*** (0.017) |
| Province 500,000 + | 0.076*** (0.012) | 0.077*** (0.024) | 0.076*** (0.012) |
| Attractiv. of hospitals | 0.002*** (0.0009) | 0.0005 (0.0007) | 0.002*** (0.001) |
| Constant | 0.82*** (0.052) | 0.808*** (0.088) | 0.82*** (0.050) |
| | | | |
| Rho | | 0.885 | |
| DW original statistics | | 0.219 | |
| DW transformed statistics | | 1.977 | |
| R-squared | 0.27 | 0.64 | |
| sigma | | | 0.12 |
| Log likelihood | | | 367.81 |
| Wald □ | | | 191.59*** |
| F - test | 26.92*** | 303.90*** | |
| *** significant at 99%; ** significant at 95%; significant at 90%. Standard errors are in brackets | | | |

Coefficients estimated by applying OLS show all a high level of significance but for the value added in agriculture. The Prais-Winsten transformation and the truncated regression confirm the signs of the estimated coefficients, although in Prais-Winsten regression they are not always significant. The value of the coefficients is similar for the pooled and the truncated regression, differing only for standard errors.

The share of elderly people over the total population (both over 65 and over 85, though more marked effects can be observed for the first group), show an inverse effect on the efficiency score; such negative effect persists whatever the model estimated.

While the value added in productive factors has always a really minimum impact on efficiency, it is significant only for industry and tertiary. In particular, the positive coefficients for industry sector would reveal a higher productivity of it, in spite of the circumstance that the greatest part of population, in Italy, is employed in the tertiary sector, that, in the time interval considered, contributed more to create job opportunities.

The dummy variables for provinces located in Northern and Central Italian Regions have a positive and significant effect on efficiency scores. This circumstance leads to revise the result of the first part of the analysis, based on DEA only and confirms how efficiency scores have to be "corrected" with further specifications of the analysis.

There could be, moreover, an agglomeration effect. The agglomeration economies literature explores the positive link between productivity and city size or density (Baicker and Chandra, 2010): cities, by virtue of their density, may facilitate the generation, transmission, and acquisition of new ideas and technologies[35].

In this context, while ideally, all patients would receive the highest possible quality of care, in spite of the area where they live, in the presence of dissimilar levels of care, determined by a different distribution of hospital structures and other resources, there may be spillover benefits to other provinces that provide higher-quality care: the investment in quality, or the higher specialization in treating some conditions that are more frequent in one area, for example, might drive learning across organisations and improve the quality of care provided.

The "attractivity of hospitals" coefficient has to be interpreted in the light of these considerations. The positive and significant value of it would imply patients' mobility across provinces, to those areas where the structures perceived to guarantee the highest quality are located; on the other hand, there is an opposite effect for patients living in bigger provinces, who may prefer not to leave their province of residence.

In the most populated areas, the number of hospitals is higher: however, a greater neighbourhood density might act as density offsetting goods; it might generate increased negative externalities such as heightened antisocial behaviour, faster spreading of

[35] This is the Marshallian notion of "knowledge spillovers," where one's neighbors influence one's adoption of new technologies so that cities should be more productive places.

communicable diseases, and more public health hazards. Consequently, a greater amount of resources may be needed in more congested areas (Mukherjee, Santerre and Zhang, 2010).

**Table 5b.**

**Regression results – Efficiency scores – 2 outputs DEA.**

| Variables | OLS pooled regression | GLS –Prais Winsten | Truncated regression |
|---|---|---|---|
| % Population 65 + | 0.002 (0.004) | 0.001 (0.004) | 0.002 (0.004) |
| % Population 85 + | -0.0009 (0.024) | -0.00008 (0.025) | -0.0009** (0.026) |
| Value added agricult. | 0.0002*** (0.00003) | 0.0002*** (0.00003) | 0.0002 (0.00002) |
| Value added industry | 0.000007*** (0.000002) | 0.000008*** (0.000002) | 0.000007*** (0.000002) |
| Value added tertiary | -0.0000003** (0.0000008) | -0.0000004 (0.0000008) | -0.0000003*** (0.0000008) |
| North | -0.014 (0.016) | -0.014 (0.017) | -0.014 (0.017) |
| Centre | -0.018 (0.018) | -0.018 (0.019) | -0.018 (0.018) |
| Province 500,000 + | -0.002 (0.013) | -0.002 (0.014) | -0.002 (0.013) |
| Attractiv. of hospitals | -0.002*** (0.001) | -0.002*** (0.001) | 0.002*** (0.001) |
| Constant | 0.456*** (0.052) | 0.457*** (0.052) | 0.456*** (0.052) |
| | | | |
| Rho | | 0.032 | |
| DW original statistics | | 1.567 | |
| DW transformed statistics | | 1.620 | |
| R-squared | 0.20 | 0.20 | |
| sigma | | | 0.12 |
| Log likelihood | | | 348.79 |
| Wald $\chi^2$ | | | 128.47*** |
| F - test | 14.26*** | 1016.69*** | |
| *** significant at 99%; ** significant at 95%; significant at 90%. Standard errors are in brackets | | | |

The greatest part of the comments to the results of the 1 output DEA estimation can be confirmed here. Some findings, however, seem in contrast with previous results. The coefficient estimated for “attractivity of hospitals” is now inversely correlated with the efficiency scores. Some coefficients (as those ones related to age groups and value added in productive sectors) are not significant. In the Prais-Winsten regression, the value of the DW statistics does not lie anymore in the “acceptance region” of the test, but in the so called “indecision area”. Probably the inclusion, among outputs in the efficiency scores, of infant survival modifies the framework of the analysis. Explanatory variables to include in further analyses might regard the share of paediatric population, or the education level, together with the inflows-outflows of patient from one province to the other or, at least, from a Region to the other, in order to better characterize the pattern of mobility.

### 3.4. Conclusions.

In this last part of the analysis, efficiency in health services across Italian provinces has been evaluated by considering one or two outputs (standardized population and infant survival) against inputs of the health system (doctors at hospitals, paediatricians and beds). Following an innovative two-stages procedure, environmental variables, such as proxies for income, composition of population, index of attractivity of hospitals and some geographical dummies, have then been considered.

In methodological terms, a two-stage semi-parametric procedure has been employed in the first step: output efficiency scores were estimated by solving a standard DEA problem with provinces as DMUs. Secondly, these scores were explained in a regression with the "environmental" factors mentioned above as independent variables.

The fact that a province is seen as far away from the efficiency frontier is not necessarily a result of inefficiencies engendered within the health system. There is not a clear geographic distribution of inefficiency across provinces, given that high scores of efficiency are reported both for provinces located in Northern or Southern Regions.

The second stage procedures, carried out by estimating a OLS pooled regression, a truncated model and GLS with Prais-Winsten correction, shows how explanatory variables are highly and significantly correlated with output scores.

Given the significance of variables such as geographical dummies or the index of attractivity for hospital structures, there might be some policy implications to consider, related to patients' mobility and decentralization.

Although decentralization in the provision of healthcare appear as a factor positively correlated with efficiency, the latter is influenced by patients' mobility, that is likely to increase when regional differences are wide. As stressed by Lagravinese, Paradiso and Mastromarco (2011), if a demarcation among socio-economic conditions persists, without improvements in administrative and organisational culture in less developed Regions, decentralization may enhance differences at province and regional level and impact on the level of efficiency and the overall quality of care.

This may require a strong role for central government in controlling and monitoring regional healthcare outcomes and, even before, in the implementation of social policy to equalize the starting conditions between Regions.

# CONCLUSIONS

The present dissertation has examined the crucial aspects that define hospital care in Italy. Indicators for quality proposed by the economic literature have been illustrated, together with the opportunity of considering aspects related to demand, supply and institutional factors, among which there is the modality of reimbursement.

The objectives that has been reached can be summarized as follows.

In the first chapter, an accurate survey of the literature of quality in health care has been carried out. Several classification criteria for the studies reviewed have been followed, by considering the variation of quality across time, the different interpretation of the notion of quality given by patients, providers, third-party payers, and the effects of different reimbursement schemes on the quality of hospital care.

The first and the second chapter outlined the methodology and the variables to consider when carrying out an analysis of quality in a framework characterized by heterogeneity of structures and variety in the reimbursement systems as the Italian NHS.

In the second chapter, a random intercept model has been run, with the objective of sketching out eventual differences in the achievement of positive outcomes at different levels of analysis. The classification has been based on Regions, ASLs and the typology of structures.

The outcomes considered were related to 30 days mortality and readmission rates for specific conditions (acute myocardial infarction, congestive heart failure, stroke, chronic obstructive pulmonary disease). A positive impact on quality of hospital care due to the reimbursement systems was found.

Finally, in the third chapter, an efficiency analysis at the level of provinces has been run. The results of the analysis stressed once again the role of institutional and "environmental" factors in determining an improvement in terms of efficiency and effectiveness across provinces.

The positive contribution given by the present dissertation to the literature related to the quality of hospital care is significant. The issue of quality has been treated in an exhaustive and original way; several empirical approaches have been performed at regional, provincial, ASL, and type of structure level, as to identify any variation in quality due to a different organisational framework. The cross section analysis has been based on random intercept models and truncated regressions.

Data of the National Program for the Evaluation of health outcomes, carried out by the Ministry of Health with AGENAS, have been employed. Data have then been combined with information about hospital structures extracted from the Ministry of Health database. Five different datasets, one for each outcome indicator, have been built.

Conclusions that can be drafted confirm the main results obtained in the literature. Moreover, the application to the Italian context allows to obtain relevant policy implications. There is a positive impact on quality due to the choice of reimbursement system; the greater autonomy accorded to the Region might favour competition within hospital sector.

Although there is still not enough empirical evidence at an international level, in the light of the results obtained in this dissertation it can be concluded how an improvement in quality for hospital care is possible by intervening on institutional variables. The competition model to implement would be based on volume of production, price and, significantly, on quality.

## Bibliography


- Afonso A., Aubyn M.S. (2005) "Non parametric approaches to education and health efficiency in OECD countries", *Journal of Applied Economics*, 2: 227-246.

- Aigner D.J., Chu, S.F. (1968), "On estimating the industry production function", *American Economic Review*, 58 (4): 826 - 839.

- Aigner D.J., Lovell C.A.K., Schmidt P.J. (1977), Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6, 21 - 37.

- Aiura H., Sanjo Y. (2010), "Privatization of local public hospitals: effect on budget, medical service quality, and social welfare", *International Journal of Health Care Financing Economics*, 10: 275–299.

- Anand S., Ammar W., Evans T., Hasegawa T., Kissimova-Skarbek K., Langer A., Lucas A.O., Makubalo L., Marandi A., Meyer G., Podger A., Smith P., Wibulpolprasert S. (2003), "Report on the Scientific Peer Review Group on Health Systems Performance Assessment" in *Health System Performance Assessment. Debates, Methods and Empiricism* by Murray J.L. and Evans D.B. (eds.), World Health Organisation, Geneva.

- Ashton C.M., Del Junco D.J., Souchek J., Wray N.D., Mansyur C.L. (1997), "The association between the quality of inpatient care and early readmission: a meta-analysis of the evidence", *Medical Care*, 35(10): 1044-1059.

- Baicker K., Chandra A. (2010), *Understanding Agglomerations in Health Care*, in Glaeser E.L. (ed.), *Agglomeration Economics*, The University of Chicago Press, 2010, pp. 211 – 236.

- Banker R.D., Conrad R.F., Strauss R.P. (1986), "A Comparative Application of Data Envelopment Analysis and Translog Method: An Illustrative Study of Hospital Production", *Management Science*, 32 (1): 30-44.

- Banker R.D., Morey R.C. (1986), "Efficiency analysis for exogenously fixed inputs and outputs", *Operational Research*, 34(4): 513–521.

- Banker, R.D., Natarajan, R., (2008), "Evaluating contextual variables affecting productivity using data envelopment analysis", *Operational Research*, 56(1): 48-58.

- Bazzoli G.J., Chen H., Zhao M., Lindrooth R.C. (2008), "Hospital financial condition and the quality of patient care", *Health Economics*, 17: 977-995.

- Beitia A. (2003), "Hospital quality choice and market structure in a regulated duopoly", *Journal of Health Economics*, 22: 1011-1036.

- Bentler P. M. (1980), "Multivariate Analysis with Latent Variables: Causal Modelling", *Annual Review of Psychology*, *31* (1): 419–456.

- Berchialla P., Foltran F., Di Lenarda A., Barbati G., Franchin L., Salvatore L., Gregori D. (2010) "Hospitalization rate as a proxy for the quality of life evaluation: the case of dilated cardiomiopathy", *Journal of Preventive Medicine and Hygiene*, 51 (4): 152-156.

- Berta P., Callea G., Martini G., Vittadini G. (2010), “Hospitals responses to a policy limiting upcoding: Evidence from Italy”, www.coripe.unito.it/files

- Billett J., Majeed A., Gatoulis M., Cowie M. (2008), “Trends in hospital admissions, in-hospital case fatality and population mortality from congenital heart disease in England 1994 to 2004”, *Heart*, 94 (3): 342-348.

- Bjertnaes O.A., Sjetne I.S., Iversen H.H. (2012), “Overall patient satisfaction with hospitals: effects of patient-reported experiences and fulfilment of expectations”, *BMJ Quality and Safety*, 21(1): 39-46.

- Blundell R., Bond S., (1998), “Initial conditions and moment restrictions in dynamic panel data models”, *Journal of Econometrics*, 87 (1), 115–143.

- Bowlin W.F., Charnes A., Cooper W.W., Sherman H.D. (1985), “Data Envelopment Analysis and Regression Approaches to Efficiency Evaluation and Estimation”, *Annals of Operations Research*, 2: 113-118.

- Boyle A., Fuld J., Ahmend V., Bennett T., Robinson S. (2011), “Does integrated emergency care reduce mortality and non-elective admissions? A retrospective analysis”, *Emergency Medicine Journal*, 29(3):208-212

- Brekke K.R., Siciliani L., Straume O.R. (2008), “Competition and waiting times in hospital markets”, *Journal of Public Economics*, 92: 1607—1628.

- Brekke K.R., Siciliani L., Straume O.R. (2011), “Quality competition with profit constraints”, *NIPE Working Paper*, 05/2011.

- Breyer F. (1987), “The specification of a hospital cost function”, *Journal of Health Economics*, 6, 147-157.

- Brook R., McGlynn E., Cleary P. (1996), “Measuring quality of care”, *The New England Journal of Medicine*, 335(13): 966–970.

- Bryk A.S., Raudenbush S.W. (1992), *Hierarchical linear models, applications and data analysis methods*. Sage, CA.

- Busse, R., Geissler, A., Quentin, W., Wiley, M. (2011), “Diagnosis-Related Groups in Europe: Moving towards transparency, efficiency and quality in hospitals”, *European Observatory on Health System and Policies Series*, Open University Press.

- Byrne M.A., Pietz K., Woodard L., Petersen L.A. (2007), “Health care funding levels and patient outcomes: a national study”, *Health Economics*, 16: 385-393.

- Cantù E., Carbone C., Anessi-Pessina E. (2011), "Do Italian Regions effectively use DRG funding to steer provider behaviour?" in Ongaro E., Massey A., Holzer M., Wayenberg E. (eds.), *Policy, performance and management in governance and intergovernmental relations: Transatlantic perspectives*, Edward Elgar, Chelthenam, UK.

- Cantù E., Carbone C. (2007), *I sistemi di finanziamento: strumenti per governare i comportamenti degli erogatori di prestazioni sanitarie*?, in *L’aziendalizzazione della Sanità in Italia*, Rapporto Oasi 2007, EGEA, Milano.

- Carbone C., Jommi C., Salvatore D., (2004) *I sistemi regionali di finanziamento corrente delle aziende sanitarie: un'analisi di quattro casi*, paper presented at the annual conference of the Italian Association of Health Economics, "I livelli di governo della sanità: finanziamento, assetti istituzionali e management", Milano 4-5 November 2004.

- Carlisle R.T. (2007), "Internet report cards on quality: what exists and the evidence on impact", *The West Virginia Medical Journal*, 103(4):17-21.

- Cavalieri M., Gitto L., Guccio C. (2012), *Reimbursement systems and quality of hospital care: an empirical analysis for Italy*, paper presented at the annual conference of the Italian Society of Public Economics, Pavia 24-25 September 2012.

- Chang C.F., Troyer J.L. (2011), "Trends in potentially avoidable hospitalizations among adults in Tennessee, 1998-2006", *Tennessee Medicine*, 104(10): 35-38,

- Charnes A., Cooper W.W., Rhodes E. (1978), "Measuring the efficiency of decision making units", *European Journal of Operational Research* 3 (4): 392-444.

- Chillingerian J.A. Sherman H.D. (1997), "DEA and Primary Care Physician Report Cards: Deriving Preferred Practice Cones from Managed Care Service Concepts and Operating Strategies", *Annals of Operational Research*, 73 (1): 35-66.

- Coelli T., Rao P., Battese G. (1998), *An introduction to efficiency and productivity analysis,* Boston: Kluwer Academic Publishers.

- Christiansen C. L., Morris C.N. (1997), "Improving the Statistical Approach to Health Care Provider Profiling", *Annals of Internal Medicine*, 127 (2): 764 –768.

- Chua C.L., Palangkaraya A., Yong J. (2010), "A two-stage estimation of hospital quality using mortality outcome measures: an application using hospital administrative data", *Health Economics*, 19 (12):1404-1424.

- Coffey R.M., Andrews R.M., Moy E. (2005), "Racial, ethnic, and socioeconomic disparities in estimates of AHRQ patient safety indicators", *Medical Care*, 43: I48–57.

- Cooper Z., Gibbons S., Jones S., McGuire A. (2011), "Does hospital competition save lives? Evidence from the English NHS choice reforms", *The Economic Journal*, 121, F228-F260.

- Copnell B., Hagger V., Wilson S.G., Evans M., Sprivulis P.C., Cameron P.A. (2009), "Measuring the quality of hospital care: an inventory of indicators", *Internal Medicine Journal*, 39: 352-360.

- Cremonesi P., Di Bella E., Montefiori M. (2010), "Cost analysis of emergency department", *Journal of Preventive Medicine and Hygiene*, 51(4):157-163.

- Custers T., Hurley J., Klazinga N., Brown A. (2008), "Selecting effective incentive structures in health care: a decision framework to support health care purchasers in finding the right incentives to drive performance", *BMC Health Services Research*, vol. 8.

- Daidone S., D'Amico F., "Technical Efficiency, Specialization and Ownership Form: Evidences from a Pooling of Italian Hospitals", CEIS Tor Vergata, Research Paper Series, No. 143..

- Dawson D., Goddard M., Street A. (2001), "Improving performance in public hospitals: a role for comparative costs?", *Health Policy*, 57: 235-248.

- Debreu G. (1951), "The coefficient of resource utilization", *Econometrica*, 19: 273 -292.

- Donabedian A. (1966), "Evaluating the Quality of Medical Care", *The Milbank Memorial Fund Quarterly*, 44 (3): 166-203.

- Donabedian A. (1988), "The quality of care. How can it be assessed?" *Journal of American Medical Association* 260: 1743–1748.

- Donabedian A. (2005), "Evaluating the Quality of Medical Care", *The Milbank Quarterly*, 83: 691–729

- Downey L.V., Zun L.S. (2010), "The correlation between patient comprehension of their reason for hospital admission and overall patient satisfaction in the emergency department", *Journal of the National Medical Association*, 102(7): 637-643.

- Eapen Z.J., Fonarow G.C., Dai D., O'Brien S.M., Schwamm L.H., Cannon C.P., Heidenreich P.A., Bhatt D.L., Peterson E.D., Hernandez A.F. (2011), "Comparison of composite measure methodologies for rewarding quality of care: an analysis from the American Heart Association's Get With The Guidelines program", *Circulation: Cardiovascolar Quality and Outcomes*, 4(6): 610-618.

- Ehreth J. (1994), "The Development and Evaluation of Hospital Performance Measures for Policy Analysis", *Medical Care*, 2(6): 568-587.

- Eisenhart C. (1947), "The assumptions underlying the analysis of variance", *Biometrics* 3: 1–21.

- Elferink M.A., Wouters M.W., Krijnen P., Lemmens V.E., Jansen-Landheer M.L., van de Velde C.J., Siesling S., Tollenaar R.A. (2010), "Disparities in quality of care for colon cancer between hospitals in the Netherlands", European Journal of Surgical Oncology, 36, Suppl 1:S64-73.

- Elwyn G., Buetow S., Hibbard J., Wensing M. (2007), "Measuring quality through performance. Respecting the subjective: quality measurement from the patient's perspective", *British Medical Journal*, 335: 1021–1022.

- Evans D.B., Lauer J.A., Tandon A., Murray C.J.L. (2003), "Determinants of Health System Performance: Second Stage Efficiency Analysis", in *Health System Performance Assessment. Debates, Methods and Empiricism* by Murray J.L. and Evans D.B. (eds.), World Health Organisation, Geneva.

- Eye A.V., Clogg C.C. (eds.) (1994), *Latent Variable Modelling: Applications for Developmental Research*, Thousand Oaks, Sage: Thousand Oaks, California, 1994. [Cited by Landrum *et al.*, 2000].

- Farrar S., Yi D., Sutton M., Chalkley M., Sussex J., Scott A. (2009), "Has payment by results affected the way that english hospitals provide care? difference-in-differences analysis.

- Farrell M.J. (1957) "The measurement of productive performance", *Journal of the Royal Statistical Society* 120(3): 253-282.

- Felder S., Tauchmann H. (2010), "Federal state differentials in the efficiency of health production in Germany: an artifact of spatial dependence?", *European Journal of Health Economics*, DOI 10.1007/s10198-011-0345-8.

- Farsi M., Filippini M. (2006) "An analysis of efficiency and productivity in Swiss hospitals", *Swiss Journal of Economics and Statistics*, 142(1): 1-37.

- Filippini M., Farsi M. (2008), *Cost efficiency and scope economies in multioutput utilities in Switzerland*, Strukturberichterstattung 39, Berne: Study on behalf of the State Secretariat for Economic Affairs, SECO.

- Finocchiaro Castro M., Guccio C., Pignataro G., Rizzo I. (2011), *Hospital care reimbursement mechanisms and the adoption of medical technology in the Italian NHS*, paper presented at the annual meeting of the Italian Society of Public Economics, Pavia, 2011.

- Fischer C., Anema H.A., Klazinga N.S. (2011), "The validity of indicators for assessing quality of care: a review of the European literature on hospital readmission rate", *European Journal of Public Health*, published online December 2nd, 2011, doi: 10.1093/eurpub/ckr165.

- Fong J., Marsh G.M., Stokan L.A., Weilian Sang, Vinson C., Ruhl L. (2008), "Hospital quality performance report: an application of composite scoring", *American Journal of Medical Quality*, 23(4): 287-95.

- France G., Taroni F., Donatini D. (2005), "The Italian health care system", *Health Economics*, 14: 187-202.

- Francese M., Piacenza M., Romanelli M., Turati G. (2011), *Understanding Inappropriateness in Health Care: The Role of Supply Structure, Pricing Policies and Political Institutions in Caesarean Deliveries*, ERSA conference papers no.11/1439.

- Freund D.A., Lichtenberg F.R. (2000), *The impact of hospital quality related practice on health outcomes*, Working Paper n. 18, Center for Policy Research, Maxwell School of Citizenship and Public Affairs, Syracuse University.

- Fried H., Lovell K.C.A., Schmidt S. (2008), "Efficiency and productivity", in Fried H., Lovell K.C.A., Schmidt S. (eds.), *The measurement of productive efficiency and productivity growth*, New York: Oxford University Press.

- Friese C.R., Aiken L.H. (2008), "Failure to rescue in the surgical oncology population: implications for nursing and quality improvement", *Oncology Nursing Forum*, (5):779-785.

- Gasper W.J., Glidden D.V., Jin C., Way L.W., Patti M.G. (2009), " Has recognition of the relationship between mortality rates and hospital volume for major cancer surgery in California made a difference? A follow-up analysis of another decade", *Annals of Surgery*, 250(3): 472-483.

- Gaynor M., Seider H., Vogt W.B. (2005) "The volume-outcome effect, scale economies, and learning-by-doing", *American Economic Review*, 95(2): 243-247.

- Gifford J.M., Husain N., Dinglas V.D., Colantuoni E., Needham D.M. (2010), "Baseline quality of life before intensive care: a comparison of patient versus proxy responses", *Critical Care Medicine*, 38(3): 855-860.

- Girotra S., Lu X., Popescu I., Vaughan-Sarrazin M., Horwitz P.A., Cram P. (2010), "The impact of hospital cardiac specialization on outcomes after coronary artery bypass graft surgery: analysis of medicare claims data", *Circulation: Cardiovascolar Quality and Outcomes*, 3(6): 607-614.

- Gitto L. (2010), *Multiple sclerosis patients' preferences: a preliminary study on disease awareness and perception*, DEMQ Working Papers, n.3 /2010.

- Glickman S.W., Ou F., DeLong E.R., Roe M.T., Lytle B.L., (2007), "Pay for Performance, Quality of Care, and Outcomes in Acute Myocardial Infarction", *Journal of the American Medical Association*, 297(21): 2373-2380.

- Goddard M., Smith P. (2001), "*Equity of access to health care services: theory and evidence from the UK", Social Science and Medicine*, 53 (9): 1149-1162.

- Goldstein H. (1987), "Multilevel covariance component models", *Biometrika*, 74: 430–431.

- Goossens-Laan C.A., Visser O., Hulshof M.C., Wouters M.W., Bosch J.L., Coebergh J.W., Kil P.J. (2011), "Survival after treatment for carcinoma invading bladder muscle: a Dutch population-based study on the impact of hospital volume", *British Journal of Urology International*, 110(2): 226-232.

- Greene W.H (1980), "Maximum likelihood estimation of econometric frontier functions", *Journal of Econometrics*, 13 (1): 27-56.

- Greene W.H. (2007), *Econometric analysis*, Prentice Hall.

- Greenfield D., Pawsey M., Braithwaite J. (2011), "What motivates professionals to engage in the accreditation of healthcare organisations?", International Journal of Quality in Health Care, 23(1): 8-14.

- Groene O., Klazinga N., Wagner C., Arah O.A., Thompson A., Bruneau C., Suñol R. (2010) "Investigating organisational quality improvement systems, patient empowerment, organisational culture, professional involvement and the quality of care in European hospitals: the 'Deepening our Understanding of Quality Improvement in Europe (DUQuE)' project", *BMC Health Service Research*, 10: 281.

- Grossbart S.R. (2006), "What's the Return? Assessing the Effect of ''Pay-for-Performance' Initiatives on the Quality of Care", *Medical Care Research Review*, 63: 29S-48S

- Grosskopf S., Valdmanis V. (1987), "Measuring hospital performance: a non parametric approach", *Journal of Health Economics*, (6): 89-107.

- Hadad S., Hadad Y., Simon-Tuval T. (2011), "Determinants of healthcare system's efficiency in OECD countries", *European Journal of Health Economics*, 7 December 2011 [Epub ahead of print]

- Hadley J., Zuckerman S. (1994), "The role of efficiency measurement in hospital rate setting", *Journal of Health Economics*, 13: 335-340.

- Hagen T.P., Veenstrab M., Stavemc K. (2006), *Efficiency and patient satisfaction in Norwegian hospitals*, Health Economics Research Programme at the University of Oslo HERO 2006.

- Häkkinen U., Joumard I. (2007), "Cross-Country Analysis of Efficiency in OECD Health Care Sectors: Options for Research", *OECD Economics Department Working Papers*, No. 554, OECD Publishing.

- Herrera-Kiengelher L., Villamil-Alvarez M., Pelcastre-Villafuerte B., Cano-Valle F., López-Cervantes M. (2009), "Relationship between health providers and patients in Mexico City", *Revista de Saude Publica*, 43(4): 589-594.

- Howard D.H. (2006), "Quality and consumer choice in healthcare: evidence from kidney transplant", *Topics in Economic Analysis & Policy*, 5(1): 1–20.

- Jackson B.E., Suzuki S., Coultas D., Su F., Lingineni R., Singh K.P., Bartolucci A., Bae S. (2011), "Safety-net facilities and hospitalization rates of chronic obstructive pulmonary disease: a cross-sectional analysis of the 2007 Texas Health Care Information Council inpatient data", *International Journal of Chronic Obstructive Pulmonary Disease*, 6: 563-571.

- Jacobs R. (2000), *Alternative Methods to Examine Hospital Efficiency: Data Envelopment Analysis and Stochastic Frontier Analysis*, Discussion Paper 177, The University of York, Centre for Health Economics.

- Jacobs R., Smith P.C., Street A. (2006), *Measuring efficiency in health care: analytical techniques and health policy*, Cambridge: Cambridge University Press.

- Jarlier A., Charvet-Protat S. (2000), "Can improving quality decrease hospital costs?", *International Journal for Quality in Health Care"*, 12, 2, 125-131.

- Jha A.K., Orav E.J., Epstein A.M. (2010), "The effect of financial incentives on hospitals that serve poor patients", *Annals of Internal Medicine*, 153: 299-306.

- Jommi C., Cantù E., Anessi-Pessina E., (2001), "New funding arrangements in the Italian National Health Service", *International Journal of Health Planning and Management*, 16 (4): 347-368.

- Joynt K.E., Harris Y., Orav E.J., Jha A.K. (2011), "Quality of care and patient outcomes in critical access rural hospitals", *Journal of American Medical Association*, 306(1): 45-52.

- Kazandjian V.A., Wicker K., Ogunbo S., Silverman N. (2005) "Understanding safer practices in health care: a prologue for the role of indicators", *Journal of Evaluation in Clinical Practice*, 11: 161–170.

- Klazinga, N. (2011), *Health Service Outcomes,* in *Health system performance comparison: an agenda for policy, information and research*, European Observatory on Health Systems and Policies.

- Koopmans T.C. (1951), "An analysis of production as an efficient combination of activities", in Koopmans T.C. (ed.), *Activity Analysis of Production and Allocation*, Monograph No. 13, New York: Wiley.

- Kumbhakar S.C., Park B.U., Simar L., Tsionas E.G. (2007), "Nonparametric stochastic frontiers: A local maximum likelihood approach", *Journal of Econometrics*, 137: 1-27.

- Kunkel S., Rosenqvist U., Westerling R. (2007), "The structure of quality systems is important to the process and outcome, an empirical study of 386 hospital departments in Sweden", *BMC Health Service Research*, 7:104.

- Kuosmanen T. (2006), *Stochastic Nonparametric Envelopment of Data: Combining Virtues of SFA and DEA in a Unified Framework*. Discussion Paper, MTT Agrifood Research Finland.

- Kuosmanen T., Johnson A. (2010), "Data Envelopment Analysis as nonparametric Least Squares Regression", *Operations Research*, 58: 149 - 160.

- Landrum M.B., Bronskill S.E., Normand S.T. (2000), "Analytic Methods for Constructing Cross-Sectional Profiles of Health Care Providers", *Health Services and Outcomes Research Methodology*, 1 (1): 23–47.

- Langenbrunner, J.C., Cashin, C., O'Dougherty, S. (2009), 'Designing and Implementing Health Care Provider Payment Systems: How-to Manuals', *World Bank*, Washington.

- Lau H., Litman K.C. (2011), "Saving lives by studying deaths: using standardized mortality reviews to improve inpatient safety", *Joint Commission Journal on Quality and Patient Safety*, 37(9): 400-408.

- Leach L.S., Myrtle R.C., Weaver F.A., Dasu S. (2009), "Assessing the performance of surgical teams" *Health Care Management Review*, 34(1): 29-41.

- Lilford R., Mohammed M.A., Spiegelhalter D., Thomson R. (2004), "Use and misuse of process and outcome data in managing performance of acute medical care: avoiding institutional stigma", *Lancet*, 363: 1147–1154.

- Lin V., Gruszin S., Ellickson C., Glover J., Silburn K., Wilson G. *et al.*(2007), "Comparative evaluation of indicators for gender equity and health", *International Journal of Public Health*, 52: S19–26.

- Linna M. (1998), "Measuring hospital cost efficiency with panel data models", *Health Economics*, 7: 415-427.

- Liotta G., Mancinelli S., Scarcella P., Emberti Gialloreti L. (2011), "Determinants of acute hospital care use by elderly patients in Italy from 1996 to 2006", *Archives of Gerontology and Geriatrics*, 54(3): 364-369.

- Ljunggren B., Sjoden P.O. (2001), "Patient reported quality of care before vs. after the implementation of a diagnosis related groups (DRG) classification and payment system in one Swedish county", *Scandinavian Journal of Caring Sciences*, 15 (4): 283-294.

- Ljunggren B., Sjoden P.O. (2003), "Patient-reported quality of life before, compared with after a DRG intervention", *International Journal for Quality in Health Care*, 15: 433-440.

- Louis D.Z., Yuen E.J., Braga M., Cicchetti A., Rabinowitz C., Laine C., Gonnella J.S. (1999), "Impact of a DRG-based hospital financing system on quality and outcomes of care in Italy", *Health Services Research*, 34: 405-415.

- Lucas R., Farley H., Twanmoh J., Urumov A., Evans B., Olsen N. (2009), "Measuring the opportunity loss of time spent boarding admitted patients in the emergency department: a multihospital analysis", *Journal of Healthcare Management*, 54(2):117-124; discussion 124-125.

- Magee H.F. (2003), "The Hospital Data Project Comparing hospital activity within Europe", *European Journal of Public Health*, 13 (3).

- Mainz J. (2003), "Defining and classifying clinical indicators for quality improvement", *International Journal of Quality in Health Care*, 15: 523-530.

- Mangano A. (2011), *Hospital care funding in Italy*, *Background paper for the InterQuality project – WP4*, provisional version 28th November 2011.

- Mapelli V. (2000), *Tre riforme sanitarie e ventuno modelli regionali*, in L. Bernardi (eds.), *La finanza pubblica italiana, Rapporto 2000*, Il Mulino.

- Marshall M., Shekelle P., Leatherman S., Brook R.H. (2000), "The Public Release of Performance Data. What Do We Expect to Gain? A Review of the Evidence", *Journal of the American Medical Association*, 283(14):1866-1874

- Mayer-Oakes S.A., Oye R.K., Leake B., Brook R.H. (1988), "The early effect of Medicare's prospective payment system on the use of medical intensive care services in three community hospitals", *Journal of the American Medical Association*, 260: 3146-3149.

- McClellan M., Staiger D. (1999), *The Quality of Health Care Providers*, National Bureau of Economic Research Working Paper Series No. 7327.

- McClellan M., Staiger D. (2000), *Comparing the Quality of Health Care Providers*, NBER Chapters in *Frontiers in Health Policy Research*, 3: 113-136, National Bureau of Economic Research, Inc.

- Mohammed M.A., Deeks J.J., Girling A., Rudge G., Carmalt M., Stevens A.J., Lilford R.J., (2009) "Evidence of methodological bias in hospital standardised mortality ratios: retrospective database study of English hospitals". *BMJ: British Medical Journal*, 338. PMID: 19297447 PMCID: 2659855.

- Morandi I., Pieroni E., Giuliani F., Cislaghi C. (2008), *Criticità delle tariffe nel SSN,* paper presented at the annual meeting of the Italian Association of Health Economics, Matera, 2008.

- Morandi I. (2009), *Le tariffe ospedaliere in Italia: nazionali e regionali*, paper presented at the AIES-AGENAS meeting "Le tariffe in sanità: strumento di finanziamento, regolazione e valutazione", Rome, 2009.

- Morandi I., Arcangeli L. (2009), "Le tariffe nazionali e regionali", *Monitor,* 5 (Suppl. 1): 60-73.

- Morandi I. (2010), *I sistemi tariffari regionali vigenti nell'anno 2009*, Rapporto AGENAS sui ricoveri ospedalieri, 2010.

- McCue M.J., Thompson J.M. (2006), "Early effects of the prospective payment system on inpatient rehabilitation hospital performance", *Archives of Physical Medicine and Rehabilitation*, 87:198-202.

- Milcent C. (2005), "Hospital ownership, reimbursement systems and mortality rates", *Health Economics*, 14: 1151-1168.

- Monterosso L., Kristjanson L.J., Aoun S., Phillips M.B. (2007), "Supportive and palliative care needs of families of children with life-threatening illnesses in Western Australia: evidence to guide the development of a palliative care service", *Palliative Medicine*, 21(8):689-696.

- Moreno Serra R., Wagstaff A. (2010), "System-wide impacts of hospital payment reforms: evidence from Central and Eastern Europe and Central Asia", *Journal of Health Economics*, 29: 585-602.

- Morikawa M. (2010), *Hospital Productivity: An analysis at medical-area level*, Research Institute of Economy, Trade and Industry (RIETI), Discussion Paper no. 10041.

- Mukherjee K., Santerre R.E., Zhang N.J. (2010), "Explaining the efficiency of local health departments in the U.S.: an exploratory analysis", *Health Care Management Science*, 13: 378–387.

- Murillo-Zamorano L. (2004), "Economic efficiency and frontier techniques", *Journal of Economic Surveys*, 18: 33 -77.

- Murray J.L., Evans D.B. (2003), *Health System Performance Assessment. Debates, Methods and Empiricism*, World Health Organisation, Geneva.

- Mutter R., Valdmanis V., Rosko M. (2010), "High versus lower quality hospitals: a comparison of environmental characteristics and technical efficiency"*, Health Services and Outcomes Research Methodology*, 10: 134-153

- Nakano A., Mainz J., Lomborg K. (2008), "Patient perception and assessment of admission to acute cardiac care unit", *European Journal of Cardiovascolar Nursing,* 7(1): 10-15.

- Nyhan R.C., Cruise P.L. (2000), "Comparative performance assessment in managed care: Data envelopment analysis for health care managers", *Health Care Quarterly*, 8: 18-27.

- Normand S.L., Glickman M.E., Gatsonis C.A. (1997), "Statistical methods for profiling providers of medical care: issues and applications", *Journal of the American Statistical Association*, 92: 803-814.

- Osler M., Iversen L.H., Borglykke A., Mårtensson S., Daugbjerg S., Harling H., Jørgensen T., Frederiksen B. (2011), "Hospital variation in 30-day mortality after colorectal cancer surgery in Denmark: the contribution of hospital volume and patient characteristics", *Annals of Surgery*, 253(4): 733-738.

- Palangkaraya A., Yong J. (2012), "Effects of competition on hospital quality: an examination using hospital administrative data", *European Journal of Health Economics*, published online 7 March 2012, DOI 10.1007/s10198-012-0386-7

- Palmer S., Torgerson D.J. (1999), "Economic notes: definitions of efficiency", *British Medical Journal*, 318(7191):1136.

- Papanicolas I., McGuire A. (2011a), "Using a latent variable approach to measure the quality of English NHS hospitals", LSE Health, Working paper n. 21.

- Papanicolas I., McGuire A. (2011b), "Using a Vector Autoregression Framework to measure the quality of English NHS hospitals", LSE Health, Working paper n. 22.

- Peabody J., Shimkhada R., Quimbo S., Florentino J., Bacate M., McCulloch C.E., Solon O. (2011), “Financial incentives and measurement improved physicians' quality of care in the Philippines”, *Health Affairs*, 30: 773-781.

- Pham J.C., Kirsch T.D., Hill P.M., DeRuggerio K., Hoffmann B. (2011), “Seventy-two-hour returns may not be a good indicator of safety in the emergency department: a national study”, *Academic Emergency Medicine*, 18(4): 390-397.

- Pitrou I., Lecourt A.C., Bailly L., Brousse B., Dauchet L., Ladner J. (2009), “Waiting time and assessment of patient satisfaction in a large reference emergency department: a prospective cohort study, France”, *European Journal of Emergency Medicine*, 16(4):177-182.

- Propper C., Burgess S., Gossage D. (2008), “Competition and quality: evidence from the NHS internal market 1991-9”, *The Economic Journal*, 118: 138-170.

- Propper C. (2012), “Competition, incentives and the English NHS”, *Health Economics*, 21: 33-40.

- Purdy S., Griffin T., Salisbury C., Sharp D. (2011), “Emergency respiratory admissions: influence of practice, population and hospital factors”, *Journal of Health Services Research Policy*, 16(3): 133-140.

- Rangachari P. (2008), “Knowledge sharing networks related to hospital quality measurement and reporting”, *Health Care Management Review*, 33(3): 253-263.

- Rabe-Hesketh S., Skrondal A., Pickles A. (2002), “Reliable estimation of generalized linear mixed models using adaptive quadrature”, *The Stata Journal*, 2: 1-21.

- Robinson J.C., Shortell S.M., Li R., Casalino L.P., Rundall T. (2004), “The Alignment and Blending of Payment Incentives within Physician Organisations”, *Health Services Research*, 39(5): 1589-1606.

- Romano P.S., Rainwater J.A., Antonius D. (1999), “Grading the Graders: How Hospitals in California and New York Perceive and Interpret Their Report Cards”, *Medical Care*, 37, 3, pp. 295-305

- Rosko M.D., Mutter R.L. (2010), “Inefficiency differences between critical access hospitals and prospectively paid rural hospitals”, *Journal of Health Politics, Policy and Law*, 35: 95-126.

- Sari N. (2002), “Do competition and managed care improve quality?”, *Health Economics*, 11: 571-584.

- Sartini M, Cremonesi P, Tamagno R, Cristina M.L., Orlando P. and the SIMEU Group (2007), “Quality in emergency departments: a study on 3,285,440 admissions”, *Journal of Preventive Medicine and Hygiene*, 48(1): 17-23.

- Schoenfelder T., Klewer J., Kugler J. (2011), “Determinants of patient satisfaction: a study among 39 hospitals in an in-patient setting in Germany”, *International Journal of Quality in Health Care*, 23(5): 503-509.

- Scott C., Gerardi D. (2011), “A strategic approach for managing conflict in hospitals: responding to the Joint Commission leadership standard, Part 2”, *Joint Commission Journal on Quality and Patient Safety*, 37(2):70-80.

- Seccareccia F., D’Errigo P., Maraschini A., Casali G., Rosato S., Badoni G. (Research group for the Mattone Study, Outcome-BYPASS (2011), “The Mattone Outcome-BYPASS study: short-term outcome in patients undergoing coronary artery bypass graft surgery in Italian hospitals. Final results”, *Giornale Italiano di Cardiologia*, 12(6): 439-449.

- Shaw C., Groene O., Mora N., Sunol R. (2010), “Accreditation and ISO certification: do they explain differences in quality management in European hospitals?”, *International Journal of Quality in Health Care*, 22(6): 445-451.

- Shen H.C., Chiu H.T., Lee P.H., Hu Y.C., Chang W.Y. (2011), “Hospital environment, nurse-physician relationships and quality of care: questionnaire survey”, *Journal of Advanced Nursing*, 67(2): 349-358.

- Silber J.H., Rosenbaum P.R., Ross R.N. (1995), “Comparing the Contributions of Groups of Predictors: Which Outcomes Vary With Hospital Rather Than Patient Characteristics”, *Journal of the American Statistical Association*, 90 (429): 7–18.

- Simar L., Wilson P. (2007), “Estimation and inference in two-stage, semi-parametric models of production processes”, *Journal of Econometrics*, 136(1): 31-64.

- Skrondal A., Rabe-Hesketh S. (2007), “Latent Variable Modelling: A Survey”, *Scandinavian Journal of Statistics*, 34: 712-745.

- Soberman Ginsburg L. (2003), *Factors That Influence Line Managers’ Perceptions of Hospital Performance Data*, Department of Health Policy, Management & Evaluation at the University of Toronto.

- Spandonaro F., d’Angela D. (2012), *Indicatori di performance: un indice unico di performance dei SSR*, in *VIII Rapporto CEIS Sanità*, Health Communication s.r.l., Roma, 2012.

- Street A., Hakkinen U. (2009), *Health system productivity and efficiency*, in Smith P.C., Mossialos E., Papanicolas I., Leatherman S. (eds.), *Performance measurement for health system improvement: experiences, challenges and prospects*, Cambridge: Cambridge University Press.

- Studnicki J., Platonova E.A., Fisher J.W. (2011), “Hospital-level variation in the percentage of admissions originating in the emergency department”, *American Journal of Emergency Medicine*, 26 December 2011 [Epub ahead of print]

- Swamy P.A.V.B. (1971), *Statistical inference in random coefficient regression models*, Springer, New York.

- Tay A. (2003), “Assessing competition in hospital care markets: the importance of accounting for quality differentiation”, *RAND Journal of Economics*, 34(4): 786-814.

- Teng C.I., Dai Y.T., Shyu Y.I., Wong M.K., Chu T.L., Tsai Y.H. (2009), "Professional commitment, patient safety, and patient-perceived care quality", *Journal of Nursing Scholarship*, 41(3): 301-309.

- Theunissen N.C.M., Vogels T.G.C., Koopman H.M., Verrips G.H.W., Zwinderman K.A.H., Verloove-Vanhorick S.P., Wit J.M. (1998), "The proxy problem: child report versus parent report in health-related quality of life research", *Quality of Life Research*, 7: 387-397.

- Tiebout C. (1956) "A pure theory of local public expenditures", *Journal of Political Economy*, 64(5): 416–424.

- Tokur S., Lederle K., Terris D.D., Jarczok M.N, Bender S., Schoenberg S.O., Weisser G. (2011), "Process analysis to reduce MRI access time at a German University Hospital", *International Journal for Quality in Health Care*, 24(1):95-99.

- Tsai C.L., Sullivan A.F., Ginde A.A., Camargo C.A. Jr. (2010), "Quality of emergency care provided by physician assistants and nurse practitioners in acute asthma", *American Journal of Emergency Medicine*", 28 (4): 485-491.

- van der Linden W.J., Hambleton R.K. (eds.) (1997), *Handbook of Modern Item Response Theory*, Springer: New York, 1997. [Cited by Landrum, Bronskill and Normand, 2000].

- van Westreenen H.L., Ijpma F.F., Wevers K.P., Afzali H., Patijn G.A. (2011), "Reoperation after colorectal surgery is an independent predictor of the 1-year mortality rate", *Diseases of the Colon & Rectum*, 54(11): 1438-1442.

- Venkatesh A.K., Geisler B.P., Gibson Chambers J.J., Baugh C.W., Bohan J.S., Schuur J.D. (2011), "Use of observation care in US emergency departments, 2001 to 2008", *PLoS One*, 6(9): e24326.

- Vita M.G. (1990), "Exploring hospital production relationships with flexible functional forms", *Journal of Health Economics*, 9:1-21.

- Volpp, K.G.M., Williams, S.V., Waldfogel, J., Silber, J.H., Sanford Schwartz J., Pauly, M.V. (2003), "Market reform in New Jersey and the effect on mortality from acute myocardial infarction", *Health Services Research*, 38: 515-533.

- Volpp, K.G.M., Ketcham, J.D., Epstein, A.J., Williams, S.V. (2005), "The effects of price competition and reduced subsidies for uncompensated care on hospital mortality", *Health Services Research*, 40: 1056-1077.

- Weber E.J., Mason S., Carter A., Hew R.L. (2011), "Emptying the corridors of shame: organisational lessons from England's 4-hour emergency throughput target", *Annals of Emergency Medicine*, 57(2):79-88.

- Wright J., Shojania K.G. (2009), "Measuring the quality of hospital care", *British Medical Journal*, 338: b569.

- Yu K., Ariste R. (2009), *Comparisons of Hospital Output in Canada: National and International Perspectives*, 42nd Annual Meeting and members of Canadian Institute for Health Information.

- Zineldin M., Camgöz-Akdağ H., Vasicheva V. (2011), "Measuring, evaluating and improving hospital quality parameters/dimensions-an integrated healthcare quality approach", *International Journal of Health Care and Quality Assurance*, 24(8): 654-662.

- Zuckerman S., Hadley J., Iezzoni L. (1994), "Measuring hospital efficiency with frontier cost functions", *Journal of Health Economics*, 13: 255-280.

**Reports:**

- Agency for Healthcare Research and Quality (2008), Report on *Identifying, Categorizing, and Evaluating Health Care Efficiency Measures*, Healthcare Research and Quality, U.S. Department of Health and Human Services.

- EuNetPas (European Network for Patient Safety) www.eunetpas.eu,

- EuroDRG (*Diagnosis-Related Groups in Europe: towards Efficiency and Quality*), www.eurodrg.eu,

- INTERQUALITY (International Research Project on Financing Quality in Healthcare InterQuality), WP1, WP2, WP4, 2012.

- OECD (2002), *Health Care Quality Indicators (HCQI)*, www.oecd.org/health/hcqi

- OECD (2011), *Health at a Glance - 2011* [http://www.oecd.org/health/healthataglance];

- ONS (2006), *Public Service Productivity -- Health*, UK Centre for the Measurement of Government Activity.

- SIMPATIE (Safety Improvements for Patients in Europe) www.simpatie.org

- WHO (2000), *The World Health Report 2000. Health Systems: Improving Performance*, World Health Organisation, Geneva.

- WHO (2004), *PATH (Performance Assessment Tool for quality improvement in Hospitals)*, www.pathqualityprojects.eu

**International Organisations and Databases:**

- OECD Health Data 2011 – www.oecd.org

- Agency for Healthcare Research and Quality (AHRQ) – www.ahrq.org

- European network for Health Technology Assessment (EUnetHTA) – www.eunehta.net

- European Society for Quality in Healthcare (ESQH) – www.esqh.net

- Health Technology Assessment International (HTAi) – www.htai.org

- International Society For Pharmacoeconomics and Outcomes Research (ISPOR) – www.ispor.org

- International Society for Quality in Health Care (ISQua) – www.isqua.org

- National Institute for Health and Clinical Excellence (NICE/NHS) – www.nice.org.uk

- National Quality Forum (NQF) – www.qualityforum.org

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