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Chapter 21
Linking Cost Control to Cost Management in Healthcare Services:
An Analysis of Three Case Studies

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ABSTRACT

The issue of healthcare costs has become increasingly problematic over the years. This chapter summarizes the problems faced by hospitals when measuring the costs of healthcare treatments, explaining how an Activity-Based Costing (ABC) framework can be successfully adopted in healthcare settings. After describing the theoretical foundations of cost control and cost management, the chapter continues with the analysis of three real-life applications of ABC in a hospital, drawn from the process analysis and activity-based costing experience developed at the Azienda Ospedaliero-Universitaria "Ospedali Riuniti" (Joint Hospitals) of Trieste, Italy. In particular, the cases are about cost measurement in cardiology, odontostomatology, and radiology, and describe the technical solutions applied for computing the costs of selected therapeutic and diagnostic treatments. A particular emphasis is placed on how these measures have been subsequently used by hospital managers and medical personnel in order to gain insights and to improve the efficiency of the processes developed within the organization.

INTRODUCTION

Healthcare has experienced significant changes in competition and regulation over the last decades, with an ever prominent role played by market forces in shaping national policy debates regarding funding and cost containment (Cardinaels & Soderstrom, 2013). Considering that in many countries healthcare ranks among the largest economic sectors (Ditzel et al., 2006), it is not surprising that healthcare represents a significant portion of public spending. Moreover, most countries have

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experienced a rise in the percentage of Gross Domestic Product (GDP) devoted to national health systems over the past few decades (Reinhardt et al., 2004; Perotti, 2006; Pammolli & Salerno, 2006; WHO, 2000, 2010; McKinsey Global Institute, 2008; Armeni & Ferrè, 2013; Scheggi, 2012). In 2011, countries in the Organization of Economic Cooperation and Development (OECD) spent an average of 9.5% of their GDP in healthcare, up from an average total spending of 7.8% in 2000 (OECD Health Statistics, 2013). The reduced growth rates (or, in some cases, even recessions) that several European countries experienced between 2008 and 2013 put a strain on public spending, and forced some governments, where national health services are established, to introduce drastic measures for ensuring financial stability.

The compounded effect of aging populations and increases in health care costs prompted many governments to strive for betterments in the efficiency of the management of their national health services, often by means of tightened budget constraints and widespread cost cutting efforts. The gradual introduction, started in the 1980s, of Diagnosis-Related Groups (DRG) for funding healthcare providers is an example of such efforts. Under this mechanism, the payment to the providers (hospitals and physicians) depends on the nature of the patient's illness, not on the amount of resources used to treat the payment. An increase of resources used to treat the illness, therefore, does not translate in an increase in hospital reimbursement, thus shifting the cost risk from the insurers (private or governmental) to the providers of healthcare (Cardinaels & Soderstrom, 2013). Hospitals have reacted by introducing cost containment measures, including governance models and cost accounting systems designed around corporate examples. However, simply transferring systems and methods from for-profit corporations to providers of healthcare services could lead to erroneous results (Alexander & Weiner, 1998), especially when decisions concerning the appropriateness of different medical treatments are based exclusively on cost information.

In order to understand the root causes of the surge in healthcare expenditures, it is useful to consider that, even if in most countries healthcare is not provided a in competitive market context, there is nonetheless a demand for and supply of healthcare services. Healthcare demand, although peculiarly subjective, is mainly driven by supply. In fact, the availability of specific medical treatments often generates its own demand. In turn, supply is influenced mainly by technology (i.e., the ability to treat). Historically, technology has transformed medicine into a discipline in which professionals deal not only with the symptoms, but also with the causes of the disease (Drouin et al., 2008). New therapies, products, and medical services set expectations to a new level, pulling up demand. Supply is influenced by capacity: since health care is free or heavily subsidized for many patients, the mere presence of healthcare facilities affects the rate of their consumption (Drouin et al., 2008; Ehrbeck et al., 2010). Finally, supply is also affected by incentives offered by providers: funding policies set by healthcare regulators and governments can determine under- or overproduction of specific treatments or services.

Demand, on the other hand, is relatively insensitive to price (being most users fully or partly subsidized), and it is mainly driven by social norms, wealth (the higher a country's GDP, the higher the demand for healthcare services), current and expected health. The influence of said variables on the demand and supply of healthcare tends almost invariably to generate an increase in the availability of healthcare products and services, since the system is apparently unbounded, given the probable evolution of medical technology and healthcare expectations. Although the above factors are indubitably relevant, it is our opinion that one of the drivers which can explain a significant part of the healthcare costs is complexity, and how it is managed. In the last century, the role of medicine and physicians has changed dramatically. Approximately a century ago, before the discovery of penicillin, medics acted like craftsmen in that they could have all the necessary knowledge in their field, and they had the ability to apply it. As a result, autonomy, in sense of independence and self-sufficiency, emerged as one of the principal values of the medical profession. The current situation is completely different: the number of medical treatments and surgical procedures has increased, and so has the number of drugs available.

Quoting a TED talk on the subject (Gawande, 2012):

There was a study where they looked at how many clinicians it took to take care of you if you came into a hospital, as it changed over time. And in the year 1970, it took just over two full-time equivalents of clinicians. That is to say, it took basically the nursing time and then just a little bit of time for a doctor who more or less checked in on you once a day. By the end of the 20th century, it had become more than 15 clinicians for the same typical hospital patient -- specialists, physical therapists, the nurses.

The increased complexity in the medical treatments had as a side-effect the emergence of coordination issues among different specialists, because the processes have become more fragmented, involving a larger number of professionals. Therefore, organizational problems have become increasingly important for healthcare providers, and so have the costs associated with them. However, there is mounting evidence that the most expensive care is not necessarily the best care: the most effective and often the most efficient healthcare treatments are those developed with a systematic approach. Having components of the highest quality does not assure the best results, and yet in today's medicine there is a great emphasis on components (the best drugs, the best technologies, the best specialists, etc.). *What it lacks is a holistic approach to processes*.

Therefore, it is not surprising that, given the recent surge in healthcare costs, cost analysis and control in the production of healthcare services has become increasingly important. In our view, one of the most important supports for providers to better organize their activities is the availability of relevant information. Therefore, the data analyzed should be elaborated within a framework that takes into consideration the systemic reality (i.e., the information should be able to reflect the level of complexity, the interconnections, and the constraints of the system). Translating this concept into the measurement and reporting of costs means the cost accounting system should provide information with a level of detail and a depth of analysis consistent with the complexity of the processes being measured. In this sense, Activity Based Techniques (ABT) represents an indubitable improvement over traditional measurement systems in providing valuable information for process management interventions such as Activity Based Management (ABM) and Business Process Reengineering (BPR).

BACKGROUND

The traditional view of cost accounting is that services or products consume resources (Baker, 1998, p. 3). Conventional cost systems therefore, assume a direct relationship exists between the level of product or services provided and the amounts of the resources utilized. Traditional performance measures of productivity, such as "labor productivity", defined according to this view, are therefore flawed. Traditional cost systems led to over-emphasize the distinction between "variable costs" (i.e., costs that are correlated to variation in the output performed) and "fixed costs" (i.e., costs that are not dependent on the level of goods or services produced) (Cooper & Kaplan, 1998, p. 111).

In contrast, Activity Based Costing (ABC) theory recognizes that resource usage is intimately linked with the implementation of activities. The causal relation among these "entities" is expressed by a parameter called a "resource driver" which explains the measure of the resource consumption triggered by a definite activity (Cooper & Kaplan, 1988; Bubbio, 1993; Kaplan & Cooper, 1998; Sandison et al., 2003). Products and services, instead, consume activities. An "activity driver" thus defines the consumption of activities caused inside the organization by the delivery of products or services. As we will specify better later, activity drivers may synthetize either volume-related or non-volume-related connections between activities and products.

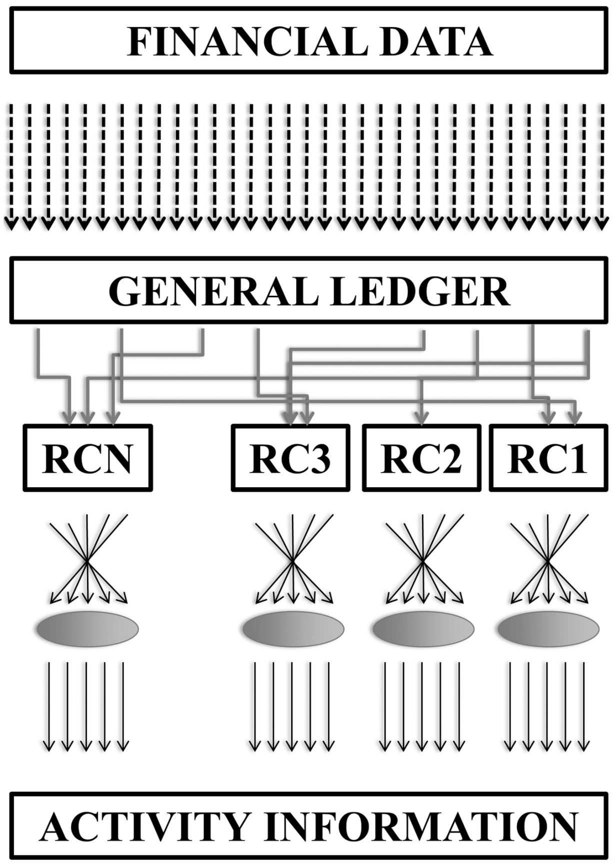
The ABC framework reveals a "double productivity circuit" that must be properly managed to achieve a superior level of efficiency (De Rosa, 2000, p. 17). At one side of the circuit there is what we may call a "resources productivity" which compares outputs in term of activities performed to inputs expressed by the amount of resources consumed. At the other side of the circuit stands the "activities productivity" which matches outputs obtained, articulated in term of products or services delivered, to inputs consumed, measured by the quantity of activity required to produce the outputs (Grisi, 1997, p. 101).

Cokins (2001) uses the analogy of an optical lens to show how ABC "serves as a translator of general ledger data to provide more focused information for improved decision support. The lens not only translates the ledger costs into a more useful and flexible format, it also provides more sensory information". ABC, therefore, is neither a replacement for the general ledger accounting nor for responsibility accounting. Rather, it is a decoder of information provided by these systems in favor of its end users, such as managers and analysts, who apply cost data in decision making. "It translates expenses into a language that people can understand. It translates expense into elements of costs, namely the work activities, which can be more flexibly linked or assigned to business processes or cost objects based on demand-driven consumption patterns, not simplistic cost allocations" (Cokins, 2001, p. 11-12). Figure 1 summarizes the present stage of the cost assignment process at the hospital analyzed by this study, where the ABC still operates within a specific responsibility center (Hospital Departments), providing information to final users expressed in terms of cost of activities performed in that Department.

The accuracy of information provided certainly increases when compared to a traditional cost accounting system, but it still lacks the completeness of information encompassing all responsibility centers. The aim of the project launched by the hospital, based on the case studies conducted to date, is to expand the model to its full potential, providing information common to all responsibility centers of the organization, as shown in Figure 2.

A major improvement in cost assessment provided by the ABC methodology consists of the proliferation of cost objects. While the organizational departments are necessarily linked to the product or the service they contributed to deliver, activities may be perceived as performed in order to serve numerous "entities", such as different "customers", "suppliers", "channels" or, even, "type of customer order", "type of freight-haul trip", etc. Each of these entities may "serve as an intermediate repository to capture the diversity of the type of work output". By means of this attribution of costs to intermediate cost objects, ABC is able to recognize the role of complexity in determining the level of resource usage. Once

Figure 1. Current stage of the cost assignment process

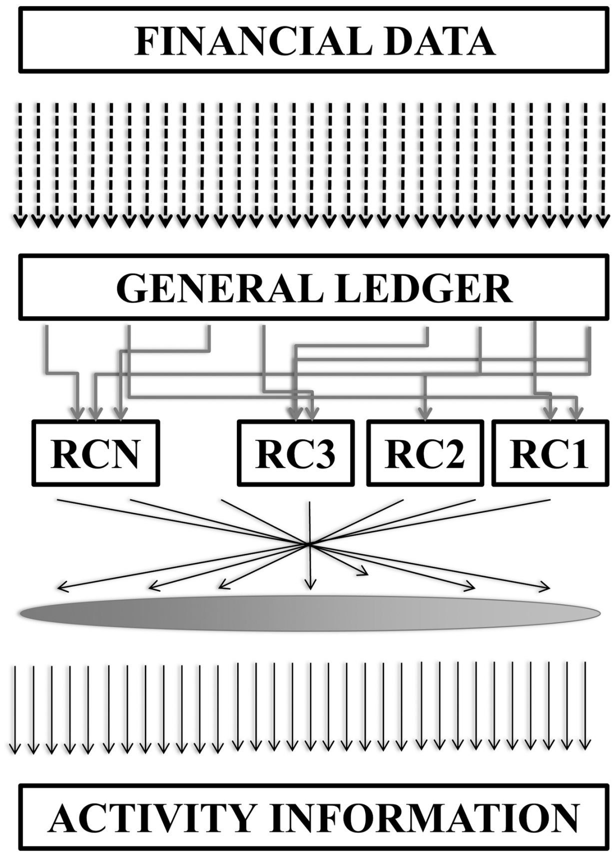


activity costs have been preliminary traced to intermediate cost-objects, these costs are further retraced to subsequent stages based on appropriate activity drivers. Not recognizing this pattern of input-output relationship among activities would normally produce a significant distortion on the final cost figure computed. In Health Care Organizations, "cost-objects are any patient, product, service, contract, project, or other work unit for which a separate cost measurement is desired" (Baker 1998, p. 5).

Another fundamental difference between "activity-based" and "conventional" cost systems is the use of *non-unit cost drivers* for assigning resource usage to cost object. ABC system assign costs using drivers based on the "quantity" of each activity used. Since the drivers are expected to appropriately synthetize the "root causes" that induced the activity to be performed, they may occur on several levels:

1. *Unit level drivers* correlate the increase of the resource consumption with every "unit" of a "cost-object" served. The "cost-object" may be a product or service delivered (e.g., a "specific treatment") or a customer served (e.g., "a single patient"); nevertheless, it can also be a supplier.
2. *Batch level drivers* link, instead, the variation of the inputs to activities carried out for every "batch" of "cost-objects". The costs incurred in performing these activities must,

Figure 2. Desired stage of the cost assignment process



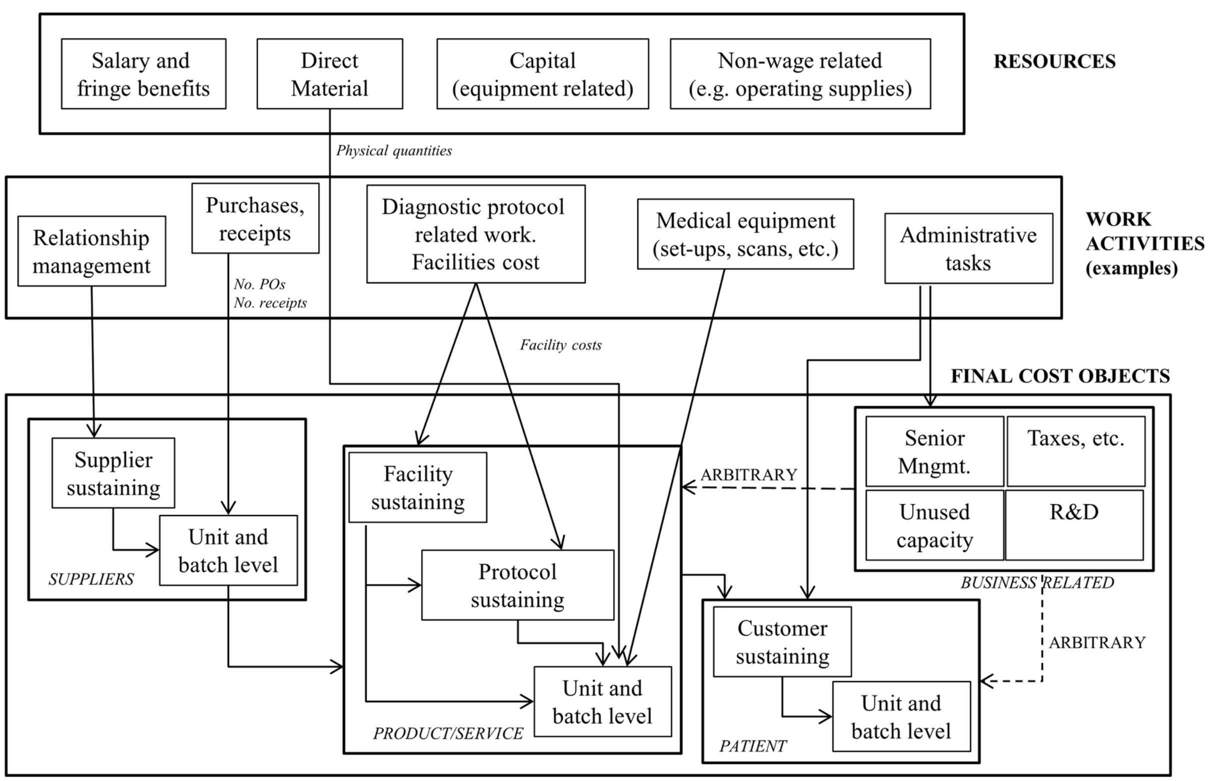
therefore, be assigned to individual batches, provided that they are completely "fixed", regardless of the number of units in the batch.

3. In addition to activities and costs that are outlined by "unit" and "batch" drivers, there is a third, higher-level of activities, usually labeled "sustaining activities". Their occurrence does not vary in accordance with the amount of "batches" or "unit" of the selected cost-object served in a specific period of time. Indeed, the amount of sustaining activities performed "reflect policy or strategy or response to the importance" of the cost-object. In short, they are "overhead work activities whose existence can be attributed to suppliers, products, service lines, channels, or customers" (Cokins, 2001). Each of those entities will have its "sustaining" cost object. This led to existence of specific *sustaining activity drivers* that must be used in order to correctly trace costs incurred in performing these activities to the pertaining "sustaining" cost object. Among these drivers, the following two should be certainly mentioned:
   a. **Product Level Drivers:** Which assume the necessity of the inputs to support the production of each different type of product.
   b. **Facility Level Drivers:** Which are related to the facility's manufacturing process. Users of the ABC system will need to identify the activities which generate costs and then match the activities to the level bases used to assign costs to the products.

Moreover, among the sustaining activities, we should mention the so-called "business sustaining activities" which "do not directly contribute to customer value, responsiveness, and quality. That does not mean those activities can be eliminated or even reduced without doing harm to the business entity. For example, preparing required regulatory reports certainly do not add to the value of any cost object or to the satisfaction of the customer. However, that activity does have value to the organization because it enables it to function in a legal manner" (Cokins, 2001, p. 71) Costs incurred in performing these activities are usually traced to a "sustaining cost object group". Although these costs may be attributed to the main cost objects in order to determine their full cost, their allocation is always arbitrary.

The existence of numerous cost objects and the presence of multiple levels of variability conduce to the identification of intermediate stages of activities; that is, activity outputs that are inputs to successive work activities. The cost of the resource used at the intermediate level cannot easily be traced directly to final cost objects because it is extremely difficult to perceive the causal relationship linking them. As a result, a multistage cost assignment process emerges in which a significant amount of what may be labeled as "organizational work activity" supports the activities that are in closer proximity to products and customer services. It is, therefore, possible to explicitly detect and measure the variation and diversity of resource consumption due to different products or service lines. By means of the multistage cost assignment process, the cost of these support activities is traced in proper proportions to other activities that require their work. These costs are eventually burdened into

Figure 3. Framework for cost assignment in healthcare using ABC



the primary activity costs. The ABC approach requires mapping every administrative and clinical activity involved in the treatment of specific medical condition (Ostinelli, 1995).

The activities identified are the analytical components of a process (i.e., a "net" of activities performed in the accomplishment of a specific aim) that "starts when the patient first presented for treatment and extended through surgery, recovery and discharge" (Baker, 1998). In order to adequately perceive the major interrelations existing among different activities, a process map should consequently be drawn. In hospitals, as in businesses, this requires the involvement in the project of "groups of experts" (i.e., multidisciplinary teams composed of personnel that possess "expertise" in performing each and every step of the process). Significant improvements in the level of efficiency may arise in this step of the work through the removal or the amendment of activities that prove to be redundant, erroneous, or useless and therefore are labeled as "non-value-added".

In fact, ABC is not only a method of costing, it also represents the first step toward Activity Based Management (ABM), a group of techniques for better managing the organization. ABC measures the cost and performance of activities, resources and cost-objects in order to generate more accurate and meaningful information for decision-making. By means of the data and information provided by ABC systems, managers gain a thorough understanding of their processes and cost behavior. This knowledge is easily diffusible within the organization: ABC and ABM describe activities using an "action-verb-adjective-noun" grammar convention that is highly understandable. "Such wording is powerful because managers and employee teams can better relate to these phrases, and the wording implies that the work activities can be favorably affected, changed, improved, or eliminated" (Cokins, 2001). In conclusion, the knowledge provided by the ABC system acts as a strong incentive for reengineering initiatives such as non-continuous improvement projects. It also supports ABM and its quest for continuous improvement by allowing management to gain new insights into activity performance by focusing their attention on the sources of demand for activities.

One major enhancement introduced by ABC is the focus placed on capacity costs. Prior to its introduction, in fact, "many organizations had very little insight and understanding about the location and cost of unused and non-productive capacity" (Gupta & Galloway, 2003, p.136). By means of measuring unused capacity, the ABC framework provides the critical link between the cost of resources used and the cost of resources available, as reported in the conventional financial statements. Advocates of ABC therefore developed the following fundamental equation (Kaplan & Cooper, 1998, p.118):

Cost of resources supplied = cost of resources used + cost of unused capacity

In the three case studies presented in this chapter, this relationship will be employed in order to explain the different components of the cost of treatments. Additionally, we should mention Time-Driven Activity Based Costing (TDABC) as an enhancement of traditional ABC systems. Its proponents advocate that it improves the original methodology by: eliminating the need for time consuming, subjective, interviews and survey process to define resource pools; that it reduces the processing time required to elaborate the data (thus allowing a more detailed mapping of the resource consumption patterns); that it is easier to maintain and update; and that it enables more accurate representations of over/under capacity by expressing it in units of time (Kaplan & Anderson, 2003; Cleland, 2004; Kaplan, 2005; Demeere et al., 2009; Dewi et al., 2009; Dejnega, 2011; Öker et al., 2013).

Accurate cost measurement in health care is a difficult task, mainly because of the inherent complexity of healthcare itself (Kaplan & Porter, 2011). In fact, every treatment involves the consumption of many different types of resources – personnel, equipment, space, and supplies – each with different capabilities and costs. If one follows the care cycle, it appears clear how different resources, pertaining to different responsibility centers, are being activated every time a patient requires a treatment. This mix of clinical and administrative activities, and the variety of medical conditions presented by patients, adds complexity to the process, rendering the calculation of costs particularly difficult (Francesconi, 1993; Waters et al., 2001; Doyle et al., 2002, 2008; Geri & Ronen, 2005; Järvinen 2005; Cinquini et al., 2009; Chea, 2011; Bahadori et al., 2012; Eriksen et al., 2011; Groves et al., 2013; Kaplan et al., 2013; Kuchta & Zabek, 2011; Popesko, 2013).

The already complex path of care is further complicated by the highly fragmented way in which health care is delivered today (Kaplan & Porter, 2011). Care is also idiosyncratic; patients with the same condition often take different paths through the system. There is also a lack of standardization due to the fact that medical practices allow for considerable discretion – physicians in the same organizational unit performing the same medical process often use different procedures, drugs, devices, tests, and equipment. In operational terms, healthcare could be described as a highly customized job shop (Kaplan & Porter, 2011).

AN ANALYSIS OF THREE CASE STUDIES IN HEALTHCARE COST ACCOUNTING

The three case studies that follow summarize the results of a research effort aimed to improve the theoretical and operational framework of the process analysis and activity-based costing (ABC) at the *Azienda Ospedaliero-Universitaria* (AOU – Teaching Hospital) *"Ospedali Riuniti"* (Joint Hospitals) of Trieste, Italy. The AOU arises from the integration between the pre-existent hospitals of Trieste and the Faculty of Medicine and Surgery of the University of Trieste.

The aim of the project undertaken was to gradually enhance the AOU cost system, providing it with some ABC features that are currently still lacking. As a matter of fact, the hospital's cost system is still based on the traditional paradigm of organizational structure and control which is based upon responsibility centers. While this logic might still be considered useful for budgetary control reasons, it is not certainly helpful in determining the accurate costs of specific healing treatments provided by the hospital, especially when these treatments differ in complexity and intensity of resource usage. Indeed, the cost data gathered within the current AOU cost system lack the granularity required in order to correctly "trace" the resource consumption to definite activities or processes performed. It is, consequently, very challenging to compute the realistic cost of a detailed cost object. All the case studies where developed by multidisciplinary teams in which there was a jointly contribution of competences pertaining to different scientific areas (medicine and accounting).

Case Study 1: Cost Measurement in Hemodynamics

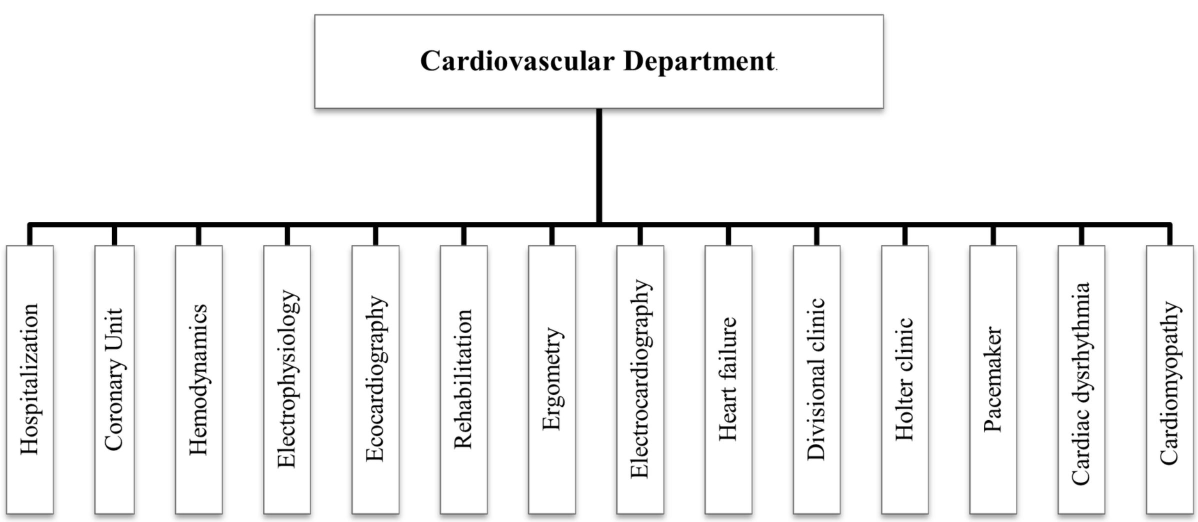
This case study describes the project undertaken in 2012 at the Cardiovascular Department of the AOU (Azienda Ospedaliera Universitaria – Teaching Hospital) of Trieste, Italy, and more exactly in the Cardiology Unit, in order to measure the costs of two specific procedures. G. Sinagra, Head of the Cardiovascular Department at the Teaching Hospital of Trieste, significantly contributed to the development of this case study, along with A. Salvi, A. Perkan, and L. Massa. The authors are also thankful to C. Ciccarelli, who developed a thesis on this topic under the supervision of G. Sinagra, A. Rebelli, and G. Grisi, and to the entire staff of the Cardiology Unit.

The organizational structure of the unit presented a high level of complexity, and the relevant data were stored in a multitude of databases. For these reasons, the analysis focused preliminarily on the macroscopic aspects of the organization, limiting the microanalysis to just two specific diagnostic and therapeutic processes. The two investigated processes, however, played a relevant role in the activities performed within the organizational unit. As a preliminary result, the following organizational chart was developed to illustrate the structure of the Cardiovascular Department:

The conventional cost system, already adopted by the hospital and although structured by responsibility centers, does not possess the required level of analysis necessary to reflect the organizational complexity shown in the above chart. For example, the Cardiovascular Department has nine different clinics (each requiring a specific cost pool), while the hospital cost system has only one cost center for all the clinics included in the Department. Therefore, it was necessary to implement a specific phase for the definition of the analytical cost pools and the measurement of the resources they used. The assigned resources were grouped by their nature as follows:

1. **Labor Costs:** Fixed costs traced to the specific cost pools using a driver based on personnel shifts.
2. **Cost of Equipment Utilization:** Fixed costs that correspond to yearly depreciation charges.
3. **Consumables:** Variable costs that, at least for medical supplies (the most relevant items in terms of value) are specific to the single treatments performed. The term "specific" in this context is used to identify the cost of a resource that is used *exclusively* for a specific treatment, or within a specific center, etc.
4. **Intermediate Care and Medical Services:** Variable costs linked to the specific treatments that require them.
5. **Administrative and General Overhead:** Indirect fixed costs that, not being accurately traceable, have been attributed to the cost pools using a traditional allocation basis.

Figure 4. Organizational chart of the cardiovascular department



Once computed the amount of resources used within each cost pool, the project shifted its focus to the cost of single treatments. As already stated, the project aimed to measure the cost of only few medical treatments, due to the high level of technical complexity encountered (number and variability of treatments performed by the organizational units), and the time and cost constrains of the studies. More specifically, the attention of the research team shifted to the Clinic of Hemodynamics which deals with diseases related to the blood circulation. This clinic performs about 1,800 treatments per year, highly differentiated by nature and complexity, classified in the following three categories, in order of growing immediateness of action required: electives, urgencies, and emergencies.

The study focused on the measurement of costs attributable to the activities performed within the Cardiology Unit. In particular, the analysis concerned three specific treatments: coronarography, percutaneous transluminal coronary angioplasty (PTCA) and coronarography followed by PTCA which correspond to different DRG (Diagnosis-Related Group). The following step consisted in defining the flow of the activities performed within the organizational units analysed, in order to determine the cost of the objects identified. At the present stage, the analysis of the activities was confined to those performed in the chosen units, whereas, in more advanced stages of the project, it would be advisable to extend the analysis to interactions arising among different Departments.

Figure 5 illustrates the main activities that compose the therapeutic and diagnostic processes in case of to the elective (i.e., scheduled) treatments:

As shown in Figure 5, the process for elective cases starts with patient check-in and pre-hospitalization tests. Then, pre-treatment hospitalization, medical treatment (diagnostic and/or therapeutic), and treatment hospitalization follow. After discharge, the protocols usually require a set of post-dismissal controls. The above chart illustrates the standard procedure in the Clinic; in reality, the processes may show considerable deviation from the norm, depending on the results of the procedures performed, or on the specific conditions of the patients. The process flow changes dramatically in cases of emergencies, when the entire procedure is started by emergency room or ambulance personnel. The analysis performed by the research team involved the entire personnel belonging to the Clinic, and identified different types of procedures, differentiating among elective, urgency, and emergency treatments. Table 1 summarizes the volume of single treatments analyzed, grouped by category.

Figure 5. Process flow of elective treatments

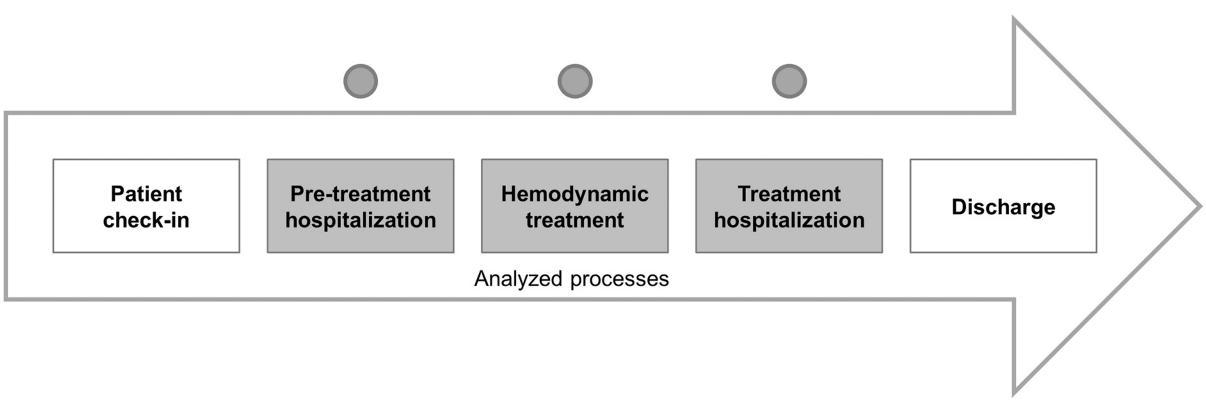


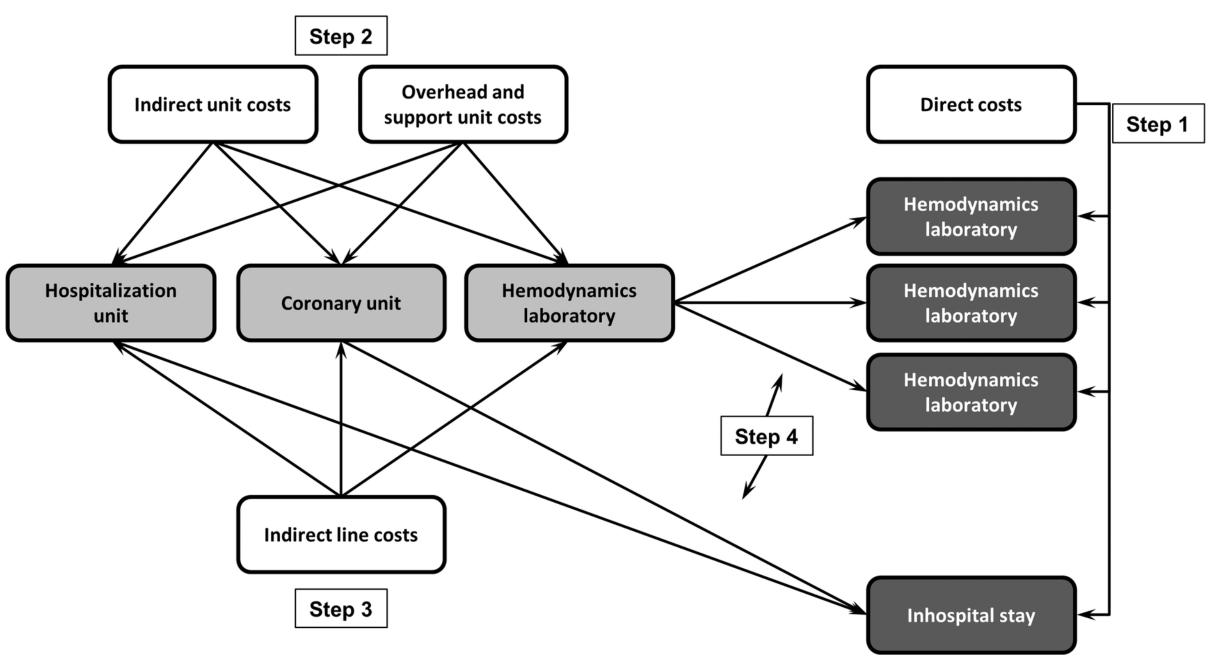
Table 1. Volume of treatments analyzed

	Number of Treatments Analyzed	Average Time (Minutes)
Coronarography	938	88.0
Angioplasty without coronarography	40	96.7
Coronarography followed by angioplasty	554	120.8
Other treatments performed	254	141.6
Total number of treatments performed	**1,786**	**106.0**

The cost attribution process that was developed within the Clinic of Hemodynamics for the three medical treatments previously mentioned (coronarography, PTCA, coronarography+ PTCA) is shown in Figure 6.

The first step in the four-stage cost allocation process developed by the research team required the determination of costs specifically attributable to the three cost objects (i.e., the processes corresponding to the three single treatments analysed). Direct costs consist of drugs, medical and general materials, linens, laboratory analyses and other diagnostic treatments provided by other departments. The precision of these measurements is assured by the availability of accurate record keeping activities performed by the personnel and gathered in specific databases used within the unit. Where necessary, missing data were collected (measuring the standard usage ratio of each resource consumed) and summarized in an appropriate bill of material for each treatment. The amount of these costs is approximately €350 for coronarography, €1,225 for PTCA without coronarography, and €1,484 for coronarography followed by PTCA.

Figure 6. The logic of cost allocation in the cardiovascular department



In step 2, indirect unit and overhead costs were traced to the functional cost pools, according to specific resource drivers. The most important overhead cost was certainly represented by personnel costs, which amounted approximately to €7 million per year, corresponding to 134 full-time equivalent workers. The resource driver chosen in this case was a duration driver, derived by the analysis of personnel average shifts. Starting from the yearly cost data available from the traditional cost accounting system, it was possible to trace personnel expenses to each functional cost pool using as a driver the time dedicated by the different professional figures (physicians, nurses, physiotherapists, and technicians) to each cost pool. Temporary shifts of personnel among different cost pools were also accurately recorded, in order to obtain precise cost measures. Table 2 illustrates the time and cost data details relevant to this attribution process.

It should be noted that data reported in the previous table represent, by themselves, a noteworthy result for the Hospital's management made possible by the thorough organizational analysis performed by the team. From a cost measurement point of view, the high level of detail of the analysis allowed us to identify the precise mix of activities performed by different professional figures, and, therefore, to compute the accurate cost of resources utilized.

The remaining overhead costs consisted of depreciation, maintenance, cleaning, laundry, utilities, garbage disposal, security, EDP, and other indirect costs. Within this class, there are also consumables of indirect usage (medical and non-medical), and intermediate care and medical services not included in the previously mentioned bill of materials. These costs are classified as indirect because of some limits of the current Hospital information system, which does not provide the detailed information needed in order to trace them directly. The amount of this various resources usage had been attributed to the functional cost pools using the same traditional allocation basis employed by the Hospital cost system to assign these costs to the responsibility cost units. In step 3, the indirect line costs (e.g., depreciation of medical equipment, depreciation of furniture, and costs used by the different line for multiple procedures) have been determined and charged to the different lines. The results of the second and third steps are reported in Table 3.

The cost of hospitalization (step 4) was attributed to the cost objects by means of a driver represented by the number of days of hospitalization. This choice constituted a deliberate simplification assumed by the project team in order to contain the complexity of the cost measurement process when the project was being initially developed. In fact, to provide more precise cost information, it would be possible to apply resource drivers capable of capturing the different complexity and length of the treatments performed in favour of the hospitalized patient, and, therefore, the intensity of the resource consumption. The management of the Hospital is aware of the measurement error deriving by this choice, and is currently pondering the use of more informative drivers, similar to those described above. Table 4 illustrates the relative importance of resource usage for ordinary hospitalization and for coronary unit hospitalization (intensive care), and provides information about the average cost arising from combining the two classes of cost. It should be emphasized that the use of an average cost measures such as these can lead to cross-subsidization effects among treatments requiring different levels of care.

In the final step (4), activity drivers were also applied in order to trace the amounts of resources used within the Hemodynamics cost pool to serve the two cost objects considered. In this case the team decided to use a time driven method. As an example, for medical personnel cost, the activity driver was linked to the standard duration of the treatment, and was so calculated (shown in Box 1).

The Department has two surgery rooms devoted to Hemodynamics treatments. Their production capacity was determined as the sum of the hours

Table 2. Time and cost data of the different activity lines

	Total			Profile											
				Physicians			Nurses			Physiotherapists			Administratives and Technicians		
Activity lines	**Hours**	**Weight (%)**	**Costs (€)**	**Hours**	**Weight (%)**	**Costs (€)**	**Hours**	**Weight (%)**	**Costs (€)**	**Hours**	**Weight (%)**	**Costs (€)**	**Hours**	**Weight (%)**	**Costs (€)**
Coronary Unit	1,037	27.2	2,198,719	183	23.7	653,301	818	33.3	1,506,159	36	33.3	39,259			
Hospitalization unit	1,022	26.8	2,036,893	213	27.6	762,065	773	31.5	1,235,569	36	33.3	39,259			
Hemodynamics lab.	375	9.8	977,522	114	14.8	425,618	225	9.1	516,573				36	7.5	35,331
Electrophysiology lab.	146	3.8	250,979	38	4.9	135,955	36	1.5	44,362				72	15.1	70,662
Cardiac dysrhythmia amb.	49	1.3	89,621	13	1.6	45,259	36	1.5	44,362						
Cardiomyopathy amb.	61	1.6	104,876	13	1.6	45,259	48	2.0	59,618						
Divisional amb.	48	1.3	87,653	12	1.6	43,291	36	1.5	44,362						
Electrocardiography amb.	48	1.3	87,653	12	1.6	43,291	36	1.5	44,362						
Ergometry amb.	7	0.2	16,252	3	0.4	11,914	4	0.1	4,338						
Holter amb.	72	1.9	80,265	0	0.0	572	36	1.5	44,362				36	7.5	35,331
Pacemaker amb.	110	2.9	224,679	38	4.9	135,955	72	2.9	88,724						
Heart failure amb.	67	1.8	127,595	19	2.5	67,978	48	2.0	59,618						
Rehabilitation amb.	292	7.7	448,542	40	5.2	143,111	216	8.8	266,172	36	33.3	39,259			
Ecocardiography	218	5.7	424,141	74	9.6	264,755	72	2.9	88,724				72	15.1	70,662
Secretary	261	6.8	112,298										261	54.7	112,298
Total	**972**	**100.0**	**1,691,278**	**224**	**100.0**	**801,385**	**604**	**100.0**	**744,641**	**36**	**100.0**	**39,259**	**108**	**22.6**	**105,992**

Table 3. Indirect costs charged to the different units

Cost Voices	Cardiology Unit Costs (€)	Macro-Activity Line Costs (€)			
		Hospit. Unit	Coronary Unit	Hemodynamics Laboratory	Other Lines
Physicians and nurses	7,155,392	2,036,893	2,198,719	977,522	1,942,257
Other personnel	112,298	32,312	32,777	11,847	35,362
Materials	61,547	36,114	25,433		
Chemical tests, radiological tests	942,529	553,043	389,486		
Instruments, furniture	743,515	50,163	133,358	402,031	157,964
Inpatient meals	202,722	152,216	50,506		
Laundry services and related supplies	371,013	84,140	72,819	19,747	194,307
Cleaning services	248,772	58,991	82,298	26,788	80,695
Overhead costs	1,965,896	605,962	567,085	167,648	625,202
Total	**11,803,684**	**3,609,834**	**3,552,481**	**1,605,582**	**3,035,787**

Table 4. Comparison of costs of ordinary hospitalization and intensive care (Coronary unit)

Cost Voices	Hospit. Unit	Coronary Unit	Total (€)
Physicians and nurses	2,036,893	2,198,719	4,235,613
Other personnel	32,312	32,777	65,089
Materials	36,114	25,433	61,547
Chemical tests, radiological tests	553,043	389,486	942,529
Instruments, furniture	50,163	133,358	183,520
Inpatient meals	152,216	50,506	202,722
Laundry services and related supplies	84,140	72,819	156,959
Cleaning services	58,991	82,298	141,289
Overhead costs	605,962	567,085	1,173,046
Total costs	**3,609,834**	**3,552,481**	**7,162,315**
Total days of confinement	10,235	2,196	12,431
Total Day Hospital accesses	883		883
Total	**11,118**	**2,196**	**13,314**
Cost per day	**325**	**1,618**	**538**

Box 1.

$$Cost\ of\ personnel \times \frac{Avg.\ total\ time\ needed\ for\ the\ treatment}{Total\ surgery\ room\ hours\ available}$$

of programmed activities (seven hours per day, five days a week – holidays excluded) and the hours necessary for facing emergencies). The second addendum was assessed considering the number of hours in which the four specialized cardiologists working for the Department are normally required to be available for emergencies. The organizational analysis, developed by the research team in order to assess the impact of the personnel shifts on the level of production, has revealed the high level of efficiency achieved in the management of the resources. As a matter of fact, the existence of unused capacity is fully justified by the necessity to grant the immediateness of treatment to emergency cases (15% of the annual number of treatments), and by the relevant number of urgency cures performed by the unit (44% of the annual cases), for which, of course, no planning is possible.

The high incidence of urgency and emergency treatments can be explained by the "hub" role played by the Hospital within its surrounding reference area (provinces of Trieste and Gorizia, with a total population of 376,500 inhabitants). It is worthwhile to observe that the above described production capacity was measured in terms of theoretical capacity, whereas ABC authors normally suggest the use of practical capacity (Cooper & Kaplan, 1998, p. 112; Kaplan & Anderson, 2007, p. 52-54), such as the maximum level at which an organization can operate efficiently, net of unavoidable operating interruptions, such as repair time or waiting time. This choice was made for streamlining the cost measurement process, and was also applied to the two following case studies.

In addition to cost of personnel, the above reported activity driver was deemed suitable to trace most of other cost items, including equipment, laundry services, secretarial costs, utilities, management of human resources, cleaning services, waste disposal services, heating and conditioning, security, legal services, IT services, etc. For some of these costs, the driver adopted does not fully reflect the cause and effect relationship between the usage of the resource and the service provided. However, the measurement error thus introduced has been considered not relevant, while the benefits arising from streamlining the cost measurement process have been reputed significant. A second class of drivers, based on the amount of the supplies or drugs used, was instead applied, respectively, to administrative and purchase costs, and to hospital pharmacy costs. In line with the methodology initially proposed by Cooper and Kaplan (1992, p.3), according to whom the cost measurement system must be designed in order to respect the following equation:

Activity availability = Activity usage + Unused capacity

The cost model designed by the team separates the costs of unused capacity referring to the Hemodynamics clinic from the total of the costs attributable to the treatments. The costs of unused capacity, that, in this context, can be aptly described as the costs caused by "readiness to perform", have been estimated as 23% of total costs. As previously mentioned, this amount can be considered moderate, due to the degree of optimization achieved in the use of human resources. Table 5 reports the non-specific costs (total and per unit), resulting from the cost measurement process developed in the Cardiology department, when applied to the cost objects selected for this study.

As shown in the above table, after separating the cost of unused capacity from the cost of the activities performed, the management of the Hospital decided to attribute this cost to the single treatments to compute their full cost. This choice arises from considering this portion of capacity not as an inefficiency, but rather as a constraint imposed by the peculiarities of healthcare services performed by governmental entities which need to

Table 5. Total and per-unit indirect costs of the different treatments

Cost Voices	Hemodynamics Laboratory Costs (€)								
	Total	**Coronarography**		**PTCA**		**Coronarography Followed by PTCA**		**Other**	**Unused Capacity**
		Total	**Unit**	**Total**	**Unit**	**Total**	**Unit**	**Total**	
Physicians and nurses	977,522	328,804	351	15,408	385	266,581	481	143,268	
Other personnel	11,847	3,985	4	187	5	3,231	6	1,736	
Instruments, furniture	402,031	135,229	144	6,337	158	109,638	198	58,923	
Cleaning services	26,788	9,011	10	422	11	7,305	13	3,926	
Laundry and related supplied products	19,747	6,642	7	311	8	5,385	10	2,894	
Overhead costs	167,648	47,695	51	2,997	3	50,019	53	29,137	
Total	**1,605,582**	**531,366**	**566**	**25,661**	**570**	**442,159**	**761**	**239,885**	**366,512**
Procedure weight	***1.00***	***0.44***		***0.02***		***0.35***		***0.19***	
Unused capacity cost		**159,816**	**170**	**7,489**	**187**	**129,572**	**234**	**69,635**	
Indirect costs		**691,181**	**737**	**33,150**	**757**	**571,731**	**995**	**309,520**	

be ready to properly face urgencies and emergencies. This requirement, from an economic point of view, is reflected in an increase of the average cost for the average intensity (elective, urgent, and emergent) with which the treatments are provided. The intensity of the treatment, therefore, drives the intensity of resource usage. However, it should be noted the cost of unused capacity has been allocated to the treatments on the basis of their volume, thus employing a transaction driver, not a duration or intensity driver.

The final results of the cost measurement process are summarized in the following tables. Column number 3 of Table 6 reports the amounts of specific costs determined in step 1 of the process, while column 4 summarizes the combined results of steps 2, 3 and 4. The total cost of each procedure is therefore determined by the sum of its direct and indirect costs. Table 7 instead summarizes the average cost for hospitalization.

Considering jointly the data provided by Tables 6 and 7, it is possible to determine the standard cost

Table 6. Unitary costs of the diagnostic and therapeutic treatments studied

	Number of Procedures (1)	**Average Duration (Minutes) (2)**	**Single Procedure Direct Costs (3)**	**Single Procedure Indirect Costs (4)**	**Total Single Procedure Costs (5)**
Coronarography	938	88.0	350	737	**1,087**
PTCA	40	96.7	1,225	757	**1,982**
Coronarography + PTCA	554	120.8	1,484	995	**2,479**
Total/average	**1,532**	**100.1**	**€783**	**€831**	**€1,614**

Table 7. Average unitary cost for hospitalization

	Hospitalization Unit	Coronary UNIT	Average
Cost of one day of hospitalization (€)	325	1.618	538

of various kinds of treatments performed arising from the combination of the variables considered (type of treatment, and length and type of hospitalization). This leads to different cost levels for each type of treatment, depending on the length and on the kind of hospitalization required. It is also possible to calculate average cost figures for recurring classes of treatments. For example, in the case of coronoragraphy followed by angioplasty, out of 544 observed instances, 494 were treated exclusively within the Cardiology department; therefore the cost of hospitalization reported in Table 4 is appropriate. The average hospitalization length for this treatment was 6.3 days, of which 1.5 in intensive care, leading to a total cost for the treatment as summarized in the Table 8.

Case Study 2: Cost Measurement in Odontostomatology

The second case study is about the Dentistry and Stomatology Clinic within the Department of Specialist Surgery of the AOU (Azienda Ospedaliera Universitaria – Teaching Hospital) of Trieste, Italy. R. Di Lenarda, Chair of the Department of Medical, Surgical and Health Sciences at the University of Trieste and Head of the Dentistry and Stomatology Clinic at the AOU (Teaching Hospital) of Trieste, significantly contributed to the development of this case study. The authors are also thankful to A. Avanzini, who developed a master thesis on this topic (under the supervision of R. Di Lenarda, A. Rebelli, and G. Grisi) and to the entire staff of the Dentistry and Stomatology Unit.

Table 8. Total cost of a selected treatment, including hospitalization

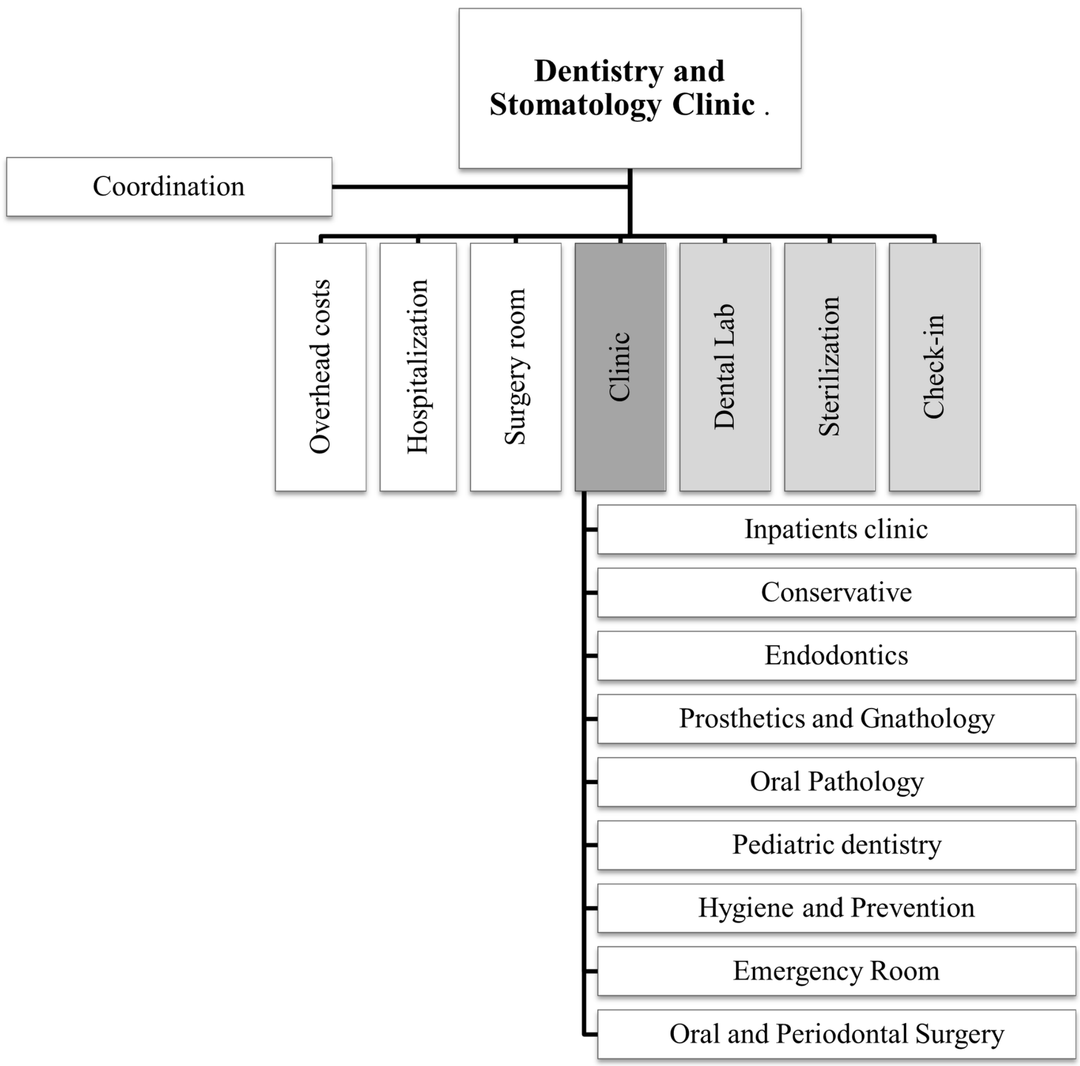
Coronarography Followed by Angioplasty	Costs (€)
Procedure cost	2,479
Hospitalization unit cost	1,560
Coronary Unit cost	2,427
Total	**6,466**

The Clinic, which hosts a graduate program in Odontostomatology Surgery, has adopted an organizational model where teaching, research, and assistance to patients coexist. In this unit, in fact, the three activities produce tangible synergic benefits, as it will be explained in the course of this paragraph. The involvement of medical students in the activities of the clinic allows them to hone their skills, thanks to a learning by doing process, while simultaneously increasing the efficiency level of the treatments provided by the clinic. As a matter of fact, their presence allows the clinic to reach significant volumes of treatments, without a corresponding increase in personnel costs. Obviously, this model requires the constant presence of tutors who supervise the activities performed by the medical students, within the boundary of their privileges, thus enabling the transfer of knowledge and competencies through field training.

This case study outlines, on one hand, the process developed in order to compute the actual cost of the treatments performed within the clinic, and, on the other hand, the "what if" analysis done in order to appraise the "cost savings" granted by the organizational model above described. All the data collected refer to 2011.

Similarly to the previous case study, the project team undertook an in-depth analysis of the organizational structure of the clinic, in order to determine the macro-activities performed within the organization and to define the cost pools necessary to the cost allocation process. Figure 7 illustrates the cost pools identified as a result of this first stage of the research.

Figure 7. Primary and auxiliary cost pools identified within the Clinic



The different cost pools, illustrated in Figure 7, mainly collect the costs of resources specifically used to perform the same set of activities. The cost of these resources was traced to the pertaining pools considering the specific usage of equipment and physical space. The same can be said for labor costs that were traced to the pertaining cost pools in accordance to the specific and rigorous schedule of personnel shifts adopted by the unit. In ABC terms, the parameters used to trace the resource costs to the cost pools are called resource drivers. Auxiliary clinic costs and overhead were attributed to the cost pool using traditional allocation bases.

Some cost pools (Hospitalization and Surgery room) aggregate cost of resources devoted to serve inpatients. The volume of the output performed by these resources, however, is negligible when compared to the main area of activities, constituted by ambulatory care. In fact, due to the importance of the latter, the relative cost pool is detailed in more analytical, second-level, cost pools, corresponding to sets of activities grouped according to similarity in therapeutic characteristics and use of specific resources. Given the prevalence of ambulatory care, the case study focused on the costs of outpatient treatments. In order to compute their costs, however, it was necessary to determine the costs of ancillary services (Check-in, Dental Laboratory, and Sterilization), which were consequently aggregated in specific cost pools. These costs were eventually allocated to the primary cost pools. The cost pool called "Overhead cost" is a mere aggregate of indirect costs that could not be correctly attributed to other cost pools, and it was mainly created for practical reasons.

Table 9 illustrates the relations existing among the cost pools and the volume of selected treatments (described as activities in the ABC terminology) performed by the resources that belong to the cost pools, highlighting how the same treatment can be performed using resources pertaining to different cost pools.

The measurement of the costs specifically attributable to each treatment (mainly constituted by materials and medicines) was a difficult, yet essential, stage of the research process. The complexity of this endeavor was mainly due to the lack of detailed databases in the hospital information system. As a matter of fact, the only information available was the total amount of materials and drugs consumed in the reporting period, divided in five main categories. A Bill of Material (BOM) for each treatment was therefore prepared, thanks to the direct involvement of medical and clinical staff. However, only the most relevant costs were considered in the BOM, while the residual material costs were attributed to the treatments using a volumetric cost allocation basis.

As previously mentioned, the cost measurement process developed by the team required, in this case, the preliminary determination of the costs of ancillary services. Three auxiliary cost pools were therefore identified (Dental Laboratory, Sterilization, and Check-in). The amounts so determined were then allocated downward to the principal cost pools. In one instance the entire cost of the auxiliary cost pool (Dental Laboratory) was traced to a single primary cost pool (Dental Prosthetics and Gnathology), because the totality of the outputs of the former was used as inputs by the latter. In all other cases, the costs were traced to the primary cost pools by means of traditional, yet appropriate, drivers. The organizational structure of this Clinic is characterized by the presence of a check-in service internal to the unit, whereas other hospital departments generally rely on a centralized check-in system. Consequently, the cost of the treatments determined in this case, unlike the costs calculated for the Hemodynamics clinic, also includes the cost of the resources used to perform this activity. Table 10 shows the results of the allocation of the costs of the auxiliary centers to the primary centers.

Once the full amount of costs pertaining to the primary cost pools was determined, these costs were traced to the single treatments using activity drivers differentiated between personnel cost and other fixed costs. An intensity driver (time needed for performing each single treatment) was chosen in order to trace the personnel costs (previously attributed to the cost pools) to each treatment. The reason for employing an intensity driver lay in wanting to place the right emphasis on the different costs deriving from the use of personnel with different skills and wages. As a matter of fact, the intensity driver chosen was determined by combining data regarding the time needed to perform a task by different categories of personnel and their hourly cost. The other costs were mainly attributed using duration drivers.

Quantifying the time needed for the different treatments was another complex task faced by the project team, since such measurements had never been attempted before in the organization. Moreover, in order to determine the intensity driver needed to trace the personnel costs, the average time for performing a treatment was measured for

Table 9. Volumes and descriptions of selected treatments provided by the different cost pools

Cost Pool Treatment	Inpatients Clinic	Conservative	Endodontics	Prosthetics and Gnathology	Oral Pathology	Pediatric Dentistry	Hygiene and Prevention	Emergency Room	Oral and Periodontal Surgery	Total
Visit	195	202	33	920	1,331	939	730	9,348	696	**14,387**
Dental restoration	7	9,512	242	0	113	1,520	8	343	48	**11,793**
Dental radiograph	188	1,307	2,734	9	372	424	1,842	7,157	450	**14,479**
Small suture	193	8	50		324	14	7	1,064	4,357	**6,017**
Removal of therapeutic devices	144	43	43		340	39	27	492	3,610	**4,738**
Dental prosthesis				444						
Extraction	192	5	49	0	337	220	7	1,020	4,385	**6,215**
Wound irrigation		809	233		47	58	626	1,084	41	**2,898**
Root smoothing	27	5			4		2,436	18	19	**2,509**
Other	128	318	1,203	125	967	1,492	5,393	920	946	**11,947**
Total volume	**1,074**	**12,209**	**4,587**	**1,498**	**3,835**	**4,706**	**11,076**	**21,446**	**14,552**	**74,983**

Table 10. Allocation of the auxiliary cost centers to the primary cost centers

	Total costs (€)	Primary Cost Centers								
		Emergency Room	Pediatric Dentistry	Conservative	Prosthetics and Gnathology	Endodontics	Oral Pathology	Oral and Periodontal Surgery	Hygiene and Prevention	Inpatients Clinic
Costs before allocation	**2,762,079**	**446,176**	**127,753**	**282,687**	**140,443**	**140,990**	**126,519**	**186,642**	**151,551**	**73,658**
Sterilization	**214,202**	36,605	15,434	40,408	3,556	11,509	9,771	60,488	33,113	3,317
Dental Laboratory	**96,568**	0	0	0	96,568	0			0	0
Check-in	**213,193**	0	19,124	49,614	6,087	18,640	15,584	59,135	45,009	0
Overhead costs	**343,367**	98,207	21,550	55,908	6,860	21,005	17,562	66,637	50,720	4,918
Costs after allocation	**3,629,409**	**580,988**	**183,861**	**428,617**	**253,514**	**192,144**	**169,436**	**372,902**	**280,393**	**81,893**

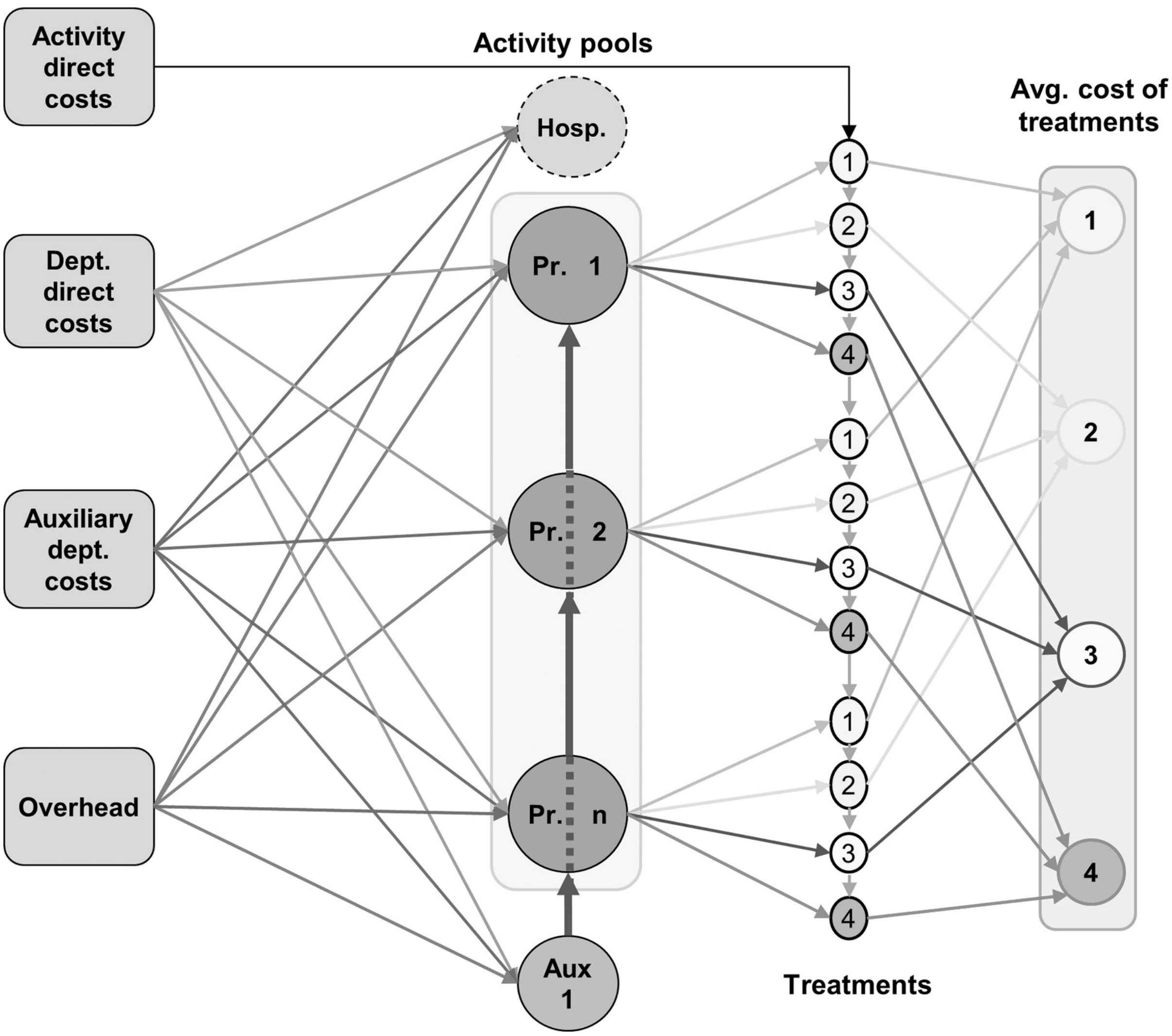
each category of personnel involved (physicians, nurses, medical students, etc.). For this purpose, each treatment was divided into three different phases: 1) preparation of the patient and of the necessary devices; 2) treatment; 3) cleaning and reset of the dental unit. Physicians are rarely involved in the first stage, and never in the third. The methodology adopted does not allow for the separation of the cost of unused capacity that is, therefore, attributed to the treatments. The cost allocation process is summarized in Figure 8.

As shown in Figure 8, the various primary activity cost pools may perform the same treatments; therefore, their cost may vary depending on where it is performed. For this reason, the project team deemed necessary to calculate the average cost of each treatment.

When designing this cost measurement model, it was decided to take into account only the actual costs incurred by the hospital. The cost of medical students, who do not receive a salary from the hospital, therefore, does not affect the cost calculation process described above. This choice was consciously taken by the project team, in order to fully appreciate the cost containment effects generated by this particular form of organization. As an example of the data produced by the cost measurement implemented, Table 11 shows the cost of selected treatments performed using the resources pertaining to a specific cost pool (Oral and Periodontal Surgery).

In the subsequent phase of the project, the research team developed a simulation aimed to quantify the cost containment effects generated thanks to the involvement of medical students in the processes analyzed. In the previous phase of the process, costs were calculated employing what could be described as a "top-down" approach. In fact, the starting point for the calculations was represented by the total costs incurred by the hospital for the physicians employed in the Dentistry

Figure 8. Cost allocation process in the Dentistry and Stomatology Clinic



and Stomatology Clinic, which was then traced to the different cost pools, as shown in Table 12.

The simulation employed a "bottom-up" approach, attempting to estimate the total cost of the physicians necessary to perform the same set of activities offered by the Clinic, starting from the standard costs of the treatments. The first step consisted in determining the per-minute cost of medical staff. The yearly average cost of physicians was, therefore, divided by the number of average minutes worked, resulting in a per-minute cost of physicians of approximately €1. On the basis of the standard time of each treatment (measured in the first phase of the project), the research team then calculated the total minutes necessary to perform the various treatments offered within the Clinic. This approach allowed for the attachment of a value to the activities performed by medical students as if they were physicians employed by the hospital. The results of the simulation are reported in Table 12, and show a considerable difference in financial resources needed, in this hypothesis, in order to offer the same set and volume of treatments. The above described simulation, although based

Table 11. Total and per-unit costs of selected treatments performed by the Oral and Periodontal Surgery cost pool

Treatment	Qty	Cost (€)	
		Total	Per Unit
Small suture	4,357	96,498.96	22.15
Removal of therapeutic device	3,610	56,066.48	15.53
Extraction of permanent tooth	2,330	77,789.96	33.39
Extraction of residual root	1,698	61,433.77	36.18
Short visit	444	8,805.39	19.83
Removal of dental prosthesis	389	7,014.84	18.03
Surgical tooth extraction	350	19,251.69	55.00
Gingivectomy	295	20,560.68	69.70
Intraoral radiograph	273	4,165.44	15.26
Specialist visit	252	6,376.66	25.30
Ortopantomograph	177	2,787.71	15.75
Dental scaling and root planing	49	1,677.25	34.23
Other wound irrigation	41	738.32	18.01
Treatment of stomatitis	30	893.07	29.77
Dental restoration through filling – up to 2 layers	23	1,074.98	46.74
Pre-prosthetic surgery	22	598.34	27.20
Dental restoration through filling – more than 2 layers	21	1,040.17	49.53
Removal of oral lesion	20	712.88	35.64
Root smoothing	19	674.14	35.48
Oral swab	16	253.11	15.82
Oral biopsy	16	525.32	32.83
Removal of internal fixator	13	501.62	38.59
Other dental repair (selective polishing)	13	428.72	32.98
Removal of gingival tissue	9	224.82	24.98
Gingival biopsy	9	295.49	32.83
Gingivoplasty	8	217.27	27.16
Crown reapplication	8	155.23	19.40
Extraction of deciduous tooth	7	200.54	28.65
Osteoplasty	7	311.75	44.54
Apicoectomy	6	269.42	44.90
Removal of mandibular dental lesion	5	305.80	61.16
Splinting	5	236.02	47.20
Tooth polishing	4	85.09	21.27
Temporary filling	4	73.92	18.48

Table 12. Simulated "bottom up" approach in the calculation of physician costs in the Dentistry and Stomatology Clinic

Cost Pool	Actual Costs ("Top Down" Approach) (€)	Number of Physicians Necessary on the Basis of the Volume of Output	Annual Average Cost of a Physician (€)	Simulated Costs Based on Output ("Bottom Up" Approach) (€)
Emergency Room	91,785.51	2.93	84,005	245,879.92
Pediatric dentistry	36,714.21	0.93	84,005	78,227.59
Conservative	45,892.76	3.87	84,005	324,982.31
Prosthetics and gnathology	59,856.04	0.64	84,005	54,097.05
Endodontics	45,892.76	1.34	84,005	112,852.77
Oral Pathology	45,892.76	0.82	84,005	68,899.35
Oral and Periodontal Surgery	64,249.86	2.87	84,005	241,207.88
Hygiene and Prevention	45,892.76	4.59	84,005	385,803.49
Inpatients clinic	18,357.10	0.21	84,005	17,390.07
Total	**454,533.74**	**18.21**	**84,005**	**1,529,340.41**

on extremely simplified assumptions, still offers valuable contributions to a better understanding of the economic benefits arising from this peculiar method of organizing the delivery process of the treatments.

Case Study 3: Cost Analysis of Computed Tomography

The third case study, building on previous experiences of cost measurement in radiology (Stacul et al., 2006; 2009), was developed within the Radiology department of the Teaching Hospital of Trieste, which offers specialist radiological treatments grouped in the following areas: interventional radiology, echography, nuclear magnetic resonance, and computed tomography. M.A. Cova, Chair of the Radiology Department at the AOU (Teaching Hospital) of Trieste significantly contributed to the development of this case study, along with R. Cuttin, F. De Grassi. The authors are also thankful to V. Tolot, who developed a master thesis on this topic (under the supervision of M.A. Cova, A. Rebelli, and G. Grisi) and to the entire staff of the Radiology department.

A specific cost pool was designed for each of the specialties previously listed. The project, however, primarily focused on the analysis of the cost drivers relevant for the computed tomography (CT) treatments. In fact, the department recently invested in new CT equipment, thus expanding the set of diagnostic treatments offered and the volume of activities performed. All the data collected in this study refer to 2012.

A particular emphasis was placed on *time* as the main determinant of the costs for CT, because the treatment is also performed under conditions of urgency. Given the high volume of treatments performed under those circumstances, it was not possible to staff the equipment using on-call personnel. Instead, it was necessary to have on-duty personnel available on site, in order to face emergency and urgency situations. This differentiates the organization of the Radiology department from the one of the Hemodynamic clinic, leading to a greater difference in costs between elective and urgency CT treatments, compared to the same difference calculated for the hemodynamics treatments.

The methodology applied was developed along the following phases:

1. Organizational analysis aimed to identify:
    a. Different sets of resources devoted to perform the same type of specialist treatments (cost pools);
    b. Clusters of treatments, differentiated by type and conditions of performance (elective/urgency).
2. Definition of costs specific to each cluster (mainly consumable material costs).
3. Designation of appropriate resource drivers and other cost allocation bases needed in order to trace or allocate the overhead costs to the previously identified cost pools.
4. Definition of the proper activity drivers necessary for tracing the cost aggregated in the previous step to the different treatments.

The hospital cost accounting system aggregates all the financial information regarding the Radiology department in one single cost center, although the department is divided into two different subunits. Moreover, the level of analysis of data provided by the cost accounting system is not adequate for the aims of the project team. This led to some difficulties in gathering and analyzing all the necessary data, only overcome thanks to interfunctionality of the team.

With reference to phase 1b), seven types of CT treatments were initially identified:

1. CT angiogram,
2. Abdominal CT,
3. Neck CT,
4. Cranial CT,
5. Skeletal muscular CT,
6. Thoracic CT,
7. Urinary tract CT.

All the treatments listed above were differentiated upon the employment of a contrast medium (i.e., a substance used to enhance the contrast of structures or fluids within the body in medical imaging), since its use determines an increase in the time needed to perform the treatments, adding further medical procedures, otherwise unnecessary. Additionally, treatments were differentiated depending on whether the patient was internal or external (most, but not all, external patients are subject to elective treatments). This led to 28 theoretical clusters of treatments, subsequently reduced to 24 thanks to the elimination of some unlikely combinations (some treatments are only performed using a contrast medium). The clusters so identified represent the final cost objects selected by the research team. As previously mentioned, one relevant factor influencing the amount of costs of the treatments is represented by the use of resources during night and holiday shifts, according to the work organization adopted by the unit, which requires the presence of personnel on-duty during those periods. As it will explained later, this factor influences the amount of available capacity and, therefore, the cost of the treatments performed under urgency regimes.

CT scans are performed using two separated sets of resources (CT machines and physical spaces), called "sections" from now on, with a total output of approximately 21,000 treatments per year. Table 13 shows time schedule for the two groups of resources:

As shown in Table 13, the two sections do not always operate at the same time. Section 1 is operational 24 hours a day, 7 days a week, whereas section 2 does not work at nights and on weekends and holidays (although it is sometimes used as a backup facility during downtimes of section 1). Therefore, the total capacity is compounded considering the working hours of the two sections combined, including both personnel and equipment. The greater level of costs caused by urgencies (due to the necessity of having

Table 13. Schedule of usage of CT equipment

	CT Section 1							
Time slot	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**	**Holidays**
7:20am-2pm	Elective	Elective	Elective	Elective	Elective	Urgent	Urgent	Urgent
2pm-8pm	Urgent	Urgent	Elective	Urgent	Urgent	Urgent	Urgent	Urgent
8pm - 7:20am	Urgent	Urgent	Urgent	Urgent	Urgent	Urgent	Urgent	Urgent
	CT Section 2							
Time slot	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**	**Holidays**
7:20am-2pm	Elective	Elective	Elective	Elective	Elective	---	---	---
2pm-8pm	Elective	Elective	Urgent	Elective	Elective	---	---	---
8pm - 7:20am	---	---	---	---	---	---	---	---

resources available for a longer period of time) and the different rates of utilization of capacity during urgencies (due to the more efficient saturation attainable for elective treatments), make particularly important differentiating the cost of the treatments in reference to this attribute of the activity. In cost accounting literature, attributes are coding schemes associated with each activity that facilitate reporting of activity cost (Kaplan & Cooper, 1998, p. 92). For this reason, determining the per-unit cost of each section was considered less relevant. Moreover, the different equipment used by the two sections, characterized by different levels of efficiency, could lead to different levels of cost per treatment, without any relevance from an economic point of view, since the use of different equipment does not appear to be linked to a deliberate choice.

Figure 9 illustrates the steps undertaken for measuring the cost of CT treatments provided by the unit.

Figure 9 highlights the following steps:

1. Costs of materials are traced to the treatments (step 1).
2. Indirect and overhead costs are attributed to different cost pools, including the one relevant for our analysis (CT), using resource drivers and appropriate allocation bases (step 2).
3. Costs directly referring to a single cost pool are traced to it (step 3).
4. Costs of the CT cost pool are differentiated between operating hours dedicated to elective treatments and hours needed to face demand of treatments arising from urgencies (step 4). Naturally, the resource driver used in this step was a duration driver.
5. Costs pertaining to each cost pool are traced to the treatments, by means of an activity driver also represented by a duration driver.

Table 14 shows the direct costs of the treatments, typically consumable materials.

As a result of the activities performed in step 2, Table 15 reports costs of personnel, divided by category, for the CT cost pools and for the other pools combined.

Table 16, reports, for all the clusters of treatments considered, the volume of output and the per-unit cost figures obtained as the final outcome of the cost measurement process here described.

The ratio between the volume of urgent and elective treatments is 3:4, while the ratio between their respective costs varies from 1.8 to 2.1, depending on the treatment. The same cost ratio,

Figure 9. Steps of the cost measurement process for CT treatments

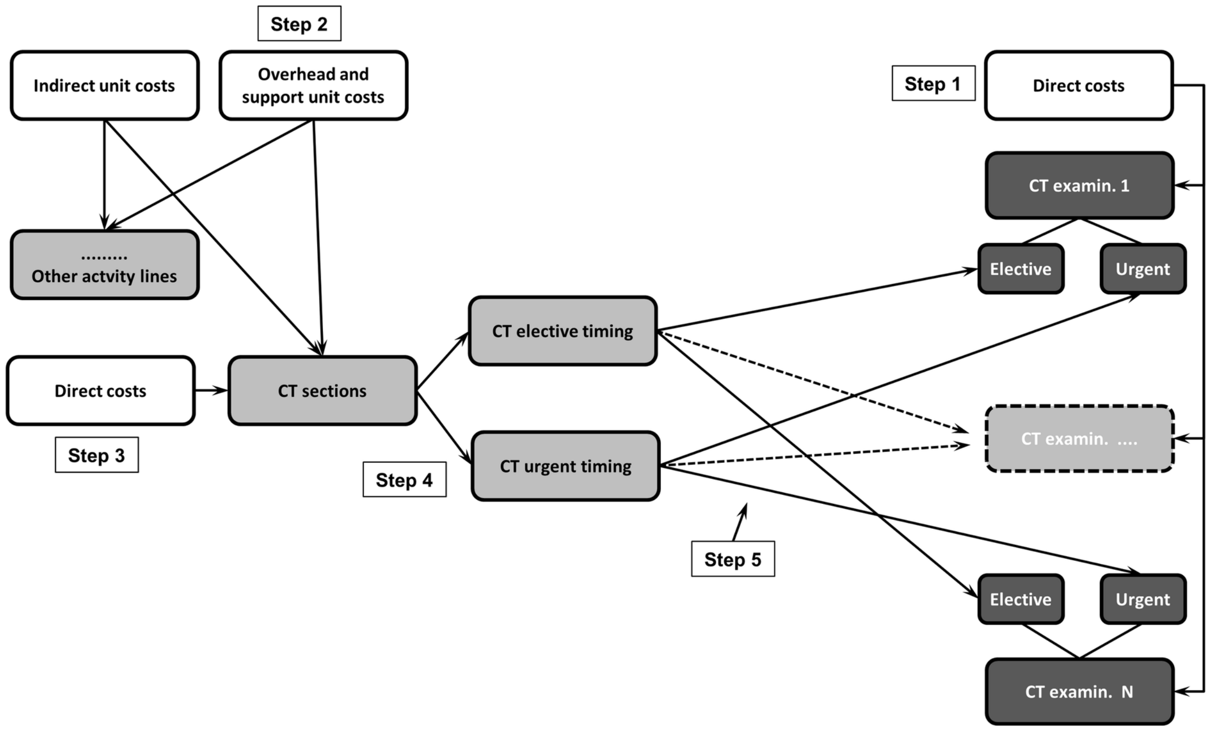


Table 14. Direct costs of the CT treatments

Treatment	With/Without Contrast Medium	Cost of Direct Materials (€)
CT angiogram	With contrast	30,4
	Without contrast	0,9
Abdominal CT	With contrast	29,8
	Without contrast	0,9
Neck CT	With contrast	29,4
	Without contrast	0,9
Cranial CT	With contrast	29,4
	Without contrast	0,9
Skeletal muscular CT	With contrast	29,4
	Without contrast	0,9
Thoracic CT	With contrast	29,4
	Without contrast	0,9
Urinary tract CT	With contrast	29,7

when calculated taking into consideration the average cost for each of the two classes of treatment, decreases to 1.5 due to the greater weight of elective treatments (characterized by a lower per-unit cost). The management of the hospital reputes that the ratio of 1.5 represents a valid measure of the different intensity in the consumption of the resources between urgent and elective treatments. The average cost per treatment, calculated ignoring the attribute of urgency, is approximately equal to €126. It is therefore evident the measurement error it conveys, since it underestimates (by €31, or 19.7%) the cost of urgent treatments, and overestimates (by €24, or 23.6%) the cost of elective treatments. The size of the error demonstrates how insidious comparisons may be, when made between structures devoted uniquely to elective treatments and structures that, instead, also need to face urgencies. In particular, comparisons are improper when conducted in terms cost per unit (i.e., on the basis of volumetric terms). Such calculations, in fact, do not allow to adequately consider the greater complexity (and, therefore, the increase in costs) deriving from the delivery of urgent treatments.

The differentiation between internal and external patients, instead, did not lead to uniform and significant variances in cost figures. An additional step in the analysis could consist in further detailing the diagnostic treatments, achieving a more precise and accurate measurement of times.

FUTURE RESEARCH DIRECTION

The methodology applied in the previous case studies allowed to identify a unitary framework for organizational analysis and cost measurement, developed within the Teaching Hospital of Trieste. This framework is susceptible to be applied to other units of the hospital in order to fully appreciate differences in cost of treatments arising from complexity in the activities performed and different use of available resources. Information so generated should be subsequently employed to develop new forms of organizations capable of reducing the level of process complexity (without affecting the volume and the quality of the care provided), and the amount of unused capacity. In order to improve the performance levels of healthcare processes it is indispensable to transcend departmental boundaries. Cost reductions and performance improvements, in fact, can only be achieved through reconfiguring treatment processes, adopting what Cokins (2001, p. 38) calls "a cross-functional process-based thinking". The purpose of accounting is to provide decision makers with reliable and relevant information. Its value is therefore maximized if it drives management to change unnecessary routines. Additional research opportunities exist in examining how incentive systems may be configured in order to achieve this goal.

CONCLUSION

The application of the ABC framework within the Teaching Hospital of Trieste, in order to obtain new and relevant information about the costs of selected treatments, has led to highlight the following issues:

1. ABC methodology is particularly useful for appreciating the different levels of complexity at which activities can be performed. Complexity, in fact, is one of the typical characteristics of healthcare services because of the tight interconnection among all the different activities involved in the therapeutic processes, and because of the high technological content of the resources employed. Moreover, processes in healthcare cannot be easily standardized, since the manners of their execution are imposed by the conditions of the patient. The three case studies emphasized the significant differentials in costs arising from contexts characterized

Table 15. Cost of personnel divided by category in Radiology cost pools

	All Personnel			Physicians			Nurses			Technicians			Other Personnel		
	Avg, Weekly Hours	**%**	**Total Cost (€)**	**Avg, Weekly Hours**	**%**	**Total Cost (€)**	**Avg, Weekly Hours**	**%**	**Total Cost (€)**	**Avg, Weekly Hours**	**%**	**Total Cost (€)**	**Avg, Weekly Hours**	**%**	**Total Cost (€)**
CT pool	568	24.4%	1,302,761	174	28.8%	689,056	144	26.7%	181,795	250	22.9%	431,910	0	0.0%	0
Other pools	1.756	75.6%	3,790,574	430	71.2%	1,701,182	396	73.3%	504,334	841	77.1%	1,448,907	108	100.0%	136,152
Total	**2.324**	**100.0%**	**5,093,335**	**604**	**100.0%**	**2,390,237**	**540**	**100.0%**	**686,129**	**1.091**	**100.0%**	**1,880,817**	**108**	**100.0%**	**136,152**

by varying degrees of complexity. At the same time, the cases allowed to illustrate the cost measurement methodology employed, underlining how the analysis of a complex system can only be performed by adopting a set of complex parameters. In fact, any organization involved in the delivery of complex activities needs to adopt a complex (and therefore expensive) managerial accounting system. However, the benefits, in terms of relevance of the information generated by the system, almost invariably repay the costs.

2. Some organizations, such as hospitals, banks, and insurance companies, are already used to measurement because they are subject to various forms of control by external authorities, requiring them a constant flow of data. In these contexts, developing an advanced cost accounting system is a relatively simplified process, because:
   a. Available databases are often already adequate to the task, although integrations and adjustments may be needed,
   b. The gathering of new data needed to fill the informational gap is usually facilitated by a habit of attention to measurement.
3. Companies reap the full benefits of ABC systems if they use them as a basis for developing "what-if" analyses. Information generated by ABC systems does not need to be systematic, but it can be produced on an *ad hoc* basis when the organizational decision making process requires it. The relevance of ABC information is connected to its capability of drawing attention to cost determinants. Therefore, the ABC methodology is a valid support for decision-making, and an excellent cost analysis tool, but it does not necessarily represent the most efficient cost measurement system. As a matter of fact, being based on the analysis of activities, ABC systems are prone to a high rate of obsolescence, and their maintenance costs

Table 16. Final per-unit cost figure, divided by type of CT scan, origin of patient, and timing of the treatment (elective/urgent)

Treatment	Origin of Patient	Contrast Medium (CM)	Urgent		Elective		Total/Average	
			Volume	Per-Unit Cost (€)	Volume	Per-Unit Cost (€)	Volume	Per-Unit Cost (€)
CT Angiogram	External	With CM	4	314	695	162	699	163
		Without CM						
	Internal	With CM	567	323	753	166	1,320	233
		Without CM						
Abdominal CT	External	With CM	16	283	904	149	920	151
		Without CM	1	160	127	76	128	76
	Internal	With CM	972	270	1,335	142	2,307	196
		Without CM	245	159	185	75	430	123
Neck CT	External	With CM	4	259	148	138	152	142
		Without CM	1	134	1	64	2	99
	Internal	With CM	19	239	73	128	92	151
		Without CM	4	133	8	63	12	86
Cranial CT	External	With CM	7	183	310	103	317	105
		Without CM	6	113	469	55	475	56
	Internal	With CM	245	186	508	104	753	131
		Without CM	5,527	113	3,321	54	8,848	91
Skeletal muscular CT	External	With CM			17	104	17	104
		Without CM	2	154	229	73	231	74
	Internal	With CM	65	290	65	152	130	221
		Without CM	1,320	155	828	73	2,148	123
Thoracic CT	External	With CM	18	243	459	131	477	135
		Without CM	5	130	128	62	133	64
	Internal	With CM	278	237	750	127	1,028	157
		Without CM	104	129	494	60	598	72
Urinary tract CT	External	With CM	1	385	124	197	125	199
		Without CM						
	Internal	With CM	3	377	73	191	76	199
		Without CM						
Total/Average			**9,414**	**157**	**12,004**	**102**	**21,418**	**126**

tend to be steep, because activities evolve over time, especially in complex organizations. Traditional cost accounting systems, on the other hand, tend to be more stable and less expensive, because responsibility centers change less frequently than activities do. Unfortunately, the quality of information they provide is not up to the level of that assured by the implementation of ABC systems.

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KEY TERMS AND DEFINITIONS

Activity-Based Costing (ABC): A costing methodology that identifies activities performed within an organization and use them to assign the cost of resources to products or other cost object.

Activity Driver: A measure of frequency and intensity of cost object demands on an activity, used in ABC for tracing activity costs to cost objects.

Capacity: The ability to produce during a given time period, with an upper limit imposed by the level and quality of resources available.

Cost Pool: An accounting term that refers to a group of associated costs that all relate to a specific cost object. It is usually used to correlate costs with a specified cost driver.

Overhead: A group of costs that are necessary to the continued functioning of an organization but cannot be immediately associated with its output.

Resource Driver: A measure of quantity of resource consumed or required by an activity. It is used in order to trace an appropriate portion of cost to the activity.