

# ADOPTION OF A RISPACS SYSTEM IN A HOSPITAL: COST-BENEFIT ANALYSIS

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## ABSTRACT

*Cost-benefit analysis (CBA) is one of the most widely used evaluation methods for studying the effects of different programs on the allocation of resources and the well-being of the involved agents. Therefore, it is possible to assess the cost-effectiveness of a PACS by analysing the relationship between costs and savings. A complete digitalization of the radiology acquisition, reporting and archiving process leads to a significant improvement in the quality of reporting, allowing the radiologist to intervene directly on the image display, making it faster and more accurate. The savings resulting from the implementation of the PACS can only be appreciated after some time; they take the form of a reduction in the running costs of the Diagnostic Imaging Service, above all due to the lower consumption of X-ray films. Secondly, there is a reduction in the number of staff employed in activities related to film processing and the redistribution of the space required for archives. A proper financial plan and a dilution of the required investment over several years allow an improvement of the systems to be achieved without increasing the costs for the company.*

## INTRODUCTION

Technological innovations of the last decade have inevitably brought radical changes, both in daily life and in the work environment, ensuring a simplification of some activities such as, for example, data and information searching.

Specifically, nowadays, there are a number of information systems in healthcare related to radiology practices, such as prevention, diagnosis, therapy, care and administrative aspects.

These include Hospital Information System (HIS), Radiology Information System (RIS) and Picture Archiving and Communication System (PACS). These systems are completely independent, although it is possible to interchange certain classes of data between them.

Information systems, in general, have the function of coordinating the collection, management, presentation and exchange of information. In an organization, such as a hospital or radiology department, an information system's purpose is to enable the management of information that is useful to understand the status of the organization's operations. An information system is the automated component of the information system. Within the hospital, radiology is probably the department in which greater use is made of advanced technologies: among these, information technology occupies a prominent place. Within an ideal integrated information system for radiology, the following features should be present: digital acquisition of images provided by various diagnostic equipment and associated data; processing and storage of information relating to different moments of the patient's medical history; sharing of all information of clinical and administrative utility.

In particular, Hospital Information System (HIS) aims to manage the information needed for various aspects of hospital life in a unified manner. The HIS systems

nowadays installed are mainly oriented towards administrative-financial purposes. As regards the information content managed by the system is concerned, in general, in a HIS there are three main classes of data: those relating to patients (personal details, clinical history, etc.), those relating to activities (days of hospitalization, diagnostic tests, etc.) and those relating to resources (staff, equipment, financial resources).

The RIS (Radiological Information System) is a subset of the HIS, since it is responsible for managing the information generated in the radiology department, within the hospital structure. The

RIS is responsible for the booking and acceptance of patients in radiology, logistical aspects, reporting, archiving of reports. The main phases in which RIS intervenes during radiological operating cycle are:

- Exam Request. In this phase, RIS is implemented through activities of collection of a series of administrative information and clinical interest. The administrative information includes: the patient's personal details, the type of examination to be performed, the operator and the room, the presence of any time constraints on the performance of the examination (urgent or routine examination). These data can be collected directly from the patient or acquired from other information systems.
- Radiological diary management;
- Acceptance phase. The patient's arrival at radiology to perform the diagnostic exam provides the RIS with an additional opportunity to correct or supplement the data collected up to that point. These items, collected prior to the examination, may also be intended to refine the process of authorization to perform the examination. If the exam is finally cleared, then through RIS the patient is accepted for the exam

- (to be distinguished from over-the-counter, which has a purely administrative meaning). When digital diagnostic equipment (Angiography, CT, MRI, etc.) is linked to the RIS by means of a dedicated protocol, defined by the DICOM standard under the term “work list management”, patient data entry occurs automatically, without operator intervention. This automatic passage of data between RIS and equipment avoids errors that could lead to misalignment of information.
- Execution of the examination, which coincides with the production of the diagnostic images and associated data.
  - Reporting. Generally, RIS keeps, for at least one year, all reports on “online” memories. Subsequently, the report is placed on an off-line support (i.e., accessible thanks to the intervention of an operator who manually retrieves the memory support and inserts it into the reader). Moreover, the progressive reduction in the cost of digital memories is leading to a progressive abandonment of offline archiving, with the maintenance of the entire archive of reports online, so that it is immediately available.
  - Archiving phase. The RIS stores the textual information collected and generated during the diagnostic process. For the archiving of the images the information system used is represented by the PACS.
  - Management of the system archive to quickly perform statistics on multiple parameters. Statistical data can also be used to monitor whether the system is functioning optimally, to detect which dysfunctions are occurring, to identify necessary changes, and to correct them. In particular, statistical data are used to quantify the productivity of the system, detect variations in the demand for examinations so as to predict fluctuations, and detect the quantitative relationship between the number of internal and external examinations performed;
  - Stock management. It allows constant monitoring of inventories of contrast media, secretarial aids, guides, medications, signaling the need for new orders.

PACS (Picture Archiving and Communication System) consists of a network of computers interfaced with digital equipment in a system designed to acquire, transmit, store, display and process digital images. The three goals and benefits of PACS are organizational, clinical, and economic:

- Organizational aspect: The main objective is to improve accessibility to images and clinical, laboratory or specifically radiological information related to the patient and thus allow more accurate and faster diagnosis. In the electronic archive, this information does not degrade over time, is not lost and can be quickly viewed;
- Clinical aspect: the main objective is the improvement of diagnostic accuracy, especially for the application of sophisticated digital image processing methods. The real-time availability of images of all diagnostic examinations performed by the patient will improve the quality of interpretation and speed up the flow of information and reports, thus promoting the rationalization of work, saving time and reducing errors.

- Economic aspect: The cost of implementing and managing a digital image storage and transmission system is the crucial node in the implementation of PACS. The complete dematerialization of radiographic images has advantages in terms of speed of access, reduction of space and time for archiving, as well as greater security for the preservation of iconography, even after many years, for scientific, legal etc. evaluations.

PACS and RIS are integrated within HIS. This last solution is still not sufficiently perfected since RIS and PACS have not experienced a simultaneous and homogeneous development: consequently, they are currently almost always separate systems, often with limited possibilities of data exchange. In recent years, however, many research centers and most of the radiological industries have made a considerable effort to make possible an increasingly effective integration between RIS and PACS.

### *Cost-Benefit Analysis*

Cost-benefit analysis (CBA) represents one of the evaluation methods widely used to study the effects that various programs produce on the allocation of resources and on the well-being of the agents involved. Therefore, it is possible to consider the economic viability of a PACS through the analysis of relationship between costs and savings. It consists of an attempt to translate into monetary terms all the resources required to implement a given program, and all the possible effects that such a program may cause. The comparison between the resources employed (in terms of costs) and the results obtained (in terms of benefits) is used to understand the economic impact of the program in question. In particular, the cost represents the burden that a company must bear in order to acquire the inputs it needs, such as sophisticated equipment, computers, communications networks and displays. In determining costs, in addition to the initial investment for hardware, which represents the historical cost of the project, it is also necessary to calculate the annual operating expenses generated by the project itself, in terms of both variable costs (such as consumables and maintenance services), and potential fixed costs related to the personnel involved in the new healthcare program, which must be incurred regardless of the level of activity. The cost of adopting and maintaining a PACS system can be entirely absorbed by savings on the purchase, storage and disposal of films and the reduction of personnel involved in their handling, as well as by the increased productivity of the Radiology OUs, which can lead to a significant reduction in hospitalization times. The dematerialization and networked availability of each patient’s imaging archive allows quick access to their iconographic history at any corporate location, preventing unnecessary duplication (and associated costs) and reducing the risk of fraudulent use of images. The adopted systems should be able to interface with existing equipment and adopt common modes of use, to reduce the need for training and homogenize processes. The standardization of the access modalities and their networking would easily allow the adoption of teleradiological workflows in the business units where there is a shortage of personnel or the average number of examinations carried out is not such as to justify the presence of radiologists in the hours of

COSTI PRE-PACS	2017	2018	2019	2020	2021		
Costo pellicole (iva inclusa 22%)	€ 685.640,00	€ 685.640,00	€ 685.640,00	€ 685.640,00	€ 685.640,00		
Costo annuo rotoli carta termica ecografia	€ 8.500,00	€ 8.500,00	€ 8.500,00	€ 8.500,00	€ 8.500,00		
Buste esami da archiviare	€ 10.000,00	€ 10.000,00	€ 10.000,00	€ 10.000,00	€ 10.000,00		
Costo manutenzione sviluppatrici	€ 12.800,00	€ 12.800,00	€ 12.800,00	€ 12.800,00	€ 12.800,00		
Costo personale archivio (70% temp/uomo) x 4	€ 72.800,00	€ 72.800,00	€ 72.800,00	€ 72.800,00	€ 72.800,00		
Costo locali archivio	da valutare	da valutare	da valutare	da valutare	da valutare		
Costo movimentazione pellicole depositi esterni	da valutare	da valutare	da valutare	da valutare	da valutare		
Smattonimento pellicole escluso raccolta differenziata	11.500,00	11.500,00	11.500,00	11.500,00	11.500,00	<b>Totale 5 anni</b>	
Costo totale per anno pre-pacs	<b>801.240,00</b>	<b>801.240,00</b>	<b>801.240,00</b>	<b>801.240,00</b>	<b>801.240,00</b>		<b>€ 4.006.200,00</b>
<b>RIDUZIONE COSTI ADOZIONE PACS</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>		
Costo pellicole							
Costo annuo rotoli carta termica ecografia							
Costo manutenzione sviluppatrici	0	0	0	0	0		
Costo personale archivio	€ 72.800	€ 36.400	€ 18.200	€ 9.100	€ 4.550		
Costo locali archivio	da valutare	da valutare	da valutare	da valutare	da valutare		
Costo movimentazione pellicole depositi esterni	da valutare	da valutare	da valutare	da valutare	da valutare		
Smattonimento pellicole escluso raccolta differenziata	11.500,00	11.500,00	11.500,00	11.500,00	11.500,00	<b>Totale 5 anni</b>	
totale per anno	<b>€ 84.300</b>	<b>€ 47.900</b>	<b>€ 23.700</b>	<b>€ 20.600</b>	<b>€ 16.050</b>		<b>€ 198.550</b>
<b>COSTO SISTEMA PACS</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	costo unitario	
Sener (4 X PO CON PS)	€ 200.000					50.000	
Sener archivio (ARCHIVIO CENTRALE + 2 PRESIDII SENZA PS)	€ 80.000					40.000	
Costo dvd per esami esterni (15000 x 1,2 Eur)	€ 18.000	€ 18.000	€ 18.000	€ 18.000	€ 18.000		
Costo 16 Workstation (in aggiunta alle consolle esistenti)	€ 192.000					12.000	
Costo 7 x PO = 42 consolle visualizzazione	€ 294.000					7.000	
Costo 12 carrelli sala operatoria (2/3 per ospedale)	€ 90.000					7.500	
Costo 12 robot CD/DVD in aggiunta a quelli esistenti	€ 78.000					6.500	
Software	€ 80.000	€ 8.000	€ 8.000	€ 8.000	€ 8.000		
Costo personale gestione PACS							
manutenzione aggiornamento hardware		€ 10.000	€ 10.000	€ 10.000	€ 10.000		
totale per anno	<b>€ 1.032.000</b>						
accantonamento imprevisti		€ 10.000	€ 10.000	€ 10.000	€ 10.000		
Manutenzione	0	€ 90.000	€ 90.000	€ 90.000	€ 90.000	<b>Totale 5 anni</b>	<b>Risparmio 5 anni</b>
Spesa per anno	<b>1.032.000,00</b>	<b>136.000,00</b>	<b>136.000,00</b>	<b>136.000,00</b>	<b>136.000,00</b>		
Spesa totale per anno PACS + spese ineliminabili	<b>1.116.300,00</b>	<b>183.900,00</b>	<b>165.700,00</b>	<b>156.600,00</b>	<b>152.050,00</b>	<b>1.774.550,00</b>	<b>2.231.650,00</b>
Costo per anno	<b>354.910,00</b>	<b>354.910,00</b>	<b>354.910,00</b>	<b>354.910,00</b>	<b>354.910,00</b>		
distribuzione spesa con pagamento dilazionato	372.100,00	556.000,00	537.800,00	156.600,00	152.050,00	1.774.550,00	2.231.650,00

Tab. 1

lower influx, freeing up valuable resources for other activities or balancing the workloads with structures that instead are occasionally in situations of overload. The number of Imaging Diagnostics investigations in a hospital setting has an almost linear relationship with the number of cases treated, so that as efficiency increases and therefore as the number of admissions and bed occupancy turnover increases, there is an increase in requests for X-ray investigations. A UOC of Imaging Diagnostics with long turnover times can significantly slow down the activity of the entire hospital and represent, like the other services, a slowdown for the activity of hospitalization. Le metodiche che producono un numero elevatissimo di immagini per esame (TC, RM volumetrica e PET-TC) hanno reso di fatto impossibile stampare su pellicola esami formati da 800 e più immagini, che possono pertanto essere trattate, movimentate, esaminate e archiviate esclusivamente in formato elettronico. After the introduction of computer-based equipment (CT, MRI, PET) the digitization of images has rapidly extended to traditional radiographic images, which, in many areas are still generated in analog mode and only later transformed into digital images (CR systems). This kind of equipment should be considered residual, as almost exclusively "direct digital" radiographic equipment, in which the image is acquired in digital format without conversions, is offered on the market. All major imaging equipment vendors adopt a common image processing standard (DICOM), which allows all machines to read and manipulate images from different equipment. Various hardware and software

components are required to accomplish typical PACS functions:

- image acquisition devices from the different diagnostic modalities (or imaging systems);
- storage devices for diagnostic images on digital media (archive system);
- image display, processing and printing devices, represented by workstations and their peripherals. This group of equipment will also include systems for reproducing on non-erasable media the surveys to be provided outside the firm.

The capacity of the archives should be sized on the basis of the space needed, considering the average of the surveys carried out in previous years and the equipment in use.

The cost of storage media has progressively decreased over the last few years and will probably continue to decrease. This consideration leads to not initially overdoing it when sizing storage capacity. It is foreseeable, in fact, based on market trends, that every three years the capacity of storage disks will double without any change (in absolute terms) in their price. On the other hand, it is essential that the archives be scalable and expandable, so that, during the theoretical operating life of the system, further memories can be added and the overall cost of these will decrease. With a large and robust set of hardware and appropriate management software, archive servers can support many processes running concurrently. In addition to their primary function of archiving images, the archive servers have the task of managing the flow of images coming to the PACS from the acquisition

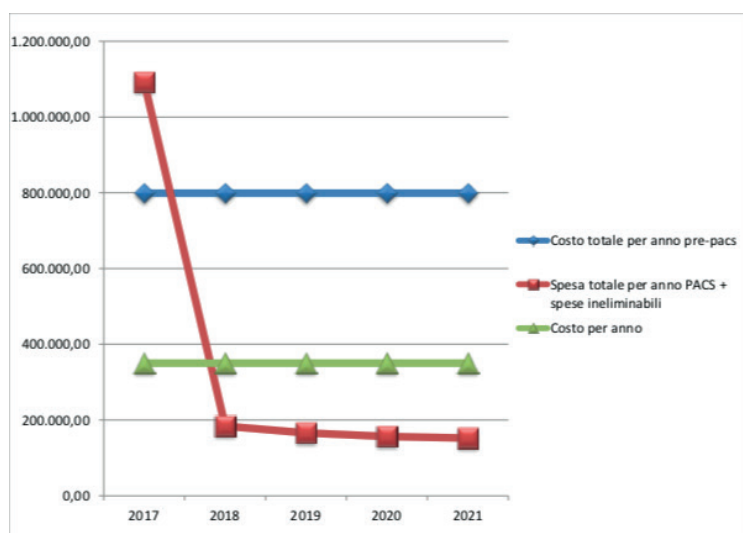
computers and sending them to the various workstations. From the point of view of a filmless radiology system, the PACS system has mission-critical functions and, therefore, it is essential that, as with the hardware, the database also has redundant archives to safeguard the data even in the event of faults. The mission-critical role within the system and the need for privacy protection imposes, moreover, access control procedures, both from an IT and physical point of view, to the data.

In many realities, the coexistence of analog systems with digital or hybrid digital systems (CR systems), forces the maintenance of the inefficient production of X-ray films. Many of the benefits of digitization are nullified by the need to still produce hard-copy on film. Also unquestionable is the cumbersome nature of the manual archiving mechanism, resulting in inefficiencies and possible loss of radiograms. Regarding the economic values, the consumption of films for the year 2016 was about 400,000 films for a counter value of about € 562,000 + VAT (22%). The cost of disposing of the films is variable and is estimated at approximately € 11,500/year + the cost of separate collection, as disposal does not normally include the separation of paper envelopes and copies of reports from the films being disposed of.

The cost and configuration of the PACS system vary according to the technical choices and the manufacturing company. Each manufacturing company has different solutions, but the average cost can be assumed according to the scheme in Table 1.

The amortization of a PACS system, i.e., the administrative-accounting procedure by which the cost of an asset is spread over a number of years, is scheduled over five years.

The first year does not require any hardware maintenance costs, as the electronic equipment is under warranty, so the cost of the maintenance fee is absent. Any offers including maintenance for the period indicated may be negotiated if necessary. Estimated maintenance for subsequent years also covers hardware replacement in case of failure. It should be noted that some of the figures in the table may vary considerably from one manufacturer to another, and the reported costs are an average reference. However, the calculated overall cost, for a system suitable for the needs



Tab. 2

shown, has never exceeded the reported cost estimate. A higher cost is represented by the pairs of monitors to be installed for dedicated mammography reporting stations. The pathway for the production, interpretation and archiving of radiographic investigations in the Radiology OUs shows significant slowness and undoubtedly presents opportunities for improvement. The path of acceptance, execution, reporting, and archiving is undoubtedly made faster and more efficient by the introduction of a PACS system. The hypothesized cost largely balances the expected annual expense of traditional films over the 5 years considered.

*A more rapid turnover of radiological investigations has, clearly, a positive impact on the efficiency of the system, with shortening of hospitalization times and elevation of the rotation indexes per bed. Ideally, no more than 24 hours should elapse between the request for investigation, execution and submission of the report for ordinary hospitalizations. The adoption of a PACS system would lead to an improvement in this parameter: suffice it to think that the UOCs of Orthopedics almost systematically request the radiographic investigations of their patients for viewing.*

*A complete digitalization of the process of acquisition, reporting and archiving of radiology leads to a significant improvement in the quality of reporting, allowing the radiologist to intervene directly on the display of images, making the reading faster and more accurate. Similarly, the need to request previous examinations in the archive would be eliminated, as examinations would be available automatically, when present, for comparison. The whole workflow would be faster, as there would be no need to wait for the development and printing of the images to pass to another patient. It has been calculated that the introduction of a PACS system would increase requests for examinations, not so much because of the ease with which results and images would be available, but because of the rapidity of turnover of requests, resulting in shorter waiting lists for examinations and increased bed turnover rates. The benefits of rapid and continuous system availability would be quickly detectable by medical personnel. Analyzing them more specifically, these benefits appear to be:*

- *Patient Benefits: reporting times are reduced, radiation exposure is lower (duplication between different sites is eliminated), and consultations between colleagues are faster. Finally, patient stress and the need for repeat investigations are significantly lower.*
- *Benefits for healthcare staff: reduce time and labor costs, better organize exams, increase professional growth for staff. Quick and consistent access to previous exams. Guaranteed preservation of images. Better diagnoses. Improved teaching capacity because of the ease of creating teaching archives for radiologists and other staff in training. Improved staff attitude toward work for improved job skills.*
- *Benefits to facility administrators: decreased non-specialist support staff, reduced film costs, shorter length of stay, reduced litigation, and improved management.*
- *Benefits to society: increased productivity, decreased queues, greater equity of treatment in quality, efficiency and accessibility of medical care, continuity of care without the need for travel.*

- *Benefits to ambient: long-term reduction of waste and film disposal*

The cost analysis available in Table 1 has been reproduced in the following graph, which shows the rapid decrease in costs compared to the film-based system, with a substantially constant trend, which would make it possible to reach a break-even point (the point at which revenues and costs are equivalent) as early as the second year of operation.

## CONCLUSIONS

The savings made possible by the creation of the PACS can only be appreciated after some time; they take the form of a reduction in the management costs of the Diagnostic Imaging Service, above all due to the lower consumption of X-ray films; secondly, a re-

duction in the number of personnel employed in activities related to the treatment of films and the redistribution of the space required for the archives. Better use of equipment and technical staff is also possible. Above all, however, there is the economic benefit of reducing the time the patient spends in hospital, thanks to a more efficient and rapid system. In conclusion, the technological and professional advantages offered by a PACS system and the extraordinary potential for improving communication (among physicians and to the benefit of patients) and the quality of reports, must be balanced by a careful evaluation of the costs that the use of such a system introduces. A correct financial plan and a dilution of the required investment over several years allow for an improvement in the systems without increasing the company's costs.

## REFERENCES

1. Malathi Srinivasan et Al: Saving time, Improving Satisfaction: the impact of a Digital Radiology System on Physician Workflow and System Efficiency Journal of Healthcare Information Management Vol 20, N2, pag 123-131;
2. AI, De Backer et Al: Picture Archiving and Communication System – Part 2 Cost-Benefit consideration for Picture archiving and communication system JBR-BRT, 2005, 87: 296-299;
3. Ehsan Samei et Al: AAPM/RSNA Tutorial on Equipment Selection: PACS Equipment Overview Radiographics 2004, 24: 313-334;
4. A. Giovagnoni, G.M. Ragetti La complessità nella valutazione economica per l'adozione dei sistemi PACS in F. Schiavon, G Guglielmini, A. Rotondo (a cura di) La comunicazione radiologica nella società del benessere Springer-Verlang Italia 2012 pag. 147-158;
5. Bruce I. Reiner et Al: Effect of Filmless Imaging on the Utilization of Radiologic Services Radiology 2000; 215:163–167
6. Huang HK. PACS: basic principles and applications. New York, NY: Wiley, 1999.
7. Reiner B.I., Siegel E.L.: Technologists' productivity when using PACS: comparison of film- based versus filmless radiography. AJR, 2002, 179: 33-37.
8. Crowe BL. Overview of some methodological problems in assessment of PACS. Int J Biomed Comput. 1992;30: 181-6.
9. <https://www.aiic.it/wp-content/uploads/2016/01/C3-Cagliari-2015.pdf> SISTEMI RIS E PAC dal capitolato alla gestione, corso del VX convegno nazionale AIIC
10. Anatomia Radiologica tecniche e metodiche in radiodiagnostica III Edizione, Fernando Mazzucato
11. SISTEMI RIS E PAC dal capitolato alla gestione, corso del VX convegno nazionale AIIC
12. "Introduzione di sistemi PACS filmless omogenei in Radiologia: Valutazione economica ed analisi costo/benefici", Angela Maddalena, Giuseppina Morgera, Ornella Nappli, Fabio Tamburro
13. Report AIFM Linee Guida per la progettazione, acquisizione, implementazione e gestione di un sistema RIS/PACS

