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A product-based technology transfer model for medical image management systems: the PACS-INR case

Un modelo de transferencia de tecnología basado en productos para sistemas de gestión de imágenes médicas: el caso PACS-INR

Marco Antonio Núñez-Gaona,*,‡ Heriberto Aguirre-Meneses,*,§
María de Lourdes Martínez-Gudiño¶

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Palabras clave: *modelo de transferencia de tecnología, valor de la innovación, propiedad intelectual, sistemas médicos, PACS.*

* Instituto Nacional de Rehabilitación «Luis Guillermo Ibarra Ibarra». CDMX, México.
‡ Medical Systems Department. ORCID: 0000-0002-8450-6003
§ Medical Systems Department. ORCID: 0000-0002-2655-1367
¶ Brain Imaging Department, Instituto Nacional de Psiquiatría «Ramón de la Fuente Muñiz». CDMX, México.

Correspondence:
Heriberto Aguirre-Meneses
Calzada México Xochimilco No. 289, Col. Arenal de Guadalupe, 14389, Tlalpan, CDMX.
Phone: 5559991000, Ext. 16154.
E-mail: ultrahamher@gmail.com

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Abstract

Introduction: technology transfer is of utmost importance when it takes place between two public health institutions. Through this process, the patients can be better cared for, the technology receiver optimizes its resources, and the provider assesses its technology. **Objective:** *i*mplement an instance based in a phased model with deliverables for the technology transfer of the software components of the PACS-INR system for the storage, transmission and viewing of medical images between the Instituto Nacional de Rehabilitación «Luis Guillermo Ibarra Ibarra» (INR-LGII) and the Instituto Nacional de Psiquiatría «Ramón de la Fuente Muñiz» (INPRFM). **Material and methods:** the model proposed considers the stages of innovation assessment, institutional mechanisms for transfer, intellectual property protection, process management, and technology assimilation, as well as the activities carried out at each stage and the actors involved to comply with the interinstitutional agreement. **Results:** based on a phased technology transfer model with deliverable products, a PACS-INR instance was implemented at INPRFM, allowing multimodality image query, retrieve and viewing in accordance with a legal interinstitutional agreement and under the guidelines of the government programs, promoting innovation and extending patient care services. **Conclusion:** since the deployment of the PACS-INR instance, INPRFM medical staff gained rapid and organized access to medical images, enabling early diagnosis, follow-up and personalized treatment of disabling neurological disorders such as stroke, Alzheimer's and Parkinson's, while fostering technological innovation among public health institutions, sharing resources and expertise in the design and development of complex medical systems.

Resumen

Introducción: *la transferencia de tecnología es de suma importancia cuando tiene lugar entre dos instituciones sanitarias públicas. Mediante este proceso, los pacientes pueden ser mejor atendidos, el receptor de la tecnología optimiza sus recursos y el proveedor evalúa su tecnología.* ***Objetivo:*** *implementar una instancia basada en un modelo por etapas con entregables para la transferencia tecnológica de los componentes de software del sistema PACS-INR para el almacenamiento, transmisión y visualización de imágenes médicas entre el Instituto Nacional de Rehabilitación «Luis Guillermo Ibarra Ibarra» (INR-LGII) y el Instituto Nacional de Psiquiatría «Ramón de la Fuente Muñiz» (INPRFM).* ***Material y métodos:*** *el modelo propuesto considera las etapas de evaluación de la innovación, los*

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mecanismos institucionales para la transferencia, la protección de la propiedad intelectual, la gestión de procesos y la asimilación de la tecnología, así como las actividades que se realizan en cada etapa y los actores involucrados para el cumplimiento del acuerdo interinstitucional. ***Resultados:*** *con base en un modelo de transferencia de tecnología por etapas con productos entregables, se implementó una instancia PACS-INR en el INPRFM, que permite la consulta, recuperación y visualización de imágenes multimodales de acuerdo con un convenio interinstitucional legal y bajo las directrices de los programas gubernamentales, promoviendo la innovación y ampliando los servicios de atención al paciente.* ***Conclusión:*** *desde el despliegue de la instancia PACS-INR, el personal médico del INPRFM obtuvo un acceso rápido y organizado a las imágenes médicas, lo que permitió el diagnóstico precoz, el seguimiento y el tratamiento personalizado de trastornos neurológicos discapacitantes como el ictus, Alzheimer y Parkinson, al tiempo que fomentó la innovación tecnológica entre las instituciones sanitarias públicas, compartiendo recursos y experiencia en el diseño y desarrollo de sistemas médicos complejos.*

INTRODUCTION

Technology transfer (TT) and knowledge transfer (KT) are processes where an organization called the provider transfers technology, skills, and knowledge to another organization named the receiver, which can access the receiver's technological developments.[1,2]

In recent years, under a highly competitive global environment, more attention has been paid in developed countries to TT and KT as alternatives to give the receiver the possibility of using the technology under the same conditions and with the same benefits as the provider, who in turn may receive some remuneration or consideration. Innovation is a new organizational or marketing method for a significantly improved product or service within the company's internal practices, workplace organization, or external relations.[3] Innovation is the key element that explains competitiveness.[4]

In this way, both TT and KT boost the development of the organizations involved and make them more competitive; on the one hand, they encourage innovation in research centers, increase the value of their products and services, and increase the possibility of accessing the resources needed to carry out research.[5-7] On the other hand, the receiver benefits from scientific and technological advances by reducing costs and can share information on the experience of using the technology and the knowledge acquired.

Several studies on technology transfer focus mainly on universities as a provider due to their important contribution to technological development and innovation.[8] However, public research institutes are another important source of research, because they have highly specialized personnel and the necessary infrastructure to develop and innovate.

In the healthcare sector, the promotion of strategic TT projects plays a fundamental role in providing new and better services for safe and quality care in the diagnosis and treatment of diseases; being necessary to apply scientific and technological advances that represent high investment costs and specialized training.[9,10]

However, TT projects between universities, research centers, and companies are not always easy tasks. For this, the presence of a Technology Transfer Office (TTO) or a Knowledge Transfer Office (KTO) as an intermediary is necessary to assist in the execution and structuring of technological development and innovation projects.[11]

The objective of requesting support from a TTO or KTO is to increase the economic return on investment to help the sustainability of the Research, Development, and innovation (R + D + i) system, ensuring its efficiency and consequent permanence.

Although the role of a TTO or a KTO is essential in the innovation process of the system (R + D + i), some factors can compromise the development of transfer projects, especially when the innovation represents new knowledge for the organizations that receive the technology. These factors include the failure rate of innovation projects, the mechanism's coordination, the lack of time, and mainly, the high costs they represent for the organizations.[12]

The above makes evident the complexity of undertaking a technology transfer project, even with the participation of specialized entities such as a TTO or a KTO, even more so when the entities sharing the technology are governmental institutions.

There are several documented cases on the technology transfer process in healthcare where the parties involved are usually a public institution or a university and a company that commercializes

the technology. Each of them analyzes aspects of importance for carrying out successful transfer processes, as well as the factors that hinder their implementation and use in the entities receiving the technology.

Murad et al., 2023,[13] consider that effective communication between the technology provider and the technology receiver is a key factor during the transfer process. Based on the above, the intention and feasibility of sharing technology can be established, promoting innovation and optimization of resources. Other critical factors for the success of an effective technology transfer are political support, preparation of the environment where the technology will be implemented and training for its understanding, among others. However, the study by Murad et al. found that in most cases the technology was only partially transferred due to the high technology gap between the provider and the receiver, which limited its functionality in the new environment.

Pyataeva, 2021,[14] highlights the importance of the personnel involved in the technology transfer process, from developers to end users, who must be aware of the capabilities of the technology and its impact on the organization's workflows. It also mentions the importance of government programs to share resources with the aim of creating technological networks in benefit of patient care, allowing for the extension and improvement of health services.

In turn, Klemme et al., 2021,[15] mention that there is poor understanding of how healthcare institutions can successfully acquire, apply and adopt new knowledge and technologies generated from academia because of research and development. For this reason, it is essential to implement agile models that consider technological, organizational and institutional capabilities to ensure a successful transfer process.

Santos et al,[16] conducted in 2019 an analysis of the technology transfer process for the introduction of linear accelerators as part of the Brazilian Unified Health System plan. The objective of this program was to create and expand 80 radiation therapy centers for oncology treatment. However, by 2017, five years after the start of the program, only three centers were released, the implementation of the other centers was delayed, suspended or canceled for various reasons such as engineering and architectural (infrastructure) aspects of the hospitals receiving the technology or by determination of the executive committee (policy), among others. This case shows the complexity of the technology transfer process where the scope of the project, the adaptability of the technology to environments different from the original one and centralized decision making could lead to slow and unstable procedures.

PACS-INR: CASE STUDY

A PACS (Picture Archiving and Communication System) is a system for storing and communicating medical images in a digital format used in imaging services to improve the quality of patient care.

In the health information systems context, technology transfer can play a role in complex and costly innovation projects which require specialized infrastructure and personnel to operate. This kind of system requires constant upgrades to assure a correct performance, and therefore, it could comply with the organization's requirements to support image-based diagnostic medical services. In addition, the system must be adapted to the organization's workflow and budget. It is worth mentioning that a commercial PACS acquisition requires an investment of hundreds of thousands of dollars, depending on the type and complexity of the system. These costs do not allow its purchase for many public health institutions. In addition, its acquisition generates a high technological dependence on the selected receiver and continuous long-term investment in system growth, upgrading, and license renewal.

In this context, and to reduce or eliminate the costs associated with patents, licenses, updates, and maintenance, in 2004, at the *Instituto Nacional de Rehabilitación «Luis Guillermo Ibarra Ibarra»* (INR-LGII), the decision was made to design and implement the PACS-INR based on a three-layer high availability architecture (Display, Business Logic, Data Storage) *(Figure 1)*.

This architecture allows high cohesion and low coupling between its components;[10] also, it meets the requirements established in the DICOM (Digital Imaging and Communications on Medicine) standard for the transfer, storage, and visualization of medical images; and under the guidelines of the Federal HIPAA (Health Insurance Portability and Accountability Act) to ensure the security and privacy of patient information generated from medical practice.[17]

Broadly speaking, PACS hardware architecture consists of storage devices such as a specialized server, medical-grade display devices, a network communications infrastructure, and DICOM services

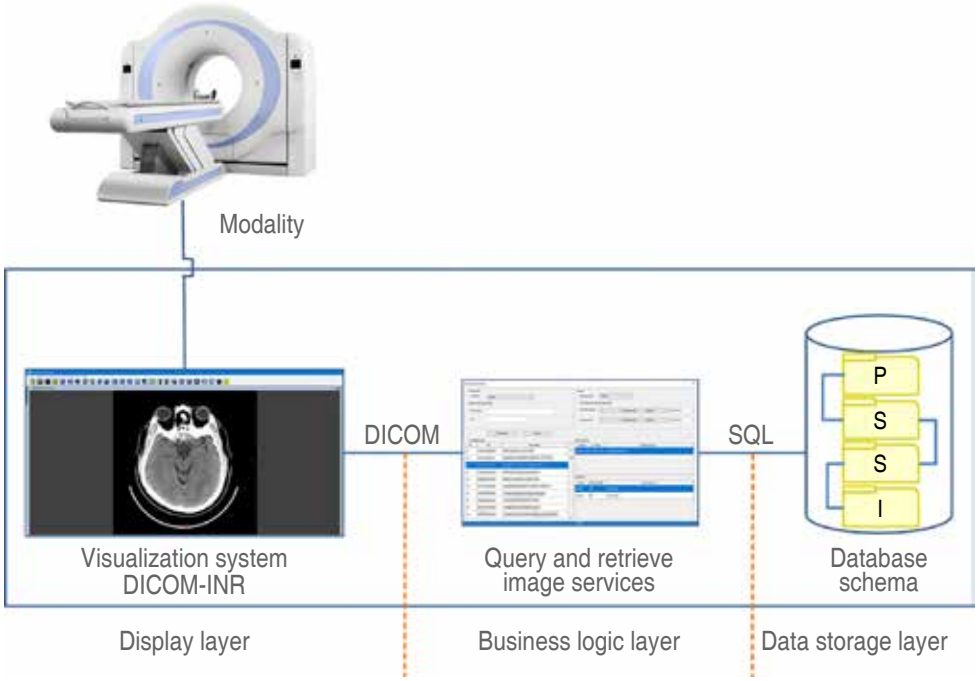

Figure 1:

PACS-INR software components and intercommunication through DICOM and SQL (Structured Query Language) standards. Source: authors.

and application entities to support the storage, display and query/retrieval of medical images.

Based on the multi-modality study throughput analysis at INR-LGII, which is 100,000 average medical image studies mapped to an annual physical storage of 5 TB, over 400 client application entities to visualize medical images using concurrent transactions, and, a 10 Gb network rate to support server-client communication, 24/7 scheme with 99% availability, and, 17 years of continuous service, we laid the foundation to replicate this environment with an infrastructure of similar characteristics. In the case of INR-LGII, the first production version was deployed in 2007 on an EMC CLARRION CX500/CENTERA G4 system with 40 TB of storage on 2 redundant servers and an Oracle 10G database. The hardware components were discontinued by the manufacturer in 2011 and the second version of PACS-INR was deployed in 2014 on an EMC VNX5300/CENTERA G4 system with 90 Tb with the database upgraded to Oracle version 11. The DICOM INR application entities were reused without recompilation.

It is worth mentioning that PACS-INR is currently at the TRL8 (Technology Readiness Level 8), in the production stage.[18,19] It is a functional system evaluated in a productive operating environment, fully integrated with operational hardware and software systems, such as Hospital Information System (HIS), Radiology Information System (RIS), and medical imaging equipment. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios, serving all areas of INR-LGII and attending 398 user requests (clients configured in the PACS-INR) for transfer and medical image visualization.

Due to its flexible and scalable architectural design, the PACS-INR can operate in different scenarios like hospitals, clinics, and radiology laboratories. The production environment has been tested at INR-LGII during peak usage hours and an average of 90 clients have been identified with retrieved studies at the same time without errors.

The scope and success of PACS-INR have been disseminated in different forums, arousing the interest of various health institutions.[20,21] Such is the case of the Brain Imaging Department (BID) of the *Instituto Nacional de Psiquiatría «Ramón de la Fuente Muñiz»* (INPRFM),[22] which required a PACS for the management of magnetic resonance imaging, computed tomography, ultrasound, nuclear medicine, and X-ray images generated in the institution.

In 2016, the BID expressed interest to INR-LGII in using an instance of the PACS-INR software components to systematize the deployment, acquisition and storage of medical images generated at INPRFM.

In Mexico, the contract of a TTO or a KTO represents high costs for Federal Health Institutions. For that reason, the authorities of INR-LGII and INPRFM decided to implement an interinstitutional linkage scheme without intermediaries for PACS-INR technology transfer, taking as a reference firstly the Mexican initiative named National Digital Strategy, which includes as one of its objectives the improvement and expansion of health infrastructure and equipment.[23] In addition, the Law of the National Health Institutes, which has among its attributions to promote linkage between national institutions, was considered.[24]

This article describes the model implemented to transfer the PACS-INR software components developed at INR-LGII (provider) according to the infrastructure and workflow of INPRFM (receiver) based on the phases of a linear transfer process. The proposal for the technology transfer model considers five stages: 1) innovation assessment, 2) institutional mechanisms for transfer, 3) intellectual property protection, 4) process management, and 5) technology assimilation.

Material and methods (stages description for the transfer model)

The five stages were established according to the regulatory scheme of the National Institutes of Health, where INR-LGII is the provider of the PACS-INR technology and INPRFM is the receiver. These stages are composed of activities and deliverables as described below.

1. **Assessment of the innovation** (product: assessment report).
   a. Technological feasibility: this activity defines the operational and infrastructure requirements for the proper performance of the PACS-INR at the INPRFM, considering:
      a.1. Image modality settings (image production and acquisition protocols established according to BID workflow; DICOM application entities settings using the standard specifications defined in the modality conformance statement).
      a.2. PACS server architecture analysis based on the image production (physical storage, memory capacity, backup scheme, file system configuration, database management).
      a.3. Diagnostic imaging workstation usage (diagnostic or clinical purpose must be defined to establish user permissions/role and medical image viewing technology). This will be determined by the recipient based on their workflow.
      a.4. Network communications study (network traffic analysis to support medical imaging transactions, availability of a virtual private network for remote monitoring). This item is performed in conjunction with the recipient's IT staff to evaluate the transfer of images between modalities, server and imaging workstations.
   b. «Know-how»: the purpose is to share knowledge, procedures, and techniques with INPRFM staff to reproduce the PACS-INR operation at INPRFM.
      b.1. Verification of the console of the application entity running on the PACS server (execution of DICOM echo, storage, query-retrieve services to verify system availability).
      b.2. Verification of available storage space (analysis of medical image production per day-week-month and resizing of the file system on the server storage devices).
      b.3. Verification of database integrity (execution backups, adjustment of database schema according to the production of studies, administration to ensure the integrity of the information).
      b.4. Training program for use of the DICOM-INR Viewer (patient search, study retrieval, image display, and use of processing tools).
   c. Impact on the receiver: The objective is to identify the effect of the PACS-INR technological innovation on the BID workflow. To establish the usefulness of the PACS-INR instance at INPRFM, a satisfaction survey is defined for system users (considering aspects related to the ease of use of the image viewer, availability of processing tools, recovery of study time, loss or duplication of studies, technical support, identification of improvements and changes identified in the workflow).
2. **Mechanism for technology transfer** (product: interinstitutional agreement).
   Preparation of the statements and clauses contained in the technology transfer collaboration

agreement to grant free use of the software components of PACS-INR.
   a. Statements: includes voluntary assertions about certain facts or situations involving the interests of the entities participating in the transfer process.
   b. Clauses: includes aspects such as the object of transfer, coverage, responsibilities of the receiver and the provider, intellectual property and confidentiality.
   c. Software licensing: consists of the specific items related to the licensing contract for the PACS-INR software components for its operation within INPRFM's facilities, establishing the responsibilities to comply with the interinstitutional agreement.
3. **Intellectual property protection** (product: certificate of inscription).
   Public copyright registration: responsibilities and obligations must be defined among the participating institutions when generating new components susceptible to registration by the corresponding authorities.
4. **Process management** (product: usability testing).
   a. DICOM server configuration: register and configuration of the DICOM application entities in the PACS server to allow study transactions.
   b. Data base configuration: establish permissions in the database scheme according to DICOM information model (patient-study-series-images).
   c. File system configuration: define the storage capacity according to image modality production.
   d. System implementation (deployment): delivery of the system for daily use after validation tests.
5. **Technology assimilation** (products: operation record and user's guide).
   a. Training: consists of a program to teach the functionality of the system's software components to perform a query, retrieval, and visualization of medical images. It includes a user's guide for the use of processing tools.
   b. Technological support: a communication scheme is defined to resolve incidents during the system's operation.
   c. Monitoring: a virtual private network (VPN) is required to control a server to host the PACS-INR system.

RESULTS (PACS-INR TRANSFER MODEL)

Figure 2 shows the PACS-INR interinstitutional transfer model defined for medical imaging management at INPRFM. The interaction between the entities involved enables the implementation of the model by fulfilling specific functions by establishing interinstitutional linkage programs and policies (regulations), identifying areas of opportunity for technological innovation at INPRFM, and driving the development of cutting-edge technology at INR-LGII. The five stages contained in the model deliver outputs (products) as evidence of compliance.

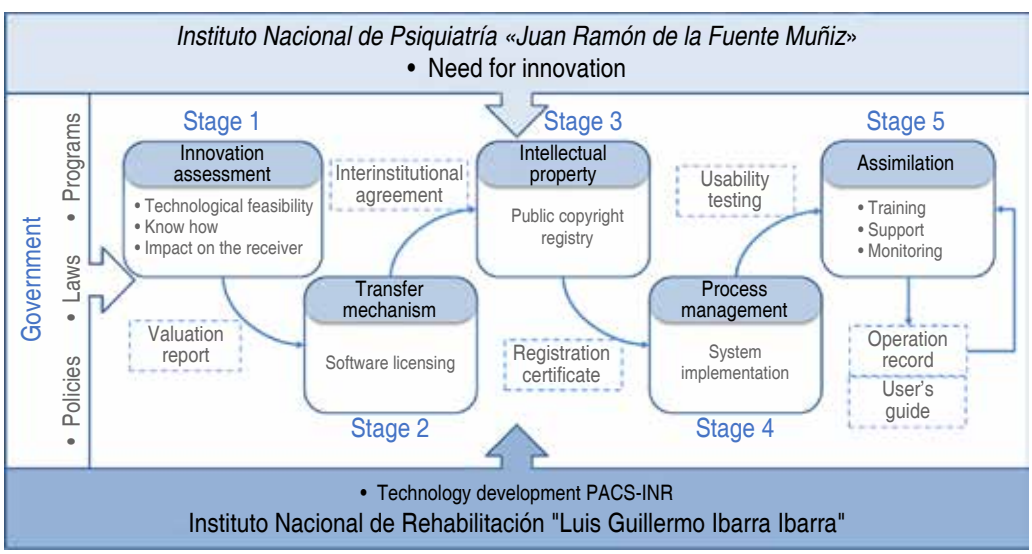

Figure 2:

PACS-INR technology transfer model.
Source: authors.

In **Stage 1**, with deep analysis of the requirements, infrastructure, and workflow defined, it was established the technological feasibility for the operation of PACS-INR in the BID's operating environment. The feasibility analysis revealed that INPRFM has the capacity and infrastructure to manage the PACS-INR filing systems, databases, and applications, making it possible to replicate its operation in INPRFM's operating environment.

The communication network is adequate to support image transfer generated by the imaging equipment. Also, it was verified that this equipment has the DICOM service licensing for storage, query, and retrieval.

Images generated in the BID comprise the modalities of magnetic resonance imaging (MRI), computed tomography (CT), X-ray (CR and RF), ultrasound (US), and nuclear medicine (NM), with a projected 750,000 images per year. The storage space per modality was determined with a total of 10 TB, considering a storage period for the next ten years.

The PACS-INR instance installed at INPRFM started operating with ten users for consultation, retrieval and viewing of medical images generated in the five modalities. However, at the time of writing, the number of users increased to 250 clients to meet new needs without additional licensing costs.

Regarding knowledge, procedures, and techniques (know-how) for the assessment of innovation, a qualitative analysis was carried out based on the usefulness of the PACS-INR for the management of medical images at INPRFM.

This analysis first considers the experience of INR-LGII personnel in developing, configuring, and updating the system as a factor that adds value to the technology. Another factor considered for this purpose is the level of maturity of PACS-INR as a technology in use under high-availability operating conditions and which has been the subject of intellectual property rights recognized by the competent authorities.

Finally, the PACS-INR impact on the BID's workflow considers the availability to dispose of a medical imaging visualization subsystem named DICOM-INR Viewer, which allows displaying the images in several places simultaneously in comparison with the previous method using a CD or DVD, which only make possible to visualized images by only one physician at a time.

In **Stage 2**, software licensing was established as a technology transfer mechanism within the interinstitutional agreement, defining the object to transfer, the coverage, obligations, and responsibilities of those involved. *Table 1* shows the most relevant aspects of the interinstitutional agreement endorsed by the authorities and medical and research personnel of INR-LGII and INPRFM.

Stage 3 establishes the mutual recognition agreement of the intellectual property rights generated by the execution of the interinstitutional agreement. Likewise, both INR-LGII and INPRFM must recognize those involved in its realization. Ownership of intellectual property rights will be shared when personnel from both institutions participate in new developments. It is worth mentioning that new components have not yet been co-developed for use in the INPRFM, however, at this stage the basis for mutual recognition when this happens has been established.

Stage 4 includes the installation and setup of the application server with a database, setting of the file systems, and enabling of the application entities (users) that will be able to consult, retrieve and display the medical images in the different areas of the INPRFM using the DICOM-INR viewer. This stage includes the evaluation of security, information integrity and infrastructure performance tests, evaluated based on average speed tests of image recovery from different modalities, obtaining the following: a) 3 minutes for an MRI study with a size of 1 GB. b) 20 seconds for a CR study with a size of 13.5 MB. c) 8 seconds for an RF study with a size of 129 MB. d) 15 seconds for a NM study with a size of 69.8 MB. e) 4 minutes for a CT study with a size of 522 MB. f) 10 seconds for a US study with a size of 22.3 MB. These tests were performed at peak workload times, with more than 40 simultaneous connections to verify the performance of the instance under stress conditions.

The evaluation of the DICOM-INR viewer was performed through qualitative usability tests by the radiologist physicians responsible for diagnostic imaging at the BID to identify factors such as image quality, application stability and ease of locating the processing tools. These usability test focuses on gathering information, findings and possible enhancements about user experience.

According to feedback from BID staff, the PACS-INR instance implemented at INPRFM since 2018, allowed streamlining the process of patient care, optimizing the daily workflow in addition to having a historical archive of medical images to follow up, promoting clinical research on the diseases treated in this institution. It is important to mention that the adaptation of the users of the PACS-INR instance at INPRFM was simple given that they previously had a commercial solution that was impossible to

Table 1: INR-LGII-INPRFM Interinstitutional Agreement Summary.

Object	The «INR-LGII» provides the «INPRFM» with the technology transfer to grant the use of a software license called «Medical Image Storage, Distribution and Visualization System» (PACS-INR)	
Coverage	The technology transfer does not include source code, so any modification or update after the base installation requires a new development process and its corresponding agreement	
Obligations	**INR-LGII**	**INPRFM**
	Allow «INPRFM» to use the software license	Not to transfer the software license to use the «INR-LGII» software
	To provide «INPRFM» with access, configuration, training on the use of the transfer objects	To have the necessary infrastructure and equipment
Responsibilities	Maintain the integrity and efficient operation of the software	Maintain the confidentiality of user accounts
	Request information to install and configure the software	Notify incidents in the operation of the software via telephone or e-mail
	Request information to determine the clients for installing the DICOM-INR viewer	

maintain due to high costs, and that was replaced by the transferred technology without inconveniences, promoting technological independence.

Finally, **Stage 5** defines the main aspects to ensure the system operation implemented at INPRFM and its consequent assimilation. It includes a training program for INPRFM staff on the use of the DICOM-INR viewer and a guide explaining the main exceptions they may face during the image consultation, retrieval, and display process, to communicate them to INR-LGII support staff or resolve them on-site.

Through a remote technology support scheme is possible to monitor the database integrity, user configuration, and storage space using the VPN. A technological support scheme was implemented to ensure the continuity of the service and the availability of medical images for the diagnosis performed by the BID. The purpose of the PACS-INR monitoring actions installed at INPRFM is to verify the continuity of the service and the availability of medical images for the diagnosis, available space, connection errors, and database sizing, among others.

DISCUSSION

Despite the growing tendency to establish technology transfer agreements, most are between universities or research centers as technology providers and companies that need this technology to innovate a product or service. We can find countless examples in the scientific literature concerning technology transfer and innovation mechanisms, mainly in developed countries, where economic and regulatory conditions favor university-industry collaboration.[25-27] A fundamental aspect for the functioning of this transfer scheme is the presence of a technology transfer office, either incubated within the research centers themselves or as a third party that provides the service as an intermediary during the process, as noted by Cunningham et al[28] in their 2020 publication.

Less common are cases like the agreement established through the interinstitutional agreement between INR-LGII and INPRFM, whose objective is to provide technology to organizations that do not have the necessary conditions to carry out research and development. This scenario occurs in countries with emerging economies, such as those that predominate in Latin America, where some barriers prevent successful technology transfer. Mazurkiewicz and Poteralska[29] mention organizational-economic, technical, and systems barriers as determining aspects to consider when initiating the technology transfer process.

In this sense, at the organizational-economic level is essential to make the presence of technology public so potential receivers can access to government programs, which facilitates the exchange of knowledge, technologies, and techniques developed in public administration institutions optimizing resources.

In the proposed model, the definitions of the roles of provider, receiver, and facilitator in the technology transfer process are essential to achieve the objectives defined in the technical factor compliance agreement. The technology provider is responsible for verifying the infrastructure and requesting its adequacy according to the needs of technology operation in the receiver, which in turn must analyze the potential provider according to its workflow.

Thus, this model takes advantage of the role played by government agencies as a facilitating entity and policy manager for knowledge exchange between public institutions, assuming the functions of a technology transfer office. In a recent paper, Siegel et al[30] highlight the importance of fostering technology transfer among national laboratories. Based on a report from the National Academies of Science, Engineering, and Medicine, the authors recognize the importance of public policy as a mechanism that can provide new theoretical and empirical insights into technology transfer.

The case of PACS-INR transferred to INPRMF through the proposed model is an example of how public institutions can exchange knowledge and technology through direct linkage mechanisms to improve health services. Considering this scheme, it is possible to carry out scalable and transferable R + D + i projects with the objective of optimizing the material, financial and human resources assigned to each institution.[31] In this sense, the PACS-INR instance requires a diversity of actors such as information technology personnel, radiologists, health information systems specialists, authorities and legal team, whose functions are specified in the interinstitutional agreement. In the same way, the responsibilities of each actor are defined in the clauses established in the agreement, minimizing the risks of early termination, either due to non-compliance with commitments or due to false statements in the legal instrument. The risks associated with the use of technology are mitigated by continuous remote monitoring of the instance, the integrity of the database and incidence control.

The solution proposed as a model based on an agreement between public health institutions, obeys the guidelines of the National Digital Strategy for sharing technological resources and knowledge, which makes this proposal susceptible to be extended to other institutions through a formal request such as a collaboration agreement.

One of the main limitations that may arise in the implementation of this technology transfer model, whose mechanism is based on an interinstitutional agreement, has to do with the time allotted to comply with the legal aspects. This factor may delay the implementation of the solution; however, the medium and long-term benefits usually make up for the waiting time for its use by the receiving entity. In this case, the start of the transfer process was in May 2016 and the deployment at INPRFM was in January 2018. Of this time, the analysis of the recipient's infrastructure, installation of the instance, operational testing, validation of the DICOM-INR viewer, staff training and performance testing took approximately four months (from August to December 2017). Even with the time inconvenience attributed to the legal process, the continuous operation of the instance until today is a proof of the usefulness of the model.

CONCLUSIONS

The technology transfer model between INR-LGII and INPRFM demonstrated that the PACS-INR software architecture is flexible and functional in operating environments with different hardware infrastructures, operating system, database managers, workflow, and image production capacity.

With the appropriate transfer mechanism and an agreement accepted by both parties, it was possible to carry out a successful process that can be replicated in other institutions, obtaining the same benefits provided by a commercial product without investing large amounts of the institution's budget.

The intellectual property of PACS-INR allows extending the system's capabilities by adding tools focused on the diagnosis performed by each institution, depending on their specialty; this encourages the development of medical applications adapted to the specific needs of each institution to complement the basic technology and reduce technological dependence.

Considering the transfer of technology from PACS-INR to INPRFM as an investment in R + D + i allowed increase competitiveness, identifying the most cost-effective technologies that meet the receiver's requirements, access and knowledge sharing, infrastructure optimization, technical risk reduction, implementation time reduction, cost reduction, create opportunities to join efforts to develop new products and processes, and, access to profitable R + D + i investments under a scheme of income, participation, or donations.

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