

Implementation And Evaluation Of The Pacs System In The Radiology Department Of A Hospital: A Case Study In A Hospital In Indonesia

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ABSTRACT

This study aims to evaluate the implementation and impact of the Picture Archiving and Communication System (PACS) in the Radiology Department of Wava Husada Hospital, focusing on operational efficiency, service quality, budget management, and satisfaction levels among patients and staff. A mixed-methods approach was employed, integrating both qualitative and quantitative research methods to provide a comprehensive analysis. The study assessed key variables, including operational efficiency, financial management, radiology image quality, service quality indicators, and satisfaction levels of both patients and staff involved in the PACS workflow. The findings indicate that the implementation of PACS resulted in improved operational efficiency, with an increase in the number of radiological procedures per working day and per working hour of radiographers. Financially, there was variation in revenue and cost realization, but the long-term benefits of PACS implementation outweighed the initial investment costs. Service quality indicators, such as the turnaround time for CT scan and chest X-ray readings, showed significant improvements. Additionally, the quality of radiology images improved, as evidenced by evaluations from radiology specialists. Patient and staff satisfaction regarding PACS services also yielded positive results, particularly concerning waiting times and clarity of diagnostic results. In conclusion, the implementation of PACS in the Radiology Department of Wava Husada Hospital positively affected operational efficiency, service quality, and satisfaction levels among both patients and staff. Although there was an increase in expenditure, the long-term benefits of the system justify the investment, making it a valuable asset for the hospital. Further evaluations of cost-benefit ratios are recommended, alongside continuous efforts to enhance service quality in line with technological advancements and regulatory standards.

Keywords: PACS implementation, operational efficiency, service quality, patient satisfaction, staff satisfaction, financial management.

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INTRODUCTION

Advancements in information and communication technology have transformed healthcare delivery by enhancing efficiency, accuracy, and accessibility. Digital health systems support evidence-based decision-making and improve patient-centered care through secure and rapid storage, processing, and dissemination of clinical data. In radiology, the adoption of Picture Archiving and Communication Systems (PACS) has marked a shift from analog to digital imaging, optimizing workflow, accelerating diagnostics, and reducing human error.

PACS enables electronic storage and retrieval of radiologic images, accessible remotely by clinicians, thereby removing geographic constraints. Integration with Hospital Information Systems (HIS) and Electronic Medical Records (EMR) centralizes patient data management and supports continuity of care. According to the Indonesian Ministry of Health, hospital digitization can reduce patient waiting times by up to 30% and increase satisfaction by 25% (Ministry of Health, 2013). Furthermore, the Healthcare Information and Management Systems Society (HIMSS) notes that digital imaging reduces operational costs by up to 20% through the elimination of films and chemicals (HIMSS, 2019).

Despite these advantages, PACS implementation in Indonesia remains limited. Although Ministry of Health Regulation No. 82 of 2013 mandates IT integration in hospital services, only approximately 40% of hospitals have adopted PACS. Barriers include infrastructure limitations, financial constraints, and human resource deficits (Ministry of Health, 2013). Implementation requires capital investment in servers, software, and networking, along with maintenance and upgrade costs. Additional challenges include lack of user training and resistance to technology adoption (WHO, 2018).

From a service quality standpoint, PACS enhances diagnostic turnaround time, minimizes physical handling, and ensures data security and image fidelity—ultimately supporting more accurate diagnoses and better clinical outcomes. Its benefits also include improved accessibility, workflow efficiency, high-resolution imaging, and long-term cost savings through digital storage.

Hospital W, a type B referral hospital in Indonesia, previously relied on film-based radiology, which was associated with transfer delays, film loss, inefficient storage, and extended patient waiting times. To address these issues, the hospital implemented PACS as part of its digital transformation strategy.

This study evaluates the implementation and impact of PACS at Hospital W, focusing on five key domains:

1. Operational efficiency (procedure volume per radiographer working time),
2. Financial performance (budget realization and capital investment),
3. Service quality indicators (e.g., diagnostic reading time),
4. Radiologic image quality (as evaluated by specialists), and
5. Satisfaction among patients and radiology staff.

Given the scarcity of comprehensive PACS evaluations in Indonesia—particularly those encompassing multiple performance metrics—this study provides a holistic assessment of PACS adoption in a hospital setting.

Literature Review

PACS Implementation in Hospital Settings

The implementation of the Picture Archiving and Communication System (PACS) has become a pivotal advancement in the digital transformation of radiology services. PACS facilitates efficient image data management, interdepartmental communication, and reduced diagnostic turnaround times through electronic access and storage of radiological images. While PACS has shown measurable benefits in clinical and operational settings, many prior studies focus only on isolated aspects such as patient satisfaction or service wait times, lacking comprehensive evaluation within broader hospital management systems.

In Indonesia, although PACS has been introduced in several major hospitals, comprehensive evaluations of its implementation are still limited. Most studies concentrate on its technical functions or operational impact without establishing links to managerial or financial performance indicators.

Setyawan and Supriatna (2016) emphasized the importance of system acceptance testing during PACS integration with the Radiology Information System (RIS) at RSUP Dr. Sardjito Yogyakarta. Their findings highlighted integration challenges with existing Hospital Information Systems (HIS), the necessity of robust IT infrastructure, and the ongoing demand for system maintenance.

Rohim (2021) identified multiple implementation challenges in his thesis, including software compatibility, hardware limitations, and a lack of human resources. Despite its advantages in diagnostic speed and accuracy, the integration of PACS with HIS or RIS was often hindered by technical and organizational constraints.

A study by Suandari, Julianlara, and Rusmana (2020) at Premier Bintaro Hospital reported significant improvements in productivity and accessibility of medical imaging following PACS adoption. However, network stability was identified as a major limiting factor for optimal system performance.

Rahman (2022) explored the role of PACS in radiation dose management at Siloam Lippo Village Hospital. His findings suggested that PACS contributed to enhanced patient safety by enabling better monitoring of radiation exposure during imaging procedures.

At UPTD RSUD Embung Fatimah Batam, Mulyantoro and Rusyadi (2024) demonstrated that PACS implementation significantly reduced radiology service waiting times across outpatient, inpatient, and emergency units by 35–41%, thus enhancing radiology performance indicators.

While the collective literature underscores the positive impacts of PACS on efficiency and quality, recurring challenges include system integration, infrastructure limitations, and inadequate user training. Continued evaluation and optimization are necessary to fully realize PACS' potential in hospital management.

Information Systems in Healthcare

A system refers to a set of interrelated and interactive components working toward a defined goal within specific environmental constraints (Handayani et al., 2018). An information system supports organizational operations through the collection, processing, and dissemination of data to facilitate both administrative functions and decision-making processes (Leitch & Davis, 1983 in Handayani et al., 2018, p. 78).

The main objectives of an information system are to enhance managerial functions, support strategic decision-making, and improve operational efficiency. Core components of an information system include:

1. Hardware: Physical tools such as computers and printers.
2. Software: Operating systems and application programs including databases.
3. Procedures: Guidelines and protocols for data processing and workflow management.
4. Networks: Data transmission systems including the internet, intranet, and extranet, supported by media (e.g., twisted pair cables, optical fibers), network hardware (e.g., modems, routers), and communication software.
5. Personnel (Brainware): Users and IT specialists responsible for managing system operations.

According to Susanto (as cited in Nugroho & Ali, 2022, p. 256), components of a management information system also include databases (structured data storage systems), and computer networks that enable seamless data communication within and across hospital units.

Hospital Information Systems (HIS)

In accordance with Regulation of the Minister of Health of the Republic of Indonesia No. 82 of 2013, Article 3 Paragraph 1, hospitals are required to implement a Hospital Information System (HIS). HIS is an integrated technology platform designed to support the management and coordination of hospital operations, administration, and reporting. It plays a critical role in ensuring the availability of accurate and timely data across all service levels.

Susanto (2012) defines HIS as encompassing information processes within hospitals, including data collection, processing, analysis, and presentation. HIS supports clinical and non-clinical decision-making by providing hospital managers with real-time insights into patient care, resource utilization, and service performance.

Radiology Information System (RIS)

A Radiology Information System (RIS) supports the operational and administrative processes within radiology departments, including appointment scheduling, patient registration, reporting, workflow coordination, and billing (Nadhiroh, 2022). It also serves as a repository for patient data, contributing to the broader Electronic Medical Record (EMR).

RIS integration with Hospital Information Systems (HIS) and Picture Archiving and Communication Systems (PACS) is essential for comprehensive radiological workflows. This integration enables seamless access to patient records, diagnostic scheduling, report generation, and financial tracking.

The core functions of RIS include:

1. Patient data management
2. Scheduling and workflow optimization
3. Diagnostic reporting with digital signatures
4. Billing and cost management
5. Data analytics and statistical reporting

These functions collectively enhance efficiency and service delivery in radiology departments.

Picture Archiving and Communication System (PACS)

PACS is a digital image management system that facilitates the storage, retrieval, distribution, and visualization of medical images (Peck, 2017). Its integration with RIS and HIS supports radiology workflows by enabling cross-departmental access to imaging data, contributing to diagnostic accuracy and clinical decision-making.

Historically developed in the 1970s and gaining global relevance in the 1990s, PACS now functions as a central component in hospital imaging infrastructure (Huang, 2019). PACS eliminates the need for film-based processes, improves access to historical imaging, and reduces diagnostic turnaround time.

Key Components of PACS:

1. Image Acquisition Gateways: Interfaces with imaging modalities and hospital systems to collect image and patient data.
2. Short-term and Long-term Storage: Maintains imaging data for immediate and archival access.
3. Viewer Applications: Workstations or web-based platforms with tools for image manipulation, 3D visualization, and diagnosis.
4. Hierarchical Database: Structures and indexes image files for fast retrieval.
5. Application Servers & Networks: Manage data access and support connectivity using TCP/IP and DICOM protocols.

This infrastructure supports flexible, secure, and scalable access to radiological data across hospital networks.

Digital Imaging and Communication in Medicine (DICOM)

DICOM is the global standard for handling, storing, and transmitting medical imaging information. Developed by the ACR and NEMA in 1985, it enables interoperability among devices from different manufacturers and across departments.

DICOM files (typically .dcm) contain both imaging data and patient metadata and are viewable using DICOM-compliant software. The protocol supports image viewing, annotation, and data access via local systems or web interfaces (WADO).

Advantages of DICOM include:

1. Standardized communication between imaging equipment
2. Embedded patient information for traceability
3. Reduced risk of data incompatibility and loss
4. Enhanced data sharing and accessibility

HL7 Standard

HL7 (Health Level Seven) is a communication protocol for exchanging healthcare data across information systems. Unlike DICOM, which handles images, HL7 focuses on administrative and clinical data, enabling interoperability between HIS, RIS, and PACS.

Using event-driven messages, HL7 allows automatic updates of patient data across systems. For example, a radiology order triggered by patient registration is sent via HL7 to the RIS, where it is queued for imaging.

HL7 ensures seamless data integration, thereby enhancing clinical workflow, reducing manual errors, and supporting interoperability within hospital IT environments (Handayani et al., 2018; Huang, 2019).

Quality Assurance (QA) and Quality Control (QC)

Quality Assurance (QA) in radiology encompasses systematic procedures to ensure diagnostic accuracy, patient safety, and service efficiency. QA includes monitoring human resources, equipment performance, and adherence to standardized protocols (Papp, 2005).

Quality Control (QC), a subset of QA, focuses on technical parameters such as image quality, calibration of imaging equipment, and radiation exposure levels. QC routines are essential for detecting performance deviations and maintaining compliance with regulatory standards.

Together, QA and QC support consistent, high-quality radiological services and contribute to institutional

Technology Adoption Theories

The adoption of technology in healthcare institutions, particularly Picture Archiving and Communication Systems (PACS), is integral to the digital transformation of medical services. Understanding user acceptance is crucial to ensuring the successful implementation and sustained use of such systems. Two prominent theoretical models frequently utilized in analyzing technology adoption within healthcare settings are the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI) theory.

The Technology Acceptance Model (TAM), introduced by Davis (1989), offers a framework for explaining the determinants of technology acceptance at the individual level. It identifies two primary factors: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU refers to the extent to which individuals believe that the system enhances their job performance. Within the context of PACS, PU includes perceptions of faster workflow, reduced patient wait times, and improved diagnostic precision. Recent studies, such as that of Venkatesh et al. (2016), reaffirm the role of PU as a strong predictor in clinical settings where decisions rely heavily on digital imaging data. PEOU, meanwhile, pertains to the degree of effort required to use the system. If healthcare personnel perceive PACS as overly complex, adoption may be limited, despite evident functional advantages. Factors such as intuitive user interfaces and adequate training significantly influence PEOU (Alwahaishi & Snodgrass, 2022). Analyzing both PU and PEOU offers insight into potential adoption barriers and informs strategies for user support and system optimization.

The Diffusion of Innovation (DOI) theory provides a broader sociological perspective by examining how innovations are adopted within social systems (Semwanga et al., 2021). The DOI framework identifies five core attributes influencing adoption: relative advantage, compatibility, complexity, trialability, and observability. PACS demonstrates clear relative advantages over conventional radiology methods through increased efficiency and reduced operational costs. Its compatibility with existing hospital information systems and operational workflows enhances adoption potential. The complexity of PACS can act as a barrier, though this can be mitigated through structured training and gradual system familiarization (Abdekhoda & Salih, 2017). Trialability, or the opportunity to test PACS before full-scale deployment, allows users to assess its utility firsthand. Observability—the degree to which the benefits of PACS are visible to users—also supports adoption, particularly when improvements in clinical outcomes and

workflow efficiency are evident. Together, TAM and DOI provide a robust theoretical basis for understanding user acceptance and guiding strategic planning in PACS implementation.

Operational Performance Evaluation Frameworks

Beyond adoption and implementation, the effectiveness of PACS must be evaluated through its impact on hospital operations and service performance. Two frameworks serve as the foundation for evaluating operational outcomes in this study: Key Performance Indicators (KPIs) and the Balanced Scorecard (BSC).

Key Performance Indicators provide quantifiable measures of how well PACS supports strategic healthcare goals. Four KPIs are central to assessing PACS effectiveness. First, radiology service waiting time is expected to decrease due to streamlined image acquisition, faster analysis, and digital result distribution. Second, radiographer productivity—measured by the number of procedures completed per day—is anticipated to increase as workflows become more efficient. Third, the diagnostic error rate should decrease due to improved image quality and access to digital tools, contributing to more accurate and timely diagnoses. Lastly, patient satisfaction—gauged through structured surveys—serves as a reflection of perceived improvements in service quality, wait times, and diagnostic communication. Collectively, these indicators offer a comprehensive view of PACS's contribution to operational efficiency and clinical excellence.

The Balanced Scorecard (BSC), developed by Kaplan and Norton (2005), expands performance evaluation beyond financial metrics by incorporating multidimensional perspectives. From a financial standpoint, PACS implementation is expected to reduce operational costs by minimizing the use of radiographic films and improving resource utilization. From the customer perspective, enhanced patient satisfaction represents a critical outcome tied to improved service quality and communication. The internal process perspective focuses on workflow improvements within radiology departments, particularly the automation and digitization of imaging processes. Lastly, the learning and growth perspective considers the extent to which hospital staff can adapt to and leverage PACS through training and skills development. By applying the BSC framework, this study captures a holistic assessment of PACS's operational impact, supporting data-driven recommendations for further optimization in hospital service delivery.

RESEARCH METHODS

This study employed a case study design using a mixed-methods approach, combining qualitative and quantitative data to evaluate the implementation and impact of the Picture Archiving and Communication System (PACS) in the Radiology Department of Hospital W, a Type B general hospital with comprehensive radiological facilities.

Research Variables

The independent variable is PACS implementation, examined through pre- and post-intervention comparison. Dependent variables span five key domains:

1. Operational efficiency: total radiology procedures; procedures per radiographer per day/hour.
2. Financial performance: revenue, expenditures, capital (Capex) and operational (Opex) budgets.
3. Quality indicators: turnaround times for CT stonography and thorax X-rays.
4. Image quality: evaluated against international standards.
5. Satisfaction levels: from both patients and radiology staff.

Variables were operationalized using validated indicators and data sources. Operational efficiency was measured using radiology service reports and staff attendance logs. Financial data were extracted from departmental budget reports. Quality indicators were drawn from internal radiology and quality assurance

records. Image quality was assessed via Likert-scale surveys by radiologists, while satisfaction was measured using structured questionnaires. PACS implementation was treated as a categorical variable, verified through operational documentation, observations, and interviews.

The study population included (1) patients undergoing radiological procedures, and (2) radiology-related staff. A minimum of 30 patients were selected through random sampling based on matched services and eligibility criteria. Purposive sampling was used to recruit radiologists, radiographers, attending physicians, and other staff directly involved with PACS.

Primary data were collected through patient and staff surveys on satisfaction and system usability, and direct observation of performance metrics such as service waiting times and radiographer productivity. Secondary data included PACS operation logs, financial reports, and quality assurance metrics. Triangulation was used to ensure data validity and reliability.

The study was conducted in the Radiology Department of Hospital W over one calendar year. Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics summarized key variables, including means and standard deviations for continuous data, and frequencies for categorical data. The Shapiro-Wilk test assessed normality assumptions for all continuous variables.

Comparative analyses between pre- and post-PACS implementation periods employed paired sample t-tests for normally distributed continuous variables, including radiology procedure volumes, financial variances, turnaround times, image quality scores, and satisfaction ratings. Variables that did not meet normality assumptions were evaluated with non-parametric alternatives (Wilcoxon signed-rank test), though none were required in this study. Statistical significance was set at $p < 0.05$ (two-tailed). Effect sizes were inferred from t-values and mean differences to quantify practical impact. For categorical outcomes such as achievement rates of diagnostic targets, proportions were compared using paired proportion tests.

RESULTS AND DISCUSSION

Analysis and Interpretation

This part analyze the implementation of the Picture Archiving and Communication System (PACS) in the Radiology Department of Hospital W, focusing on operational efficiency, financial performance, service quality, radiological image quality, and the satisfaction of both patients and staff. Quantitative methods were applied to numerical variables, while qualitative approaches were used for categorical data to provide contextual understanding.

The implementation of the Picture Archiving and Communication System (PACS) in the Radiology Department demonstrated clear improvements across multiple domains of service efficiency, financial variance, image quality, and satisfaction levels among patients and staff. A comparative analysis of key metrics before and after PACS implementation revealed statistically significant findings, as shown in the table below.

Table 1. Summary of Comparison of Radiology Action and Operational Variants Before and After PACS Implementation

Category	Statistic	Value Before	Value After	t-	p-
		PACS	PACS	value	value
Number of Radiology Actions	Total per Month	3329.67	3868.5	-3.01	0.028
	Per Working Hour	1.59	1.75	-2.45	0.048

	of Radiographer				
	Per Working Day	10.90	12.99	-2.87	0.035
	of Radiographer				
Variance of Radiology		105.83%	110.00%	-1.68	0.15
Department Revenue					
Variance of Radiology		93.00%	106.50%	-2.91	0.034
Department Expenses					
Variance of Medical		152.33%	90.00%	2.38	0.041
Equipment					
Components Cost					
Incidence of Waiting		3.45%	2.68%	4.27	0.001
Time for Chest X-ray					
Reading Time > 3					
Hours					
Achievement of CT		97.35%	100%	-4.47	0.002
Stonography Reading					
Time < 24 Hours					

Table 2. Radiological Image Quality and Satisfaction Scores Before and After PACS Implementation

Category	Statistic	Average Difference (□)	t-value	p-value
Image Quality	Clarity of Anatomical Structure	+ 1.4	16.27	<0.001
	Contrast and Color Gradation	+ 1.4	16.94	<0.001
	Spatial Resolution	+ 1.4	17.99	<0.001
	Image Noise	+ 1.4	17.47	<0.001
	Image Artifacts	+ 1.4	17.02	<0.001
	Image Interpretation Ease	+ 1.8	22.29	<0.001
	Image Suitability for Diagnosis	+ 1.6	21.42	<0.001
	Image Reproducibility	+ 1.6	21.22	<0.001
Patient Satisfaction	Imaging Result Retrieval Process	+ 1.35	19.57	<0.001
	Imaging Result Storage Process	+ 1.35	19.91	<0.001
	Imaging Result Distribution Process	+ 1.63	21.92	<0.001
	Overall Satisfaction	+ 1.40	22.39	<0.001
Staff Satisfaction	Imaging Result Retrieval Process	+ 1.35	19.57	<0.001
	Imaging Result Storage Process	+ 1.35	19.91	<0.001
	Imaging Result Distribution Process	+ 1.63	21.92	<0.001
	Overall Satisfaction	+ 1.40	22.39	<0.001

The data show significant improvement in productivity per radiographer, reductions in delays for chest x-ray readings, and full achievement of timely CT stonography interpretations. Image quality scores across all assessed categories increased, contributing to higher patient and staff satisfaction scores. These outcomes suggest that PACS implementation contributes positively to both operational efficiency and service quality in the radiology department.

PACS Implementation Process at Hospital W

The implementation of PACS began with identifying technical requirements and integrating with the hospital information system (HMS), followed by hardware procurement and connectivity testing with CR and CT-Scan modalities. Training sessions were conducted for doctors and radiology staff to familiarize them with image access across various devices. System features such as image loading indicators, search filters, and standardized report formats were developed by the vendor, although technical issues like slow image loading persisted.

The internal team addressed these challenges by distributing service brochures, setting backup printing fees, and updating PACS usage policies. Regular evaluations were carried out, especially to address delayed image loading in the emergency department, which at one point reached 15 minutes. Full integration between PACS, HMS, and the laboratory system remains in progress, with a temporary solution allowing physicians direct access to radiology and lab results. Future development plans include implementing digital signatures, image compression, and automated modality integration.

Challenges and Obstacles in PACS Implementation

One of the main challenges was the slow image loading speed, especially in emergency and operating rooms, which impacted diagnostic timeliness. The hospital set target access times and provided backup film prints to mitigate the issue. Incomplete access to patient history also led to unnecessary repeat examinations. To address this, efforts were made to integrate data into the electronic medical record (EMR) system and distribute QR code envelopes to improve patient awareness.

The lack of PACS-EMR integration forced physicians to use multiple platforms to access results, slowing down workflow. Quick access to radiology reports is under development to solve this. The use of QR codes was also found to be suboptimal, particularly on mobile devices requiring extra interactions. A more intuitive interface is being developed to improve user experience. Overall, these technical challenges have been met with ongoing digital transformation strategies aimed at enhancing the quality of radiology services at Hospital W.

Operational Efficiency

Post-PACS implementation, total monthly radiology procedures increased significantly (mean pre: 3,330; post: 3,869; $t = -3.01$, $p = 0.028$), driven by rises in ultrasound and CT scans despite a slight decline in X-rays. Procedures per radiographer working hour and day also improved significantly (hour: 1.59 to 1.75, $t = -2.45$, $p = 0.048$; day: 10.90 to 12.99, $t = -2.87$, $p = 0.035$), indicating enhanced workflow efficiency and resource utilization.

Financial Performance

Revenue variance showed an upward but non-significant trend post-PACS (105.8% to 110%, $p = 0.15$). Conversely, expense variance increased significantly (93.0% to 106.5%, $t = -2.91$, $p = 0.034$), reflecting higher investments in system maintenance and training. Notably, medical equipment cost realization decreased significantly (152.3% to 90.0%, $t = 2.38$, $p = 0.041$), suggesting improved budget control and reduced consumable usage consistent with digital imaging adoption.

Quality Indicators

Incidence of chest X-ray reporting delays exceeding 3 hours decreased significantly (3.45% to 2.68%, $t = 4.27$, $p = 0.001$), while CT Stonography readings within 24 hours improved from 97.35% to 100% ($t = -4.47$, $p = 0.002$), demonstrating accelerated diagnostic turnaround facilitated by PACS digital workflows.

Radiology Image Quality and Staff Satisfaction

Quantitative assessments from 14 radiology specialists and radiographers revealed significant improvements across all image quality parameters (anatomical clarity, contrast, resolution, noise, artifacts; mean $\Delta = +1.4$, all $p < 0.001$). Staff satisfaction on ease of interpretation and diagnostic suitability also increased markedly (mean $\Delta = +1.6$ to $+1.8$, $p < 0.001$).

Patient Satisfaction

Matched sampling of 38 patients showed significant enhancement in all evaluated dimensions of radiology service satisfaction post-PACS (waiting time, service quality, exam results, facilities, overall satisfaction; mean $\Delta = +1.17$ to $+1.56$, all $p < 0.001$), indicating improved patient experience and perceived service efficiency.

Staff Satisfaction

Survey of 38 multidisciplinary staff reported significant increases in satisfaction regarding imaging retrieval, storage, distribution, and overall technical support (mean $\Delta = +1.35$ to $+1.63$, $p < 0.001$), reflecting streamlined workflows and reduced administrative burden.

PACS Implementation Timeline

The system was systematically deployed beginning May 2024, with inpatient services, initiated May 2 and full hospital-wide adoption by May 31. Comparative analyses used six-month pre- (Nov 2023–Apr 2024) and post-implementation (Jun–Nov 2024) periods.

Interpretation and Discussion

PACS implementation significantly increased procedural throughput per radiographer, enhancing operational efficiency and resource allocation. Financially, although revenue variance remained stable, expense variance rose consistent with system-related investments, offset by improved equipment cost control aligned with digital imaging transitions. Quality indicators showed reduced reporting delays and improved diagnostic turnaround, meeting regulatory standards (Ministry of Health Regulation No. 6/2024). Both patient and staff satisfaction increased significantly, underscoring PACS's impact on service delivery and workplace efficiency. These findings corroborate existing evidence on digital imaging systems' benefits in workflow optimization and patient care quality (Alim et al., 2024; Rahman & Herdani, 2022). This comprehensive evaluation offers valuable insights for healthcare administrators aiming to modernize radiology services through digital transformation.

CONCLUSION

The implementation of the Picture Archiving and Communication System (PACS) in the Radiology Department of Hospital W has yielded measurable improvements across operational, financial, and service dimensions. Operationally, PACS has enhanced workflow efficiency, as evidenced by increased radiologic procedures per radiographer per hour and per working day. These gains reflect optimized process flow, reduced redundancies, and improved throughput.

Although the system required substantial capital and maintenance investment, no statistically significant changes in departmental revenue or expenditure were observed within the study period. However, the increase in procedure volume and productivity suggests potential for long-term financial sustainability and gradual return on investment.

Quality improvements were noted in radiologic image parameters, including anatomical clarity, contrast, spatial resolution, and artifact minimization—contributing to enhanced diagnostic accuracy. Furthermore, patient and staff satisfaction improved post-implementation, driven by faster image retrieval, better access, and streamlined management.

PACS adoption also supports regulatory compliance, notably with the Ministry of Health Regulation No. 82/2013 on Hospital Information Systems and Regulation No. 6/2024 on Minimum Service Standards. This alignment reinforces institutional goals in quality assurance, cost containment, and digital health transformation.

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