Clinician Acceptance and Adoption of PACS in Radiology Services: An Exploratory Study

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Abstract. This exploratory study explores the acceptance and adoption of Picture Archiving and Communication Systems (PACS) among clinicians practicing radiology services in Hail City, Kingdom of Saudi Arabia. A survey was conducted with 142 clinicians from various specialties from four public hospitals located there and focused on clinician satisfaction with inpatient and outpatient services as well as perceptions about PACS usage as well as the overall impression of radiology services; data analysis included descriptive statistics. Findings show high levels of patient satisfaction with waiting times for investigations in both inpatient and outpatient settings; Radiology staff were perceived as approachable and willing to discuss clinical information with participants, PACS usage was highly rated by clinicians for viewing reports and images, participants reported high satisfaction with image quality, reliability and ease of use; and PACS was seen to shorten reporting speeds as well as waiting times. Correlations were observed between clinician age, approachability of radiology staff, speed of reporting, wait time for investigations and overall satisfaction with PACS use in radiology practice, adoption rates and satisfaction levels of users; continuous improvements to efficiency and service awareness, as well as improvements to adoption rates, are key components to increasing adoption rates and satisfaction levels among healthcare institutions and radiology practitioners alike. Future research could include patient perspectives to gain a holistic view of its impact on overall healthcare experiences.

Keywords: PACS; acceptance; adoption

1. Introduction

Radiology services play a crucial role in modern healthcare, providing essential diagnostic information that assists clinicians in making accurate diagnoses and treatment decisions. With the advent of Picture Archiving and Communication Systems (PACS), the way radiology services are delivered and accessed has been revolutionized. PACS has transformed traditional film-based radiology into a digital and easily accessible platform, offering a multitude of benefits such as rapid image storage, retrieval, and transmission. The successful integration of PACS into clinical workflows is crucial for efficient and effective patient care. To ensure the optimal utilization of PACS and its seamless integration with clinical practice, it is essential to understand the perspectives and satisfaction of clinicians who rely on these services.

1.1. Adoption of PACS in clinical practice

The adoption of PACS has rapidly increased in healthcare settings worldwide [1 - 5]. Several studies have investigated the factors influencing the adoption of PACS among clinicians [6 - 9]. These factors include ease of use, system reliability, speed of image retrieval, and integration with electronic health records (EHRs). Positive experiences with PACS have been reported, including improved accessibility to images, faster report turnaround times, and enhanced collaboration between radiologists and clinicians [10 - 12].

1.2. Impact on workflow and efficiency

PACS has the potential to impact the workflow and efficiency of clinicians significantly. Studies have demonstrated that the implementation of PACS reduces the time spent on image retrieval and film handling, leading to improved productivity and streamlined processes [13 - 15]. However, challenges related to system downtime, connectivity issues, and learning curve have also been reported, which may hinder the overall satisfaction of clinicians [13], [16 - 18].

1.3. Clinician satisfaction with PACS

Clinician satisfaction is a crucial aspect of successful PACS implementation. Several studies have explored the satisfaction levels of clinicians with PACS [19 - 20]. Factors influencing clinician satisfaction include ease of use, system reliability, speed of image retrieval, image quality, integration with clinical workflow, and technical support [21 - 24]. High levels of satisfaction have been reported when these factors are met, leading to increased clinician acceptance and utilization of PACS.

1.4. Impact on patient care

The successful implementation of PACS and the satisfaction of clinicians using the system have a direct impact on patient care. Studies have shown that PACS improves the timeliness and accuracy of diagnoses, facilitates multidisciplinary collaboration, and enhances communication between clinicians . Clinician satisfaction with PACS positively influences their engagement with the system, leading to better patient outcomes and overall healthcare quality.

1.5. Future directions

While PACS has transformed radiology services, ongoing advancements and innovations continue to shape its future. Integration with artificial intelligence (AI) algorithms, mobile device compatibility, and interoperability with other healthcare systems are areas of development [22], [29]. Understanding clinicians' evolving needs, concerns, and satisfaction levels with these emerging technologies will be crucial for their successful integration into clinical practice.

1.6. Research Problem

The research problem centers on understanding the factors that influence clinician acceptance and adoption of PACS in radiology services. Despite the technological advancements and potential benefits of PACS, there is a gap in comprehensive understanding of the clinician's perspective, which includes their satisfaction with the system, its usability, and the perceived impact on clinical workflow and patient care. This gap may hinder the

effective implementation and utilization of PACS, potentially affecting the quality of radiology services and patient outcomes.

1.7. Research Question

Given the outlined research problem, the study seeks to answer the following primary research question: What are the key factors that influence clinician acceptance and adoption of PACS in radiology services, and how do these factors impact clinician satisfaction, system usability, workflow efficiency, and patient care?

2. Research Method

The study was conducted at four major public hospitals in Hail City, Kingdom of Saudi Arabia (KSA). The target population consisted of clinician personnel who actively use PACS in all hospital departments, excluding radiologists. The study employed an exploratory, descriptive approach using a survey method to gather information. The validity and reliability of the survey questions were tested during the work of Lindsay, McKinstry, Vallely, et al. The study encompassed five areas related to clinician satisfaction with radiology services concerning PACS, including demographic information, inpatient work, outpatient work, radiology systems (e.g., ease of access, on-call service, PACS), and overall impression. The study also aimed to examine the relationship between clinicians' perceptions of PACS.

The sample size for the target population of clinician personnel at the four major public hospitals in Hail, KSA, was calculated using the Raosoft sample size calculator website [30]. The estimated population size was based on the following inputs: margin of error: 5%, confidence level: 95%. The estimated sample size was determined to be 342 participants. The survey used in this study comprised 23 questions and was distributed in the four public hospitals in Hail City. The first part of the survey consisted of five questions to gather demographic and background information. The second part focused on inpatient work, the third on outpatient work, the fourth on the radiology system (PACS), and the fifth part on overall opinion. The survey was accompanied by a brief introduction about the study's objectives and a consent form.

The study employed a non-probability convenience sampling method to select clinician personnel from four major public hospitals in Hail City, Kingdom of Saudi Arabia (KSA). This sampling method was chosen due to the practical constraints of accessing a specific population of healthcare professionals who actively use PACS in their clinical practice. The participants were selected based on their availability and willingness to participate in the study, ensuring a diverse representation of various specialties and experience levels.

Data collection commenced on February 1, 2023, and continued until the end of June 2023. The survey was distributed online via email to clinician personnel who met the inclusion criteria, which included being actively involved in using PACS for radiology services within the selected hospitals. A total of 300 surveys were distributed, targeting clinicians across different departments to capture a broad perspective on PACS usage and satisfaction.

The response rate was approximately 56% of the estimated sample size, with 168 completed surveys received. The relatively high response rate may be attributed to the participants' interest in the subject matter and the convenience of the online survey format, which allowed for easy access and completion.

Upon collecting the surveys, they were examined for accuracy, completion, and integrity. Subsequently, they were analyzed using SPSS (Statistical Package for Social Science). Descriptive analysis was employed in the study, including frequencies, percentages, means, and standard deviations.

2.1. Statistical Analysis

This study employed a Chi-square test to compare categorical variables and identify any statistically significant associations between responses. A P-value of less than 0.05 was considered indicative of statistical significance. In cases where the Chi-square test was not applicable due to expected counts of less than 5 in more than 20% of cells, a Fisher exact test was utilized. Additionally, a 2x2 table was created for certain variables to facilitate analysis. The results were then presented in a clear and comprehensible format, providing quantitative findings.

3. Result

3.1. The Descriptive Analysis of Participants' Demographic and Work Characteristics

The study participants' ages varied from 25 years and more, and most participants were between 25-29 years (Table 1). Of the participants, 30.3% had 15 years or less experience in healthcare practice, and 18.3% of participants had more than 20 years in practice. Most of the specialties represented in the responder group were from orthopedics (20.4%), Neurology (9.2%), and 64% of the specialty coded as 'other' (i.e., pediatrics, hematology, Oncology, ICU, family medicine, neurosurgery, OB-GYN, ENT, and Emergency).

Table 1. Participants' Demographic and Work Characteristics

Participants Demographic	**N (N=142)**	**Percentage %**
Gender		
Male	34	23.9
Female	108	76.1
Age		
25-29	52	36.6
30-39	30	21.1
40-49	10	9 7
50-59	41	28.9
60-69	9	6.3
70+	0	0
Specialty		
Internal medicine	8 21	14.8
Oncology	8	5.6
Neurology	13	9.2
Respiratory	0	0
Cardiology	0	0
Urology	0	0
Orthopedics	29	20.4
General surgery	0	0
Endocrine	7	4.9
Others	64	45.1
Experience		
0-5	34	23.9
6-10	33	23.2
11-15	43	30.3
16-20	26	18.3
20+	26 6	4.2

Participants Demographic	N (N=142)	Percentage %
Position		
Intern	13	9.2
Resident	41	28.9
Fellow	5	3.5
Assistant consultant	4	2.8
Consultant	56	39.4
Others	23	16.2

3.2. Inpatient Services: Satisfaction with Wait Time for Investigations

Regarding inpatient services, the findings indicate that a significant majority of participants, approximately 80.3%, expressed either high satisfaction or satisfaction with waiting times for investigations. Conversely, only 10.6% of participants reported dissatisfaction or strong dissatisfaction with waiting times (Fig. 1). In terms of approachability, 75% (106 participants) stated being either highly satisfied or satisfied with the accessibility of radiology staff when ordering investigations, while only 7% perceived the radiology staff as unapproachable. Moreover, around 90% of participants indicated that the radiology staff demonstrated interest in discussing clinical information with referring clinicians, whereas only 9.9% reported a lack of interest from the radiology staff in such discussions (Table 2).

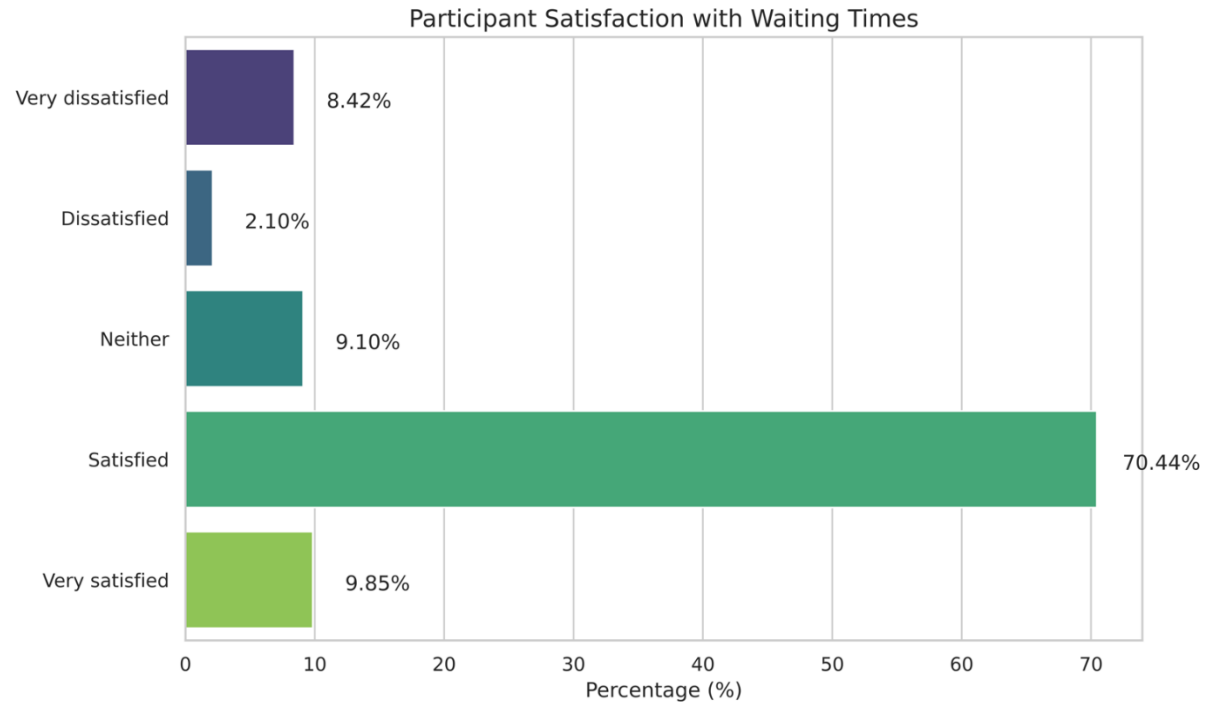

Figure 1. Analyzing Participant Satisfaction: Insights into Waiting Times

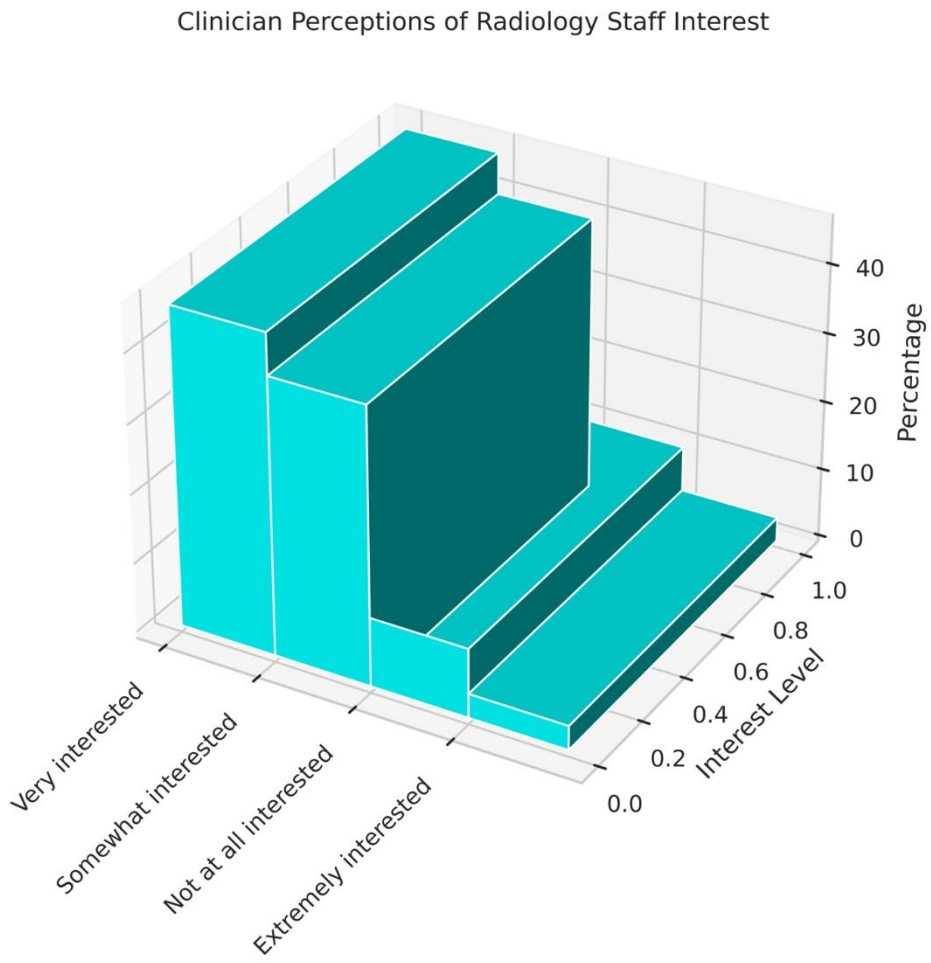

Figure 2. Clinician Perceptions of Radiology Staff's Interest in Discussing Clinical Information

3.3. Outpatient Services: Satisfaction with Wait Time for Investigations

In terms of outpatient services, the results indicate that 54.3% of participants expressed high satisfaction or satisfaction with the wait time for outpatient investigations. Additionally, 18.3% of participants reported being neither satisfied nor dissatisfied, suggesting a neutral stance. On the other hand, only 27.5% of participants expressed dissatisfaction or strong dissatisfaction with the waiting time for investigations (Fig. 2). These findings highlight that a significant majority of participants were satisfied or had a neutral perspective regarding the wait time for outpatient investigations.

3.4. Radiology System: Perceptions of PACS Usage and Satisfaction

Table 2, 3, 4: Clinician Perceptions of PACS Usage and Satisfaction

Clinicians were asked about their utilization of PACS for viewing reports, images, or both. The responses indicated a similar frequency, with 69% of participants utilizing PACS for viewing reports and 78% for viewing images. Furthermore, the majority of participants responded positively to PACS in terms of image quality (88%), reliability (90%), and ease of use (86%) (Table 3).

In terms of the speed of reporting, approximately 73% of participants felt that PACS had improved, while 23% perceived little improvement. Only 4% expressed the belief that there had been no improvement in the speed of reporting. Additionally, 75% of respondents believed that PACS had improved the waiting time for investigation, while 25% perceived little or no improvement. These findings highlight the positive impact of PACS on the speed of reporting and waiting time for investigations, according to the majority of participants.

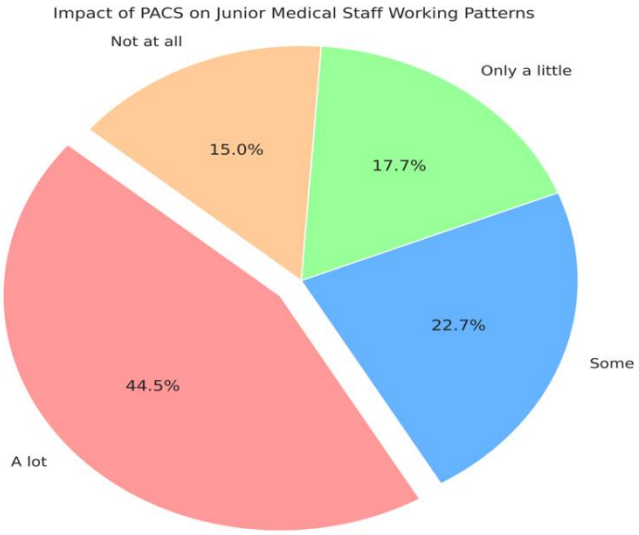

Figure 3. The Influence of PACS on Junior Medical Staff's Working Patterns

Table 2. Quality of images

Quality of Images	Frequency	Percent	Mean	Standard Deviation
Poor	11	7.70%		
Below Average	7	4.90%		
Average	16	11.30%		
Good	67	47.20%		
Excellent	40	28.20%		
Total	141	100%	3.83	1.111

Table 3. Reliability

Reliability	Frequency	Percent	Mean	Standard Deviation
Poor	4	2.80%		
Below Average	13	9.20%		
Average	17	12.00%		
Good	81	57.40%		
Excellent	30	21.30%		
Total	145	100%	3.87	0.921

Table 4. Ease of use

Ease of Use	Frequency	Percent	Mean	Standard Deviation
Poor	12	8.50%		
Below Average	8	5.60%		
Average	17	12.00%		
Good	75	52.80%		
Excellent	30	21.10%		
Total	142	100%	3.725	1.118

Table 5 revealed a noteworthy correlation between the advancing age of clinicians and the rising value of the radiology report. Additionally, a connection was observed between the increased value of the report and the heightened proficiency of clinicians in interpreting the investigations they frequently requested ($p=0.000<0.05$).

Table 5. Correlation Between Report Value and Clinician Interpretation Ability

Statistical Test	Value	Degrees of Freedom (df)	Asymptotic Significance (2-sided)
Pearson Chi-Square	34.352	6	<0.001*
Likelihood Ratio	41.472	6	<0.001*
Fisher's Exact Test	32.581	N/A	<0.001*
Linear-by-Linear Association	1.19	1	0.155
Number of Valid Cases		144	

* Indicates a statistically significant result.

Furthermore, a significant correlation was observed between an improvement in the approachability of the radiology staff and an increase in overall satisfaction with radiology services and Picture Archiving and Communication Systems (PACS) ($p=0.000<0.05$).

Table 6 revealed a statistically significant association between the enhanced speed of reporting due to PACS and the satisfaction of clinicians towards radiology services and PACS ($p=0.024<0.05$).

Table 6. Association Between Reporting Speed and Clinician Satisfaction

Statistical Test	Value	Degrees of Freedom (df)	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.68	1	0.017*
Pearson Chi-Square (with Continuity Correction)	4.402	1	0.036*
Likelihood Ratio	5.122	1	0.023*
Fisher's Exact Test	N/A	N/A	0.023*
Linear-by-Linear Association	5.64	1	0.017*
Number of Valid Cases		142	

* Indicates a statistically significant result.

Our result demonstrates a highly significant correlation between the improvement in wait time for investigations through PACS and the increased satisfaction towards radiology services and PACS ($p=0.000<0.05$).

There was a significant association ($p=0.000<0.05$) observed between the increase in PACS' improvement in the working pattern of junior medical staff and clinician satisfaction. Clinician satisfaction was influenced by several factors, including the waiting time for investigations, the approachability of radiology staff, the effectiveness of PACS, and the impact of these factors. Among them, the most frequent radiology modality demonstrated the highest level of satisfaction. Furthermore, an increase in the value of the radiology report was found to have a positive correlation with overall satisfaction.

4. Discussion

The present study aimed to investigate clinicians' perceptions of radiology services and the utilization of Picture Archiving and Communication Systems (PACS). The results provide valuable insights into the satisfaction levels and perceived benefits of these systems among the participating clinicians. Also, according to a recent study, physicians have demonstrated a positive response to PACS. Although satisfied, it is important to acknowledge that challenges and issues still persist and need to be resolved for successful implementation and system interoperability [22]. Moreover, multiple studies in KSA were consistent with our findings and showed that healthcare workers demonstrated a high level of acceptance of utilizing systems in health organizations[30], [31].

In terms of inpatient services, a significant majority of participants expressed satisfaction with waiting times for investigations. This indicates that the radiology department effectively managed the timing of inpatient investigations, meeting the expectations of clinicians. The high satisfaction levels suggest that timely access to radiology services was achieved, which is crucial for prompt diagnosis and patient management. Nevertheless, researchers have determined that there is insufficient evidence to support a substantial alteration in the duration of hospital stays following the integration of Picture Archiving and Communication Systems (PACS). The findings demonstrate no statistically significant difference in the length of hospitalization prior to and after the implementation of PACS [32].

The approachability of radiology staff also played a vital role in clinician satisfaction. The majority of participants reported being highly satisfied or satisfied with the accessibility of radiology staff when ordering investigations. This indicates that the radiology staff demonstrated a responsive and cooperative approach, which facilitates effective communication and collaboration between referring clinicians and radiologists. Such an approach is essential for ensuring the seamless integration of radiology services into the overall patient care process.

Outpatient services, including the wait time for investigations, also received positive feedback from the participants. A significant majority expressed satisfaction or high satisfaction with the wait time for outpatient investigations. This suggests that the radiology department successfully managed the scheduling and prompt delivery of outpatient services, minimizing delays and inconvenience for patients and clinicians alike. Attitudes, knowledge, awareness, and expectations influenced patients' perception of using PACS for medication refills in outpatient settings. While overall satisfaction was reported, there is a need to enhance efficiency and service awareness to increase adoption and satisfaction rates further [33], [34].

The utilization of PACS was found to have a positive impact on various aspects of radiology services. Participants reported high levels of satisfaction with PACS, particularly in terms of image quality, reliability, and ease of use. These findings indicate that PACS has effectively enhanced the accessibility and usability of radiology images and reports, facilitating accurate and efficient interpretation by clinicians. The positive perceptions of PACS highlight its potential as a valuable tool in radiology practice. Moreover, the researchers reached a conclusion that the role of the radiographer has evolved in three main aspects: (1) communication within their work; (2) image processing; and (3) image quality assurance, which includes the responsibility of releasing patients.

Importantly, the study revealed significant correlations between certain factors and overall clinician satisfaction. The increasing age of clinicians was associated with a higher value placed on the radiology report,

suggesting that more experienced clinicians recognize the importance and relevance of radiological findings in their clinical decision-making process.

Furthermore, the improvement in the approachability of radiology staff was significantly associated with increased satisfaction with radiology services and PACS. This emphasizes the importance of effective communication and collaboration between radiologists and referring clinicians, fostering a positive working relationship and enhancing overall satisfaction with the services provided.

The study also demonstrated the positive impact of PACS on the speed of reporting and wait time for investigations. The majority of participants perceived improvements in these aspects, highlighting the potential of PACS in streamlining radiology processes and reducing delays in patient care. The positive association between PACS improvement and clinician satisfaction indicates that the utilization of such systems can have a substantial positive effect on overall clinician experience and workflow. Additionally, the integration of PACS enhances radiologists' utilization of clinical decision-support tools. Having integrated access to these tools is crucial during the initial deployment phase, as the acceptance and effectiveness of decision support tools may be compromised without seamless integration [35].

It is important to acknowledge certain limitations of the study. The study sample consisted of a specific group of clinicians from various specialties, and the findings may not be generalizable to the entire clinician population. Additionally, the study focused on clinician perceptions and satisfaction, but patient perspectives and outcomes were not assessed. Future research could consider incorporating patient feedback to provide a more comprehensive understanding of the impact of radiology services and PACS on the overall healthcare experience.

5. Conclusion

This study investigated clinician acceptance and adoption of PACS in radiology services. The findings provided insights into clinician satisfaction, system usability, perceived impact on workflow, and patient care. Overall, the study revealed that clinicians expressed satisfaction with PACS, and perceived improvements in efficiency and service awareness would further enhance adoption and satisfaction rates. The study sample consisted of clinicians from various specialties, with the majority being between the ages of 25-29. Participants reported high satisfaction with waiting times for investigations in both inpatient and outpatient settings. They also expressed satisfaction with the accessibility of radiology staff and their interest in discussing clinical information. These findings indicate positive clinician experiences and effective communication between referring clinicians and radiology staff.

Regarding PACS usage, a significant proportion of clinicians utilized PACS for viewing reports and images, with positive perceptions of image quality, reliability, and ease of use. The majority felt that PACS had improved the speed of reporting and waiting time for investigations. These findings highlight the positive impact of PACS on workflow efficiency and suggest that it contributes to enhanced patient care and timely decision-making. The study also revealed a correlation between the advancing age of clinicians and the perceived value of the radiology report. Clinicians with more experience demonstrated heightened proficiency in interpreting the investigations they frequently requested, indicating the importance of experience and knowledge in radiology practice.

This study provides valuable insights into clinician acceptance and adoption of PACS in radiology services. The findings demonstrate overall satisfaction with PACS and emphasize the need for continuous improvements in efficiency and service awareness to enhance adoption rates and satisfaction levels further. Healthcare institutions should prioritize the integration and utilization of PACS to optimize its benefits in radiology practice, including improved workflow, efficient access to images and reports, and enhanced patient care. Future research could explore additional factors influencing clinician satisfaction and further assess the impact of PACS on patient outcomes.

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