Hospital Administration

PICTURE ARCHIVING AND COMMUNICATION SYSTEMS (PACS): ACCEPTANCE AND IMPACT AT TERTIARY CARE HOSPITALS

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ABSTRACT

BACKGROUND: A picture archiving and communication system (PACS) is a computerized means of replacing the roles of conventional radiological film: images are acquired, stored, transmitted, and displayed digitally. When such a system is installed throughout the hospital, a filmless clinical culture prevails. PACS has become a standard component for radiology or hospital information system.

METHODS : A comprehensive descriptive and observational study was undertaken from May 2013 to July 2013. The study setting involved two tertiary care public hospitals and a corporate hospital. Convenience sampling was used to select Key Informants. The Key Informants included Radiologists (9), Clinicians (7), Technicians (6), IT Support Team (4), Medical Superintendent (2) & GE PACS Engineer (1). Unstructured interview schedule and Structured questionnaire was used to assess user acceptance of the technology and to evaluate the end user perception towards the technology

RESULTS : After the implementation and integration of PACS at the hospitals, it was observed that the workflow had changed. The noticeable change was seen in the post examination phase between the completion of the procedure and availability of images to the radiologists and clinicians. Before PACS implementation at two public hospitals, the examination was followed by approximately an hour-long process of film development which was further followed by the sorting of the previous images before the patient folder could reach the radiologist. Post PACS this had been replaced by a five minute activity of processing a plate, containing a cassette with patient details, and the screen containing image, in the CR processor and transmitting the image to PACS by a technician.

CONCLUSION: Whenever new technology is introduced in a healthcare setting, there is bound to be an initial learning curve to bring the end users on board. PACS leads to utilization of resources in a better way provided training and other ergonomic requirements are taken care of for the end users.

KEYWORDS : PACS, RIS, HIS, Radiology

BACKGROUND:

A picture archiving and communication system (PACS) is a computerized means of replacing the roles of conventional radiological film: images are acquired, stored, transmitted, and displayed digitally. When such a system is installed throughout the hospital, a filmless clinical culture prevails. (Strickland, n.d.) PACS has become a standard component for radiology or hospital information system.(Aldosari, 2012) It has made possible the storage management of images easier for healthcare organizations.(Ahmadi, Mehrabi, Sheikhtaheri, & Sadeghi, 2017) New technologies are sometimes easily accepted in healthcare organizations to improve service quality and efficiency (*OECD: Improving Health Sector Efficiency: The Role of Information and Communication Technologies. Paris*, n.d.). Although PACS has fundamentally changed healthcare organizations, it has proven to be a real challenge for many of them (Paré & Trudel, 2007)(Honeyman-Buck, 2003)**.** The planning and purchase of PACS is a major financial investment and its implementation has a long-term effect on a provider's daily operations.(Mancino & Russo, 2007) The evaluation of PACS implementation has been done from various perspectives. (Buccoliero, Calciolari, Marsilio, & Mattavelli, 2009) The impact of PACS on the overall efficiency of delivering imaging services has been calculated to reduce the cost per image produced in the face of increasing demand for the service.(Sutton, 2007) Various studies have revealed that user acceptance is an essential tool before implementing PACS as it greatly determines the success rate.(Aldosari, 2012)

METHODS

A comprehensive descriptive and observational study was undertaken from May 2013 to July 2013. The study setting involved two tertiary care public hospitals (main hospital and an associated hospital) located at different and distant locations in the same city with different technicians while the patients and end users were shared for both the hospitals and a corporate hospital. Both the public hospitals were under the same top management control with disaster data recovery available at both the places. Convenience sampling was used to select Key Informants from public hospitals: Radiologists (6), Clinicians (5), Technicians (6), IT Support Team (4), Medical Superintendent (2) & GE PACS Engineer (1). Three radiologists and two clinicians were also interviewed from a corporate hospital to get an insight into their perspective. Non-participant observation was done to analyze the workflow of the radio diagnosis department of the hospital. Semi-structured interviews were conducted with the Key Informants to understand the comprehensive planning for implementation of PACS along with the process of implementation, PACS workflow and the changes in the workflow in the radiology department. Structured questionnaire was used to assess user acceptance of the technology and to evaluate the end user perception towards the technology. Data was analysed by using Microsoft Office Suite.

RESULTS

After the implementation and integration of PACS at both the public hospitals, it was observed that the workflow had changed. The noticeable change was seen in the post examination phase between the completion of the procedure and availability of images to the radiologists and clinicians. Before PACS implementation the examination was followed by approximately an hour long process of film development which was further followed by the sorting of the previous images before the patient folder could reach the radiologist. Post PACS this had been replaced by a five minute activity of processing a plate, containing a cassette with patient details, and the screen containing image, in the Computed Radiography (CR) processor and transmitting the image to PACS by a technician.

There were changes in image delivery performance after the implementation of PACS Table 1 & Table 2)

Table 1. Image Delivery Performance before implementation of PACS

Film Management System	
Windowing images, Printing images and Developing films	15-20 minutes
Delivery of Developed films to the office	5 minutes
Clerks retrieving the patients films and combine with current films	5-10 minutes
Residents receiving the image folder in reading room	5-10 minutes

Table 2. Image Delivery Performance after implementation of PACS

PACS	
Period during which acquisition gateway receives images from the imaging device and format images into DICOM standard image file	2-3 minutes

Elapsed time of transferring image files from acquisition computer to PACS controller	2-5 minutes
Processing time for managing and retrieving image files at PACS server	3-5 minutes
Time needed to distribute image files from server to display workstation	2-5 minutes

It was observed that there was a range of 30-45 minutes per examination on film based system i.e. Pre-PACS compared to a much less duration of 9-18 minutes for the entire process Post-PACS. In the case of film based system, the clinicians were dependent on staff for order, transport and disposition of the film. Using PACS, the clinicians were no longer dependent on staff for image accessibility.

Radiologists Perspective
Radiologists interviewed were enthusiastic at the time of PACS implementation as they anticipated streamlined work process post implementation. A generational difference was quite evident between the junior and senior radiologists regarding their view of the new workflow. Few radiologists especially the junior radiologists did not see the modified workflow as threatening as compared to the senior radiologists. Senior doctors saw the technology as a threat to their skills and independence. The radiologist's professional role shifted to more of a consulting role over the period of time post PACS implementation phase. The use of PACS has led to the re-conceptualization of the clinical work process leading to a deeper understanding and collective knowledge of technology and organization.

Radiologists attributed certain factors contributing to the change in the work process. All these factors created opportunities for the radiologists to engage themselves in more complex diagnostic problems and are listed as follows –
1. Easy access of images
2. Capacity to show the images over the internet to the clinicians
3. Interpret large images in volumes instead of separate images.

Clinician's Perspective
Clinicians use gave a mixed review on this latest technology. Few clinicians appreciated the technology and the change in the work culture while a few of the senior clinicians still preferred the traditional approach towards work. They specifically stated that PACS had not made any remarkable change in their work practice and considered the advancement more beneficial for the radiologists. The only benefit they perceived was the availability of many sequences at the same point in time as it is not possible to print all the sequence of the images. However, they acknowledged the efficiency that PACS had brought in terms of decision making.

User Acceptance of PACS
Training
The results obtained after analyzing the data on formal training in computers and PACS training are given in Figure 1 & Figure 2 respectively.
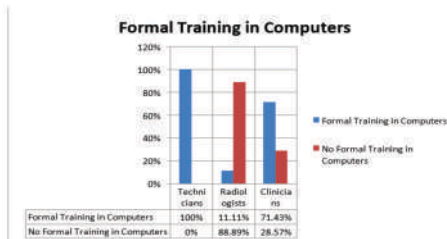

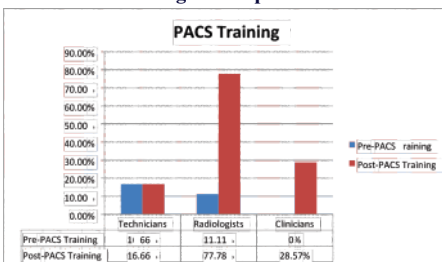**Figure 1. Formal Training in Computers**

Figure 2. PACS Training

There were few users who had received training before and after installing PACS. However, there was a lack of formal training program and there was no uniformity in training being imparted . Few users were trained once for an hour and for few, two sessions were held.

Format of Reporting
78% of the radiologists were comfortable in writing report on the computer while 22% were comfortable in writing hand report. On the other hand, not even a single radiologist was comfortable dictating reports and subsequent typing. 78% of the radiologists also reported that having radiology reports on PACS was very useful to them.

Table 3. PACS as a useful advancement

Response	Radiologists	Clinicians
Strongly Agree	100%	85.72%
Agree	0%	14.28%

Most of the users acknowledged the fact that PACS was a useful advancement for the hospital. (Table 3)

Improvement in Clinician's Consultation
71.43 % of Clinicians said that PACs helped to show the images to patients. 71% said that it reduced time spent in finding the radiology reports and 57 % of them said that PACs made consultation time efficient.

Clinician's gave mixed reviews regarding the improvement in their consultation practice brought in by introduction of PACS. Most of the clinicians agreed to the fact that PACS had improved their consultation by reducing the time spent in finding images for review
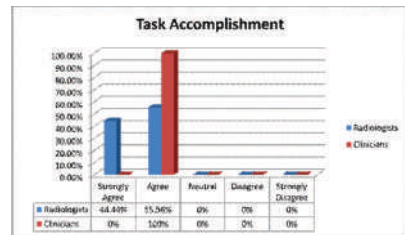
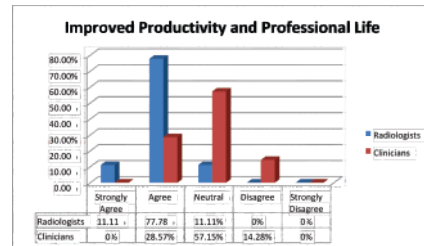### Perceived Usefulness (Figure 3 – 6)

Figure 3. Task Accomplishment

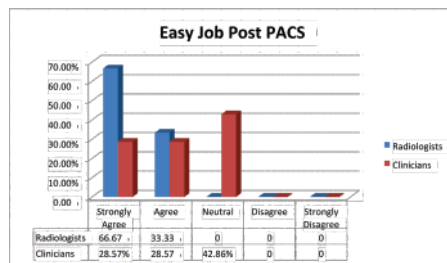**Figure 4. Improved Productivity and Professional Life**
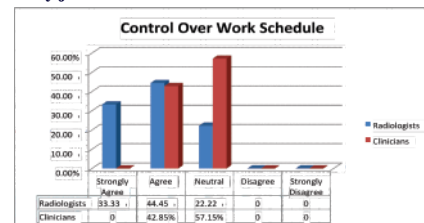

Figure 5. Easy job Post PACS

Figure 6. Control over work schedule

Radiologists and Clinicians accepted the fact to a an extent that PACS as a software was quite useful to them. 28% of the clinicians disagreed to the statement that PACS had improved their quality of work by providing better clinical care mainly due to the reason that they felt that PACS was more beneficial to the radiologists as compared to themselves.

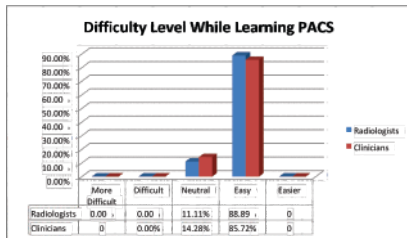*Perceived Ease of Use (Figure 7 & 8 and Table 4)*
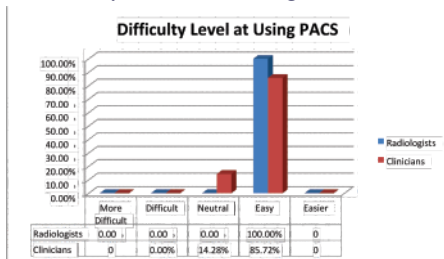

Figure 7. Difficulty level while learning PACS

Figure 8. Difficulty level at using PACS

Few users also felt that PACS had changed their job to a great extent in terms of difficulty level, Interest level, Stress level and Pleasant level.

Table 4. Changed job to a great extent in terms of difficulty level, Interest level, Stress level and Pleasant level

Parameters	Response	Radiologists	Clinicians
Difficulty Level	Easy	100%	42.85%
	Neutral	0%	57.15%
Interest Level	Interesting	77.78%	28.57%
	Neutral	22.22%	71.43%
Stress Level	Less Stressful	88.89%	85.72%
	Neutral	11.11%	14.28%
Pleasant Level	More Pleasant	11.11%	0%
	Pleasant	77.78%	71.43%
	Neutral	11.11%	28.57%

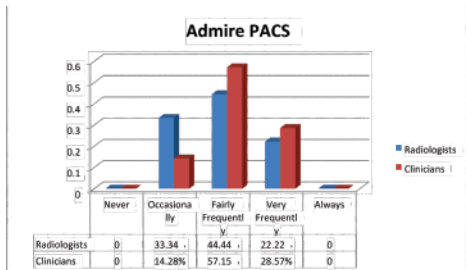*Behavior Acceptance* (Figure 9 to Figure 13)
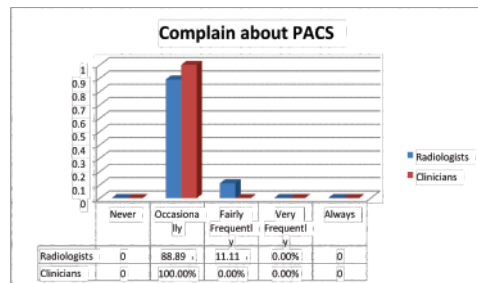

Figure 9. Admire PACS
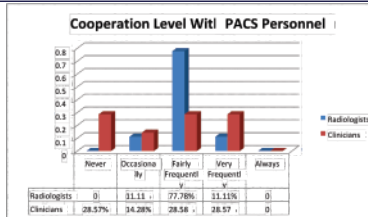

Figure 10. Complain about PACS

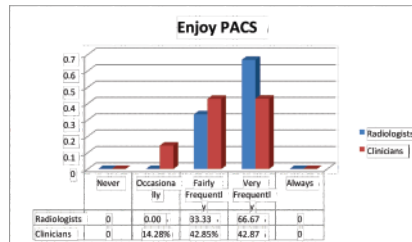**Figure 11. Cooperation Level With PACS Personnel**
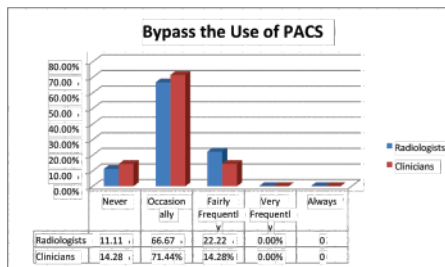

Figure 12. Enjoy PACS

Figure 13. Bypass the Use of PACS

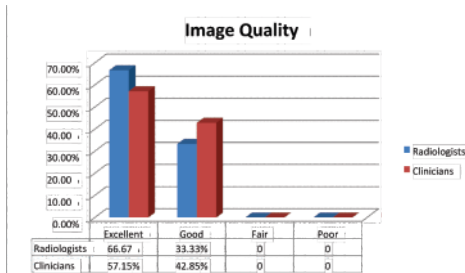*Display Workstation User Survey (Figure 14 to Figure 21 & Table 5)*
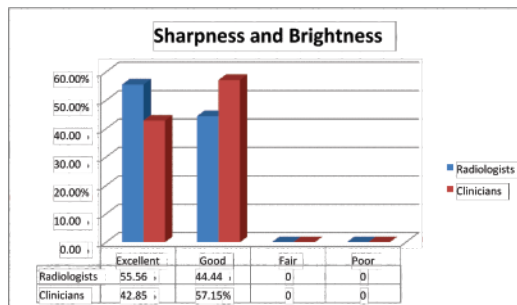

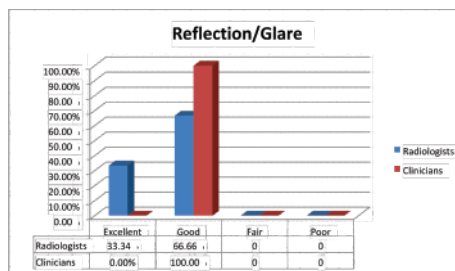*Figure 14. Image Quality*

Figure 15. Sharpness and Brightness
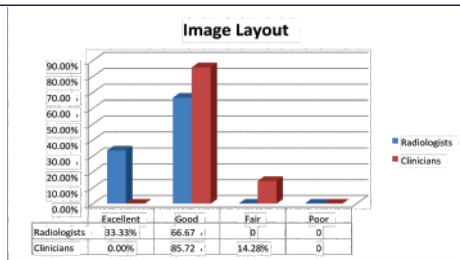

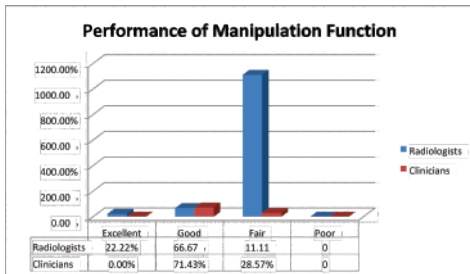**Figure 16. Reflection/Glare**

Figure 17. Image Layout

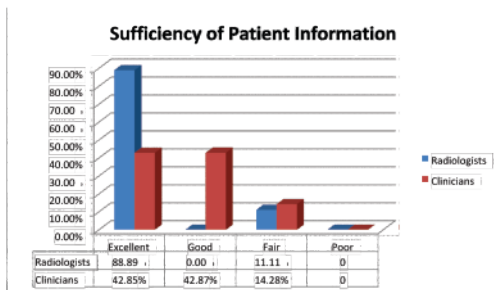**Figure 18. Performance of Manipulation Function**
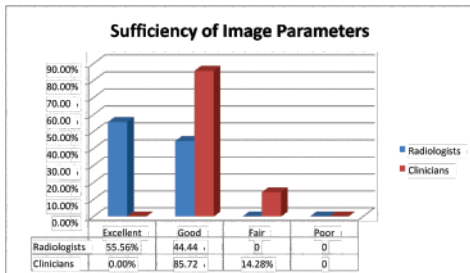

Figure 19. Sufficiency of Patient Information

Figure 20. Sufficiency of Image Parameters

Table 5. Response to different parameters

Parameter	Response	Radiologists
Timeliness of Image availability for reporting	Excellent	11.11%
	Good	77.78%
	Fair	11.11%
Written reporting service	Excellent	55.56%
	Good	22.22%
	Fair	22.22%

Figure 21. Overall Satisfaction

Frustration Levels
Most of the radiologists and clinicians agreed to the fact that PACS had

caused less frustration in terms of their work. 14% clinicians believed that frustration levels were not consistently less, sometimes frustration was more depending upon the situation. Frustration levels were high during image retrieval issues.

Technician's Perspective
83% of the technicians strongly agreed to the hospital's approach towards adoption of PACS. 66.66% technicians felt that PACS had made the department filmless while 33% believed that films were being given to the patients as few modalities were not connected to PACS due to DICOM incompatibility at the hospital.

Most of the technicians were satisfied with the software. 50% of the technicians felt the need of some kind of training program so that they could make the efficient and complete use of the adopted technology.

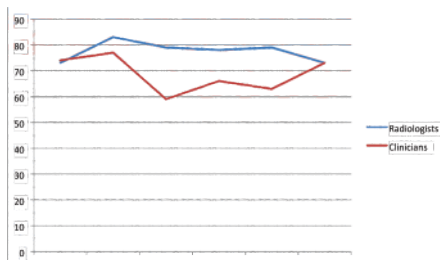**Technology Savy (Figure 22)**

Figure 22. Technology Savy

Based on the scoring done for the radiologists and clinicians, the radiologists were found to be more technology savy as compared to the clinicians mainly because of the reason that the clinicians had not yet acknowledged the benefits of PACS and many of them still preferred using traditional approach.

DISCUSSION
PACS these days has become an integral part of the radiology department of a hospital. However, the technology continues to evolve and improve at the same time, the key practical issues and challenges still remains which need to be addressed. (Berkowitz, Wei, & Halabi, 2018)

The data revealed that the degree of satisfaction varied, the satisfaction rate being 56% and 45% highly satisfied and satisfied respectively among radiologists and 28% and 71% among the clinicians, the radiologists did bypass the use of PACS 22% and 67% fairly frequently and occasionally respectively while 14% of the clinicians' by-passed its use fairly frequently and 71% occasionally. The main reason for this reluctant behavior towards the technology was not the difficulty in handling the software (most of doctors rated it as the same being easy), instead it was '*lack of training*'.

17% of the technicians felt that there was lack of training pre and post PACS installation. 11% of the radiologists felt the need and importance of pre-PACS installation training while 78% of them felt the need of post-PACS installation training which was missing. On the other hand, none of the clinicians felt the need of pre-PACS training while 28% of them wanted a proper post-PACS training in place.

There had been cases in the hospitals where the PACS server was down and the clinicians were not able to review any images until the server was retrieved. It led to enormous trouble to the patients and the doctors themselves. In order to review the images in such a situation PACS Downtime Strategy could be followed. All the modalities can be configured with a separate PACS library as a destination. Both these devices along with the rest of essential devices like CR, DR, etc. should reside on emergency power and at the same time configured with connections to separate closets. In the event of PACS failure, images can be transferred to this PACS library and when needed can be viewed from this particular library and printed for that particular time period.

The technicians reported various instances wherein the personnel handling the registration desk were not aware of the medical terminologies specifically concerning the radiological examinations and the portal for multiple areas examination for the same patient (thorax and abdomen), leading to duplicate entries being made in HIS. The multiple patient demographics went to PACS broker while the

image got attached to one and the other entry was shown as unspecified. In order to resolve the issue, it was very important for the personnel at registration to be aware of all the basic terminologies and different portals for different the examination.

89% of the radiologists felt that they were experiencing the symptoms of eye strains which mainly included itching, burning, irritating eyes, headache, etc. and out of these 55% felt that the symptoms were increasing. 86% of the clinicians complained of the same problem and 28% complained that these symptoms were increasing with time. It is very important to address this issue as it might affect the utilization of PACS because the user(s) having these symptoms might avoid using PACS and shift to the traditional approach. The monitors provided to the users should have the shielding screen to avoid eye strain to some extent.

A few surgeons felt the need of integrating PACS with the Operating room so that they could view images while operating on the patient whenever required. They could also take it a step further by integrating it to the OT cameras so that live OT images could be telecasted live for cross consultations. Virtualization would be helpful as it enables the referring doctors and the remote doctors to view same images simultaneously.

A large number of studies have revealed the reduction in the turnaround time post PACS installation from the beginning of the examination to the report delivery. (Marquez, n.d.) A lot have been spoken about reduction in waiting time, average length of stay substantiating it with the reason that PACS speeds up the phases of diagnostic process and reduces the time needed to obtain radiological results. (van de Wetering & Batenburg, 2009) Few studies also state the downtime issues which are not substantiated by a very authentic and satisfactory recovery solutions. (van de Wetering & Batenburg, 2009) The impact of PACS on the overall efficiency of delivering imaging services has been calculated to reduce the cost per image produced in the face of increasing demand for the service.(Sutton, 2007)

The users response was quite positive towards the implementation of a hospital wide PACS and its acceptance as a useful advancement to provide good quality images alongwith the reports. (Pilling, 2003)

Various studies also state that user acceptance is an essential tool before implementing PACS as it greatly determines the success rate and also stated the importance of training or familiarization programs should be given utmost importance in order to motivate the employees ultimately increasing the productivity of the system.(Aldosari, 2012)

Few studies have acknowledged the fact that PACS will play an important role in the total digital conversion in healthcare, when a part of total HIS, will benefit the quality of patient care delivered to a large extent and also emphasized on the faster decision making so that patient care can be delivered more efficiently and effectively. Few studies have also revealed significant changes in physician diagnostic behavior after PACS implementation. (Srinivasan, Liederman, Baluyot, & Jacoby, 2006)

CONCLUSION

PACS has many advantages to solve the problems of the film based culture in terms of film loss, timely availability of the images at the clinician's workstation, lost images, decreasing unnecessary repetition of examinations due to unavailability of previous images etc.

The most important advantage achieved and perceived was the accessibility to the images and the improved display as revealed by the user display workstation survey. There were no more transferring films between the departments on manual basis leading to unnecessary delays.

However, it also has a certain disadvantage basically related to lost images, unable to retrieve, downtime issues, etc. which needs to be addressed.

It is important to make sure that all the users are trained on the PACS workflow and associated PACS devices. A proper training program including both pre and post-PACS training shall let the organization reap maximum benefit out of PACS installation.

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