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Original Article

Perceived Impact of Digital Imaging Workstations on Radiology Workflow Efficiency and Clinical Decision-Making: A Cross-Sectional Study at Al-Bayda Medical Center, Libya

Ahmed M Elhain *, Azmi B A Mekaiel , Saleh Boharara

Department of Medical Radiology Faculty of Health Sciences, Omar Al-Mukhtar University, Libya

Corresponding author, Ahmed M Elhain, Email :ahmed.mostafa@omu.edu.ly

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Abstract

Background: The move from film-based radiology to digital imaging has changed how radiology departments acquire, view, store, and communicate imaging studies. Workstations integrated with Picture Archiving and Communication Systems (PACS), Radiology Information Systems (RIS), and Hospital Information Systems (HIS), and using Digital Imaging and Communications in Medicine (DICOM) standards, are now central to routine imaging practice. Their effect in developing healthcare settings depends on more than hardware availability; training, technical support, software reliability, and interoperability may all shape the benefit seen in daily work. **Objective:** This study examined how healthcare professionals at Al-Bayda Medical Center (AMC), Libya, perceived the effect of digital imaging workstations on workflow efficiency, manual workload, report-related processes, and clinical decision-making. **Methods:** A single-center cross-sectional survey was conducted among 51 healthcare professionals who routinely interacted with radiological imaging services. Data were collected using a structured questionnaire, supplemented by interviews and direct observation. Categorical variables were summarized using frequencies and percentages. Exploratory associations between selected categorical variables were assessed using Fisher–Freeman–Halton exact tests, with Cramér's V reported as a measure of association strength. A p value <0.05 was considered statistically significant for the exploratory inferential analyses. Descriptive findings were interpreted as participants' reported perceptions and were not considered evidence of objectively demonstrated improvements in workflow or clinical outcomes.
Results: Female participants represented 56.9% of the sample and male participants 43.1%. Clinicians represented 62.7% of respondents, radiology technicians 21.6%, and radiologists 15.7%. Nearly half of the participants had more than 10 years of professional experience (47.1%). The Basic PACS viewer was the most commonly reported workstation type (72.5%), followed by multimodality imaging workstations (21.6%). All respondents reported either moderate (54.9%) or slight (45.1%) workflow improvement. Decision-making was perceived to improve significantly by 56.9% of participants and slightly by 43.1%. Manual workload was reported to decrease significantly in 31.4% and slightly in 56.9%, although 11.8% reported increased manual work. The most frequent barriers were lack of training/support (43.1%) and software crashes (41.2%). Professional role was significantly associated with workstation type ($p < 0.001$, Cramér's V = 0.568). **Conclusion:** Participants generally perceived digital imaging workstations as helpful for workflow and clinical decision-making at Al-Bayda Medical Center. Because the study relied mainly on user-reported outcomes, these findings should not be interpreted as direct proof of improved operational performance. Training, stable software, responsive technical support, and stronger interoperability remain practical priorities for improving workstation use.

Keywords: digital imaging workstation; PACS; DICOM; radiology workflow; hospital workflow optimization; clinical decision-making; imaging informatics; Libya.

Introduction:

Health information technology has reshaped diagnostic imaging. During the past three decades, radiology departments have gradually moved from film-based practice to digital systems. In these systems, images are acquired, processed, stored, retrieved, interpreted, reported, and shared electronically across clinical services [1].Digital Imaging and Communications in Medicine (DICOM) provides a standard framework for storing, transmitting, retrieving, processing, and displaying medical imaging information. It helps imaging data move between modalities, archives, and viewing systems in multi-vendor environments [2,3]. Picture Archiving and Communication Systems (PACS), Radiology Information Systems (RIS), Hospital Information Systems (HIS), and electronic medical record (EMR) systems support different stages of the same pathway, from order entry and registration to image interpretation and report communication [4,5].The workstation is where this digital workflow becomes visible to users. Radiologists, radiology technologists, and referring clinicians use it to access studies, review image series, adjust window and level settings, make measurements, add annotations, compare prior

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examinations, and perform multiplanar or three-dimensional processing when available. Its value depends on more than availability. Display quality, response speed, interface design, software stability, technical support, and integration with other hospital systems are also important [6-10]. Recent reviews also suggest that artificial intelligence is increasingly being incorporated into radiology workflows to support image interpretation, prioritization of urgent examinations, and workflow optimization, although successful implementation still depends on appropriate integration with existing PACS and clinical information systems [11].

Earlier radiology informatics studies indicate that digital radiography and PACS-based workflows can reduce manual steps and improve access to imaging information. May et al. reported additional workflow savings when digital radiography was integrated with RIS [12]. Siegel and Reiner emphasized that PACS works best when implementation is accompanied by workflow redesign, rather than only replacing film with electronic images [13]. Other studies have also highlighted modality worklist integration, workflow measurement, and PACS-related process optimization [5,14,15].

These benefits are not guaranteed. In developing healthcare settings, limited training, maintenance gaps, network limitations, software instability, and weak interoperability may reduce the practical value of digital imaging systems [16,17].

At Al-Bayda Medical Center, digital imaging systems are routinely used in radiological practice. However, evidence describing how healthcare professionals in Libya perceive the operational effects of digital imaging workstations—particularly their perceived influence on workflow efficiency, manual workload, report-related processes, usability, and clinical decision-making—remains limited. In particular, there is a lack of published evidence from Libyan healthcare institutions systematically describing these user-reported outcomes in routine clinical practice. This study therefore sought to characterize healthcare professionals' perceptions of digital imaging workstation use at Al-Bayda Medical Center, with specific emphasis on workflow efficiency, manual workload, report-related processes, usability, and clinical decision-making. As a single-center study based on a local sample, the findings are intended to describe the experience of participants at this institution and should not be interpreted as representative of healthcare facilities across Libya.

Materials and Methods

This study employed a single-center cross-sectional survey to characterize healthcare professionals' perceptions of the role of digital imaging workstations in workflow efficiency, manual workload, report-related processes, usability, and clinical decision-making within a hospital radiology setting. The study was primarily descriptive, with exploratory analyses conducted to examine selected associations between categorical workstation-related variables. The manuscript was prepared in accordance with the relevant STROBE principles for cross-sectional observational studies [18].

The study was conducted at Al-Bayda Medical Center, a major healthcare facility in eastern Libya. Its Radiology Department uses digital radiodiagnostic systems and imaging workstations for routine diagnostic services.

The study included 51 healthcare professionals who routinely interacted with radiology services or digital imaging workstations at Al-Bayda Medical Center. Eligible participants comprised radiologists, radiology technicians, physicians, nurses, and other clinicians from departments that routinely relied on radiological imaging for patient care. Participants were eligible if they were healthcare professionals working at the medical center and had routine interaction with radiology services or digital imaging workstations. Individuals without such routine interaction were not eligible for participation. Recruitment was conducted using a non-probability convenience sampling approach based on staff availability during the study period.

Because the available study records did not document the total number of eligible staff approached, the number who declined participation, or specific reasons for non-participation, a response rate could not be calculated. The final sample comprised 51 participants. Given the single-center setting, non-probability sampling strategy, and relatively small sample, the study was considered exploratory, and no formal sample-size calculation was performed. Accordingly, the findings are intended to characterize the perceptions of the participating healthcare professionals at Al-Bayda Medical Center rather than to provide statistically representative estimates for healthcare professionals in Libya.

Data were collected using a structured, study-specific questionnaire, supplemented by interviews and direct observation of routine radiology workflow activities. The questionnaire was developed to capture participant characteristics, patterns of digital workstation use, and perceived operational effects relevant to the objectives of the study. Items addressed gender, professional role, years of experience, department, workstation type, frequency of use, primary workstation-related tasks, perceived workflow efficiency, report turnaround time, manual workload, usability, technical issues, upgrade recommendations, and suggested areas for improvement. The questionnaire was not adapted from a single previously validated instrument; rather, its items were developed specifically for the objectives and clinical context of the present study. Before data collection, the questionnaire was reviewed by academic supervisors and radiology professionals to assess the clarity, relevance, and appropriateness of the items (face validity).

No formal pilot study or psychometric validation was performed, and internal consistency reliability was not assessed because the questionnaire primarily comprised categorical and single-item measures rather than a standardized multi-item psychometric scale. Accordingly, the questionnaire should be considered a study-specific exploratory instrument, and the absence of formal validation and reliability testing is acknowledged as a methodological limitation. The findings should therefore be interpreted as descriptive evidence of participants' reported perceptions rather than as measurements obtained using a fully validated psychometric instrument.

Digital radiographic images were acquired and processed during routine clinical practice using the Agfa MUSICA Acquisition Workstation with NX Software Version 3.0 (Agfa NV, Mortsel, Belgium). This system represents the image-acquisition and processing workstation used for digital radiography and should be distinguished from the workstation categories assessed through the participant questionnaire. For the purposes of this study, workstation type was classified according to the primary functionality reported by participants: a **Basic PACS viewer** referred to a workstation used primarily for accessing, viewing, and reviewing radiological examinations; a **multimodality imaging workstation** referred to a workstation that supported the review of images from multiple imaging modalities and associated image-manipulation functions; and an **advanced 3D/post-processing workstation** referred to a workstation used for three-dimensional reconstruction and advanced image post-processing. These categories describe the functional level of workstation use reported by participants and do not necessarily correspond to distinct hardware platforms or software products. Accordingly, the Agfa MUSICA/NX acquisition workstation and the participant-reported PACS/workstation categories were treated as separate technical descriptions in the analysis.

Categorical variables were summarized as frequencies and percentages. Because several contingency tables had sparse cells and nominal categories, exploratory associations were tested using the Fisher–Freeman–Halton exact test rather than a conventional Pearson chi-square test. Cramér's V was used to describe effect size. A p value below 0.05 was treated as statistically significant. No multiple-testing correction was applied because the analyses were exploratory.

Ethical considerations

Permission to conduct the study was obtained from the Radiology Department at Al-Bayda Medical Center (AMC) before commencement of data collection. The study involved healthcare professionals who routinely interacted with radiology services or digital imaging workstations. Participation was voluntary, and confidentiality was maintained throughout data collection, data handling, and reporting. No personally identifying information was included in the study dataset or reported in the manuscript.

3. Results

A total of 51 healthcare professionals participated in the study and constituted the final analytical sample. The available study records did not document the total number of eligible healthcare professionals approached, the number who declined participation, the number excluded before analysis, or the specific reasons for non-participation. Consequently, a participant response rate could not be calculated. The analyzed sample comprised 29 females (56.9%) and 22 males (43.1%). Clinicians represented the largest professional group, followed by radiology technicians and radiologists. Among clinicians, 19 were female and 13 were male; among radiology technicians, 4 were female and 7 were male; and among radiologists, 6 were female and 2 were male. Nearly half of the participants reported more than 10 years of experience with medical imaging systems. Gender was summarized descriptively and was not included in inferential analyses

Table 1. Demographic and professional characteristics of participants (n = 51)

Variable	Category	Gender distribution	n	%
Gender	Female	—	29	56.9
	Male	—	22	43.1
Professional role	Clinician	F=19; M=13	32	62.7
	Radiology technician	F=4; M=7	11	21.6
	Radiologist	F=6; M=2	8	15.7
Years of experience	1–5 years	—	8	15.7
	5–10 years	—	19	37.3
	>10 years	—	24	47.1
Department	Radiology	—	20	39.2

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	Paediatric ward	—	14	27.5
	Medicine	—	4	7.8
	ICU	—	3	5.9
	CCU	—	3	5.9
	Medical ward	—	3	5.9
	Surgical ward	—	3	5.9
	Nursery	—	1	2.0

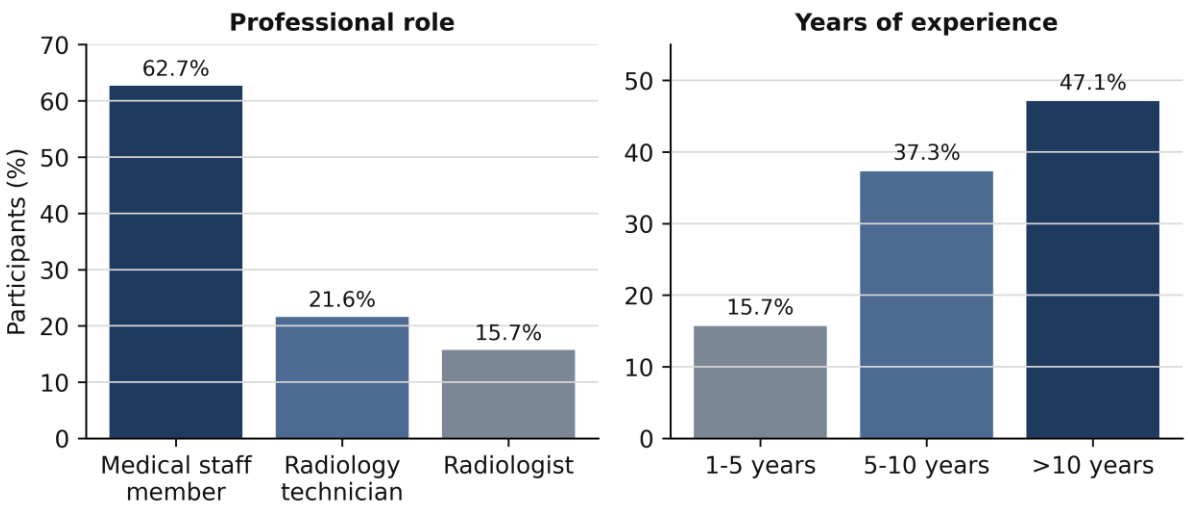

Figure 1. Professional distribution and imaging experience of participants.

Workstation utilization characteristics

The Basic PACS viewer was the most frequently reported workstation type. Most participants used workstations several times per day, and diagnostic image interpretation was the dominant reported task. This pattern suggests that the data mainly describe routine workstation use rather than extensive advanced post-processing.

Table 2. Digital workstation utilization characteristics

Workstation type	Basic PACS viewer	37	72.5
	Multimodality imaging workstation	11	21.6
	Advanced 3D/post-processing workstation	3	5.9
Frequency of use	Multiple times per day	47	92.2
	Once per day	3	5.9
	Rarely	1	2.0
Primary task	Diagnostic image interpretation	36	70.6
	3D reconstruction	8	15.7
	Teaching/training	5	9.8

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	Other	2	3.9

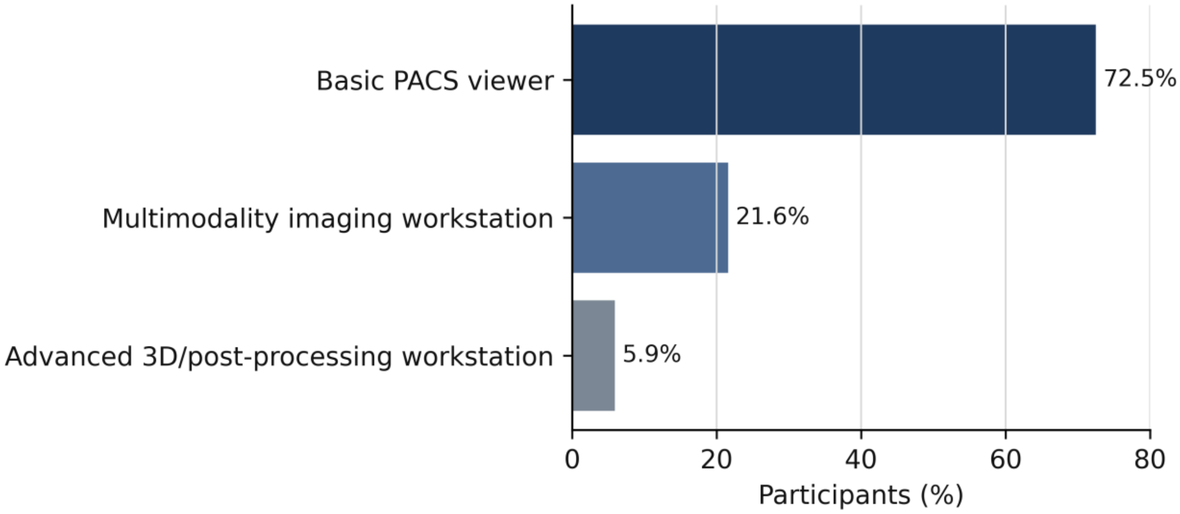

Figure 2. Distribution of digital imaging workstation types.

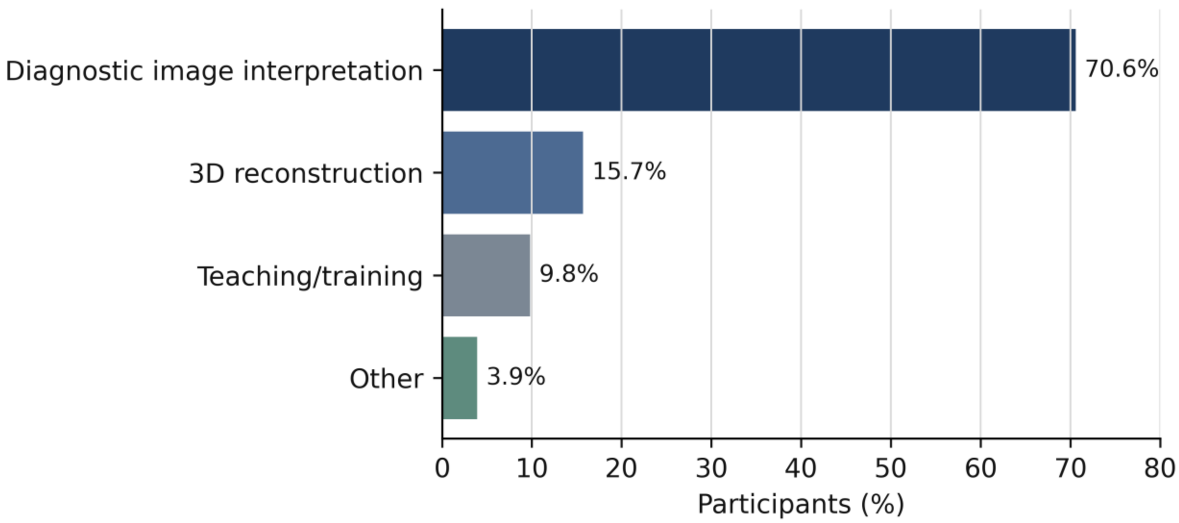

Figure 3. Primary clinical tasks performed using digital imaging workstations.

Perceived operational impact

All participants reported some degree of workflow and decision-making improvement. Most also reported shorter report turnaround and reduced manual workload, although a small proportion reported increased manual

Table 3. Perceived operational impact of digital imaging workstations

Workflow efficiency	Moderate improvement	28	54.9
	Slight improvement	23	45.1
Report turnaround time	Decreased significantly	27	52.9

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	Decreased moderately	23	45.1
	Increased turnaround time	1	2.0
Manual workload	Yes, significantly reduced	16	31.4
	Yes, slightly reduced	29	56.9
	Increased manual work	6	11.8
Clinical decision-making	Yes, significantly improved	29	56.9
	Yes, slightly improved	22	43.1

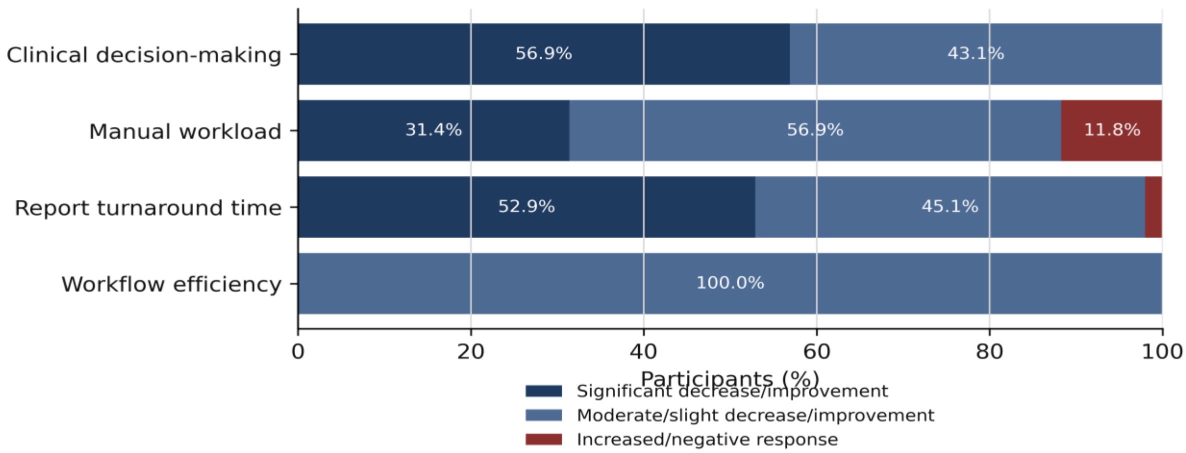

Figure 4. Perceived operational impact of digital imaging workstations.

User experience and perceived workstation value

Most participants described the workstation interface as moderately easy to use, but nearly one-third stated that training was needed for efficient use. Faster image processing was the most frequently reported valuable feature.

Table 4. User experience and perceived workstation value

Usability	Very intuitive	6	11.8
	Moderately easy to use	28	54.9
	Requires training	16	31.4
	Difficult to use	1	2.0
Most valuable feature	Faster image processing	33	64.7
	Better visualization tools	13	25.5
	Integration with other hospital systems	5	9.8

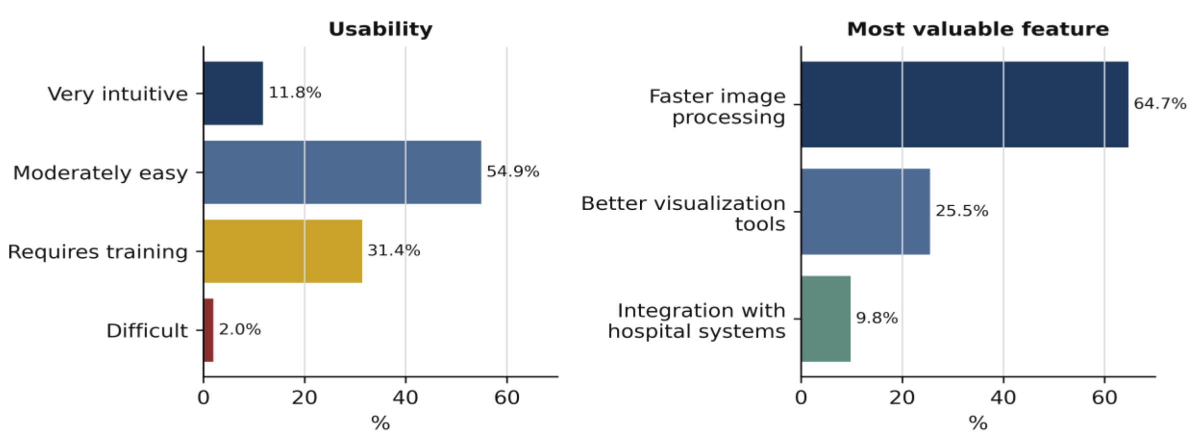

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Figure 5. User experience and perceived workstation value.

User recommendations, op technical issues

Faster loading time was the leading suggested improvement, followed by more automated reporting. nded workstation upgrading. The main barriers were lack of training/support and frequent software crashes.

Table 5. User recommendations for future workstation development

Suggested improvement	Faster loading times	27	52.9
	More automated reporting	15	29.4
	Enhanced collaboration tools	7	13.7
	Better AI integration	2	3.9
Upgrade recommendation	Strongly recommend	39	76.5
	Recommend	5	9.8
	Neutral	7	13.7

Table 6. Reported operational barriers and technical issues

Main challenge	Lack of training/support	22	43.1
	Frequent software crashes	21	41.2
	Slow processing speeds	6	11.8
	Poor integration with PACS/EMR	2	3.9
Technical issue frequency	Weekly	21	41.2
	Monthly	25	49.0
	Rarely	5	9.8

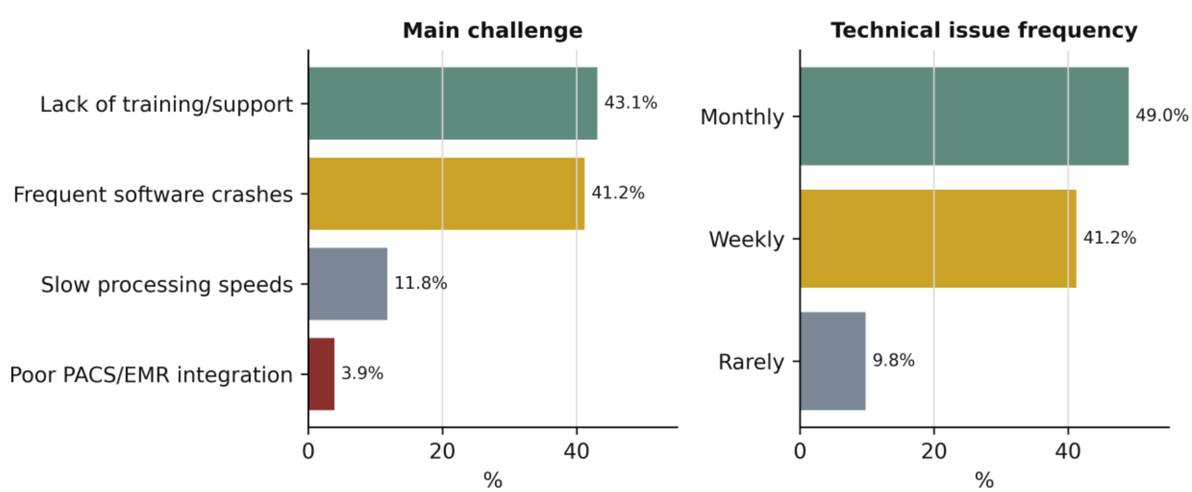

Figure 6. Operational barriers and technical performance issues.

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Discussion

This study examined how healthcare professionals at Al-Bayda Medical Center perceived the effect of digital imaging workstations on workflow efficiency and clinical decision-making. Workstation use was common, and most responses were favorable, but the findings should be interpreted as user-reported experience rather than objective evidence of operational improvement. The added gender data provide a clearer description of the study sample. Females represented a small majority of participants, but gender was not examined as a predictor of workstation use or perceived impact. For that reason, the gender findings should be read only as baseline demographic information, not as evidence of gender-related differences in digital workstation experience.The most consistent finding was the absence of negative workflow ratings. All participants reported either moderate or slight improvement. This pattern is compatible with earlier radiology informatics work showing that digital radiography, PACS, and RIS integration can reduce manual steps and improve the availability of imaging information [12-15]. Still, the present study did not measure timestamps or process durations, so it cannot quantify the actual size of any workflow gain. Reports of shorter turnaround time and reduced manual workload are also plausible. A PACS/RIS environment can reduce repeated data entry, film handling, and manual movement of imaging information, especially when modality worklist functions are used effectively [5,12]. In this study, however, these were perceptions reported by users rather than measurements extracted from RIS, PACS, or DICOM logs.

Clinical decision-making was also rated favorably. A likely explanation is that faster access to images and easier review across departments helped clinicians act with more confidence. This interpretation remains cautious: diagnostic accuracy, decision time, and patient outcome measures were not collected.

The dominance of Basic PACS viewer use is important. Only 5.9% of participants reported advanced 3D/post-processing workstation use. The findings therefore mainly describe routine digital image access and review, not advanced visualization workflows. This distinction prevents overgeneralization of the results.

The usability findings indicate a practical implementation consideration within the study setting. Although most participants reported that the workstation interface was manageable, a notable proportion indicated a need for additional training, suggesting that effective use of digital imaging workstations may depend not only on system functionality but also on user familiarity and training. This observation is consistent with previous literature on workstation and PACS selection, which has highlighted the importance of interface design, system responsiveness, image-manipulation capabilities, reporting functions, and display quality in shaping user experience and radiology workflow [6–10]. In the present study, only two participants identified better integration of artificial intelligence (AI) as a suggested improvement. Because AI integration was not directly evaluated and no AI-based intervention was implemented, this finding is presented only as a minor user-reported suggestion rather than evidence regarding the effectiveness or clinical value of AI in radiology workflow.

The two most frequent barriers were lack of training/support and software crashes. For a hospital with developing digital infrastructure, these problems are not minor technical details; they can determine whether a workstation improves daily work or becomes another source of delay. Literature on PACS implementation, including reports from developing settings, makes a similar point: infrastructure, maintenance capacity, staff training, and realistic system design are central to sustainable use [16,17,19].

Professional role was significantly associated with workstation type. This is operationally plausible because radiologists and radiology technicians are more likely to need image manipulation and post-processing functions, whereas many non-radiology clinicians may mainly use Basic PACS viewing for clinical review.

The remaining associations were not statistically significant. This should not be taken as proof that no practical relationships exist. With 51 participants and several categorical response options, some analyses had limited power and sparse cells.

Overall, the study suggests that digital imaging workstations are valued in routine radiology-related work at Al-Bayda Medical Center. The main message is practical rather than causal: workstation benefit depends on the surrounding workflow, the reliability of the system, and the preparedness of its users.

Limitations

This study was conducted in a single medical center, which limits generalizability to other hospitals and healthcare systems.

The sample was relatively small and was selected by non-probability convenience sampling; selection bias is therefore possible.

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Conclusion

Digital imaging workstations were generally perceived as helpful for workflow efficiency and clinical decision-making at Al-Bayda Medical Center.

Participants reported generally favorable perceptions of digital imaging workstation use, including perceived improvements in workflow, shorter report turnaround, reduced manual workload, and enhanced clinical decision-making. These findings suggest that healthcare professionals at Al-Bayda Medical Center perceive digital imaging workstations as beneficial to routine radiology-related activities; however, the findings represent self-reported perceptions rather than objectively measured improvements in workflow or clinical performance. Further multicenter studies incorporating objective measures of workflow efficiency, report turnaround time, workload, and clinical outcomes are needed to determine whether these perceived benefits translate into measurable operational and clinical improvements.

The study also identified barriers that could reduce the benefit of workstation adoption, especially insufficient training, software crashes, and performance limitations.

Future research should use objective workflow indicators to test whether the perceived benefits observed here translate into measurable improvements in clinical operations.

Recommendations

- Given the reported need for additional training among some workstation users, regular training and user-support activities may be considered for radiologists, radiology technicians, physicians, nurses, and other healthcare professionals who routinely use digital imaging workstations. Such training should be viewed as a practical implication of the reported usability and training needs rather than as a tested intervention, and its effectiveness should be evaluated using appropriate objective measures before firm conclusions regarding its impact on workflow efficiency or clinical performance are made.
- Strengthen technical support to reduce software crashes and shorten workflow interruptions.
- Maintain routine software updates and system checks to improve stability, loading speed, and processing performance.
- Improve interoperability between PACS, RIS, HIS, and EMR systems to reduce manual workflow steps.
- Conduct periodic workflow evaluations after workstation implementation to identify bottlenecks.
- Include objective measures in future studies, such as report turnaround time, patient waiting time, examination completion time, repeat imaging rate, downtime, and diagnostic accuracy.
- Conduct multicenter studies in Libya and comparable North African healthcare settings to improve generalizability.

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Conflict of Interest and Funding:

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