ORIGINAL ARTICLE

An Analysis of the Rate and Reasons for Rejected Radiographs in Emergency and Non-emergency Radiology Departments in Yasuj, Iran

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Abstract

Purpose: Utilizing imaging to improve physicians' diagnostic accuracy is one of the primary priorities of radiology departments. When the image is of poor quality, it is likely to be rejected, and its repetition will expose patients and staff to unnecessary ionizing radiation. Given the significant nature of this issue, the current study aimed to evaluate the rate and reasons for radiograph rejections in emergency (public practice) and non-emergency (private practice) radiology departments of Yasuj, Iran.

Materials and Methods: This cross-sectional study was carried out over 14 days in Yasuj, Iran, in the accident and emergency (round-the-clock) and non-emergency (day) medical imaging departments. In terms of quality, a total of 7,006 images were classified into the following three grades; A (Good), B (Fair), and C (rejected). The grade C radiographs were categorized into 9 classes according to the reasons for rejection.

Results: During this study, 7,006 radiographs were examined, of which 6,458 (92.2%) were categorized as grade A. Additionally, 401 radiographs (5.7%) were categorized as grade B, and 147 radiographs (2.1%) were considered to be grade C, which means that they were rejected. Out of the rejected radiographs, 69 (1.9%) were from emergency departments, while 78 (2.3%) were from non-emergency radiology departments. The most common reasons for the rejection of radiographs were the patient's incorrect positioning in 45 cases (30.6%) and the patient's motion in 43 cases (29.3%).

Conclusion: In comparison to previous research, the current study's percentage of rejected images was deemed acceptable. Radiologists are advised to frequently assess the reason and rate for rejecting radiographs to enhance the effectiveness of their radiology unit.

Keywords: Rejection Rate; Rejection Reasons; Radiograph Analysis; Radiograph Quality.

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1. Introduction

As a crucial part of diagnosis and treatment, emergency radiology departments in trauma hospitals that serve patients around the clock have aided emergency medicine specialists and trauma surgeons [1]. One of the key objectives of emergency radiology departments is to employ imaging to boost diagnostic accuracy and, as a result, treat acute or injured patients [2]. In the interests of providing specialists with diagnostic images as rapidly as possible and in the greatest quality during Mass Casualty Incidents (MCI), the emergency radiologist must be able to oversee the quality of imaging in that department [3].

One of the factors that is likely to exert an adverse impact on the quality of images in emergency departments is the night shift of staff members, which results in fatigue, poor sleep, mood decrement, and irritability [4]. On the other hand, in emergency departments, the high volume of patients and intense turnaround time requirements may compromise the radiographers' imaging accuracy [5]. The staff in non-emergency departments (private practice) are not, however, under stressful circumstances as there is no night shift. Therefore, it is feasible to improve the radiology department's technical efficacy and efficiency by evaluating radiograph quality and rectifying defects [6].

In diagnostic imaging, the accuracy of the physician's clinical diagnosis on the internal anatomical condition and physiology of the body depends on the radiographs' quality [7]. An high-quality image should meet radiological technical standards as well as possessing the necessary diagnostic value [8]. Yet, when the image is of poor quality, it is likely to be rejected, and its repetition will expose patients and staff to unnecessary ionizing radiation [9]. This repetition precludes applying the principle "As Low As Reasonably Achievable" (ALARA) in regard to ionizing radiation doses to patients and staff [10]. The potential risk of stochastic effects rises after prolonged ionizing radiation exposure [9]. Additionally, the rejected images drastically affect the department's efficiency and patient satisfaction, which in turn raises the department's expenditures [11].

According to studies, positioning errors, over/under exposure, and artifacts that necessitate image retakes are the most frequent causes of image rejection [12] . Planning the training requirements for radiographers with technical knowledge calls for a thorough investigation of the rate and reasons for image rejection [9, 13]. Furthermore, this analysis is a crucial component of Quality Assurance (QA) programs for medical imaging departments. These processes may enhance the diagnostic value of images and the workflow of the department, and eventually reduce the patient dose [14, 15].

Given the significant nature of this issue, this study aimed to examine and evaluate the rate and reasons for radiograph rejections in Yasuj, Iran, emergency (public practice), and non-emergency (private practice) radiology departments. The issues facing imaging departments will then be thoroughly discussed in the discussion section, where suggestions to minimize the rejection rate and maximize image quality will also be provided.

2. Materials and Methods

This study was approved by The Yasuj University of Medical Sciences ethical committee (the ethical code is IR.YUMS.REC.1395.38). Prior to their participation in the study, the heads of every department were informed of the evaluation's objective and methodology.

This cross-sectional study was conducted in Yasuj, Iran, in the accident and emergency (public practice) and non-emergency (private practice) medical imaging departments over the course of 14 days in February 2019. A total of 7,006 images were collected from the seven X-ray rooms which included two emergency (round-the-clock) and five non-emergency (day) departments.

Data curation from each radiology department was based on standardized checklists as recommended by the National Radiation Protection Agency (NRPA) and the International Atomic Energy Agency (IAEA) [16, 17]. Checklists contained details about the examination type, position, the grade quality of the images, and their reason, the radiographer's experience, and the type of imaging device.

Each day's data collection was carried out under the supervision of the radiologist and radiographers. In terms of quality, all of the examinations from various organs were classified into the following three grades in accordance with previous studies [18]. The Grade A (Good) was the image without any significant error. The Grade B (Fair) image was of a negligible error, not sufficient for them to be rejected since they

provided enough information for the radiologist to establish an accurate clinical diagnosis. However, in C-grade radiographs, according to radiographers or radiologists, an error existed where the image needed to be repeated.

The rejected radiographs were categorized into 9 classes according to the reasons for rejection. These included errors such as positioning, equipment, patient motion, over/under exposure, improper size of films, wrong placement of marker, film fog, artifact (foreign body), as well as error in physician request. The other reasons for radiological rejection were categorized as "others," including processing errors, patient misregistration, and unnecessary orders by the physician.

2.1. Data Analysis

Standard descriptive statistics were implemented for data analysis in IBM SPSS Statistics 21 and Microsoft Excel. The average rejection rate was computed as a percentage by dividing the total number of rejected images by the overall number of acquired images. With a 95% confidence level, the chi-square test was employed to evaluate the data.

3. Results

3.1. Sample Size

In the current study, 7,006 radiographs were analyzed, of which 3,640 (52%) were acquired in emergency and 3,366 (48%) in non-emergency departments. Of them, 4,849 (69.2%) radiographs were acquired employing digital radiography (DR), 1,866 (26.6%) radiographs utilizing computed radiography (CR), and 291 (4.2%) radiographs by analog radiology. Among 7,006 radiological images examined, most radiographs were related to the chest with 1,145 (16.3%), and knees with 784 (11.2%), respectively.

3.2. Radiograph Quality Grade Classification

Out of the 7,006 radiographs analyzed for this study, 6,458 (92.2%) were of grade A, implying the acceptable quality of acquired images. 401 radiographs (5.7%) also received grade B, indicating a negligible quality error. There were 147 radiographs (2.1%), or rejected images, that received grade C (Table 1).

Table 1. Radiograph quality grade classification

Grade of quality	N(%)
A (Good)	6458 (92.2)
B (Fair)	401 (5.7)
C (Reject)	147 (2.1)
Total	7006 (100.0)

3.3. Reasons for Qualitative Radiograph Grading

Table 2 shows that positioning error in 100 radiographs (24.9%) and artifact (foreign body) in 158 radiographs (39.4%) were the primary reasons for receiving grade B. The patient's incorrect position in 45 (30.6%) radiographs and the patient's motion in 43 (29.3%) images were the most frequent reasons for rejecting radiographs.

3.4. Grading the Radiographs' Quality based on the Type of Examination

According to the organ, most images that received a quality grade of B included hip and pelvic with 41 (16.3%) and abdominal radiographs with 25 (11.6%). Radiographs of the hip and pelvis (14, 5.6%) and the abdomen (12, 5.5%) were of the highest rates of rejection (Table 3).

3.5. Qualitative Classification of Radiographs based on Emergency and Non-Emergency Radiology Departments

According to Table 4, there were 303 (8.3%) radiographs in emergency radiology departments and 98 (2.9%) in non-emergency radiology departments that were given the grade B. Moreover, 69 (1.9%) radiographs in emergency departments and 78 (2.3%) images in non-emergency radiology departments were rejected.

3.6. Reasons for Qualitative Grading of Radiographs based on Emergency and Non-Emergency Radiology Departments

The primary reasons for receiving grade B in the emergency and non-emergency radiology departments, respectively, were artifact (foreign bodies) in 136 (44.9%) and patient motion in 31 (31.6%) radiographs. The most

Table 3. Reasons for qualitative radiograph grading

Grade of quality	Reasons for grading	N (%)
A (Good)	Good quality	6458 (100)
B (Fair)	Positioning error	100 (24.9)
	Patients Motion	51 (12.7)
	Over/under exposure	53 (13.2)
	Equipment Error	25 (6.2)
	Improper size of films	4 (.9)
	Artefact (foreign body)	158 (39.4)
	Film fog	1 (0.2)
	Wrong placement of marker	1 (0.2)
	Error in physician request	0 (0)
	Others	8 (1.9)
	Total	401 (100)
C (Reject)	Positioning error	45 (30.6)
	Patients Motion	43 (29.3)
	Over/under exposure	7 (4.8)
	Equipment Error	13 (8.8)
	Improper size of films	7 (4.8)
	Artefact (foreign body)	24 (16.3)
	Film fog	0 (0)
	Wrong placement of marker	0 (0)
	Error in physician request	7 (4.8)
	Others	1 (0.7)
	Total	147 (100)

frequent reasons for radiograph rejection in emergency departments were incorrect patient positioning and artifact, which resulted in the rejection of 26 (37.7%) and 13 (18.8%) images, respectively. In non-emergency departments, incorrect patient positioning and patient motion accounted for 35 (44.9%) and 19 (24.3%) radiographs rejection, respectively (Table 5).

Table 2. Grading the radiographs' quality based on the type of examination

Examination type	Grade of quality	N (%)
Hand/ fingers	A	502 (93.1)
	B	31 (5.8)
	C	6 (1.1)
	Total	539 (100)
Wrist	A	464 (95.3)
	B	16 (3.3)
	C	7 (1.4)
	Total	487 (100)
Forearm	A	247 (96.9)
	B	7 (2.7)
	C	1 (.4)
	Total	255 (100)
Elbow	A	222 (96.1)
	B	7 (3)
	C	2 (.9)
	Total	231 (100)
Humerus	A	68 (95.8)
	B	3 (4.2)
	C	0 (0)
	Total	71 (100)
Shoulder/ clavicle	A	141 (88.7)
	B	12 (7.5)
	C	6 (3.8)
	Total	159 (100)
Foot/ toes	A	502 (96.7)
	B	13 (2.5)
	C	4 (.8)
	Total	519 (100)
Ankle/ calcaneus	A	510 (95.9)
	B	14 (2.6)
	C	8 (1.5)
	Total	532 (100)
Tibia	A	225 (96.1)
	B	7 (3)
	C	2 (.8)
	Total	234 (100)
Knee	A	751 (95.8)
	B	27 (3.4)
	C	6 (.8)
	Total	784 (100)
Femur	A	137 (97.9)
	B	3 (2.1)
	C	0 (0)
	Total	140 (100)
Hip and Pelvis	A	196 (78.1)
	B	41 (16.3)
	C	14 (5.6)
	Total	251 (100)
Cervical spine	A	185 (90.2)
	B	13 (6.3)
	C	7 (3.4)
	Total	205 (100)
Thoracic spine	A	96 (89.7)
	B	10 (9.3)
	C	1 (.9)
	Total	107 (100)

	C	40 (3.5)
	Total	1145 (100)
Abdomen	A	179 (82.9)
	B	25 (11.6)
	C	12 (5.5)
	Total	216 (100)
Skull/ facial bones	A	622 (92)
	B	37 (5.4)
	C	17 (2.5)
	Total	676 (100)

Table 5. Qualitative classification of radiographs based on emergency and non-emergency radiology departments

Type of center management	Grade of Quality	N (%)
Emergency departments	A	3268 (89.8)
	B	303 (8.3)
	C	69 (1.9)
	Total	3640 (100)
Non-emergency departments	A	3190 (94.8)
	B	98 (2.9)
	C	78 (2.3)
	Total	3366 (100)

3.7. The Relationship between the Qualitative Classification of Radiographs, the Type of Imaging Device, and the Radiographer's Work Experience

A total of 8 (2.7%), 106 (2.2%), and 33 (1.8%) radiographs were rejected in analog, digital, and computed radiography systems, respectively (Table 6). There was a significant correlation between radiograph rejection rate and radiography system type ($p < 0.001$).

The average working experiences of the radiographers who acquired the images with grades A, B, and C were 6.04±4.98, 5.85±5.21, and 5.74±5.37 years, respectively (Table 7). The association between the job history of the staff and the radiographs' qualitative grade was insignificant (p=0.145).

Table 4. Reasons for qualitative grading of radiographs based on emergency and non-emergency radiology departments

Grade of quality	Reasons for grading	Type of department	
		Emergency departments N(%)	Non-emergency departments N(%)
A (Good)	Good quality	3268 (100)	3190 (100)
B (Fair)	Positioning error	89 (29.4)	11 (11.2)
	Patients Motion	20 (6.6)	31 (31.6)
	Over/under exposure	34 (11.2)	19 (19.4)
	Equipment Error	23 (7.6)	2 (2.0)
	Improper size of films	0 (0)	4 (4.0)
	Artefact (foreign body)	136 (44.9)	22 (22.4)
	Film fog	0 (0)	1 (1.0)
	Wrong placement of marker	0 (0)	1 (1.0)
	Error in physician request	0 (0)	0 (0)
	Others	1 (0.3)	7 (7.1)
	Total	303 (100)	98 (100)
C (Reject)	Positioning error	26 (37.7)	19 (24.3)
	Patients Motion	8 (11.6)	35 (44.9)
	Over/under exposure	3 (4.3)	4 (5.1)
	Equipment Error	11 (16)	2 (2.6)
	Improper size of films	3 (4.3)	4 (5.1)
	Artefact (foreign body)	13 (18.8)	11 (14.1)
	Film fog	0 (0)	0 (0)
	Wrong placement of marker	0 (0)	0 (0)
	Error in physician request	4 (5.8)	3 (3.8)
	Others	1 (1.4)	0 (0)
	Total	69 (100)	78 (100)

Table 6. Qualitative classification of radiographs based on the radiographer's work experience

Grade of quality	N (%)	Average personnel experience (years)
A (Good)	6458 (92.2)	6.04±4.98
B (Fair)	401 (5.7)	5.85±5.21
C (Reject)	147 (2.1)	5.74±5.37
Total	7006 (100)	6.02±5.00

Table 7. Qualitative classification of radiographs based on the type of imaging device

Type of radiology device	Grade of quality	N (%)
Digital Radiography (DR)	A	4390 (90.5)
	B	353 (7.3)
	C	106 (2.2)
	Total	4849 (100.0)
Computed Radiography (CR)	A	1799 (96.4)
	B	34 (1.8)
	C	33 (1.8)
	Total	1866 (100)
Analog	A	269 (92.4)
	B	14 (4.8)
	C	8 (2.7)
	Total	291 (100.0)

4. Discussion

Rejecting radiographs and having them taken again exposes both patients and staff to more radiation, which increases the risk of ionizing radiation-induced genetic abnormalities (gene mutations and chromosome aberrations) and carcinogenesis [19]. Also, the high rate of radiographs being rejected is a reflection of the technician's poor performance and the department's low efficiency [17]. The performance of radiographers can therefore be determined by implementing quality control (QC) programs and assessing the frequency of and reasons for radiograph rejections in each department.

Consequently, the rejection rate (Grade C) was 2.1% out of a total of 7006 radiographs analyzed in radiology departments in Yasuj, Iran. According to the guidelines of the International Atomic Energy Agency (IAEA) [20], the American Association of Physicists in Medicine (AAPM) [9], and the findings of comparable studies in Iran and other countries ranging between 1.8 and 30.8%, the rejection rate in Yasuj radiology departments is at an acceptable level [14, 15, 18, 21, 22].

In other studies, the rejection rate of radiographs was reported to be 11% by Hofmann *et al.* in Norway [14] , 4.4 and 4.9% by Foos *et al.* in the United States [15], 9% by Atkinson *et al.* in Australia [23], 4.8% by Lin *et al.* [12] in Taiwan, 7.86% and 5.91% by Bantas and colleagues [24] in New Zealand, 8.96% by Alashban and colleagues [25] in Saudi Arabia, 17% in Pakistan by Ali *et al.* [26], and 8% in Iran by Rastegar and colleagues [22].

In this study, the rejection rate of images in non-emergency (2.3%) was higher than in emergency departments (1.9%). Yet, only 2.9% of radiographs in non-emergency departments received grade B (Fair), compared to 8.3% of all images in emergency departments. Considering the patient's condition and the workload of the department, the artifact (foreign body) was the reason for grade B in 44.9% of the images in emergency departments. This indicates that the staff did not have enough time to remove the artifacts. As a result of this, the radiographers of these departments ignore the quality of the images and avoid repeating them in order to speed up their performance, considering the severity of the injuries of emergency patients. Proportionately, the number of employees and radiological equipment in each emergency department can be expanded in order to improve image quality.

Even so, since radiographers in non-emergency departments have more time to correct their errors (such as removing foreign bodies and correcting positioning), the number of radiographs with grade B in those departments has decreased with repetition, and as a result, the rejection rate has spiked in those departments compared to emergency departments.

The repetitions in non-emergency departments, however, might not have been necessary. Research has highlighted that radiographers should be capable of spotting the clinical significance of images in addition to being familiar with the technical requirements of radiography (such as positioning techniques and exposure factors) to prevent needless repetition [27]. In the discussion over the technical vs diagnostic capabilities of images, differences in the rejection rate between radiographers and radiologists have been noted. Studies have shown that radiographers' focus on technical aspects of an image might result in the rapid

rejection of radiographs with diagnostic value [28, 29]. For instance, a poor-quality image might contain sufficient details for the radiologist to render a precise diagnosis and respond to clinical inquiries, negating the need for further imaging [11]; for this reason, we classified the grade B quality in this study as negligible image errors. To prevent unnecessary repetition, It is suggested that radiographers and radiologists maintain discussions over comparing the technical features and diagnostic benefits of radiographs [23].

Consequently, regular training of radiographers by radiologists to correctly assess the diagnostic value of images might be beneficial for minimizing the repetition of images in addition to the analysis of the image rejection [27].

In the current study, it was discovered that positioning errors accounted for 30.6% of all radiograph rejections in radiology departments. Positioning errors (37.7%) and patient motion (44.9%) were the most common reasons for rejected radiographs in emergency and non-emergency departments, respectively. The error in patient positioning was cited as the most common reason for rejecting radiographs in other studies [14, 15, 17, 27, 30, 31, 32].

Important anatomical structures must be visible on radiographs for the physicians to perform a proper clinical diagnosis, which mostly depends on the radiographers positioning the patient correctly [27]. In order for radiologists to appropriately interpret the images, radiographers must produce images with the least error and greatest diagnostic quality possible. As highlighted by prior reports, radiographers should therefore always receive additional training and ongoing education to mitigate these errors [20, 33, 34].

The poor skill and knowledge of radiographers resulted in errors in patient positioning, wrong exposure parameter selection, inappropriate film size, and the presence of artifacts, which led to the rejection of 83 (56.5%) radiographs across all radiology departments. For this purpose, it is preferable to provide training guidelines for radiographers in order to improve the quality and reduce the repetition of radiological images [12].

In the current study, abdominal, hip, and pelvic images were found to have the highest quality grades of B and C. In other studies, images of the abdomen and pelvis were of the highest rate of rejection [15, 16, 23, 25, 31, 32].

Due to the sensitivity of the gonads in the abdomen and pelvis, radiographers should exercise particular caution when positioning the patient. As that, the potential of stochastic effects grows with increased patient radiation dosage brought on by repeated imaging [8]. It should be emphasized that the patient's age, sex, and health status all impact the likelihood of stochastic effects [35]. Hence, minimizing exposure to ionizing radiation during imaging is a core principle for radiological care [8]. Because of this, it has been suggested that radiographers adopt gonadal shields to lessen the radiation exposure of patients [36].

In the present study, the rejection rate of radiographs in analog, digital, and Computed radiography systems was 8 (2.7%), 106 (2.2%), and 33 (1.8%), respectively, and there was a strong link between the type of X-ray devices and the rejection rate ($p < 0.001$).

Manual interventions and under/overexposed films are likely to contribute to greater rejection rates in analog radiography (screen film) [26]. Because of the improved exposure latitude and the availability of post-processing methods, it was anticipated that the adoption of digital radiography would result in a reduction in the rate of image rejection [14, 17]. Yet, several studies have found that similar to ours, the rejection rate of radiographs in digital radiography is higher than in computed radiography [14, 17, 37].

With the least amount of radiation exposure to the patient, a perfect imaging system would deliver the highest-quality image. It is possible with digital radiography [38]. The majority of medical imaging departments in Australia now only employ digital radiography equipment as a result of financial incentives granted by the Australian Government [23]. In Iran, it is encouraged to shift from analog to digital systems due to the high rate of rejection and poor image quality in analog systems.

In this study, no significant relationship was found between the work experience of the radiographer and the rejection of radiographs ($p=0.145$). The skill of radiographers to perform their jobs effectively seems to be more crucial than work experience. Due to occupational burnout, radiographers with more work experience might not have the necessary skills to function in the radiology department, which would lead

to an increase in errors and image repetition. Research has also indicated that radiographer occupational stress and burnout might be exacerbated by the high departmental workload and the vast number of patients [39, 40]. Burnout in the healthcare sector may exert a detrimental impact on patient care, healthcare expenses, and productivity [41, 42]. Radiographers' levels of occupational burnout and stress might be mitigated, thus, by staffing radiography departments with more experts and lowering the retirement age for radiographers.

4.1. Limitations of Study

The difficulty in collecting data over a two-week period was a limitation of this study. As a result, it is recommended that this study be repeated with a larger sample size in the future and that the rejection rate of images be monitored for at least three months.

5. Conclusion

The rate of rejected images in the current study was 2.1%, which is acceptable in comparison to prior studies. Errors in patient positioning and motion were the most common sources of rejected radiographs. It is suggested that radiologists regularly evaluate the rate and reason for rejecting radiographs in order to improve the radiology department's efficiency. Moreover, radiologists can contribute to improving radiographers' ability to discern the clinical value of radiographs by structuring training sessions to avoid unnecessary repetitions. Regular X-ray training courses could also be beneficial for practicing proper patient positioning. To ameliorate the workload of the department, it is advised that trauma hospitals expand the number of imaging devices and staff.

In radiology departments, immobilizing devices can be primed and used to prevent patient motion. Placing a guide poster in the imaging room to remind the radiographer and the patient to remove artifacts may help to avoid repetition and improve image quality. Regular X-ray equipment quality control and the installation of digital and computed radiography systems are necessary for radiology departments to run more effectively.

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References

1- J. D. Robinson, J. A. Gross, W. A. Cohen, and K. F. Linnau, "Operational Considerations in Emergency Radiology." (in eng), *Semin Roentgenol*, Vol. 55 (No. 2), pp. 83-94, Apr (2020).

2- S. Wirth *et al.*, "European Society of Emergency Radiology: guideline on radiological polytrauma imaging and service (short version)." (in eng), *Insights Imaging*, Vol. 11 (No. 1), p. 135, Dec 10 (2020).

3- Suzanne T Chong *et al.*, "Emergency radiology: current challenges and preparing for continued growth." *Journal of the American College of Radiology*, Vol. 16 (No. 10), pp. 1447-55, (2019).

4- R. Smith-Coggins, K. B. Broderick, and C. A. Marco, "Night shifts in emergency medicine: the american board of emergency medicine longitudinal study of emergency physicians." (in eng), *J Emerg Med*, Vol. 47 (No. 3), pp. 372-8, Sep (2014).

5- T. N. Hanna *et al.*, "Emergency Radiology Practice Patterns: Shifts, Schedules, and Job Satisfaction." (in eng), *J Am Coll Radiol*, Vol. 14 (No. 3), pp. 345-52, Mar (2017).

6- S. M. Erturk, S. Ondategui-Parra, and P. R. Ros, "Quality management in radiology: historical aspects and basic definitions." (in eng), *J Am Coll Radiol*, Vol. 2 (No. 12), pp. 985-91, Dec (2005).

7- M. Zewdu, E. Kadir, and M. Berhane, "Analysis and Economic Implication of X-Ray Film Reject in Diagnostic Radiology Department of Jimma University Specialized Hospital, Southwest Ethiopia." (in eng), *Ethiop J Health Sci*, Vol. 27 (No. 4), pp. 421-26, Jul (2017).

8- C Maccia, M Ariche-Cohen, X Nadeau, and G Severo, "The 1991 CEC trial on quality criteria for diagnostic radiographic images." *Radiation protection dosimetry*, Vol. 57 (No. 1-4), pp. 111-17, (1995).

9- A Kyle Jones *et al.*, "Ongoing quality control in digital radiography: report of AAPM Imaging Physics Committee Task Group 151." *Medical physics*, Vol. 42 (No. 11), pp. 6658-70, (2015).

10- K. J. Strauss and S. C. Kaste, "The ALARA (as low as reasonably achievable) concept in pediatric interventional and fluoroscopic imaging: striving to keep radiation doses as low as possible during fluoroscopy of pediatric patients--a

white paper executive summary." (in eng), *Pediatr Radiol*, Vol. 36 Suppl 2 (No. Suppl 2), pp. 110-2, Sep (2006).

11- J. S. Whaley, B. D. Pressman, J. R. Wilson, L. Bravo, W. J. Sehnert, and D. H. Foos, "Investigation of the variability in the assessment of digital chest X-ray image quality." (in eng), *J Digit Imaging*, Vol. 26 (No. 2), pp. 217-26, Apr (2013).

12- Chih-Sheng Lin, Po-Chou Chan, Kuang-Hua Huang, Chun-Feng Lu, Yung-Fu Chen, and Yun-O Lin Chen, "Guidelines for reducing image retakes of general digital radiography." *Advances in Mechanical Engineering*, Vol. 8 (No. 4), p. 1687814016644127, (2016).

13- J. Nol, G. Isouard, and J. Mirecki, "Digital repeat analysis; setup and operation." (in eng), *J Digit Imaging*, Vol. 19 (No. 2), pp. 159-66, Jun (2006).

14- B. Hofmann, T. B. Rosanowsky, C. Jensen, and K. H. Wah, "Image rejects in general direct digital radiography." (in eng), *Acta Radiol Open*, Vol. 4 (No. 10), p. 2058460115604339, Oct (2015).

15- D. H. Foos, W. J. Sehnert, B. Reiner, E. L. Siegel, A. Segal, and D. L. Waldman, "Digital radiography reject analysis: data collection methodology, results, and recommendations from an in-depth investigation at two hospitals." (in eng), *J Digit Imaging*, Vol. 22 (No. 1), pp. 89-98, Mar (2009).

16- M. Y. Arbese, T. D. Abebe, and B. A. Mesele, "Determination and Analysis of Film Reject Rate at Eight Selected Governmental Diagnostic X-Ray Facilities in Tigray Region, Northern Ethiopian." (in eng), *J Med Phys*, Vol. 43 (No. 4), pp. 270-76, Oct-Dec (2018).

17- A Kyle Jones, Raimund Polman, Charles E Willis, and S Jeff Shepard, "One year's results from a server-based system for performing reject analysis and exposure analysis in computed radiography." *Journal of Digital Imaging*, Vol. 24pp. 243-55, (2011).

18- R. Roohi Shalemaei, "Films reject analysis for conventional radiography in Iranian main hospitals." (in eng), *Radiat Prot Dosimetry*, Vol. 147 (No. 1-2), pp. 220-2, Sep (2011).

19- I. Piotrowski *et al.*, "Carcinogenesis Induced by Low-dose Radiation." (in eng), *Radiol Oncol*, Vol. 51 (No. 4), pp. 369-77, Dec (2017).

20- A. A. Almalki, R. Abdul Manaf, M. Hanafiah Juni, H. Kadir Shahar, N. M. Noor, and A. Gabbad, "Educational Module Intervention for Radiographers to Reduce Repetition Rate of Routine Digital Chest Radiography in Makkah Region of Saudi Arabia Tertiary Hospitals: Protocol of a Quasi-Experimental Study." (in eng), *JMIR Res Protoc*, Vol. 6 (No. 9), p. e185, Sep 26 (2017).

21- F. Fintelmann *et al.*, "Repeat rates in digital chest radiography and strategies for improvement." (in eng), *J Thorac Imaging*, Vol. 27 (No. 3), pp. 148-51, May (2012).

22- S. Rastegar *et al.*, "Reject analysis in digital radiography: A local study on radiographers and students' attitude in Iran." (in eng), *Med J Islam Repub Iran*, Vol. 33p. 49, (2019).

23- S. Atkinson, M. Neep, and D. Starkey, "Reject rate analysis in digital radiography: an Australian emergency imaging department case study." (in eng), *J Med Radiat Sci*, Vol. 67 (No. 1), pp. 72-79, Mar (2020).

24- G. Bantas, R. J. Sweeney, and S. Mdletshe, "Digital radiography reject analysis: A comparison between two radiology departments in New Zealand." (in eng), *J Med Radiat Sci*, Jan 19 (2023).

25- Yazeed Alashban, Nasser Shubayr, Abdulrahman A. Alghamdi, Sami A. Alghamdi, and Sami Boughattas, "An assessment of image reject rates for digital radiography in Saudi Arabia: A cross-sectional study." *Journal of Radiation Research and Applied Sciences*, Vol. 15 (No. 1), pp. 219-23, 2022/03/01/ (2022).

26- A. Ali and M. Yaseen, "Digital radiograph rejection analysis during "Coronavirus disease 2019 (COVID-19) pandemic" in a tertiary care public sector hospital in Khyber Pakhtunkhwa Province of Pakistan." (in eng), *Chin J Acad Radiol*, Vol. 4 (No. 2), pp. 133-40, (2021).

27- Elin Kjelle and Catherine Chilanga, "The assessment of image quality and diagnostic value in X-ray images: a survey on radiographers' reasons for rejecting images." *Insights into Imaging*, Vol. 13 (No. 1), p. 36, 2022/03/04 (2022).

28- J Mount, "Reject analysis: A comparison of radiographer and radiologist perceptions of image quality." *Radiography*, Vol. 22 (No. 2), pp. e112-e17, (2016).

29- C Saade *et al.*, "To repeat or not to repeat: Radiologists demonstrated more decisiveness than their fellow radiographers in reducing the repeat rate during mobile chest radiography." *Radiography*, Vol. 27 (No. 2), pp. 304-09, (2021).

30- J. Owusu-Banahene, E. O. Darko, F. Hasford, E. K. Addison, and J. Okyere Asirifi, "Film reject analysis and image quality in diagnostic Radiology Department of a Teaching hospital in Ghana." *Journal of Radiation Research and Applied Sciences*, Vol. 7 (No. 4), pp. 589-94, 2014/10/01/ (2014).

31- B. Stephenson-Smith, M. J. Neep, and P. Rowntree, "Digital radiography reject analysis of examinations with multiple rejects: an Australian emergency imaging department clinical audit." (in eng), *J Med Radiat Sci*, Vol. 68 (No. 3), pp. 245-52, Sep (2021).

32- Wen-Sheng Tzeng, Kuang-Ming Kuo, Chung-Feng Liu, Huan-Chung Yao, Chin-Yu Chen, and Huang-Wei Lin, "Managing Repeat Digital Radiography Images—A Systematic Approach and Improvement." *Journal of Medical Systems*, Vol. 36 (No. 4), pp. 2697-704, 2012/08/01 (2012).

33- W. Alsharif, M. Davis, A. McGee, and L. Rainford, "An investigation of Saudi Arabian MR radiographers' knowledge and confidence in relation to MR image-quality-related errors." (in eng), *Radiography (Lond)*, Vol. 23 (No. 2), pp. e27-e33, May (2017).

34- D. Waaler and B. Hofmann, "Image rejects/retakes--radiographic challenges." (in eng), *Radiat Prot Dosimetry*, Vol. 139 (No. 1-3), pp. 375-9, Apr-May (2010).

35- Jian Tong and Tom K. Hei, "Aging and age-related health effects of ionizing radiation." *Radiation Medicine and Protection*, Vol. 1 (No. 1), pp. 15-23, 2020/03/01/ (2020).

36- E. Somasundaram, S. L. Brady, and K. J. Strauss, "Achievable dose reductions with gonadal shielding for children and adults during abdominal/pelvic radiographic examinations: A Monte Carlo simulation." (in eng), *Med Phys*, Vol. 47 (No. 11), pp. 5514-22, Nov (2020).

37- Nicholas Taylor, "The art of rejection: Comparative analysis between Computed Radiography (CR) and Digital Radiography (DR) workstations in the Accident & Emergency and General radiology departments at a district general hospital using customised and standardised reject criteria over a three year period." *Radiography*, Vol. 21 (No. 3), pp. 236-41, 2015/08/01/ (2015).

38- G. J. Bansal, "Digital radiography. A comparison with modern conventional imaging." (in eng), *Postgrad Med J*, Vol. 82 (No. 969), pp. 425-8, Jul (2006).

39- S. Robertson, E. E. Olanloye, Y. Hon, A. England, H. McNair, and S. Cruickshank, "Are radiographers suffering from symptoms of compassion fatigue due to occupational stress: A systematic review." (in eng), *Radiography (Lond)*, Vol. 28 (No. 3), pp. 857-64, Aug (2022).

40- G. D. Eslick and V. V. Raj, "Occupational stress amongst radiographers: does working in private or public practice make a difference?" *Radiography*, Vol. 8 (No. 1), pp. 47-53, 2002/02/01/ (2002).

41- C. P. West, L. N. Dyrbye, and T. D. Shanafelt, "Physician burnout: contributors, consequences and solutions." (in eng), *J Intern Med*, Vol. 283 (No. 6), pp. 516-29, Jun (2018).

42- M. Agarwal, C. B. van der Pol, M. N. Patlas, A. Udare, A. D. Chung, and J. Rubino, "Optimizing the radiologist work environment: Actionable tips to improve workplace satisfaction, efficiency, and minimize burnout." (in eng), *Radiol Med*, Vol. 126 (No. 10), pp. 1255-57, Oct (2021).