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REJECT-REPEAT ANALYSIS OF RADIOGRAPHS IN DIGITAL COMPUTED RADIOGRAPHY (CR) UNIVERSITY OF ABUJA TEACHING HOSPITAL, NIGERIA.

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ABSTRACT

Background: Repeat-Reject Analysis (RRA) is a quality indicator and a critical tool for dose and image quality optimization in Radiology Departments.

Aim: This study was aimed at evaluating reject-repeat analysis of radiographs in digital computed radiography (CR) at University of Abuja Teaching Hospital, Nigeria.

Materials and Methods: The study was prospective, cross-sectional design. The study was conducted at the Department of Radiology, University of Abuja Teaching Hospital (UATH), Gwagwalada, from 1st September, 2020 to 31st March, 2021. All the rejected-repeated images were used during the study period; 377 images were rejected. An adapted data capture sheet was used from the quality assurance work book for Radiographers and Radiological Technologists. The obtained data was analyzed using micro soft excel and statistical package for social sciences (SPSS) version 22.0.

Result: Out of the total of 1362 images that were acquired during the study period, 377 images were rejected. The overall repeat-reject rate was 27.67%. The highest examination was the chest 560 (41.375), followed by lower extremities 41 (10.87%). The lowest examinations were the paranasal sinuses 1 (0.26%) and Thoracic spine 2 (0.52%). The pelvic/hips had the highest repeat-reject rate 28 (52.82%), followed by the lumbosacral spine 29 (49.15%) and then post-nasal space 16 (47.05%) respectively.

Conclusion: In this study, the overall repeat-reject rate was higher than the acceptable limit. The chest has the highest number of examinations. The pelvic/hips had the highest repeat-reject rate, followed by the lumbosacral spine and post-nasal space respectively.

INTRODUCTION

The employment of reject analysis in evaluation of image quality has quite a long history. Is an important component of quality assurance programs.[1] Image reject analysis (IRA) is the tool that provides information that would assist to achieve a sound reduction in overexposures and extra costs, IRA has therefore become a major parameter as a quality control tool in diagnostic radiography service delivery.[2] Similarly, IRA is as a quality indicator and critical tool for dose and image quality optimization in radiology departments.[3] Furthermore, reject image is described as an image that does not add diagnostic information to clinical questions because of poor image quality, and thus, the image has to be

retaken.[4] In another way, a reject image in radiography is an un-diagnostic image, as it does not provide the necessary information to aid clinical diagnosis due to its poor quality.[5]

The value of reject analysis cannot be overemphasized as "it forms a basis for determining the causes of rejected images and helps guide radiographer training, department workflow and ultimately reduces patient dose."[3] Reject analysis in digital radiography (DR) improves department efficiency.[3] The use of reject analysis as part of the overall quality assurance programs in clinical radiography and radiology services is vital in the evaluation of image quality of a well-established practice. [6] The recommended reject rate is 5% by World Health Organization and 10% by Conference of Radiation Control Program Directorates.9

A study conducted by Owusu-Banahene *at al.*[19] on reject analysis and image quality in diagnostic Radiology Department of a Teaching Hospital in Ghana reported that overexposure and patient positioning were the causes of repeats. Also in another study conducted by Audu *et al.*[7] on X-Ray Film Reject Analysis as a Quality Indicator in a Tertiary Health Centre in Northwestern Nigeria shown that, the common causes of reject/repeat are lack of collimation and improper exposure factors, both due to Radiographers' error or lack of quality control (QC) program for equipment and processor. Similarly, a study conducted by Benza et al,5 on the causes of reject images in a radiology department at a state hospital in Windhoek, Namibia the study shown that the causes of reject images included positioning, exposure, presence of grid lines, collimation, absence of anatomical markers and artifacts.

The utmost expectations of any radiological department is "to obtain images which are adequate for the clinical diagnostic purpose with minimum radiation dose to the patient."[2] However, in the Department of Radiology, University Teaching Hospital (UATH) Gwagwalada, Abuja-Federal Capital Territory of Nigeria, the researcher has observed recurrent reject-repeats. This might cause increased radiation dose to the patients, workers and other members of the public as well as decrease the efficiency of the facility. The findings of this study will serve as a baseline for making recommendations to the relevant authorities, and as a guide to radiographers and radiologists. This study was aimed at evaluating reject-repeat analysis of radiographs in digital computed radiography (CR) at University of Abuja Teaching Hospital, Nigeria.

MATERIALS AND METHODS

This study was a prospective, cross-sectional design, conducted in the University of Abuja Teaching Hospital, Gwagwalada from1st September, 20202 to 31st March 2021. Ethical approval to conduct the study was sought and obtained from the Human Research and Ethics Committee of the University of Abuja Teaching Hospital, Gwagwalada (UATH/HREC/PR/2021/012/006). All rejected-repeated images that were digitally processed using a computed radiograph (CR) system were gathered for six months and used during the study period. Three hundred and seventy-seven images were rejected. The rejected-repeated images were analyzed under three major groups, the first group was causes of reject-repeat images using the following parameters; inadequate positioning, collimation, poor inspiration, underexposure, overexposure, equipment fault, printing artifact, post-processing errors, incorrect patient identification/anatomical marker, wrong view/projection, unclear clinical history and others which include undefined. The second group was part of the body which include; the skull, paranasal sinuses, postnasal space, cervical, chest, thoracic spine, lumbar spine, abdomen, pelvic/hips, upper extremity (shoulder, Humerus, elbow join, forearm, wrist joint, and hand), lower extremities (femur, knee joint, tibia and fibula, ankle joint, feet and others) and the third group was the sizes of image receptor which include:18cm x24cm, 24cmx30cm, 30cm x40cmx, 35cm x35cm,35cm x43cm respectively). An adapted data capture sheet from the quality assurance workbook for radiographers and radiological technologists was used in the study. The reject rates of the body parts and overall were calculated as shown below. Statistical Package for the Social Sciences (SPSS) version 22 was used for data analysis.

Formula for calculating reject rate

A. For individual body parts:

Total number of rejected images per body part, divided by the total number of the images acquired, multiple by 100 to get the reject rate of the body part.

$$\frac{\textbf{Total number of rejected Images}}{\textbf{Total number of images acouired}} \times 100$$

Example, Skull: . Number of images acquired=24

. Number of rejected images=9

Therefore; $\frac{9}{24} \times 100 = 37.5\%$

$$\frac{\textbf{Overall total number of rejected images}}{\textbf{Overall total number of acquired images}} \times \mathbf{100}$$

B. For the overall Reject Rate:

The overall total of the rejected images for all body parts analyzed, divided by the overall number of the images acquired for all body parts, multiply 100 to get the overall reject rate.

$$\frac{\textbf{Total number of rejected Images}}{\textbf{Total number of images acouired}} \times 100$$

Example: -Overall rejected images =377

- Overall number of images acquired= 1362

Therefore; $\frac{377}{1362} \times 100 = 27.67\%$

The obtained data were analyzed using statistical package for social sciences (SPSS) version 22.0.

RESULTS

The results obtained in this study are presented in Table 1-5 and Figure 1 shows that, out of a total of 1362 images that were acquired during the study period, 377 (27.68%) images were rejected. The chest was 560 (41.12%) and the thoracic spine 8(0.59%). The lower extremities was 41(10.87%).

Table1 shows total x-rays exposed, total images rejected, and the overall repeat-reject rate (RRR) for each radiological examination type. RRR for CXR was above 5% - 10%, followed by lower and upper extremity with RRR of 14.43% and 27.10% respectively. The thoracic spine RRR was (25%), followed by paranasal sinuses which RRR (8.33%).

Table 2 shows the numbers of RRR and their percentages for each examination type. Chest images had rejected radiographs of (41.12%), and lower extremity (10.87%). Paranasal sinuses had rejected images of (0.26%) followed by the thoracic spine (0.52%).

Table 3 shows the main causes of reject-repeat for each examination in this study. The most frequent cause of reject-repeat for almost all types of examinations falls under others reasons which include ***double printing, **magnified image, *incomplete patient data (age, hospital number, wrong spelling), and undefined. The asterisk sign indicates the rate of occurrence. Then closely followed by inadequate positioning, patient motion, printing artifact, underexposed images among others as shown in the table below.

Table 4 Show combined distributions of radiographic examinations with their corresponding reasons for reject-repeat images. Down the table (arrow direction), are the reasons for reject-repeat images, in which others (n=62) has the highest number of RRR, followed by inappropriate positioning (n=57). Across the table, are radiographic examinations base on the anatomical regions, the chest (n=156) has the highest number of RRR followed by lower extremities (n=41) respectively.

Table 5. Show the previous studies, year of study, beginning from 2008 to present study 2021, their overall reject-repeat rate (RRR) and place of study. The present study, 27.67% RRR is nearly similar to the study conducted in 2017 and 2016, all in Maiduguri, Nigeria respectively. However, other findings show RRR far below the current findings.

Figure 1 Show the number of image sizes according their use in the Department of Radiology, UATH, 24x30cm has the highest number of use (n=2850), followed by 34x43cm (n=147) respectively.

Table1: Rate of Reject/ Repeat for Radiographic Examinations

Radiographic examination	Films used	Radiographs Rejected	Reject/repeat rate (%)
SKULL	24	9	37.5
PARA-NASAL SINUSES	12	1	8.33
POSTNASAL SPACE	34	16	47.05
CERVICAL SPINE	69	22	31.88
CHEST	560	156	27.85
THORACIC SPINE	8	2	25.00
LUMBOSACRAL SPINE	59	29	49.15
ABDOMEN	83	25	30.12
PELVIS/HIPS	53	28	52.82
UPPER EXTREMITIES	107	29	27.10
LOWER EXTREMITIES	284	41	14.43
OTHERS	69	19	27.53
TOTAL	1362	377	27.67

Table 2: Distribution of Rejected/Repeated Radiographs According to Radiographic Examinations

Radiographic examination	Number of Rejected Radiographs	Percent (%)
SKULL	9	2.38
PARANASAL SINUSES	1	0.26
POSTNASAL SPACE	16	4.24
CERVICAL SPINE	22	5.83
CHEST	156	41.37
THORACIC SPINE	2	0.52
LUMBOSACRAL SPINE	29	7.69
ABDOMEN	25	6.63
PELVIS/HIPS	28	7.42
UPPER EXTREMITIES	29	9.69
LOWER EXTREMITIES	41	10.87
OTHERS	19	5.03
TOTAL	377	100

Table 3: Common Reasons for Rejecting/Repeating Radiographs in University of Abuja Teaching Hospital

Reasons for Reject/Repeat	Number of Rejected Radiographs	Percentage (%)
Inadequate Positioning	57	15.11
Collimation	13	3.44
Patient Motion	54	14.32
Poor Inspiration	16	4.24
Under Exposed Films	41	10.87
Over Exposed Films	13	3.44
Equipment	11	2.91
Printing Artifact	55	14.58
Post Processing Error	14	3.71
Incorrect Patient ID	28	7.42
Double Exposure	0	0
Wrong View/Projection	4	1.06
Unclear Clinical History	3	0.79
Additional View(s)	6	1.25
Others (Reprinted, Undefined.…)	2	16.44
Total	377	100

Others: Include ***Double printing, **Magnified image, *Incomplete Patient data (Age, hospital Number, wrong spelling), undefined.

Table 4: The Distribution of Radiographic Examination with their Corresponding Reasons for Reject-Repeat

Reasons for Reject-Repeat ⇩ / Radiographic Examination ⇩	Pos	Col	Poor Insp	Motn	U-Exp	O-Exp	Eqpt	Artf	Post-Pro	Pt ID	D Exp	Proj	UC Hx	Ad-V	Others	Total
Skull	2	2	0	1	1	0	0	0	3	0	0	0	0	0	0	9
Para Nasal Sinuses	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Post-Nasal Space	5	1	0	9	0	0	0	1	0	0	0	0	0	0	0	16
C/Spine	2	2	0	6	2	0	0	6	1	1	0	0	0	0	2	22
Chest	25	2	14	20	13	5	6	19	7	12	0	2	2	4	25	156
T/Spine	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2
L/S spine	2	0	2	4	5	0	0	10	1	3	0	0	0	0	2	29
Abdomen	4	2	0	0	5	0	0	7	2	3	0	0	0	0	2	25
Pelvis/Hips	3	2	0	4	3	2	3	4	0	2	0	0	0	0	5	28
Upper Extremity	5	0	0	2	0	2	0	4	0	4	0	2	1	0	9	29
Lower Extremity	4	2	0	5	8	4	2	2	0	3	0	0	0	2	9	41
Others	4	0	0	2	3	0	0	2	0	0	0	0	0	0	8	19
Total	57	13	16	54	41	13	11	55	14	28	0	4	3	6	62	377

POS	Positioning
Col	Collimation
Poor Ins	Poor Inspiration
MOTN	Motion
U-Exp	Under Exposure
O-Exp	Over Exposure
EQPT	Equipment
Artf	Artifact
Post-pro	Post Processing.
Pt ID	Patient Identification
D Exp	Double Exposure
Proj.	Projection
UCHx	Unclear Clinical History
AD-V	Additional View

Table 5: Comparison of Present Study with other Previous Study

S/N	Study	Year	Reject Rate (%)	Place of Study
1	Present study	2021	27.67	Gwagwalada, Nigeria
2	Atkinson et al	2020	10	Queensland, Australia
3	Arbese *et a*l	2018	10.02	North, Ethiopia
4	Audu *et a*l	2017	16.4	Sokoto, Nigeria
5	Sadiq *et al*	2017	29.34	Maiduguri, Nigeria
6	Zewdu *et al*	2017	16.85	South, Ethiopia
7	Osahon *et al*	2016	8.9	Benin, Nigeria
8	Abubakar *et al*	2016	26.4	Maiduguri, Nigeria
9	Joseph *et al*	2015	9.62	Bauchi, Nigeria
10	Owusu-Banahene *et al*	2014	14.1	Accra, Ghana
11	Ofori *et al*	2013	19.4	Korle-Bu, Accra, Ghana
12	Jabbari *et al*	2012	7.20	Umia, Iran
13	Teferi *et al*	2012	3.1	Addis Ababa, Ethiopia
13	Nwobi *et al*	2011	24	Maiduguri, Nigeria
14	Eze *et al*	2008	8.86	Edo, Nigeria

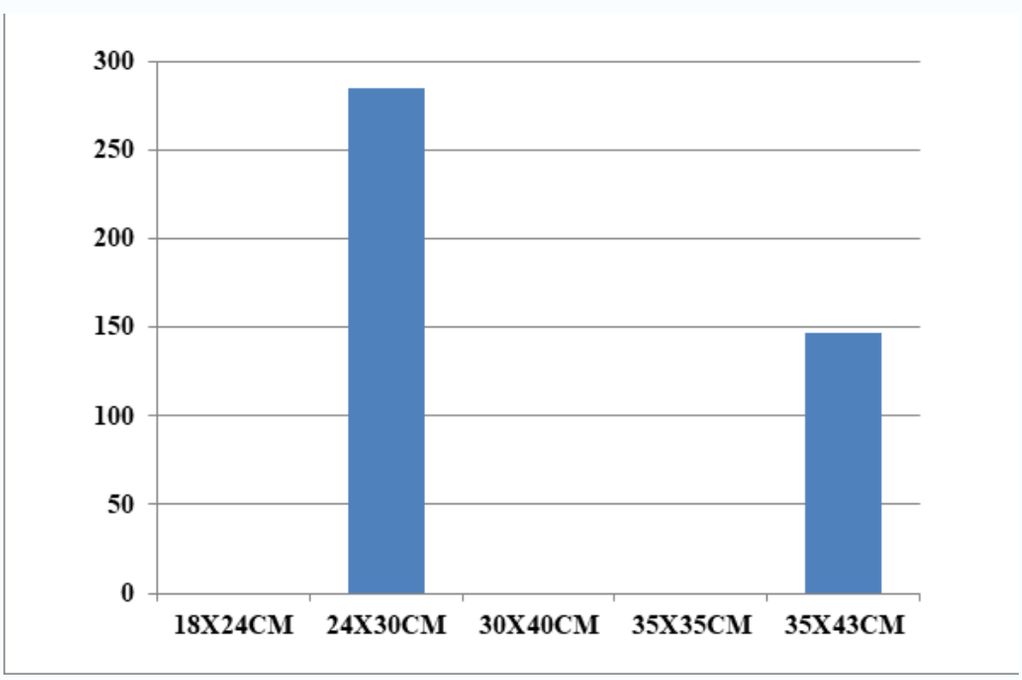

Figure1: Film Sizes

DISCUSSION

Reject-Repeat analysis is one of the quality control (QC) necessary to be carried out regularly in a standard Radiology Department as recommended by the Nigerian Nuclear Regulatory authority (NNRA) Audu *et al*,7. The overall reject rate as shown in **Table 1** is about three times higher than the recommended value for a standard Radiology department; 5% - 10% as stated by the World Health Organization (WHO),[8] and Conference of Radiation Control Program Directors.[9] The implication of the high rate is that, the patients, workers and other members of the public have been receiving unnecessary additional dose of ionizing radiation. Furthermore, it will also reduce the efficiency of the facility and increases the running coast. The current findings are similar to the studies conducted by Abubakar *et al,* [18] 26.4% and Sadiq, *et al*,[10], 29.34%, all in Maiduguri, Nigeria. The possible reasons of the similarity could be probably due to a similar method adopted and both hospitals are training institutions where young Radiographers and Residents doctors in Radiology are also trained. Therefore, chances of reoccurrence of errors in terms of patients positioning, exposure factors, unjustified request for repeats and other technical issues are high. Even though this is the first time this study is been carried out in the department, lack of close supervision cannot be completely ruled out among other factors. However, the findings of this study are contrary to the findings of the studies conducted by Owusu-Banalene *et al*,[19] (14.1%), Audu *et al*,7 (16.4%), Sokoto, Nigeria, Zewdu *et al,11* (16.85%), in South, Ethiopian, Ofori, *et al*,14 (19.4%) in Korle-Bu Accra Ghana and Nwobi *et al*,1[6] (24%) the present findings is higher, (26.67%) that all reported lower rate than what was reported in the current study. One of the main goals of CR is to reduce RRA, Audu *et al*,7 and Sadiq *et al,[10]*, in the facility where the current study was conducted this goal has not been achieved. However, this may be attributed to several reasons as reported in this study shown in **Table 2**. The overall RRR in this study is not inconsistent with other previous studies so far reviewed in terms of anatomical parts been investigated. The studies carried out by Ofori *et al*,14 and Zewdu *et al,[11]* showed a number of others reasons (35%) and Chest (19%) Pelvis (16%), extremities (13.38%), Spine (16.92%) respectively.

Furthermore, in this study, other reasons have the highest number of reject-repeat as shown in **Table 3**, closely followed by inappropriate positioning and printing artifact respectively. The findings revealed that repeated printing of the same patient due to mistakes of double-clicking the print command, incorrect input of patient bio-data (wrong spelling of a patient name, age, hospital number, gender, etc), are all included in other reasons for high reject radiographs in UATH. Therefore, it's recommended that pre-training and close monitoring by the senior Radiographers before operating the computer system should be considered strictly. The correct technique in carrying out radiographic examinations by the interns and senior Radiographers should be adhered to seriously. Routine calibration of the printer as well as x-ray equipment should be carried out periodically as recommended by the manufacturer in the manual. The patient motion was also shown to be among the reasons for reject-repeat radiographs as indicated in **Table 3.** The findings in this study are not in agreement with the findings of the studies conducted by Zewdu *et al,[11]* in South, Ethiopia which shows (23.5%) and (100%) for Tikur Anbessa and Bethzatha Hospitals respectively and Atkinson *et al*,[3] in Queensland, Australia, which shows (5%) of patient motion. This could be probably due to the language barrier in which the majority of the patients may prefer communication in their native language for better understanding or patient condition may not allow them to comply with instructions given by the radiographer. Fear may be another contributing factor, especially children and patient undergoing the examination for the first time. Although a patient in a severe or emergency condition may not likely comply with the instructions, suggestively, the Radiographer should indicate in the request card if the examination has answered the clinical question or confirm the clinical diagnosis. However, in cases where the patient's condition cannot allow for the investigation to be carried out and it's considered an emergency, the patient should be further stabilized before the radiological investigation is carried out and simple explanations before the examination should be adhere to seriously to minimize tension in apprehensive patients. Furthermore, the study showed that underexposure as shown in **Table 3** is among the major reasons for reject-repeat images, these findings are not in total agreement with the findings revealed by Joseph *et al,[13]* in Bauchi, Nigeria and Benza *et al,5* in Namibia, that reported (19%) and (16%) respectively. This may occur due to wrong exposure factors selection,

low capacity x-ray equipment, the inadequate voltage supply to the Radiology department, or technical challenges that may be from the equipment, for example, Anode Heel Effects among other reasons. A serviceable Radiology department should have a Central Uninterrupted Power Supply (UPS) system, to prevent low or high voltage supply to the equipment generally; this will prolong the life span of the equipment as well as save the management from unnecessary expenses on the equipment caused by the electrical power. Also, quality control should be periodically carried out on all the equipment to enable optimal service and as well as early detection of any fault in the machine. In a Radiology department where the power supply is not stable, the department must have their independent electric power supply or either have a separate line or high voltage generator that can operate the equipment, to be able to maintain a consistent power supply.

The current findings show that the most utilized size of the film is the 10x12 inch or 24x30cm as shown in **Figure 1,** presumably due to its portability followed by 14x17inch 0r 35x43c in UATH, Radiology department.

The implication of the overall findings implies that the occupationally-exposed workers, patients, and general population are likely to have been exposed to high doses of radiation that may have probably reached or exceeded the recommended dose limit by ICRP for radiation workers, 20 mSv per year, averaged over defined 5 years with no single year greater than50 mSv and the general population, 1mSv per year, averaged over defined 5 years with no single year greater than50 mSv. It also reduces the efficiency of the facility and increases the running cost.

CONCLUSION

In this study, the overall reject-repeat rate was higher than the acceptable limit. The chest has the highest number of examinations. The pelvic/hips have the highest repeat-reject rate, followed by the lumbosacral spine and post-nasal space respectively. Others have the highest number of reasons for reject-repeat images closely followed by inappropriate positioning, printing artifact, and patient motion in the Radiology Department, University of Abuja Teaching Hospital; Gwagwalada.

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