Analysis and Economic Implications of X-ray Film Repeat/Reject in Selected Hospitals in Ghana

Eric Kwasi Ofori, William Kwadwo Antwi, Lawrence Arthur, Cofie Afua Yeboah, Klenam Dzefi-Tettey[1]

Departments of Radiography, School of Allied Health Sciences, College of Health Sciences, University of Ghana, [1]Radiology, Korle-Bu Teaching Hospital, Korle-Bu, Accra, Ghana

Correspondence: Dr. Eric Kwasi Ofori, Department of Radiography, School of Allied Health Sciences, College of Health Sciences, University of Ghana, P. O. Box KB 143, Korle-Bu, Accra, Ghana. E-mail: erikof2001@yahoo.co.uk

ABSTRACT

Background/Aims: Repeat of X-ray examinations contributes to the radiation burden of patient and waste of resources in most developing countries. This study determined the economic implications of repeated X-ray examinations in 10 selected hospitals in Ghana. **Materials and Methods:** The study was carried out in July, 2011 using a total of 2785 radiographs from 1685 patients (85.9% adult and 14.1% pediatrics). Of these, 944 (56.0%) were female and 741 (44.0%) male. Reject films were compiled and classified according to the reasons for the reject. Time and cost analyses due to the repeat examinations were also carried out. **Results:** Out of 2785 radiographs included in the study, 540 representing 19.4% were rejected. The overall reject rate for the individual hospitals ranged from 14.6% to 20.8%. The minimum time wasted by the radiographers in repeating examinations during the 1 month study was estimated to be approximately 135 h representing 17 working days in Ghana. The loss of revenue per month due to 540 rejected/repeated radiographs amounts to approximately $6021 equating to approximately $72,256/annum. Exposure error and poor patient positioning constituted between 52.0% and 23.0% respectively of the overall causes of film rejection and were evenly distributed across the hospitals. **Conclusion:** Consistent training in radiographic techniques and standardization of protocols as well as quality assurance measures in the hospitals could help overcome the reported exposure error and poor patient positioning and improve revenue savings.

Key words: Cost implications; radiographic techniques and standardization; repeat X-ray examinations

Introduction

The production of high quality radiographs requires appropriate positioning of the patient, selection of proper exposure factors and control of film processing conditions. These result in a good image quality and precise diagnosis of the resultant image. Given the vast technological advancement which has occurred over the past decades within the field of medical imaging, there exists a need to define the optimum organizational or corporate structure which can deliver quality diagnostic outcomes.[1-3] Radiographers need to be able to deal with advanced technical equipment and be responsive to the continuous technological development within their field.[4,5] To assure quality service, service levels need to be measured within the clinical environment and a potential measurement tool is film reject analysis.[6] Studies have shown that most radiographs are rejected because of wrong patient positioning, patient or equipment motion and also the selection of the wrong exposure factors.[7-10]

Reject analysis can be done as a means of reducing departmental film expenses, minimizing radiation burden, and decreasing patient waiting times, thus increasing the quality of service delivery.[8] There is limited evidence concerning the application and effectiveness of film reject analysis within the imaging environment in Ghana, and it is important that awareness be created on the significance of reject analysis among radiology departments in the country. The aim of this study therefore is to determine the cost, time, and radiation dose implication of repeat X-ray examinations in ten selected hospitals in Ghana. The study was carried out from 1st to 31st July, 2011. For ethical considerations, the hospitals involved in the study are represented as H1-H10. These hospitals were selected to represent one referral hospital in each of the 10 regions in Ghana.

Access this article online	
Quick Response Code:	Website: www.wajradiology.org
	DOI: 10.4103/1115-1474.117903

Materials and Methods

A prospective study was conducted to evaluate subjectively the causes of radiographic film reject in imaging departments in ten hospitals in Ghana. The rejected radiographs were kept in stored boxes in the respective duty rooms during the study period and were later collected and analyzed. The rejected radiographs consisted of the basic X-ray projections (antero-posterior (AP), post-anterior (PA), and Lateral) in general radiography of adult and pediatric patients.

X-ray equipment and data collection instruments

Table 1 shows the characteristics of the X-ray machines in the 10 X-ray diagnostic centers used for the study. All X-ray machines were constant potential generators with 2.5 mm Al total equivalent filtration at 80 kVp. Two manufacturers' cassettes (Agfa and Kodak) were used with a screen-film combination speed of 400. A proforma for film reject analysis was compiled based upon previous studies,[7-9] which was completed by the radiographers each time a radiograph was found to be unacceptable. The reasons for the rejects, which were coded A-G for ease of analysis are over-exposure; under-exposure, positioning error, patient movement, equipment fault, processor fault, and "others," which required the radiographer to provide additional information in a comments box. Daily records of the total number of films used and films rejected by the radiographer in a particular room were taken and details of each rejected film were recorded on a designed form. The radiographer in-charge of the room also recorded the cause of the reject film from the coded list on the data sheet. The most common general radiography examinations carried out in the ten hospitals were selected for the study. These were chest (post-anterior and lateral); lumbar spine (antero-posterior and lateral); pelvis-AP; abdomen-AP and skull (PA and lateral). In conventional imaging, reject analysis can be described as the critical evaluation of radiographs that have been rejected as being of insufficient quality to enable a diagnostic radiological interpretation to be given.[7] A reject rate is defined as the number of films rejected in the department expressed as a percentage of the total films used. This includes radiographs that are repeated as well as films wasted due to equipment error and other factors. Retake or repeat rate refers to the percentage of clinical radiographs that have to be retaken owing to an error resulting in an image of unacceptable quality.[10] Thus, Reject Rate = ([No. of Rejected Films]/[Overall No. of films used]) × 100%.

Table 1: Specifications of X-ray machines used for the study

Diagnostic centre	Characteristics of the X-ray generator			
	Type	Manufacture date	Power rating (kVp)	Exposure mode
H1	Siemens	2002	30-150	AEC and manual
H2	Siemens	2002	30-150	AEC and manual
H3	Philips	1997	40-150	AEC and manual
H4	Philips	1998	40-150	AEC and manual
H5	Shimadzu	1992	40-125	Manual
H6	Siemens	2002	30-150	AEC and manual
H7	Philips	1997	40-150	AEC and manual
H8	Philips	1996	40-150	AEC and manual
H9	Philips	2005	40-150	AEC and manual
H10	Siemens	1999	30-150	AEC and manual

AEC – Automatic exposure control

Inter-rater agreement

Inter-rater agreement was calculated using kappa.[11] To measure the inter-rater agreement, a random selection of 50 of the radiographs, which had been assessed by the radiographer was re-evaluated by a 2nd independent radiographer. The results were then compared and kappa was calculated using Statistical Package for Social Scientists (SPSS) version 16 to determine the level of inter-rater agreement. Kappa values can range from 0 to 1 with 0 demonstrating no agreement and 1 demonstrating total agreement.

Statistical analysis

Data collected from the study were analyzed using SPSS version 16. The nature of data collected were nominal and ordinal, which enable the use of descriptive statistics such as tables, frequencies, percentages, and graphs for simplification of data analysis.

Results

Reliability test for reject films

The level of agreement between the scores of the assessors had kappa value of 94% for inter-observer reliability, indicating very good agreement.

Workload and reject rates

Diagnostic quality of 2785 radiographs from 1685 patients of which 944 (56.0%) were female and 741 (44.0%) were male who presented for selected examinations in the hospitals were subjectively assessed by the ten radiographers. Out of these radiographs, 540 (19.4%) comprising of 464 (85.9%) adult and 76 (14.1%) pediatric patients were rejected. Patients presenting for chest, pelvis, and abdomen examinations had a single projection whilst those for lumbar spine and skull examinations had two projections (Anterior posterior (AP) and Lateral (LAT)) for lumbar spine and PA and LAT for skull) accounting for the difference between the number of patients and radiographs used. Table 2 shows the reject rates per hospital and examination. The results show that the overall reject rates as well as that for individual examinations and projections across the hospitals were all higher than levels recommended (2%).[7]

Causes of film rejects

Table 3 gives the breakdown of single causes of rejections of the radiographs in all 10 diagnostic centers. Rejects related to inappropriate use of exposure factors (over-and-under exposure) constituted 52.6% of the total causes of rejection.

Incorrect patient positioning contributed 23.0% of the total films rejected. The cause of rejection due to "other" faults (poor collimation, double exposure, and double marker) recorded only 8.0% of total causes (poor collimation alone constituting 63.0%) shown in Figure 1.

Cost of rejected films

Cost analysis of films rejected [Table 4] was carried out in Ghana Cedis (GH¢). Approximately GH¢ 630.00 ($420.00 i.e., 1$ = GH¢ 1.5) was estimated to be the total cost of the rejected films in all the 10 imaging rooms within the 1 month period. This is approximated to GH¢ 7,560.00 (12 × 630) ($5,040.00) per annum of cost of only rejected films excluding other costs like processing chemical, etc., Estimation on the loss of revenue due to reject/repeat examinations was carried out and presented in Table 5. The table indicates that approximately GH¢ 9,032.00 ($6,021) was wasted to the 10 hospitals due to rejection/or repeat of 540 radiographic examinations in 1 month. This is equivalent to GH¢ 108, 384.00 ($72, 256.00) per annum.

Discussion

The results show that the overall reject rates as well as that for individual examinations across the hospitals were all higher than recommended levels. Experienced X-ray personnel typically do not repeat more than 2% of the examinations while inexperienced or careless X-ray personnel repeat 10% or even more of all examinations taken.[7] It is reported that the mean rejects rates values for individual examinations in the USA are; 5% for chest, 8% for lumbar spine and pelvis; 12% for the abdomen and 5% for skull.[7] From the total of 1685 patients, 540 repeat radiographs were performed; therefore, 32% (540/1685) of patients attending for X-ray examination had an unnecessary radiograph taken with its attending increased radiation dose to the patients. The average time taken to perform a repeat radiograph has been estimated to be approximately 15 min;[8] therefore, the minimum time wasted by the radiographic staff in producing the repeat radiographs during the 1 month study in the ten hospitals was calculated to be approximately 135 h ([540 × 15]/60])

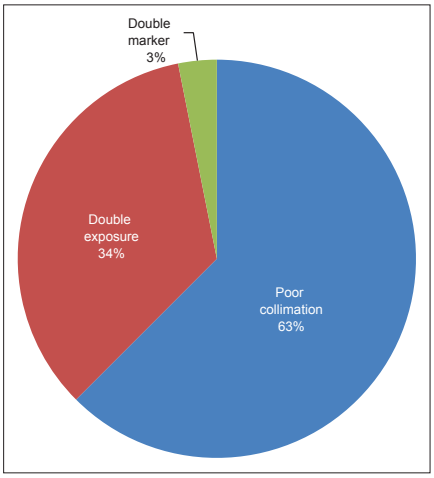

Figure 1: Analysis of other causes of rejections

Table 2: Reject rates per hospital and examinations

Hospital	Reject rate	Overall reject rate (%) per examinations				
		Chest	Lumbar spine	Pelvis	Abdomen	Skull
H1	19.0	12.4	16.9	16.7	14.3	14.3
H2	20.3	14.4	15.7	14.3	17.2	13.8
H3	20.8	14.9	16.5	14.6	16	12.1
H4	19.4	14.7	15.5	14.3	17.6	13.5
H5	20.0	12.5	15.8	14.3	16.7	15.2
H6	19.0	15.9	15.8	16.7	12.5	14.3
H7	18.0	16.3	15.5	12.5	16.7	11.6
H8	14.6	15.2	15.2	16.7	15.4	10
H9	20.7	15.1	15.4	15.4	11.1	13.5
H10	17.2	14.3	16.3	16.7	20	6.7

Table 3: Distribution of reasons for reject among the hospitals

Causes	Frequency	Percent
Overexposure only	109	20.2
Underexposure only	175	32.4
Positioning error only	124	23.0
Processing error only	28	5.2
Patient movement only	13	2.4
Artefact only	19	3.5
High film fog only	39	5.3
Others	33	8.0
Total	540	100

Table 4: Cost analysis of rejected films

Film size (cm)	Number of rejected films	Cost of film per 100 pc (GH¢)	Actual cost of rejected films (GH¢)	Cost in ($)
18×24	57	76.39	43.54	29.03
24×30	153	131.28	200.86	133.91
18×43	136	40.25	54.74	36.49
30×40	59	161.85	95.49	63.66
35×35	69	164.82	113.73	75.82
35×43	66	181.17	119.57	119.57
Total cost of rejected films			627.93	418.62

GH₵ – Ghana cedis

Table 5: Analysis of loss of revenue due to reject/repeat examinations

Examination	Frequency	Cost per a single examination (GH¢)	Total cost (GH¢)	Cost in ($)
Chest	148	16	2368	1578.66
Abdomen	34	17	578	385.33
Pelvis	44	17	748	498.67
Spine	224	17	3808	2538.66
Skull	90	17	1530	1020
Total	540		9032	6021.32

Exchange rate – $1=1.5 Ghana cedis at the time of the study; GH₵ – Ghana cedis

representing approximately 17 working days in Ghana (8 h/day) in 1 month. This obviously results in increased waiting times for patients. Medical imaging is capital intensive.[12] The loss of revenue from 540 rejected/repeated radiographs from the 10 study centers amounts to approximately $6021 per month or approximately $72,252/annum. There are currently approximately 300 imaging facilities in Ghana (mostly employing analogue X-ray equipment). The projected revenue loss translates from film rejects nationally amounts to $2,167,680/annum. This loss is substantial particularly in a developing country where resources are significantly limited.

Repeat X-ray examinations contribute to patient radiation dose and add to the expense on films, X-ray personnel time, wear, and tear on the equipment and accessories as well as inconvenience to patients. Therefore, minimizing the number of repeat films will not only reduce unnecessary exposure to patient, but can also have a significant effect on the department's running cost and time. If for no other reason, then the possible financial savings due to reduced film rejects should persuade imaging departments of the value of correctly performing film reject analysis and acting on the outcome. Radiology managers could use the evaluation of reject films to update their practice and decision making.[9,13] The cost of not doing so is high in terms of wasted resources.

The study found that the overall reject rate for the individual hospitals ranged from 14.6% to 20.8%, which is significantly higher than the 7.6% reported in Belgium;[13] 8% in UK[9] and 2.1% for conventional radiography reported in China.[6] The results also indicated that the reject rate for the individual projections were high compared with the figures reported in UK[9] namely, 6.5% for chest, 4% for the abdomen and 14.3% for lumbar spine.

Studies[6-8] regarding reject analysis showed that approximately 50% of repeats were due to error in choosing exposure factors (resulting in films or radiographs that are either too dark or too light; the film has incorrect density or shows poor contrast). Positioning error accounts for approximately 25.0% of all repeated films.[7] In this study, exposure error (over-and-under exposure) and poor patient positioning constituted approximately 52.0% and 23.0% respectively and were evenly distributed across the hospitals.

Chest and lumbar spine examinations recorded 66.8% (123/184) of the exposure error and 75.9% (107/141) of the poor positioning error. This is because the two examinations constituted almost 69.0% of the total examinations reported in all the hospitals and also as a result of high level of technique skills required for such examinations compared to rest in this study. Optimal exposure factors are a critical factor in producing quality chest radiographs as the area under examination has a wide density range from low density air-filled lung tissue to the high density heart and mediastinum. The technical challenge is to demonstrate this wide density range on one film without loss of details. Using high kVp will achieve this at the expense of reducing contrast on the film (as kVp increases, contrast decreases)[14] but this is acceptable as the detail of the lung fields is still visible whilst the X-ray beam has sufficient penetration to delineate structures in the denser mediastinum. The high kVp technique has the added advantage of delivering a lower entrance surface dose of radiation to the patient.[15,16] Correct patient positioning is also critical. Patient stands during the examination, so there is a greater chance for positioning error by the radiographer.

Lumbar spine AP radiographs are usually quite straightforward to produce. Patient lies supine on the X-ray table and the only positioning error is rotation of patient. Wrong positioning of the film under the patient is more likely and appropriate areas may therefore be missed. Positioning for the lateral projection of the lumbar spine is more subjected to variation. The exposure is relatively high[17] compared to most plain film examinations as it has to penetrate the widest aspect of the patient for the lower lumbar area but still demonstrate bony detail in the narrower upper regions of the lumbar spine. A significant amount of scattered radiation is produced within the patient during this examination and this can degrade the image unless the beam is correctly collimated specifically to include just the area of interest.

Figure 2 shows the percentages of the main causes in the overall rejected films. This result is consistent with previous studies.[13,18] The reject rate falls considerably[8] when a patient's previous films are available for viewing by the radiographer before the examination is undertaken. This never happens in Ghana as patients take their films away with them, which is likely to be a contributory factor to the high reject rates encountered. It has been suggested that lower repeat rates could be achieved with radiographers who are high level of specialization.[19] The higher reject rates in this present study is related to the fact that the hospitals involved in the study have high workloads (between 50 and 70 examinations/day) and carry out the wide range of examinations. The experience of the radiographer is a key factor,[12] but the current results do

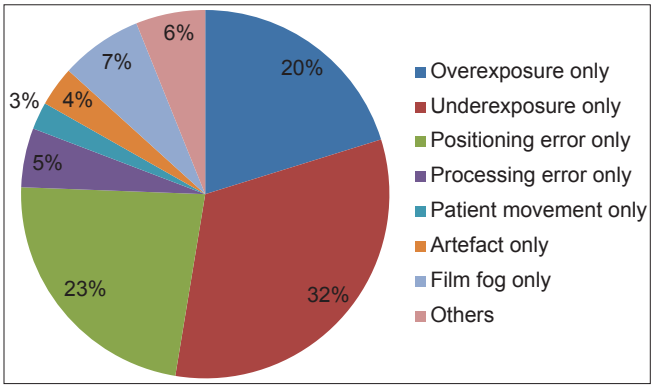

Figure 2: Percentages of the causes in the overall number of films rejected

not support such assertion since the radiographers involved in this study had been practicing for at least 6 years.

The technical issues involved in these examinations (chest and lumbar spine) can be overcome with proper and consistent training in radiographic techniques, standardization of protocols, exposure charts and prudent quality control and assurance measures.

Conclusion

The study has shown that approximately GH¢ 9,032.00 ($6,021) was wasted due to rejection or repeat of 540 radiographic examinations in 1 month and 32.0% of patients had an unnecessary radiograph taken with its attending increased radiation dose to the patients. Chest and lumbar spine examinations constituted the highest (69.0%) of all examinations in hospitals and resulted in high numbers of rejects. The results of this study have indicated that reject analysis is a useful tool in monitoring and improving diagnostic imaging services and could be used to evaluate and monitor prospectively the cost-effectiveness of diagnostic imaging departments. Imaging departments spend heavily on both capital and revenue and must therefore aimed at reducing waste due to repeat examinations.

Acknowledgment

The authors acknowledge the technical support and cooperation received from the staff of the participating hospitals and are grateful to Diane Scutt of the University of Liverpool, Mike Moores and Matt Ward of the Integrated Radiological Services Limited, Liverpool, UK and Professor Cyril Schandorf for their advise.

References

1. Moores BM. Competency requirements and CPD-Preparing for the future needs of medical imaging. Radiography 2002;8:259-68.
2. Spalding M. Towards continuing education and professional development: Drivers for change in therapy radiography. J Radiother Pract 2003;3:131-8.
3. Shanahan MC. Information literacy skills of undergraduate medical radiation students. Radiography 2007;13:187-96.
4. Hafslund B, Clare J, Graverholt B, Nortvedt MW. Evidence-based radiography. Radiography 2008;14:343-8.
5. The International Society of Radiographers and Radiological Technologists. Guidelines for the Education of Entry-level Professional Practice in Medical Radiation Sciences. 2004. Available from: http://www.isrrt.org/isrrt/Education_Standards.asp. [Last accessed on 2013 May 15].
6. Sheung-Ling L, Suk-Han AM, Chi-Kwok C. Reject analysis: A comparison of conventional film-screen radiography and computed radiography with PACS. Radiography 2004;10:183-7.
7. Wilson RL. Chiropractic Radiography and Quality Assurance Handbook. New York: CRC Press, LLC; 2000.
8. Clark PA, Hogg P. Reject/repeat analysis and the effect prior film viewing has on a department's reject/repeat rate. Radiography 2003;9:127-37.
9. Dunn MA, Rogers AT. X-ray film analysis as a quality indicator. Radiography 1998;4:29-31.
10. Finch A, Bury R, Davies G, Fife I, Huflon A. Assurance of Quality in the Diagnostic Imaging Department. 2nd ed. London; British Institute of Radiology; 2001.
11. Bryman A. Social research methods. 3rd ed. Oxford; Oxford University Press; 2008.
12. Doolen T, Aken EV. A study on medical imaging equipment productivity and utilization. In: Proceedings of the 2011 Industrial Engineering Research Conference. Arizona State University Tempe, AZ, USA: Mengqi Hu Industrial Engineering Program School of Computing, Informatics, and Decision Systems Engineering; 2011.
13. Arvanitis TN, Parizel PM, Degryse HR, De Schepper AM. Reject analysis: A pilot programme for image quality management. Eur J Radiol 1991;12:171-6.
14. McEntee MF, Brennan PC, Connor GO. The effect of X-ray tube potential on the image quality of PA chest radiographs when using digital image acquisition devices. Radiography 2004;10:287-92.
15. Fung KK, Gilboy WB. The effect of beam tube potential variation on gonad dose to patients during chest radiography investigated using high sensitivity LiF: Mg, Cu, *P* thermoluminescent dosemeters. Br J Radiol 2001;74:358-67.
16. Lanhede B, Båth M, Kheddache S, Sund P, Björneld L, Widell M, *et al*. The influence of different technique factors on image quality of chest radiographs as evaluated by modified CEC image quality criteria. Br J Radiol 2002;75:38-49.
17. International Atomic Energy Agency (IAEA) Technical Document 1423. Optimisation of the radiological protection of patients undergoing radiography, fluoroscopy and computed tomography. Report of a Coordinated Research Project in Africa, Asia and Eastern Europe. IAEA-TECDOC-1423. Vienna: IAEA; 2004.
18. Nixon PP, Thorogood J, Holloway J, Smith NJ. An audit of film reject and repeat rates in a department of dental radiology. Br J Radiol 1995;68:1304-7.
19. Peer S, Peer R, Walcher M, Pohl M, Jaschke W. Comparative reject analysis in conventional film-screen and digital storage phosphor radiography. Eur Radiol 1999;9:1693-6.

How to cite this article: Ofori EK, Antwi WK, Arthur L, Yeboah CA, Dzefi-Tettey K. Analysis and economic implications of X-ray film repeat/reject in selected hospitals in Ghana. West Afr J Radiol 2013;20:14-8.

Source of Support: This project was funded by the authors from research and book allowance given to academic staff of the University of Ghana. **Conflict of Interest:** None declared.