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Digital radiography reject analysis of examinations with multiple rejects: an Australian emergency imaging department clinical audit

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Abstract

Introduction: The largest source of manmade ionising radiation exposure to the public stems from diagnostic medical imaging examinations. Reject analysis, a form of quality assurance, was introduced to minimise repeat exposures. The purpose of this study was to analyse projection-specific reject rates and radiographic examinations with multiple rejects. **Methods:** A retrospective audit of rejected radiographs was undertaken in a busy Australian metropolitan emergency digital X-ray room from March to June 2018. The data were collected by reject analysis software embedded within the X-ray unit. Reject rates, and reasons for rejection for each X-ray projection were analysed. **Results:** Data from 11, 596 images showed overall reject rate was 10.3% and the overall multiple reject rate was 1.3%. The projections with both a high number and high percentage of rejects were antero-posterior (AP) chest (175, 18.1%), AP pelvis (78, 22.5%), horizontal beam hip (61, 33.5%) and horizontal beam knee (116, 30.5%). The projections with both a high frequency and multiple reject rate were horizontal beam knee (32, 8.4%) and horizontal beam hip (17, 9.3%). The top reasons for multiple rejects were positioning (67.1%) and anatomy cut-off (8.4%). **Conclusions:** The findings of this study demonstrated that projection-specific reject and multiple reject analysis in digital radiography is necessary in identifying areas for quality improvement which will reduce radiation exposure to patients. Projections that were frequently repeated in this study were horizontal beam knee and horizontal beam hip. Future research could involve re-auditing the department following the implementation of improvement strategies to reduce unnecessary radiation exposure.

Introduction

Diagnostic X-ray examinations account for the largest source (over 50%) of manmade ionising radiation exposure to the public.[1] Recent literature has found patients who undergo multiple X-ray examinations have an increased risk of acquiring malignancy in the future.[1–4] Currently, there is no established threshold indicating how much radiation is thought to be completely safe.[2] This highlights the importance of dose optimisation by radiographers. Maintaining a high standard of image quality whilst minimising radiation exposure to As Low As Reasonably Achievable (ALARA) is a core principle of radiography.[3]

In digital radiography (DR), reject analysis (commonly referred to as retake or repeat analysis) is a method of quality assurance that aims to examine images rejected by radiographers, to determine how many and why particular images are being rejected.[5] A rejected image is referred to as a radiograph that is discarded by the radiographer because it does not contribute any value to answering the clinical question.[5] However, a radiographer may delete multiple (two or more) radiographs before acquiring the desired image. These deleted radiographs are referred to as multiple rejects. Some common reasons for rejection include inadequate patient positioning, anatomy cut-off, under or over exposure, patient motion or artefact.

Although more efficient, modern digital radiography systems have one major downfall. The era of conventional radiography almost saw the retirement of reject analysis, with the concept of digital radiography limiting the need for it.[6,7] Previously, the most significant reason for rejection in conventional radiography (CR) was under or over exposure.[6–8] Digital radiography manufacturers emphasised that the evolution X-ray equipment would significantly reduce the need for reject analysis since under or over exposure in DR is considerably more forgiving.[6] Despite this, it has been proposed that a spike in reject rates after the changeover from CR to DR is attributed to it being easier than ever to obtain and discard radiographs.[9] The departments that still routinely conduct reject analysis, often just skim the surface by determining the overall reject rate, and the reject rates for each body part.

In recent years, radiographers who perform quality assurance have advocated reject analysis as an essential tool in digital radiography.[6] It has been reported that close to half (55%) of rejected images were not digitally rectifiable and suggested that these figures cannot be neglected.[10] Almost all relevant studies pertaining to DR found positioning to be the primary reason for image rejection, followed by anatomy cut-off.[6,9,11–13] Evidently, the need for reject analysis still exists.

Among the reviewed studies, a common trend of pelvis, hip, spine and knee examinations acquiring the highest reject rates was identified.[10–14] However, there was evidence to suggest that despite some noteworthy similarities between the literatures, the results cannot be applied across all radiography departments due to their incomparable factors. There are currently no guidelines for reject rates in radiography. This may be due to the fact that data can be skewed by a number of department-dependent factors.[13,15,16] Several studies have concluded that the weekly or monthly reject rates varied significantly.[13,15,16] It was suggested that this deviation is most likely attributed to irregularities in room utilisation.[15] Despite this variability, the overarching purpose of reject analysis is to investigate and amend department-specific issues in order to correct staff weaknesses and thus, reject analysis is still viable.[6]Whilst several studies have investigated reject rates and common reasons for rejection, no study has explored multiple reject rates. Only two studies have reported on projection-specific reject rates, with most merely focused on whole body part examinations, limiting their practicality.[13,17] The purpose of this study was to analyse projection-specific reject rates and DR examinations with multiple rejects. This study will highlight specific projections that require targeted clinical education, thus decreasing unnecessary radiation exposure.

Methods

Ethical considerations

Metro South Hospital and Health Service Human Research Committee approved an ethical exemption for this study (reference number: HREC/17/QPAH/177) and an ethics exemption was approved by Queensland University of Technology (exemption number: 1800000443).

Design

A retrospective review of data collated from March to June 2018 was performed as a clinical audit.

Setting and equipment

Equipment utilised included a ceiling mounted AGFA DXD 600 X-ray console in the Emergency Department of a busy Australian metropolitan public hospital. This room consisted of a fixed vertical detector (43 × 43 cm), a fixed table detector (43 × 43 cm), a large (35 × 43 cm) wireless detector and a small (30 × 40 cm) wireless detector. All images acquired in this room during the study period were included. The data were collected by reject analysis software within the X-ray console and plotted in a Microsoft Excel spreadsheet.

Procedure

The AGFA system has software embedded that extracts the data of all images acquired including data from rejected images. At the time of an image rejection, the performing radiographer was prompted to select a reason for rejection from a list of options including positioning, anatomy cut-off, clothing artefacts, incorrect detector, poor inspiration, patient movement, under exposed, mechanical failure, detector artefacts, over exposed, motion blur, no image, software failure, image artefact, grid artefact, other artefact and test. The investigator interrogated this data and recorded the projection type, body part, type of image, that is approved or rejected, reason for rejection and time acquired in order to calculate the number of rejects and multiple rejects. This information was stored on spreadsheets in Microsoft Excel and filtered by projection and type of image, that is approved or rejected for ease of use.

Data analysis

The raw data were analysed using descriptive statistics. The overall reject rate was calculated by dividing the total number of rejected images by the total number of images included in the study and expressed as a percentage. The overall multiple reject rate was calculated similarly by dividing the total number of multiple rejects (two or more) by the total number of images included in the study. This was presented as a percentage. By filtering the data in Microsoft Excel, frequency distribution tables were created to calculate the number of rejects and multiple rejects per body part. The body parts with the highest reject rates and multiple reject rates were expressed as percentages. This process was repeated for each specific radiographic projection and the reasons for rejects and reasons for multiple rejects. All percentages were rounded to one decimal place.

Sample size and exclusions

The total sample size was 11, 596 images, acquired from one emergency X-ray room during a three-month period (March to June 2018) that met the inclusion criteria for analysis. All accepted and rejected radiographs acquired were included in the study. This consisted of radiographs taken on fixed detectors (i.e. chest X-ray) and wireless detectors (i.e. hand X-rays). Images had to be rejected once to be considered a rejected image. Images had to be rejected more than once in the same examination to be classified as a multiple reject. There were 16 reasons for rejection included in the study. Images rejected under 'test' were excluded since they were irrelevant.

Results

Overall reject rate and multiple reject rate

There were 11, 596 images acquired during the study period. Of these, 1, 193 were rejected, giving an overall reject rate of 10.3%. The number of multiple rejects was 147, giving an overall multiple reject rate of 1.3%. Table 1 displays these figures.

Reject and multiple reject rates per body part

Table 1 demonstrates the frequency distribution of approved and rejected images for each body part. There were 22 body parts and the regions with the highest number (*n*) of rejects were chest (7.5%, 435/5780), pelvis/hip (23.8%, 151/634), knee (20.3%, 144/711), shoulder (19.0%, 98/517) and ankle (8.5%, 70/826). The body parts with the highest proportion (%) of rejects were sternum (33.3%, 11/33), pelvis/hip (23.8%, 151/634), clavicle (21.7%, 5/23), face/skull (21.2%, 7/33) and calcaneus (21.1%, 4/19).

The body parts with the highest number (n) of multiple rejects were knee (5.2%, 37/711), pelvis/hip (4.4%, 28/634), chest (0.4%, 25/5780), shoulder (2.9%, 15/517) and ankle (1.0%, 8/826). The body parts with the highest proportion (%) of multiple rejects were sternum (12.1%, 4/33), knee (5.2%, 37/711), pelvis/hip (4.4%, 28/634), thoracic spine (4.4%, 4/95) and cervical spine (3.3%, 3/91).

Table 1. Frequency distribution of approved and rejected images for each body part

	Approved images† (*n* (%))	Rejected images‡ (*n* (%))	Multiple rejects§ (*n* (%))	Total (*n*)
Shoulder	419 (81.0%)	98 (19.0%)	15 (2.9%)	517
Clavicle	18 (78.3%)	5 (21.7%)	0	23
Humerus	54 (91.5%)	5 (8.5%)	0	59
Elbow	162 (82.7%)	34 (17.4%)	5 (2.6%)	196
Forearm	115 (92.7%)	9 (7.3%)	0	124
Wrist	328 (89.4%)	39 (10.6%)	5 (1.4%)	367
Hand	295 (95.8%)	13 (4.2%)	3 (1.0%)	308
Fingers/thumb	84 (97.7%)	2 (2.3%)	0	86
Pelvis/hip	483 (76.2%)	151 (23.8%)	28 (4.4%)	634
Femur	85 (88.5%)	11 (11.5%)	1 (1.0%)	96
Knee	567 (79.8%)	144 (20.3%)	37(5.2%)	711
Tibia/fibula	218 (92.0%)	19 (8.0%)	3 (1.3%)	237
Ankle	756 (91.5%)	70 (8.5%)	8 (1.0%)	826
Foot/toes	797 (97.0%)	25 (3.0%)	3 (0.4%)	822
Calcaneus	15 (79.0%)	4(21.1%)	0	19
Cervical spine	77 (84.7%)	14 (15.4%)	3 (3.3%)	91
Thoracic spine	80 (84.2%)	15 (15.8%)	4 (4.4%)	95
Lumbar spine	196 (79.4%)	51 (20.7%)	6 (2.4%)	247
Face/skull	26 (78.8%)	7 (21.2%)	0	33
Chest	5345 (92.5%)	435 (7.5%)	25 (0.4%)	5 780
Sternum	22 (66.7%)	11 (33.3%)	4 (12.1%)	33
Abdomen	261 (89.4%)	31 (10.6%)	1 (0.3%)	292
Total	10 403 (89.7%)	1 193 (10.3%)	147 (1.3%)	*N* = 11 596

†Approved image: A successful radiograph sent to radiology for reporting

‡Rejected image: An undiagnostic radiograph deleted once; not sent to radiology

§Multiple reject: A deleted undiagnostic radiograph with more than one previous attempt; deleted and not sent to radiology

Projection-specific reject and multiple reject rates

As seen in Table 2, there were 48 individual projections analysed and the projections with the highest number (n) of rejects were antero-posterior (AP) chest (18.1%, 175/966), lateral chest (5.8%, 131/2250), postero-anterior (PA) chest (5.0%, 129/2564), horizontal beam knee (30.5%, 116/380) and AP pelvis (22.5%, 78/347). Adversely, the projections that acquired the highest reject rates (%) were lumbar spine spot view (50.0%, 2/4), horizontal beam hip (33.5%, 61/182), lateral sternum (33.3%, 11/33), horizontal beam knee (30.5%, 116/380) and odontoid (28.1%, 9/32).

The projections with the highest number of multiple rejects were horizontal beam knee (8.4%, 32/380), horizontal beam hip (9.3%, 17/182), AP chest (1.8%, 17/966), Y-scapula (4.7%, 11/235) and AP pelvis (2.6%, 9/347). However, lateral sternum (12.1%, 4/33), odontoid (9.4%, 3/32), horizontal beam hip (19.3%, 17/182), horizontal beam knee (8.4%, 32/380) and lateral thoracic spine (7.3%, 4/55) make up the projections with the highest multiple reject rates.

Reasons for rejection

There were 16 reasons for rejection included in the study. The top three reasons for rejection were positioning (58.0%), anatomy cut-off (18.3%) and clothing artefacts (6.3%), as demonstrated in Table 3.

There were 13 reasons for multiple rejects. Table 4 presents the top three reasons for multiple rejects were positioning (112 images, 67.1%), anatomy cut-off (14 images, 8.4%) and incorrect detector selected (12 images, 7.2%).

Discussion

This research has established a previously unexplored area of reject analysis: radiographs rejected multiple times in one examination. Rejected images were categorised by body part and further categorised by projections. The reject rates and multiple reject rates for each were reported. It was identified that some projections yielded reject rates as high as 50.0% and multiple reject rates as high as 12.1%. The reject rates were used congruently with the reasons for rejection to highlight areas of clinical concern. Projections with high multiple reject rates were noteworthy as radiographers could not correct the issue after one attempt. The intrinsic effects of repeated radiographs go beyond the scope of unnecessary equipment usage and labour; avoidable exposures increase patient radiation dose which is known to have adverse

Table 2. Frequency distribution of approved and rejected images for each projection

	Approved images (*n*)	Rejects (*n* (%))	Multiple rejects (*n* (%))	Total images (*n*)
Shoulder				
AP shoulder	228	33 (12.6%)	4 (1.5%)	261
Glenoid	17	4 (19.1%)	0	21
Y scapula	174	61 (26.0%)	11 (4.7%)	235
Clavicle				
Angle clavicle	18	5 (21.7%)	0	23
Humerus				
AP humerus	28	1 (3.5%)	0	29
Lateral humerus	26	4 (13.3%)	0	30
Elbow				
AP elbow	85	15 (15.0%)	4 (4.0%)	100
Lateral elbow	77	19 (19.8%)	2 (2.1%)	96
Forearm				
AP forearm	64	4 (5.9%)	0	68
Lateral forearm	51	5 (8.9%)	0	56
Wrist				
PA/Oblique wrist	210	13 (5.8%)	1 (0.5%)	223
Lateral wrist	118	26 (18.1%)	4 (2.8%)	144
Hand				
PA/Oblique hand	203	10 (4.7%)	3 (1.4%)	213
Lateral hand	92	3 (3.2%)	0	95
Fingers/Thumb				
PA finger/Thumb	84	2 (2.3%)	0	86
Pelvis/Hip				
AP pelvis	269	78 (22.5%)	9 (2.6%)	347
AP hip	70	11 (13.6%)	2 (2.5%)	81
Lateral hip	23	1 (4.2%)	0	24
HBL hip	121	61 (33.5%)	17 (9.3%)	182
Femur				
AP femur	55	8 (12.7%)	3 (4.8%)	63
Lateral femur	30	3 (9.1%)	0	33
Knee				
AP knee	297	27 (8.3%)	5 (1.5%)	324
HBL knee	264 (69.39%)	116 (30.5%)	32 (8.4%)	380
Skyline	6	1 (14.3%)	0	7
Tib/Fib				
AP Tib/Fib	114	4 (3.4%)	0	118
Lateral Tib/Fib	104	15 (12.6%)	3 (2.5%)	119
Ankle				
AP ankle	275	9 (3.2%)	0	284
Mortise ankle	257	32 (11.1%)	2 (0.7%)	289
Lateral ankle	224	29 (11.5%)	6 (2.4%)	253
Foot				
PA/Oblique foot	545	18 (3.0%)	3 (0.5%)	563
Lateral foot	215	6 (2.7%)	1 (0.5%)	221
Toes				
Toes	37	1 (2.6%)	0	38
Calcaneus				
Axial calcaneus	11	3 (21.4%)	0	14
Lateral calcaneus	4	1 (20.0%)	0	5
Cervical spine				

(*Continued*)

Table 2. Continued.

	Approved images (*n*)	Rejects (*n* (%))	Multiple rejects (*n* (%))	Total images (*n*)
AP	26	2 (7.1%)	0	28
Lateral	28	3 (9.7%)	0	31
Odontoid	23	9 (28.1%)	3 (9.4%)	32
Thoracic spine				
AP	38	2 (5.0%)	0	40
Lateral	42	13 (23.6%)	4 (7.3%)	55
Lumbar spine				
AP/PA	93	13 (12.3%)	0	106
Lateral	101	36 (26.3%)	6 (4.4%)	137
Spot view	2	2 (50.0%)	0	4
Face/Skull				
Face/Skull	26	7 (21.2%)	0	33
Chest				
PA	2435	129 (5.0%)	4 (0.2%)	2564
AP	791	175 (18.1%)	17 (1.8%)	966
Lateral	2119	131 (5.8%)	3 (0.1%)	2250
Sternum				
Lateral	22	11 (33.3%)	4 (12.1%)	33
Abdomen				
AP/PA	261	31 (10.6%)	1 (0.3%)	293

AP, anteroposterior; HBL, horizontal beam lateral; PA, posteroanterior; Tib/Fib, Tibia/Fibula.

effects on the human body.[8] Focused clinical education on these projections may be beneficial in reducing reject rates and thus patient radiation exposure.

The overall reject rate (10.3%) identified in this study was slightly high compared to recent literature reporting on modern digital radiography systems, reporting rates of 9.0%, 4.9%, 11.0%, 8.0% and 8.9%.[12,14,17–19] There are no current guidelines for reject rates in radiography, due to the fact that data can be skewed by a number of department-dependent factors such as variation in protocols and equipment.[13,15] Watkinson, Moores and Hill[15] suggested that weekly reject rates varied by a factor of two and the reject rates for some examinations fluctuated up to five-fold. Similarly, Tzeng et al.[13] suggested that generalisability is influenced by many factors including the types of examinations performed and the skill level of each radiographer in the department. Although there is some variability in reject analysis, the essence of reject analysis is to identify department-specific issues in order to plan for training needs to target staff weaknesses, as established by Foos et al.[11]

Table 3. Frequency of reasons for rejection

Reason for rejection	Number of rejects (n (%))
Positioning	692 (58.0%)
Anatomy cut-off	218 (18.3%)
Clothing artefacts	72 (6.3%)
Incorrect detector selected	51 (4.2%)
Poor inspiration	47 (3.9%)
Patient movement	33 (2.8%)
Under exposed	27 (2.3%)
Mechanical failure	17 (1.4%)
Detector artefacts	12 (1.0%)
Over exposed	5 (0.4%)
Motion blur	4 (0.3%)
No image	4 (0.3%)
Software failure	4 (0.3%)
Image artefact	3 (0.3%)
Grid artefacts	2 (0.2%)
Other artefacts	2 (0.2%)
Total	1,193 (100%)

Reject rates are subjective; their statistical significance is dependent on the relative frequency of occurrence. For example, if four ankle radiographs were performed and one of these was rejected, the reject rate would be 25.0%. On the other hand, if forty ankle radiographs were performed at another department and one of these was rejected, the reject rate would be 2.5%. For less common examinations, the reject rates were significantly higher, however due to there being fewer examinations, the statistical uncertainty was greater. Thus, reject rates as values may not necessarily be comparable between studies as they are not equal in significance and hold a high risk of bias. However, it is valuable to recognise which radiographs are commonly repeated by recognising both a high number of rejects and a high reject rate. Otherwise, they may be highly susceptible to misinterpretation.

The projections with both a high number of rejects and reject rate were AP chest (175, 18.1%), AP pelvis (78, 22.5%), horizontal beam hip (61, 33.5%) and horizontal beam knee (116, 30.5%). The study by Tzeng et al.[13] yielded similar results by concluding that AP pelvis radiographs accumulated the highest reject rate among all radiographic examinations. The study by Hofmann, Rosanowsky, Jensen and Wah[12] indicated that knee and hip examinations were of the highest reject rates (20.6% and 18.5%, respectively). The clinical audit by Jabbari, Zeinali and Rahmatnezhad[10] which investigated reject rates in three Iranian medical imaging departments similarly concluded that pelvis radiographs were of the highest repeat rate (14.0%). The clinical audit by Foos et al.[11] which explored the reject rates of two hospitals, agreed with these results by concluding that pelvis, hip and spine examinations were of the highest reject rates (above 8.0% of all these examinations were rejected).

Positioning errors (58.0%) and anatomy cut-off (18.3%) were the top reasons for rejection. This is consistent with recent literature that affirms that since

Table 4. Reasons for rejection in examinations with the highest number and rate of multiple rejects

Reason for rejection	HBL hip (n)	AP chest (n)	HBL knee (n)	Y scapula (n)	AP pelvis (n)	Lateral sternum (n)	Odontoid (n)	Lateral thoracic spine (n)	Total (n (%))
Positioning	14	17	49	14	8	0	5	5	112 (67.1)
Anatomy cut-off	1	7	0	2	2	0	0	2	14 (8.4)
Under exposed	5	0	0	0	0	0	0	0	5 (3)
Incorrect detector selected	3	1	2	0	0	6	0	0	12 (7.2)
Mechanical failure	1	2	2	0	0	0	0	0	5 (3)
Poor inspiration	0	1	0	0	0	0	0	0	1 (0.6)
Over exposed	1	0	0	0	0	0	0	0	1 (0.6)
Patient movement	1	2	0	0	0	0	0	0	3 (1.8)
Detector artefact	1	0	1	0	0	0	0	0	2 (1.2)
Patient clothing	2	3	0	0	4	0	0	0	9 (5.4)
Grid artefact	0	0	1	0	0	0	0	0	1 (0.6)
Motion blur	0	0	1	0	0	0	0	0	1 (0.6)
Software failure	0	0	1	0	0	0	0	0	1 (0.6)
Total (n (%))	29 (17.4)	33 (19.8)	57 (34.1)	16 (9.6)	14 (8.4)	6 (3.6)	5 (3)	7 (4.2)	167 (100)

AP, anteroposterior; HBL, horizontal beam lateral.

DR was introduced, the overarching reason for rejection has shifted from exposure to positioning.[16–21]

The current study was unique in that it investigated multiple reject rates in a single examination, which has not been explored in the existing literature. The projections with both a high frequency and multiple reject rate were horizontal beam knee (32, 8.4%) and horizontal beam hip (17, 9.3%). This finding suggests that the performing radiographers are not correcting the image on the second attempt, thus contributing to an increase in radiation dose to the patient. The reasons for such rejections should be noted. The top reasons for multiple rejects were positioning (112 images, 67.1%), anatomy cut-off (14 images, 8.4%) and incorrect detector selected (12 images, 7.2%). These results suggest that radiographers are unsure of how to correct the position after the initial image, with some attempting images up to five times. This figure cannot be compared with prior literature since multiple reject rates have not previously been explored.

The positional correction of horizontal beam knee images often consists of minute adjustments. However, a radiographer should be able to accurately correct the position on the second attempt from visual assessment of the initial image. Staff training on positioning patients for these projections is likely to be of benefit. An educational in-service reviewing pertinent radiographic knee anatomy and related positioning on X-ray is recommended to decrease multiple reject rates, particularly for patients undergoing these examinations in follow-up examinations. Horizontal beam hip radiographs can be difficult to achieve due to several factors including the physical limitations of equipment and patient cooperation. However, staff education surrounding the optimisation of positioning techniques could be advantageous. As a result, the amount of multiple rejects should decrease and subsequently minimise patient dose, adhering to the ‘As Low as Reasonably Achievable’ (ALARA) principle.

Several limitations are worthy of consideration in this study. Firstly, there was a high variability in the number of images acquired per radiographic projection within the sample, limiting the statistical significance. To address this in future studies, a larger sample size of more than six months would increase the viability of the study. Secondly, the department-specific differences in protocols and imaging systems limits the reproducibility of the study. Several innate confounders for reject rate included variation in projection complexity, radiographer experience, complex patient presentation, patient mobility, patient compliance, rooms/equipment utilised and patient body habitus. Thirdly, there was potential for reporting bias because radiographers must manually input the reason for rejection at the time of deletion. In times of urgency, accuracy here could be jeopardised. The study by Jabbari et al.[10] stated that a number of images were labelled as ‘other’ but no more information was given, which resulted in invaluable data. Additionally, approximately 15–20% of cases in the study by Steffen et al.[22], the reason for rejection was unavailable because they were not indicated by the radiographer. Within this study, ‘other’ was not an option for radiographers to select, so it is assumed that the correct reason for rejection was selected. However, it is possible that these manual inputs were not accurate, consequently introducing potential inconsistencies. Additionally, this study assumes that radiographers perform imaging under the correct projection label, that is lateral chests are imaged under 'lateral chest' rather than 'PA chest'. Lastly, there was some ambiguity in the categories provided for reason for rejection. There was some crossover of terms that could be used interchangeably due to their subjective variability, that is anatomy cut-off could also be described as a positioning error. A degree of uncertainty in the inter-radiographer quality threshold was also acknowledged. It is unknown if low repeat rates are accredited to high quality work or low acceptance thresholds.

In the future, this study could be repeated with a larger sample size of at least six months to reduce the discrepancy in the number of images acquired per radiographic projection. Future research in this field could include investigating the relationship between radiographer experience and reject rates. Additionally, projections with high reject rates could be further explored by comparing images of the same projection acquired with the wall bucky to images acquired with the free detector or table; or comparing grid versus no grid chest X-ray reject rates. Another potential research study could involve re-auditing the department following the implementation of quality improvement strategies to decrease the reject rates.

Conclusion

This study achieved its intended aims by reporting the reject rates and multiple reject rates of each projection in order to provide evidenced-based research to assist departments in focusing on avoiding these multiple rejects. Projections that were frequently repeated in this study were horizontal beam knee and horizontal beam hip. The findings of this study can be used to lower radiation doses to patients presenting for X-rays by forming a base for designing future quality improvement initiatives. Additionally, this study has the potential to provide a benchmark for multiple reject rates of digital radiography systems alike. Future research could involve re-auditing the department following the implementation of recommended quality improvement strategies to reduce unnecessary radiation exposure.

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Conflict of Interest

The authors declare no conflict of interest.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Fig S1