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Multi-centre digital radiography reject analysis for different clinical room use types: The establishment of local reject reference levels for public hospital departments

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Abstract

Introduction: Reject analysis in digital radiography helps guide the training of staff to reduce patient radiation dose and improve department efficiency. The purpose of this study was to perform a multi-centre, vendor agnostic reject analysis across different room usage types, and to provide benchmarks for comparison. **Methods:** Retrospective reject and exposure log data were collected via USB from fixed general X-ray systems across multiple Australian sites, for collation and analysis. The overall reject rate, local reject reference level, absolute and relative reject rates for body part categories, reject rates by room usage types and the reject rate for each reason of rejection were calculated. **Results:** Data were collected from 44 X-ray systems, across 11 hospitals. A total of 2,031,713 acquired images and 172,495 rejected images were included. The median reject rate was 9.1%. The local reject reference level (LRRL), set as the 75*th* percentile of all reject rates, was 10.6%. Median reject rates by room type were emergency (7.4%), inpatients + outpatients (9.6%), outpatients (9.2%), and hybrid (10.1%). The highest absolute reject rates by body part were chest (2.1%) and knee (1.4%). The highest relative rates by body part were knee (18.1%) and pelvis (17.2%). The most frequent reasons for image rejection were patient positioning (76%) and patient motion (7.5%). **Conclusions:** The results compare well with previously published data. The range of reject rates highlights the need to analyse typical reject rates in different ways. With analysis feedback to participating sites and the implementation of standardised reject reasons, future analysis should monitor whether reject rates reduce.

INTRODUCTION

Any X-ray image, deemed by the radiographer at acquisition to not be of a standard that is diagnostically acceptable, can be 'rejected', whereby it is not sent to the radiologist for reporting. The root causes of rejected images are varied, and can include patient positioning errors, image artefacts, and operator errors.[1] These rejected and subsequently repeated images are a source of unnecessary radiation exposure to patients and staff, as well as being a source of inefficiency in imaging departments.[2] While rejected and repeated images are inherent and somewhat inevitable in radiography, the control of repeat/reject rates by implementation of improvement measures is a vital part of any department quality assurance (QA) program.[2] The quantification of repeat/reject rates, analysis of trends over time and root cause investigations are of particular interest when targeting staff education and training,[3] implementing quality improvement measures, improving departmental workflow, and ultimately reducing patient and staff doses.[4]

The report of the American Association of Medical Physicists Task Group 151 (AAPM TG-151) recommends that data from individual systems and whole departments should be collated and used to establish benchmarks for

reject/retake rates for standard imaging procedures.[2] During this process, it is important to be comparing like with like, in terms of technology type and reject reasons.[6]

Most of the published literature on X-ray reject/repeat rates was compiled during the era of film-screen systems. These studies show that the reject/repeat rates hovered at around 10%,[5] but there is a question as to the relevance of these studies in the digital age, when the mechanisms for rejecting images and the reasons for retaking them have evolved with the technology. Reject/repeat rates for digital systems have been reported to range from 1.2% to 17% (as seen in Table 1). Local studies, Atkinson et al.[4] and Stephenson et al.[7] conducted studies in X-ray emergency departments and calculated the overall reject rates to be 9% and 10.3%, respectively, both finding "patient positioning" to be the most common reject reason. Within the local geographical region, Bantas et al.[8] performed a reject analysis comparison between two radiology departments in New Zealand and found the overall reject rate for each department to be 7.89% and 5.91%, respectively. Again, patient positioning was found to be the most frequent cause of images to be rejected.

Digital radiography reject rates found in previous publications are displayed in Table 1.

AAPM TG-151[5] suggests a target of 8%, with 10% as the upper threshold and 5% as the lower threshold for investigation and possible corrective action, and the reject/retake rates found by previous local studies generally fall within those recommended limits. No studies have been found in the literature that have compared room usage or room type in reject analysis.

A useful method of expressing a benchmark or reference level across multiple sites is to use a Diagnostic Reference Level (DRL).[21] This is typically calculated by taking the median value from each site, and then setting the 75th percentile of all median values to be the local diagnostic reference level (LDRL). CT DRL implementation and annual comparison is a well-established framework that has shown to be an effective tool in assisting with the identification of examinations that would benefit from optimisation, in the context of patient medical exposures,[21,22] but it would apply just as well in the context of repeat/reject exposure analysis. In the context of benchmarking a single value such as a reject rate, the same methodology can be applied, and a local reject reference level (LRRL) can be set at the 75th percentile of all room reject rates. This analysis is useful in this application because it gives participating sites a value to set as an action threshold, which is based on local data and can be periodically updated, to encourage continual optimisation.

The aim of the current study was to perform a multi-centre, vendor agnostic quantitative reject analysis across a range of different room use types, and to provide data for sites to use for monitoring and benchmarking. This study is the first of its kind in Australia and will publish a recommended LRRL for systems included in the study.

The specific outcomes are:

1. Calculate a typical reject rate for all systems.
2. Provide a local reject reference level (LRRL) for all systems.
3. Calculate the typical reject rate for each room use type.
4. Identify the frequently rejected exam types (body part categories), both absolute and relative.
5. Identify the most frequent reject reasons for all systems.

TABLE 1. Comparison of quantitative reject analysis results from previous studies.

Publication	Country	Technology Type	Total number of images	Reject rate (%)
Atkinson et al. (2019)[4]	Australia	DR	90,298	9%
Stephenson-Smith et al. (2021)[7]	Australia	DR	11,596	10.3%
Bantas et al. (2023)[8]	New Zealand	DR	76,325	6.9%
Haddad et al. (2023)[9]	Belgium	DR	107,277	8.3%
Otayni et al. (2022)[10]	Saudi Arabia	DR	22,500	6.93%
Alashban et al. (2022)[11]	Saudi Arabia	DR	27,238	14.38%
Ali and Yaseen (2021)[12]	Pakistan	DR	15,000	17%
Jastaniyyah et al. (2021)[13]	Saudi Arabia	DR	23,861	14.1%
Alyousef et al. (2019)[14]	Saudi Arabia	CR/DR	413	10%
Alahmadi, Alrehaili, & Gameraddin (2019)[15]	Saudi Arabia	DR	150	14.7%
Yurt et al. (2018)[16]	Turkey	DR	33,001	1.2%
Hofmann et al. (2015)[17]	Norway	DR	5417	11%
Taylor et al. (2015)[18]	UK	CR/DR	Unknown	4.6%
Khafaji & Hagi (2014)[19]	Saudi Arabia	DR	89,797	15%
Andersen et al. (2012)[20]	Norway	DR	27,284	12%

Recommendations for standardising reject recording and reporting across current and future participating sites will be made.

METHODS

Ethical considerations

Ethics approval was reviewed and granted by the Gold Coast Hospital and Health Service - Human Research Ethics Committee (HREC reference: EX/2022/QGC/80509). This project was deemed exempt from full ethical review under the qualification that this study was a quality improvement activity only. The authors are in compliance with the ethical considerations of low risk/quality improvement studies involving multiple centres. Informed consent from patients was not required as no identifiable patient data was used for analysis.

Design

This study was a retrospective study of contemporary Australian reject and exposure log data. Sites were recruited through a presentation given at a local radiographer X-ray specialty interest group, by the researchers. Where sites did not respond to a request for participation, additional recruitment was done through the local onsite medical physicist, or directly via the department X-ray team leader's contact details. Recruitment took place over approximately 6 months. Only adult public hospitals were included in the data collection. Paediatric hospitals were excluded from analysis as there was only one dedicated paediatric facility in which to compare. Privatised public X-ray departments were excluded from analysis due to the logistical challenges of obtaining data.

A survey was sent to each site who had expressed an interest in the study, requesting the following data from each X-ray system: facility name, room name, room location, comments on room usage, equipment manufacturer, equipment model, equipment installation date, software version, asset ID and any additional comments on the room or system (e.g. Lost data, etc.). Fixed X-ray systems were only eligible for data analysis, mobile X-ray systems were excluded.

Instructions were supplied to each participating site, detailing how to download the correct logs from each type of X-ray system, for each manufacturer. Reject logs and additional exposure logs (where applicable) were collected from each system directly via export onto USB typically in csv or xml file format. Reject log data were provided to the principal investigator, who was in contact with the site representative, if any further assistance was required to download additional system logs or identify unknown exam types or reject reasons. Additionally, sites were asked to align reject reasons provided in the export files with published recommended standardised reasons/categories, to aid the inter-site data comparison.

A minimum of 12 months of data were requested and used for all systems. This was to ensure there was adequate data for robust reject rate analysis.

Data analysis

All logs were collected and saved to a secure hard drive. The analysis of the raw data was completed using Microsoft Excel. The data were analysed using pivot tables in order to group and summarise exam names and reject reasons.

Imaging protocol names varied significantly between systems. A Microsoft Excel script referencing a "data dictionary" was used to group exam names into body part categories and reject reasons into the recommended categories outlined in AAPM TG-305[6]. Body part categories were assigned for each exam type using keywords in exam names, such as "ankle" in the exam name "Ankle LAT" or "chest" in "Chest PA". Where detailed information on specific body parts was unavailable (via protocol names), exams were grouped into broader categories. The data dictionary was iteratively updated as new systems were being analysed and unassigned exams or reasons were identified.

Body part categories were assigned as shown in Table 2.

TABLE 2. The complete list of body part categories assigned for each examination.

Abdomen	Elbow	Humerus	Other/Unknown	Shunt Series
Ankle	Elbow/Forearm	Knee	Paediatric Arm	Skeletal Survey
Arm	Face	Leg	Paediatric Leg	Skull
Babygram	Femur	Long Legs	Paediatric Spine	Tib/Fib
Bone Age	Foot	Long Spine	Pelvis	T-Spine
Chest	Forearm	L-Spine	QC/Test	Wrist
Clavicle	Hand	NAI (Non-Accidental Injury)	Sacrum/Coccyx	
C-Spine	Hip	Neck	Shoulder	

Reject Categories (per AAPM Task Group 305):

1. Patient Positioning
2. Patient Motion
3. Artefacts
4. Image Contrast or Noise
5. Incorrect Selection (Protocol, Detector)
6. Wrong Body Part or Patient
7. Equipment Issue
8. Practitioner-directed
9. Test/No Patient Exposure
10. Other/Unknown Failure

Where reject reasons were unclear or vague, clarification was sought from the sites directly and manually assigned a category or placed in the "Other/Unknown Failure" category.

Some vendors export reject logs separately from exposure logs. In these cases, two separate files were required to be exported for the same date range. Where the date range for these files did not align, data ranges were constrained in order to maintain consistency.

The system reject rate (%) was calculated by:

$$\text{Reject Rate}\% = \text{Total no. rejected images} \div \text{Total no. images acquired} \times 100. \quad (1)$$

The typical reject rate for all room use types was calculated by taking the median of all individual system reject rates.

The typical reject rate for each individual room usage type (e.g., emergency, inpatients, outpatients, etc.) was calculated by taking the median of all individual system reject rates of that room usage type.

The local reject reference level (LRRL) was calculated as the 75th percentile of all individual system reject rates.

The absolute reject rate (%) was determined by calculating the total number of rejected exams for that body part category divided by the total number of exams over the export time period, as shown in equation (2).

$$\text{Absolute Reject Rate}\%(\text{body part}) = \text{No. rejected images(body part)} \div \text{Total number of images acquired} \times 100. \quad (2)$$

The absolute reject rate for the most frequently rejected body part categories is the median of all values collected.

The relative reject rate (%) was determined by calculating the total number of rejected exams for that body category divided by the total number of exams of that body part category over the export time period, as shown in equation (3).

$$\text{Relative Reject Rate}\%(\text{body part}) = \text{No. rejected images(body part)} \div \text{Total no. images(body part) acquired} \times 100. \quad (3)$$

An example of the use of equation 3 to find the Relative Reject Rate % of chest X-rays, this was found as the total number of rejected "Chest" images divided by the total number of "Chest" images acquired, expressed as a percentage.

Both absolute and relative reject rates were only calculated for body part categories in which at least 20 images were acquired in order to remove rare exam types with inflated reject rates.

The most frequent relative reject rates presented for each body part category is the median of all values collected, where the exam occurred across at least 75% of systems that submitted data [at least 30 of 44 systems].

Each system was assigned a room use type based on feedback from sites on the clinical use of each room. These were categorised as emergency, inpatients only, outpatients only, inpatients + outpatients and "hybrid", which was a multi-use room used for emergency, inpatients, and outpatients. Any room usage category with less than four systems in the submitted data were excluded, as this did not provide robust or reliable data analysis for comparison.

RESULTS

Data were collected from 44 fixed general X-ray systems from 11 hospitals, across eight Hospitals and Health Services (HHS). A total of 2,031,713 acquired images and 172,495 rejected images were included for analysis. Date ranges of data varied by site, dependent on data log availability and system installation dates. System data ranged in date from November 2017 to July 2023. Data supplied ranged from a minimum of 365 days to a maximum of 2028 days. Various room types were represented, including emergency, medical imaging and outpatients fixed X-ray rooms. Resuscitation rooms and radiography/fluoroscopy (R/F) style fixed X-ray/procedure rooms were excluded from data analysis as there were only three total systems of these room types in the submitted data.

The typical (median) repeat/reject rate for all systems was calculated to be 9.1%. The LRRL was then calculated as the 75th percentile of all system reject rates. As shown by the red dashed line in Figure 1, the LRRL was 10.6%. In this graph, each of the 44 systems was given an individual system ID for anonymity, and colour coded according to the room usage type.

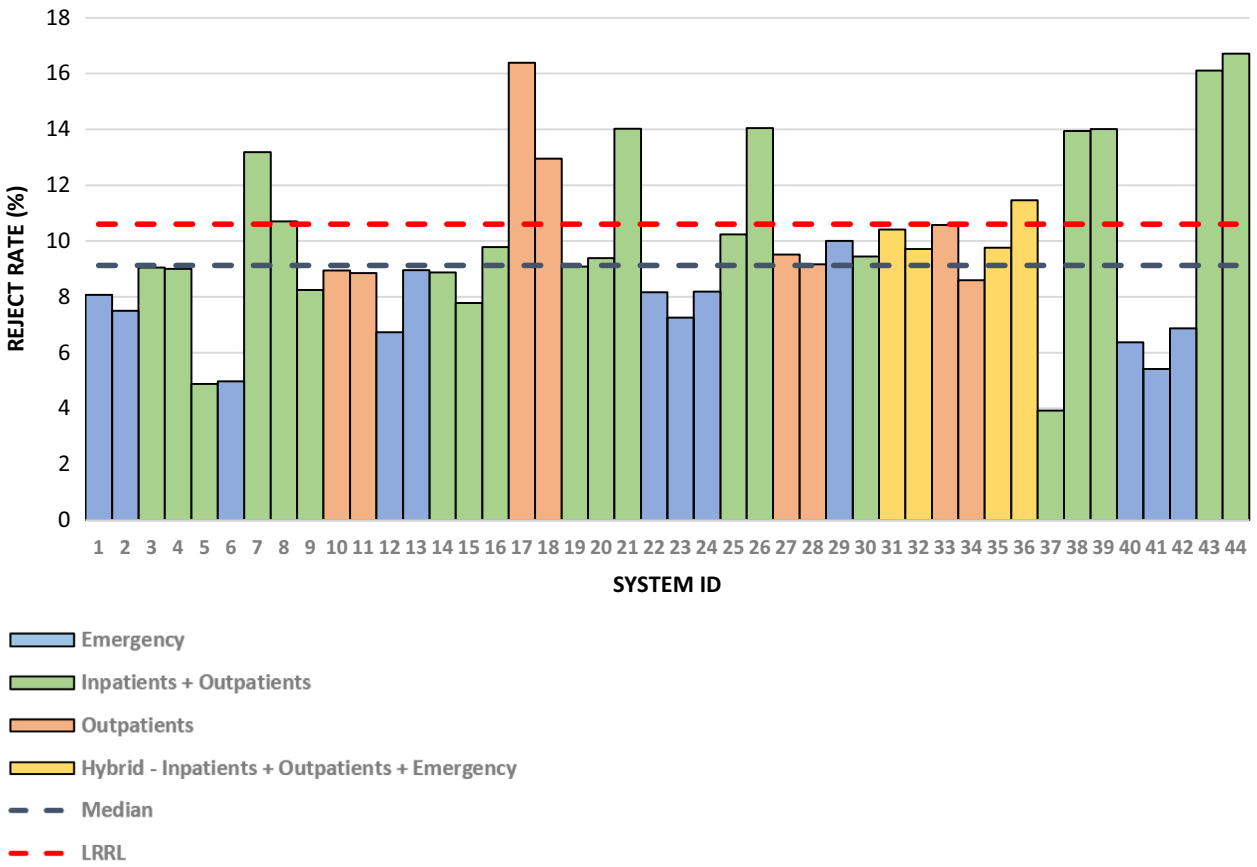

FIGURE 1. Reject rates for each system included for data analysis. The overall reject rate and LRRL are also shown.

TABLE 3. Median reject rate for each room type.

Room type	Median reject rate %	*N* (no. of systems)
Emergency	7.4	12
Inpatients + Outpatients	9.6	20
Outpatients	9.2	8
Hybrid – Inpatients + Outpatients + Emergency	10.1	4

The other metrics found for the systems were the median reject rates for each room use type, as presented in Table 3 and the most frequently rejected exam types (body part), both absolute and relative, shown in Table 4A,B.

Relative reject rates were calculated for body part categories with a minimum of 20 rejected images, removing data for rarely rejected imaging exams, as shown in Table 4B. Additionally, body part categories reported must have occurred across at least 75% of systems that submitted data (a minimum of 30 out of 44 systems). Finally, the most common reject reasons for all systems are presented in Table 5.

Table 4A. Absolute reject rate (%) for the most rejected body part categories—All room types.

	Body part	Median absolute reject rate (%)	*N* (no. of systems)
1	Chest	2.1	42
2	Knee	1.4	43
3	Shoulder	0.6	43
4	Pelvis	0.6	42
5	Ankle	0.6	43
6	Wrist	0.4	43
7	Hand	0.4	43
8	Elbow	0.3	42
9	Abdomen	0.3	36
10	Hip	0.3	37

Limitations

Data were obtained from public hospital medical imaging departments only. In the future, the addition of private medical imaging departments would add to the robustness and value of this work.

Table 4B. Relative reject rate (%) for the most rejected body part categories—All room types.

	Body part	Median relative reject rate (%)	*N* (no. of systems)
1	Knee	18.1	35
2	Pelvis	17.2	35
3	Lumbar Spine (L-Spine)	14.7	35
4	Shoulder	13.7	35
5	Cervical Spine (C-Spine)	13.0	34
6	Humerus	12.8	34
7	Femur	11.5	34
8	Elbow	11.0	34

Table 5. Reject reason rates (%) (per AAPM Task Group 305 recommended categories).

Repeat/reject reason	Median reason rate (%)
1. Patient positioning	76.0
2. Patient motion	7.5
3. Artefacts	4.8
4. Image contrast or noise	3.6
5. Incorrect selection (protocol, detector)	0.6
6. Wrong body part or patient	0.03
7. Equipment issue	0.8
8. Practitioner directed	0.1
9. Test/quality assurance/no patient exposure	1.5
10. Other/unknown failure	3.2

In some instances, exposure logs were unable to be obtained and relative reject rates were not able to be calculated for these systems (nine systems total).

Where free text reject reasons were available and the reason was not clear into which category would be appropriate, this was allocated to "Other/Unknown Failure" so this would increase the frequency of this category and reduce others.

It is also possible that radiographers may not always select the reject category that most accurately reflects the rejection reason. This study performed quantitative analysis only, no investigations were made into the qualitative accuracy of reject categories selected. The following publications have discussed qualitative reject analysis; Neep et al.,[23] Steward et al.,[24] Mount et al.,[25] Kjelle et al[1]

DISCUSSION

There was good participation from sites, with this being the first analysis of this kind to include X-ray systems across multiple hospitals, with a range of room types. Across this large data set, with over two million images, the median reject rate for all room types was 9.1%. This aligns well with other publications for comparable Australian departments at 9%[4] and 10.3%,[7] but is higher than published reject rates from other countries in the local geographical region, 7.86% and 5.91%.[8] It is encouraging that the overall rate from the current study is within the AAPM TG-151 upper limit threshold for investigation of 10%, but suggests there is room for improvement and optimisation to achieve the target rate of 8%. The purpose of this work was to provide comparison data that could be used to highlight systems that may require improvement or optimisation. This has been achieved by calculating a typical reject rate and LRRL. It can be seen in Figure 1 that the reject rate for each system has been displayed, and the LRRL is the level at which 75% of the systems fall below this rate. This clearly shows which systems could be identified for closer analysis and potential optimisation. The LRRL value of 10.6% aligns generally with the AAPM TG-151 upper limit for investigation (10%).

Figure 1 shows there is some variation in the reject rate depending on room type, where the room types are shown in different colours. Table 3 gives the median reject rate for each room type, with the inpatient and outpatients (green in Figure 1), outpatients only (orange) and hybrid rooms (yellow) falling closely to the 10% investigation threshold level. Interestingly, emergency rooms had a much lower reject rate than other room types, at 7.4%. Possible reasons for this may be that emergency presenting patients often present in pain or discomfort. Radiographers are possibly willing to accept imperfect quality imaging which may result in less frequently rejected images and a lower reject rate. Additionally, the typical emergency room type referral or clinical question is to rule out an abnormality. Hence, if this is demonstrated on initial imaging, it may be accepted rather than rejected and repeated which results in a lower reject rate. It is expected that the other three room types have similar reject rates, as these rooms experience similar patient cohort throughput. The range of reject rates is much greater for inpatient/outpatient rooms and much lower for hybrid room types.

From the data, it can be seen that 7/20 (35%) of inpatient/outpatient rooms, 2/8 (25%) of outpatient-only rooms and 1/4 (25%) of hybrid rooms have rates that fall above the 75th percentile LRRL level. These facilities may use this value to decide where to focus optimisation efforts. As previously identified, the emergency-only rooms all fall below the LRRL, as it is hypothesised by the different intent of the diagnostic process. This can be mis-leadingly reassuring, as this room type may be unlikely to breach the LRRL level. If the LRRL were to be analysed by independent room types, the

LRRL for each room type would be: emergency – 8.2%, inpatients + outpatients – 14.0%, outpatients – 11.2%, hybrid – 10.7%. This may be a more useful guide for specific room type identification and investigation.

Median absolute reject rates are given in Table 4A. These are heavily influenced by the frequency of exam type performed and can be used as an indication of the main contributor to unnecessary population dose due to rejected images. Hence, the most frequently performed examinations typically have highest absolute reject rates as some level of image rejection is inherent to any exam type. The reduction in the absolute reject rate of these exam types will have the greatest impact on reducing unnecessary radiation doses to the patient population and should not be discounted simply because they are a small percentage of the total number of exposures acquired.

Relative reject rates may be an indicator of examination difficulty (user technique or patient related). The highest relative rejected exam types should be used as the focus for staff education and training, which is often the most effective way to reduce reject rates. The most frequent relative reject rates align well with previous local publications such as Atkinson et al.[4]: pelvis/hip (23%), knee (19%), cervical spine (18%), lumbar spine (18%), shoulder/clavicle (15%), femur (15%). Stephenson et al.[7] had a significantly smaller dataset with many body part categories having less than 20 rejected images, and therefore cannot be compared to this study. Bantas et al.[8] did not provide the same level of granularity regarding body part categories and therefore cannot be compared.

In alignment with previous local publications, patient positioning is the most frequent reject reason given by a significant margin, as presented in Table 5. It was the reason given for 76% of all rejected images. Atkinson et al.[4] found a similar rate at 70% (a combination of positioning and anatomical cut-off). When combining reject rates for other reasons against those listed by Atkinson et al.,[4] there is reasonable agreement in the reject reason rates; artefacts (8%), patient motion (7%), image contrast or noise (2.7%). If sites were to adopt AAPM TG-305 recommended standardised reject reasons, it is expected for the reject reason "Other/Unknown Failure" to reduce and be redistributed into other reject reason categories and allow for more accurate data analysis and robust comparison between systems.

The results from this study will be reported back to each site, where the sites will be informed which systems are theirs, and where their performance falls in relation to the presented data. They will also be provided a breakdown of their system data into reject rates per body part and reject reasons. Sites will be able to use this data to target areas of improvement and optimisation. Future analysis should be performed to identify if site reject rates decrease after optimisation as a possible result of this paper.

CONCLUSION

It is reasonable to assume that the data comparisons performed by this study are robust, as identical methods were used for all data collected, categorisation was performed by the same person for all systems and the data set is very large. It has been shown that the results compare well with previous publications and recommendations. This analysis has shown that there is a large variation of reject rates between room types. The range of reject rates calculated across all systems highlights the need to identify typical reject rates, possibly analysed in different ways, such as room type. The method of using an LRRL may be an effective way of benchmarking sites with different room types.

With specific system analysis feedback to participating sites and the implementation of recommended standardised reject reasons, future analysis should be performed to identify if site reject rates and reasons decrease after optimisation as a possible result of this paper. With standardisation of categories between sites, statistical analysis may also be performed between datasets.

Recommendations

1. Standard repeat reject reasons should be used across all sites per AAPM Task Group 305 recommendations.

Where free text or system customisation is possible, it would be best practice to create reason categories per AAPM 305 task group recommendations as seen in Table 6 (naming slightly amended for easier staff understanding and navigation).

2. All Test/QA/No patient exposure images should be identified using a test or QA imaging protocol exam name or by rejected reason category and entries removed from reject analysis to identify true patient-related reject rates.
3. "Student" or "rejected by student" is not a valid reject reason. Instead, student images should be rejected per the categories above, and identified as User: Student. Student images may then be able to be extracted and analysed independently at each site for student-specific training purposes.
4. Per AAPM TG-305 recommendations: "We recommend that acquisition and reject information should be provided in a single log file."[8]
5. Standardised reject analysis should be performed routinely to identify improvements or areas where optimisation is required.

Table 6. Revised AAPM 305 recommended standardised reject categories with examples.

Reject Category	Examples
1. Patient Positioning	Incorrect anatomy rotation; incorrect tube angle; internal versus external rotation. Anatomy cut-off, required anatomy not visualised, anatomy obscured by collimation; detector-tube alignment; fixation device not visible. Upright versus supine; left-lateral versus right-lateral; weightbearing versus non-weight bearing
2. Patient Motion/Breathing	Voluntary or involuntary patient movement during exposure; did not follow breathing instructions. Patient has a condition that prevents cessation of moving or compliance with respiratory directions. Paediatric patients unable to follow instructions may also be included.
3. Artefacts (incl. Grid)	Known objects such as patient buttons, jewellery, etc.; O2 Line; positioning device, improper shield placement. Grid lines or similar artefact. Electromagnetic interference artefacts; detector artefacts such as dead pixels or lines; tube artefacts.
4. Overexposed, Underexposed, Image Contrast, Noise	Incorrect kVp; X-ray technique factors; Non-optimised image processing Pixel clipping. Erroneous use or non-use of grid, wrong SID.
5. Incorrect Protocol, Incorrect Detector Selection	Protocol selection error (anatomy, view); incorrect detector selected; no detector selected; bucky not pushed in far enough to initialise detector.
6. Wrong Body Part or Wrong Patient	When the body part or patient does not match the ordered exam, this represents a potential reportable error. Ideally, these would still be sent for review/reporting and would not be rejected.
7. Equipment Issue	Power failure; unexpected detector disconnection; other unexpected mechanical or software failure.
8. Practitioner Directed	Repeated imaging while positioning devices such as feeding tubes; rejected images due to physician positioning of patient.
9. Test/No Patient Exposure/QA	QC images; warm-up exposures; images obtained without exposing a patient; non-patient research (mummies, cadavers, etc.,).

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

ETHICS STATEMENT

Ethics approval was reviewed and granted by a local Hospital and Health Service—Human Research Ethics Committee (HREC reference: EX/2022/QGC/80509). This project was deemed exempt from full ethical review under the qualification that this study was a quality improvement activity only. Informed consent from patients was not required, as no identifiable patient data was used for analysis.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

1. Kjelle E, Chilanga C. The assessment of image quality and diagnostic value in X-ray images: a survey on radiographers' reasons for rejecting images. *Insights Imaging* 2022; **13**: 36.
2. Jones AK, Polman R, Willis CE, Shepard SJ. One year's results from a server-based system for performing reject analysis and exposure analysis in computed radiography. *J Digit Imaging* 2011; **24**: 243–55.
3. Little KJ, Reiser I, Liu L, et al. Unified database for rejected image analysis across multiple vendors in radiography. *J Am Coll Radiol* 2017; **14**: 208–16.
4. Atkinson S, Neep M, Starkey D. Reject rate analysis in digital radiography: an Australian emergency imaging department case study. *J Med Radiat Sci* 2020; **67**: 72–9.
5. Jones AK, Heintz P, Geiser W, et al. Ongoing quality control in digital radiography: report of AAPM Imaging

Physics Committee Task Group 151. *Med Phys* 2015; **42**: 6658–70.
6. Little K, Reiser I, Apgar B, et al. AAPM task group report 305: Guidance for standardization of vendor-neutral reject analysis in radiography. *J Appl Clin Med Phys* 2023; **24**: e13938.
7. Stephenson-Smith B, Neep MJ, Rowntree P. Digital radiography reject analysis of examinations with multiple rejects: an Australian emergency imaging department clinical audit. *J Med Radiat Sci* 2021; **68**: 245–52.
8. Bantas G, Sweeney RJ, Mdletshe S. Digital radiography reject analysis: A comparison between two radiology departments in New Zealand. *J Med Radiat Sci* 2023; **70**: 137–44.
9. Haddad L, Saleme H, Howarth N, Tack D. Reject analysis in digital radiography and computed tomography: a belgian imaging department case study. *J Belgian Soc Radiol* 2023; **107**:100.
10. Otayni A, Aftan AA, Nammazi J, et al. Assessment of Rejected Radiographs during planar imaging procedures. *J Radiat Res Appl Sci* 2023; **16**: 100556.
11. Alashban Y, Shubayr N, Alghamdi AA, Alghamdi SA, Boughattas S. An assessment of image reject rates for digital radiography in Saudi Arabia: A cross-sectional study. *J Radiat Res Appl Sci* 2022; **15**(1): 219–23.
12. Ali A, Yaseen M. Digital radiograph rejection analysis during "Coronavirus disease 2019 (COVID-19) pandemic" in a tertiary care public sector hospital in Khyber Pakhtunkhwa Province of Pakistan. *Chin J Acad Radiol* 2021; **4**: 133–40.
13. Jastaniyyah DF, Jawhari AA, Mugharbel AT, Khafaji MA, Albahiti SH. How has the COVID-19 pandemic affect the rejection rates and repeat reasoning of digital radiography? *Saudi Med J* 2021; **42**: 1041–4.
14. Alyousef KA, Alkahtani S, Alessa R, Alruweili H. Radiograph reject analysis in a large tertiary care hospital in Riyadh, Saudi Arabia. *Global J Qual Saf Healthc* 2019; **2**: 30–3.
15. Alahmadi O, Alrehaili A, Gameraddin MB. Evaluation of reject analysis of chest radiographs in diagnostic radiology. *Am J Diagn Imag* 2019; **5**:4.
16. Yurt A, Tintas M, Yüksel R. Reject analysis in digital radiography: a prospective study. *Int J Anat Radiol Surg* 2018; **7**: e4.
17. Hofmann B, Rosanowsky TB, Jensen C, Wah KH. Image rejects in general direct digital radiography. *Acta Radiol Open* 2015; **4**: 2058460115604339.
18. Taylor N. 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* 2015; **21**: 236–41.
19. Khafaji MA, Hagi SK. Direct digital radiograph. Technicians role in obtaining good images. *Saudi Med J* 2014; **35**: 879–81.
20. Andersen ER, Jorde J, Taoussi N, Yaqoob SH, Konst B, Seierstad T. Reject analysis in direct digital radiography. *Acta Radiol* 2012; **53**: 174–8.
21. Vañó E, Miller DL, Martin CJ, et al. ICRP publication 135: diagnostic reference levels in medical imaging. *Ann ICRP* 2017; **46**: 1–44.
22. ARPANSA. Multi detector computed tomography statistics | ARPANSA. 2020. Arpansa.gov.au. Available at: https://www.arpansa.gov.au/research-and-expertise/surveys/national-diagnostic-reference-level-service/mdct/statistics.
23. Neep MJ. Making the most of X-ray reject analysis in the digital age. *J Med Radiat Sci* 2023; **70**: 109–11.
24. Steward A, Semsem S, Currie K, et al. The cost of perfection: An investigation into the unnecessary rejection of clinically acceptable lateral wrist imaging. *J Med Radiat Sci* 2023; **70**: 380–7.
25. Mount J. Reject analysis: A comparison of radiographer and radiologist perceptions of image quality. *Radiography* 2016; **22**: e112–7.