



Building a Quality Infrastructure in a Large Radiography Practice

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Background

Radiographic imaging serves the highest number of patients in Radiology, representing about 60-70% of the total imaging examinations at typical community and academic hospitals [1]. The equipment technology has evolved significantly in the last few decades, from film-screen system, to computed radiography (CR) with photostimulable storage-phosphor cassettes and CR readers, and further to digital radiography (DR) with various indirect or direct conversion detector materials.

Currently, DR with wireless indirect flat panel detectors is the main workhorse; however, it still presents challenges such as dose creep, image processing complexities, and significant vendor differences. In addition, multiple studies have revealed a deficiency and disparity in technologist education and training [2-5]. Variations have been demonstrated in radiographic image acquisition, processing, and quality [5-6].

This study aims to report a quality infrastructure for imaging standardization and improvements in a large radiography practice.

Methods

Four quality improvement efforts have been established since 2019, including quantitative clinical image scoring, closed-loop radiologist feedback, DR DICOM metadata analytics, and equipment scoring and ranking.

Clinical image scoring employs a four-point (0-3) scale based on five categories (patient positioning, centering, collimation and electronic shuttering, labeling, and exposure factors), generating an ideal gold-image score of 15. A Tableau dashboard (Tableau Software, Seattle, WA) was created to monitor the image scores and showcase technologists with top scores monthly.

A radiologist feedback function integrated in the electronic health record system was utilized for convenient feedback input. A quality team identifies and disseminates root causes for constructive criticisms, and shares complimentary feedback monthly.

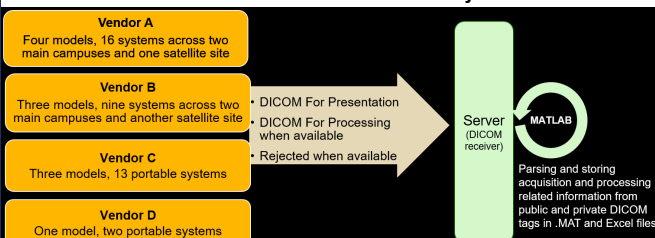
Methods cont.

Clinical Radiographic Image Quality Scoring Rubric

Rank	3	2	1	0
Key	High Quality	Acceptable	Below Standards	Unacceptable /Undiagnostic
	GOLD STANDARD! Excellent image Meets all quality criterion at its ideal.	Diagnostic image Exhibits improvement opportunities in 1-2 areas. Average /PAR image.	Improvement needed in 3 or more areas. Image offers very little diagnostic value. Another attempt should have been made.	Image is useless; should be repeated. No diagnostic value.
Image Criterion	Individual Category			
Position of Part	0 Unacceptable Quality	1 Below Imaging Standards	2 Acceptable standards achieved	3 Gold Standard Quality
Centered to Part				
Collimation /Shuttering				
Marking /Labeling				
Exposure Factors				

DR DICOM metadata analytics utilizes a set of custom MATLAB (MathWorks, Natick, MA) programs to extract and compile acquisition- and processing-related DICOM tags of all clinical images from up to 40 radiographic systems [6].

Data Flow for DR DICOM Metadata Analytics



Last, equipment scoring/ranking has been conducted to determine replacement need for all radiographic and fluoroscopic (R/F) equipment (>190 units) in the practice, plus regional sites. A scoring system was developed based on equipment age, criticality, patient volume per year, parts and service availability, depreciation, and technology relevance. The ranked list has been updated and reviewed on Tableau semi-annually.

R/F Equipment Scoring Formula

$$S(x)_{final} = a_0 \times S(x)_{age} + b_0 \times S(x)_{criticality} + c_0 \times S(x)_{volume} + d_0 \times S(x)_{parts} + e_0 \times S(x)_{depreciation} + f_0 \times S(x)_{technology}$$

* $a_0 = 10, b_0 = 8, c_0 = 7, d_0 = 5, e_0 = 2, f_0 = 2$, scaling factors refined for the six categories

R/F Equipment Scoring Rubric

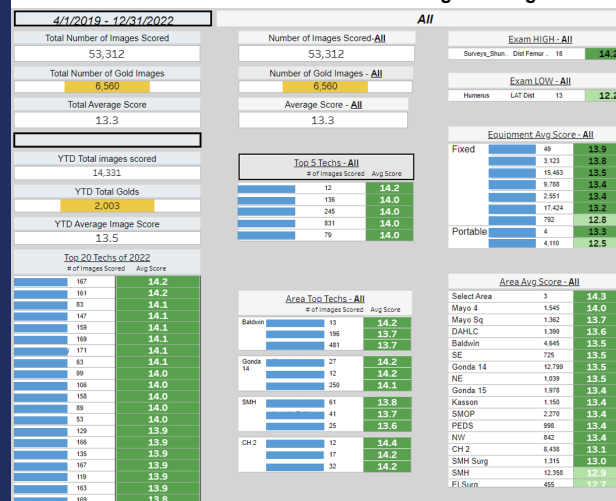
Category	0	1	2	3	4	5
Age of Equipment	0-3 Years	4-6 years	7-9 years	10-12 years	13-14 years	15+ years
Criticality			Multiple room clinic	Multiple room hospital	Only room clinic	Only room hospital
Patient Volumes/Year	0-1000	1001-2000	2001-4000	4001-6000	6000-10000	>10000
Parts and Service Availability	Vendor parts available			Part source available		No parts available
Depreciation	5 years or greater left	4 year left	3 year left	2 year left	1 year left	0
Technology	DR/Flat panel detector	Wired DR				CR/Image Intensifier

Results

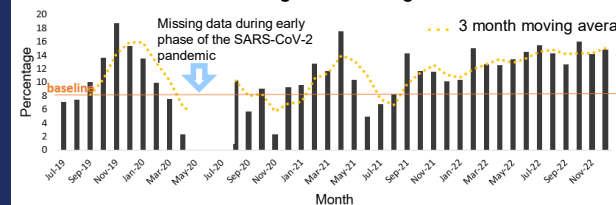
Clinical image scoring was conducted for over 52,000 images, with an average score of 13.3. The number of gold images increased from a baseline of 8.2% to 14.3%.

There were 20 radiologist feedback on average per month, 41.2% of which were complimentary. Top three constructive critiques related to imaging technique (21.7%), positioning (14.7%), and artifacts (5.9%).

Tableau Dashboard for Clinical Image Scoring



The Percentage of Gold Images over Three Years

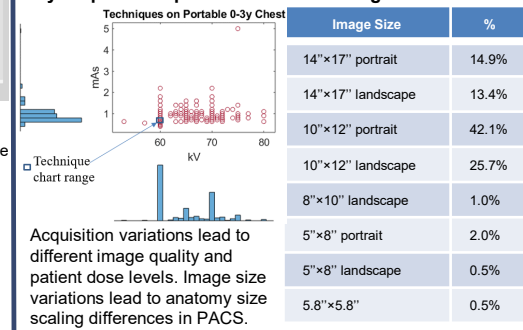


DR DICOM metadata analytics from over 2.6 million images provided data for systematic image acquisition investigation, image processing harmonization, exposure index (EI) monitoring and EI target optimization, detector utilization, and repeat/reject analysis.

Example of image acquisition variations for adult lumbar spine exams on vendor B scanners across sites.

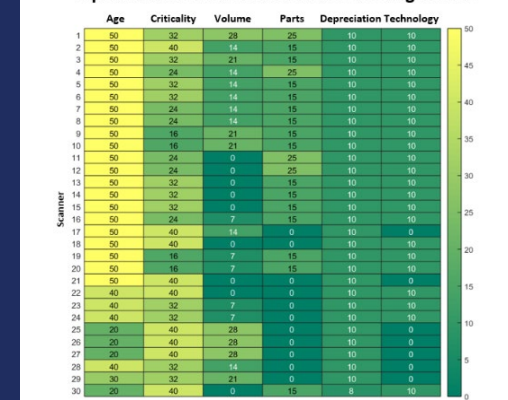
View	AEC	AEC dose consistent?	Collimation range for AEC (cm)	Collimation range for manual (cm)	EI range for AEC	EI range for manual
AP	94.0%	No	17.8 – 40.3 (24.8)	24.4 – 40.3 (24.9)	141.7 – 597.3 (289.0)	85.3 – 2635.6 (318.8)
Lateral	64.0%	Yes	18.7 – 40.3 (26.0)	8.5 – 40.3 (30.2)	45.6 – 738.3 (362.6)	148.1 – 1749.9 (551.5)
Lateral flexion/extension	26.9%	NA	24.5 – 40.3 (31.8)	24.6 – 40.3 (34.4)	54.3 – 581.5 (266.2)	159.2 – 1456.9 (539.7)

Example of image acquisition and size variations for 0-3 year pediatric portable chest AP images on vendor C.



R/F equipment scoring/ranking was successfully implemented across all sites. There was a range of equipment and technologies installed since 1995. The maintained ranked list has been used for equipment management and replacement decision-making.

Top 30 Scanner Scaled Scores and Ranking Results



Conclusions

- A quality infrastructure was built in a large radiography practice for over three years, including clinical radiography image scoring and dashboard, closed-loop radiologist feedback, DR DICOM metadata analytics, and R/F equipment scoring and ranking.
- It has been invaluable for technologist education, monitoring, image quality standardization and improvement, as well as for equipment management and replacement decision-making.

References

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