A Clinical Analytics Platform for Radiographic Protocol Optimization

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ABSTRACT

Purpose: In digital radiography (DR), the Exposure Index (EI) and Deviation Index (DI) provide standardized feedback on whether image receptor exposure is appropriately matched to patient size and clinical task. However, systematic, context-aware analysis of EI and DI across exams may not be easily available to a practice, or provided in a way that is not helpful for clinical practice quality improvement. This work describes the development and application of a clinical analytics platform to evaluate DR acquisition techniques and support Image Wisely–aligned protocol optimization using DICOM metadata.

Methods: Clinical DR DICOM metadata were extracted using a Flywheel-based analytics pipeline and analyzed within onboard Jupyter Notebooks. EI and DI distributions were evaluated relative to practice-defined target values using comparable acquisition contexts, including vendor/system, exam type, and projection view. Summary statistics including median DI, DI standard deviation, median EI, and corresponding EI target values were analyzed for each exam–view combination, with sample sizes recorded for each group.

Results: Context-stratified analysis of one month of exposures across practices within the University of Wisconsin Hospitals and Clinics (UWHC) and the University of Wisconsin Medical Foundation (UWMF) demonstrated variability in receptor exposure across common exams and views. Several exam–view combinations exhibited wide DI distributions, indicating systematic deviation from exposure targets and a need for protocol review or exposure target adjustment. For a large segment of the practice, pelvic examinations were acquired predominantly using manual techniques (≈92%), and exhibited a considerable spread of DI ranges (SD ≈ 2.62 across protocols), further supporting the need for protocol intervention and technologist support.

Conclusion: This clinical informatics platform enables automated, context-aware analysis of EI and DI using routinely available DR metadata. The approach supports data-driven protocol optimization, targeted technologist feedback, and practice-wide quality improvement. Embedding this form of analytics into routine operations may improve protocol optimization and standardization, for patient-tailored dose optimization aligned with Image Wisely principles, and improved consistency in image quality.

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MOTIVATION

Single-image review of image quality and DR exposure indicators is a core component of technologist quality assurance (QA) in DR (Figure 1). However, quality improvement initiatives such as protocol standardization and optimization require analysis of aggregated clinical data across comparable imaging contexts.

To address this need, we developed a platform for analysis of DR metadata to support practice-level quality improvement. The platform enables users to generate customizable data visualizations that can feed quality improvement dashboards (Figures 2–3). Data visualization can highlight protocol variation, exposure trends, and potential outliers. Users can also perform deeper cohort-based exploration through interactive data review and export complete metadata datasets for further analysis (Figure 4).

By combining aggregated analytics with access to image-level metadata, the platform supports data quality assurance, identification of protocol deviations, investigation of outlier examinations, and evidence-based protocol optimization.

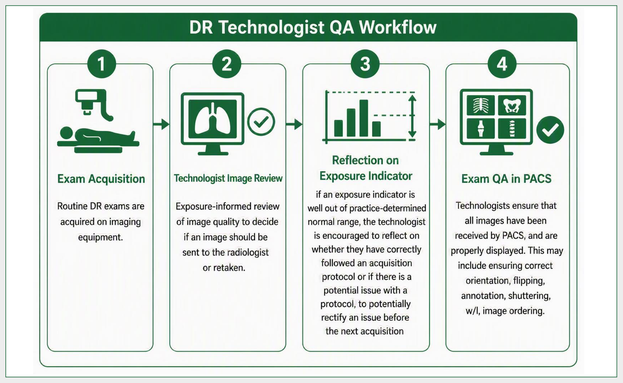


Figure 1: Technologist QA workflow for a single image

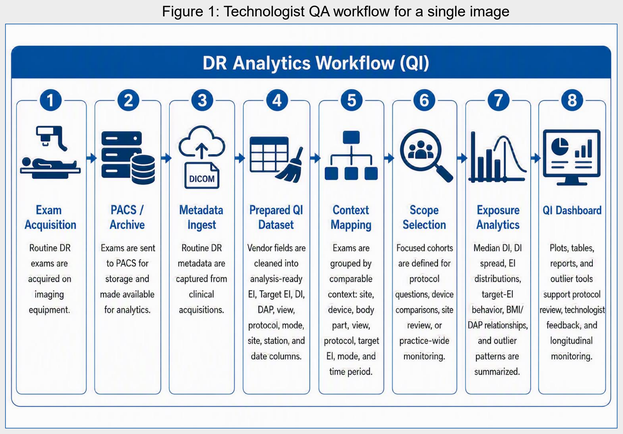
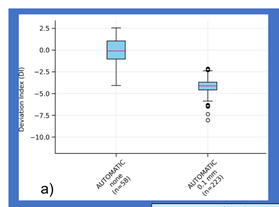


Figure 2: DR Analytics (QI) workflow

Figure 7

When looking at details (csv output) for the data in Figure 5 we found that:

a) some protocols had left a vendor default of 0.1mm Cu added filtration
b) different facilities and modes showed different exposure targets



Chest Lateral Images, Samsung

InstitutionName	ExposureControl Mode	Target ExposureIndex
ACCESS COMMUNITY HEALTH CENTER	AUTOMATIC	250
ACCESS COMMUNITY HEALTH CENTER	MANUAL	420
Stoughton Clinic	AUTOMATIC	250
UW HOSPITAL AND CLINICS	AUTOMATIC	250
UW HOSPITAL AND CLINICS	AUTOMATIC	350
UW HOSPITAL AND CLINICS	MANUAL	420
UW JANESVILLE	AUTOMATIC	360

b)

CLINICAL ANALYTICS PLATFORM

Clinical DR metadata are extracted from routine acquisitions using a Flywheel-based analytics pipeline and standardized into a prepared QI dataset that can be used for protocol optimization. Users define an analysis scope by site, device, exam, projection, protocol, acquisition mode, date range, Target EI, or patient-size surrogate as shown in Figure 3. The platform generates report-ready summaries on selectable image metrics with context-specified data visualization allowing for interactive tools for review of specific exams in the dataset as shown in Figure 4.

Interactive Tools for Clinical Data Visualization

Context-Aware Data Slicing

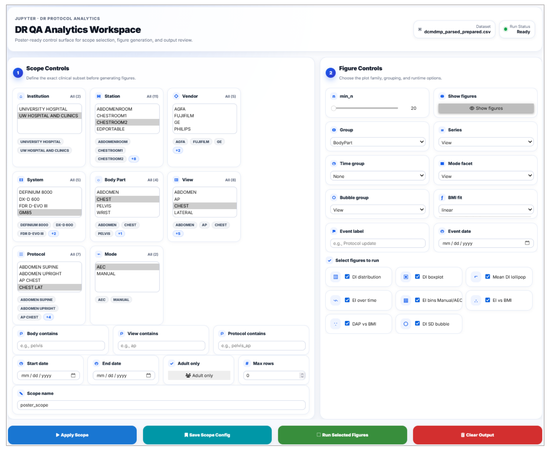
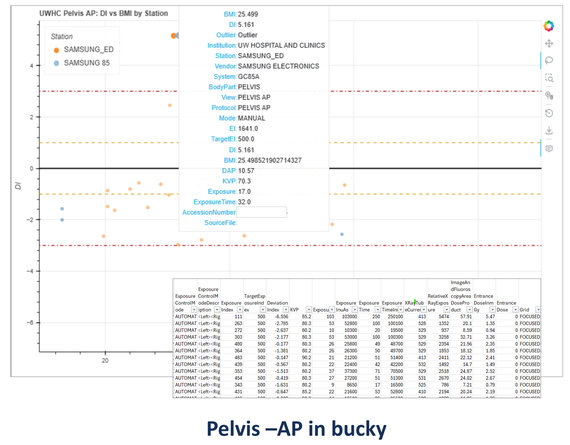


Figure 3 : User interface for customizable data visualization

Data Visualization and Interactive Data Lens



Pelvis –AP in bucky

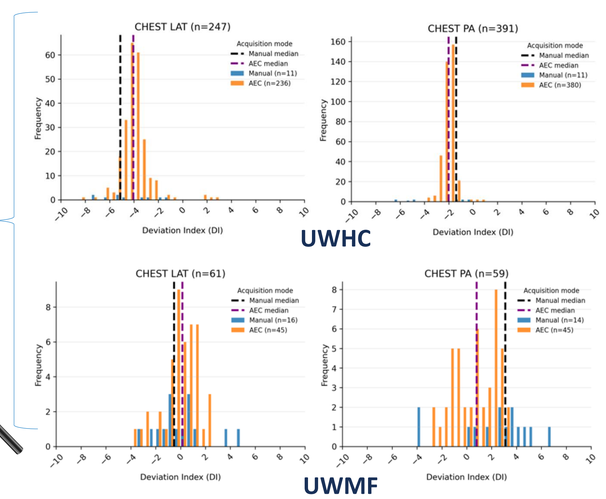
Figure 4: Data visualization showing DI vs BMI for two DR systems. Plot inset shows "data lens" for a data point. Lower image inset shows the csv display for the same data set

Use for Protocol Standardization and Optimization

Identifying deviations from target from one month of practice-sampled data

Automatic Exposure Control (AEC) vs Manual – Lateral Chest

Sample Data from May 2026



UWHC

UWMF

Figure 5: Shows DI histograms for chest (bucky) images acquired on a single vendor platform for two different practice segments (UWHC and UWMF)

Acquisition Mode Utilization and DI Variability by Site

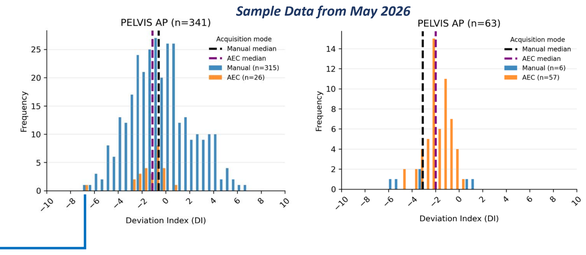
Exam	Site	MANUAL (n, %)	AEC (n, %)	DI METRICS			
		Manual n (%)	AEC n (%)	Manual Median DI	AEC Median DI	Manual SD DI	AEC SD DI
Chest LAT	UWHC	11 / 247 — 4.5%	236 / 247 — 95.5%	—	-4.2	—	1.35
Chest PA	UWHC	11 / 391 — 2.8%	380 / 391 — 97.2%	—	-2	—	0.7

Notes: Median DI and SD DI are omitted for subgroups with n < 25.

Table 1: Shows Key Performance Indicators for the UWHC data in Figure 5.

AEC vs Manual – Pelvis AP

Sample Data from May 2026



UWHC UWMF

Figure 6: Shows DI histograms for Pelvis AP images for two different practice segments (UWHC and UWMF)

Acquisition Mode Utilization and DI Variability by Site

Exam	Site	MANUAL (n, %)	AEC (n, %)	DI METRICS			
		Manual n (%)	AEC n (%)	Manual Median DI	AEC Median DI	Manual SD DI	AEC SD DI
Pelvis AP	UWHC	315 / 341 — 92.4%	26 / 341 — 7.6%	-0.5	-0.9	2.62	1.6
Pelvis AP	UWMF	6 / 63 — 9.5%	57 / 63 — 90.5%	—	-2.1	—	1.3

Notes: Median DI and SD DI are omitted for subgroups with n < 25.

Table 2: Shows Key Performance Indicators for the Pelvis AP data in Figure 6.

DeviationIndex	GridFocalDistance	DistanceSourceToDetector
-6.556	1100	1429

Table 3: Looking at the DI outlier from the UWHC AEC data in Figure 6 we saw from the image and the data that this was a pelvis inlet view for a very large patient. Even with AEC, it would be best to optimize this view separately from Pelvis AP.

Results

- Both practice segments (UWHC and UWMF) did well to utilize automatic exposure control (AEC) for chest images, allowing for evaluation of AEC exposure consistency and target achievement.
- A more detailed look at chest lateral data revealed protocol differences that need to be addressed, including variation in added filtration and exposure index targets.
- AEC was used less frequently for pelvis imaging at UWHC, with manual techniques showing a wider spread in exposures (DI). Variation in AEC utilization for pelvis between practice segments identifies opportunities for protocol review, and targeted support for technologists.
- Differences in protocols and Target EI values may affect technologists' ability to consistently achieve exposure targets when using AEC.

Conclusions

Variability in radiographic image quality is driven by the use of multiple vendors and inconsistent protocol standardization, often within the same practice. Effective quality improvement and protocol optimization require access to aggregated clinical imaging data.

We developed an interactive tool for mining and visualizing DICOM metadata within user-defined examination cohorts. Standard data visualizations can help highlight deviations from protocol targets. Extracted key-performance indicators can support practice interventions for quality improvement.

It's essential that the tool supports deeper investigation tied to individual images and image data as well as export of DICOM metadata for comparison cohorts. This data lens and export feature enables data quality assurance and identification of factors contributing to departures from imaging targets, thereby facilitating opportunities for protocol optimization and continuous quality improvement.

Our initial use of this tool on a small sample of practice data provided impactful insights for improvement.

References

[1] Long Z et al. *Four-year experience with utilization of DICOM metadata analytics in clinical digital radiography practice.* Medical Physics**.**

[2] Dave JK et al. *Current state of practice regarding digital radiography exposure indicators and deviation indices: Report of AAPM Imaging Physics Committee Task Group 232.* Medical Physics.

[3] American College of Radiology (ACR), American Association of Physicists in Medicine (AAPM), Society for Imaging Informatics in Medicine (SIIM), Society for Pediatric Radiology (SPR). *ACR–AAPM–SIIM–SPR Practice Parameter for Digital Radiography.* Revised periodically.