Institutional CT Dose Reduction: A Retrospective Evaluation of Dose Indices from 2015-2024

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ABSTRACT

Purpose: Growing attention to radiation risks and dose reduction in CT imaging presents opportunities to discuss institutional dose trends and contributing factors. The objective of this work is to analyze dose indices ($CTDI_{vol}$ and DLP) from a multi-site and multi-scanner institution over a 10-year period.

Methods: Data from a radiation dose index management system (Radimetrics, Bayer) were used to analyze diagnostic CT examinations from January 2015 to December 2024, stratified by procedure. For the ten most utilized procedures, Pearson correlation was calculated between time (defined as months since January 2015) and monthly median dose indices. Procedures with significant decreases in either dose index were further stratified by scanner model, and the model-specific monthly median dose index was calculated. To investigate the relationship between dose reductions and image quality, annual ACR phantom images were retrieved for scanners in 2015 and 2024, and low contrast detectability was evaluated.

Results: Over the 10-year period, 695,575 diagnostic CT examinations of 235,233 patients were performed on 18 unique scanners (nine models) from three manufacturers. Pearson correlations showed decreases in one or both dose indices for several high-usage procedures, including chest and abdomen/pelvis exams. Model-specific analyses suggest that acquisition of new scanners, technique changes, and reductions in multiphase imaging were temporally associated with the observed decreases in dose indices. Additionally, the detectability index of low contrast ACR phantom objects did not decrease between 2015 and 2024 despite lower $CTDI_{vol}$.

Conclusions: A retrospective review of CT exams demonstrated decreasing $CTDI_{vol}$ and DLP across frequently performed procedures, coinciding with scanner replacements and upgrades, the reduction in multiphase protocol usage, and protocol optimization efforts such as technique changes and target dose reduction.

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INTRODUCTION

- For many medical imaging applications, CT is the reference standard despite presume risks of ionizing radiation exposure
- Theoretical analyses of cancer risk from imaging has led to increased interest in dose reduction
- The current era of CT features many technical improvements contributing to dose reduction:[1]
  - Tube current and potential optimization
  - Beam shaping and collimation
  - Advanced iterative reconstruction techniques
  - Detector improvements (e.g., photon-counting)
- NCRP reports[2] showed increased effective dose from 1980-2006, but a decrease from 2006-2016
- National dose trends have not yet been updated since, and few studies have examined dose patterns at the institutional level
- To address this gap, we present monthly $CTDI_{vol}$ and DLP values for our institution's highest-volume diagnostic CT procedures from January 2015 to December 2024 and identify causes for change

METHODS AND MATERIALS

Data Collection

- Data were obtained from Radimetrics (Bayer Healthcare), an automated radiation dose index monitoring system
- All exams were performed in a system consisting of an academic medical center, a community hospital, and multiple outpatient clinics, all supervised by the same physicist (MPS)
  - "Exam" is defined as a collection of one or more CT acquisitions in one session with a unique accession number

Data Grouping

- Equipment labels and procedure names were used to distinguish diagnostic exams from interventional and PET-CT exams
- Procedure names were harmonized using a constructed library and manual review process to account for naming variations
- The ten most-utilized procedures were selected for further analyses

Statistical Analyses

- Pearson correlation was used to evaluate trends in monthly median $CTDI_{vol}$ and DLP over 10 years
- Procedures with statistically significant negative correlations ($p < 0.05$) were stratified by scanner model and correlation analysis was repeated
- Pearson correlation was also performed for mean number of acquisitions per exam and time

ACR Image Quality

- Low contrast detectability was used as a measure of image quality to compare scanners from 2015 and 2024 using retrieved ACR phantom scans

Procedure	Count (%)	Procedure (cont.)	Count (%)
CT BRAIN WO	151,841 (22)	CT CHEST PE	35,396 (5)
CT ABD/PELV W	78,205 (11)	CT C-SPINE WO	28,858 (4)
CT CHEST WO	60,416 (9)	CT NECK W	25,091 (4)
CT ABD/PELV WO	49,194 (7)	CT CHEST W	19,366 (3)
CT CAP W	40,446 (6)	CTA HEAD W	17,835 (3)

Table 1 Summary of the 10 most frequently used diagnostic procedures from 2015-2024 with count and percentage of total exams (out of 695,575)

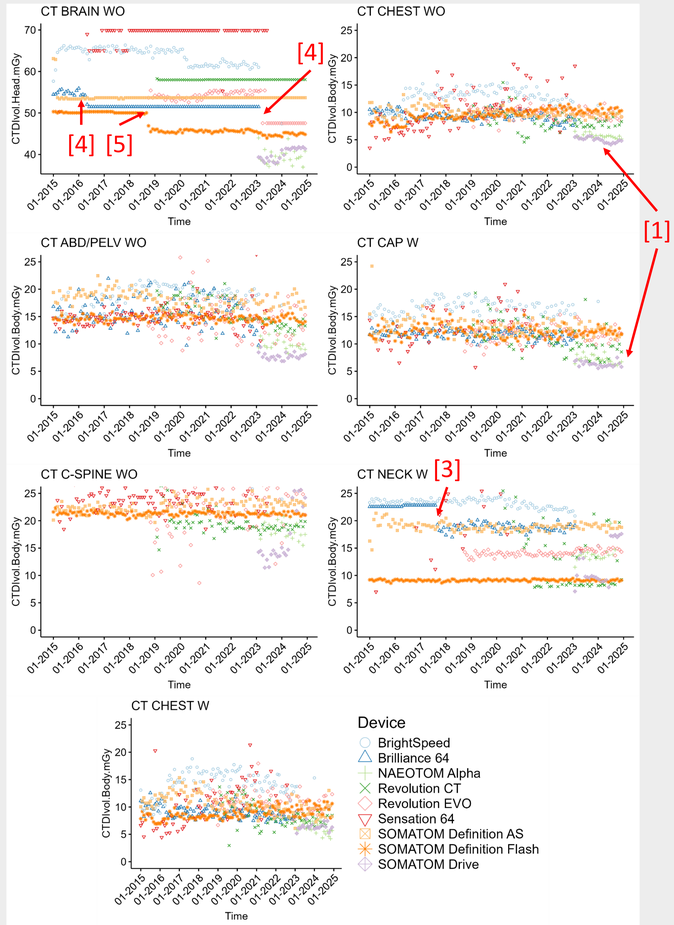

Figure 1 Scatter plots displaying the monthly median $CTDI_{vol}$ (mGy) per scanner model for the diagnostic procedures with significant overall decreases in $CTDI_{vol}$

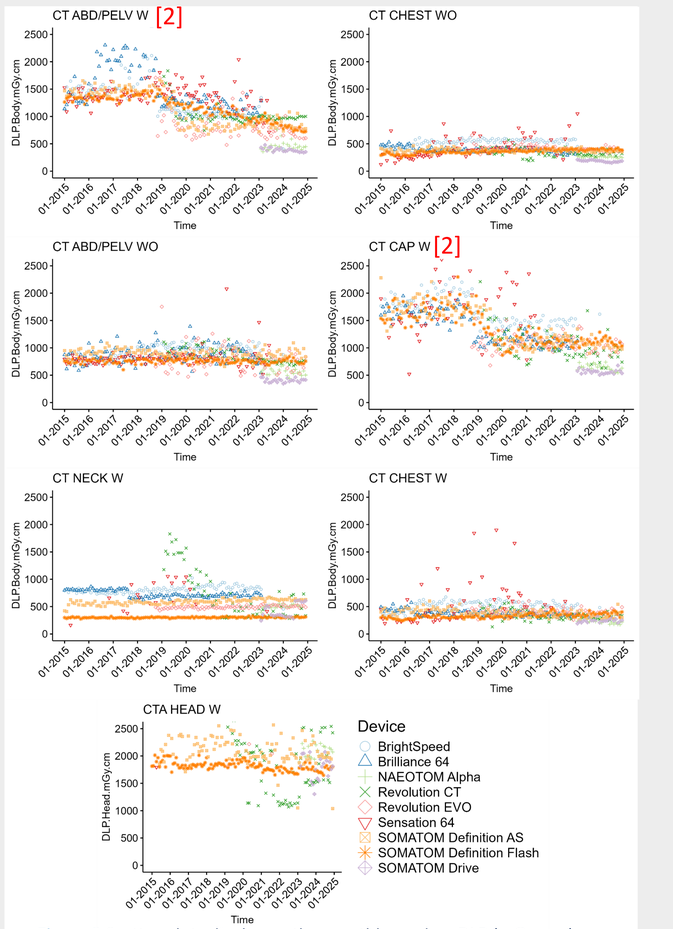

Figure 2 Scatter plots displaying the monthly median DLP (mGy×cm) per scanner model for the diagnostic procedures with significant overall decreases in DLP

REFERENCES

1. McCollough CH, Yu L. CT Radiation Dose Reduction With Preserved Diagnostic Performance: How Far Have We Come Over 25 Years? Am. J. Roentgenol. 2026
2. NCRP Reports No. 160 and No. 184

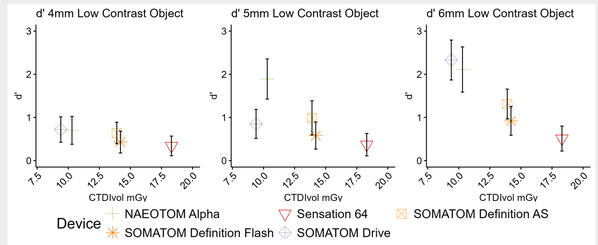

Figure 3 Detectability index (d') and $CTDI_{vol}$ for low contrast objects in the ACR phantom, scanned in 2015 (Definition AS, Flash, Sensation 64) and 2024 (Drive, Alpha). Scans were at 120 kVp with identical slice thickness/interval. Kernel is not matched.

RESULTS

- 695,575 CT exams of 235,233 patients from 18 unique scanners (9 models) were included
- Ten most utilized procedures shown in Table 1

Institutional Trends (Figures not shown)

- Significant decreases ($p < 0.05$) in monthly median $CTDI_{vol}$ and/or DLP were observed in all but one procedure (Chest for PE)
- Does indices decreased in 2023 and 2024 following introduction of new scanners
- No significant increases were observed for any procedure

Scanner Specific Trends (Figures 1 & 2)

- DLP decreases across all scanners were observed for A/P and C/A/P contrast exams
- Several stepwise reductions in $CTDI_{vol}$ for non-contrast brain exams

ACR Image Quality (Figure 3)

- Detectability index of low contrast objects (module 2) were higher for 2024 scanners (Alpha, Drive) compared to 2015 scanners (Flash, AS, 64) despite decrease in CTDIvol

DISCUSSION

Changes Attributed to Dose Reductions

1. Reductions in $CTDI_{vol}$ and DLP are observed for nearly all procedures following the acquisition of newer-model scanners in 2023 and 2024 (NAEOTOM Alpha and SOMATOM Drive) and removal of older models
2. Elimination of delayed phase acquisitions in abdomen and pelvic contrast exams led to observable DLP decreases

Stepwise reductions in $CTDI_{vol}$ are attributed to:

3. Enabling automatic exposure control for CT Neck w/ contrast on Brilliance 64 and BrightSpeed
4. Changing from axial to helical scanning with lower target doses for CT Brain w/o contrast on Brilliance 64 and Revolution EVO
5. Switching from single- to dual-energy for CT Brain w/o contrast on the Definition Flash

Analyses using size-specific dose estimate (SSDE) and effective dose are planned.

CONCLUSIONS

A retrospective review of 695,575 CT exams over a 10-year period (2015-2024) was conducted to evaluate $CTDI_{vol}$ and DLP trends over time. Both dose indices decreased across multiple high-utilization procedures and can be attributed to protocols on new scanners with advanced dose reduction capabilities, a decrease in multiphase and repeat imaging, and technique changes.