RADIATION DOSE MANAGEMENT IN PEDIATRIC HEAD CT AT A DEDICATED CHILDREN'S HOSPITAL AND REGIONAL GENERAL HOSPITALS

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BACKGROUND AND OBJECTIVE

- Computed tomography (CT) plays a large role in neurodiagnostics, with **non-contrast head CTs being the most ordered pediatric CT** examination globally [1]; however, the application of CT imaging in pediatrics comes with increased responsibility because children are more vulnerable to the stochastic effects of radiation than adults [2]
- **Diagnostic reference levels (DRLs), represented as the 75th percentile** of a dosimetric dataset, were introduced by the International Commission on Radiation Protection (ICRP) as an operational tool for the optimization of radiographic examination doses [3–4]

METHODS AND MATERIALS

- Data were retrospectively collected from five scanners located in three provincial hospitals including a pediatric facility; the **patients were grouped by age as follows: <1, 1–5, 6–10, and 11–15 years old**; most exams were performed in 2020–2023 with some studies dating back to 2016 due to an insufficient number of pediatric cases
- Volume CT dose index ($CTDI_{vol}$) and dose-length product (DLP) were extracted from PACS; **provincial DRLs were suggested as the 75th percentile** of the dose indices distribution and modeled as a **continuous function of patients' AP thickness** using quantile regression for the 75th percentile

METHODS AND MATERIALS

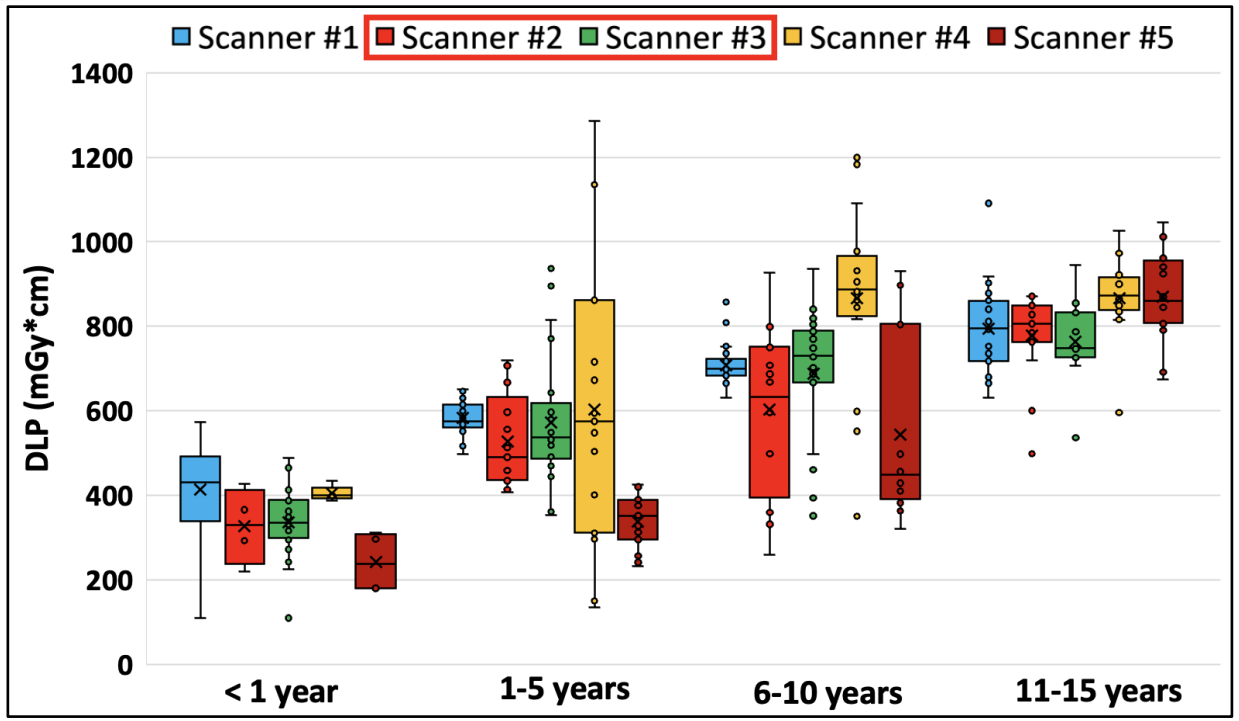
- To evaluate image quality, samples of **25 studies from each scanner** were randomized and blinded for review by a radiologist specialized in pediatric neuroimaging; **images were graded using a 4-point scale in 7 categories**
- Differences in radiation doses between scanners were assessed using the **Kruskal–Wallis test** with $p<0.05$ denoting statistical significance; factors potentially affecting image quality were evaluated using the **Pearson correlation coefficient**; differences in the image quality scores between scanners were assessed using **Pearson's chi-square test**

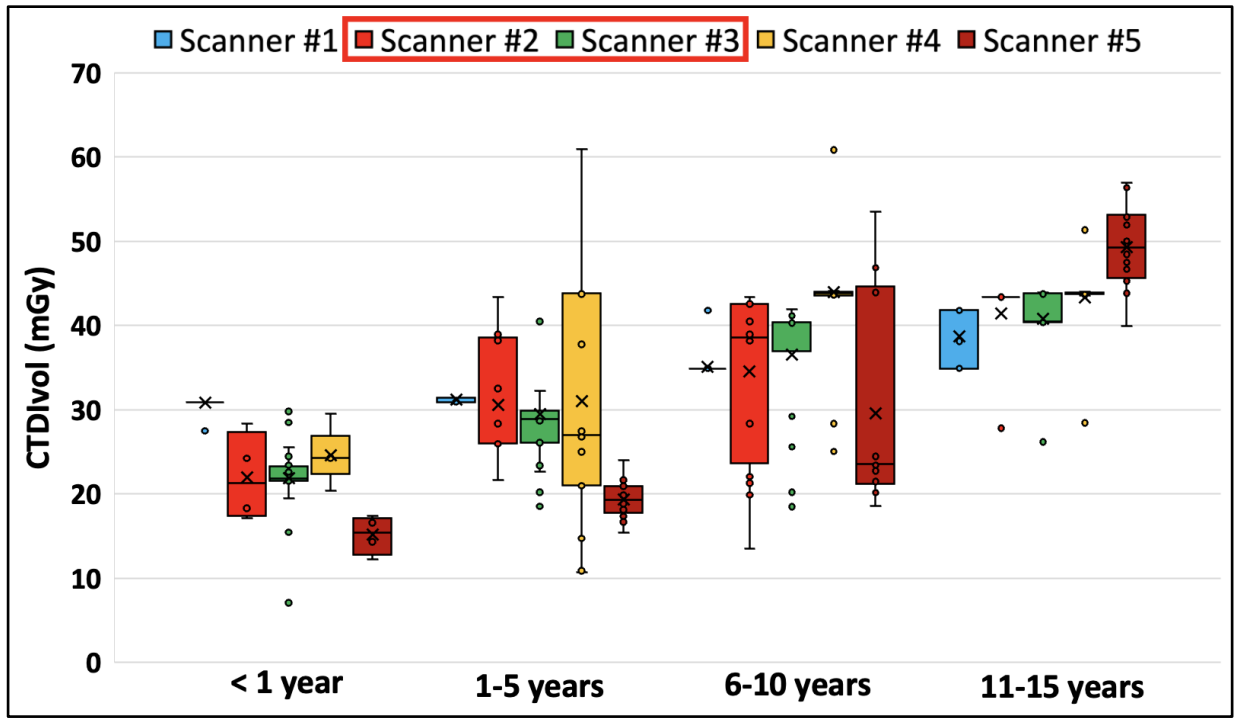
RESULTS: PATIENT SURVEY

- A total of 358 patients were surveyed, including 120 patients scanned at pediatric hospital #1
- The differences in doses between scanners were statistically significant ($p<0.05$) for all age groups
- The pairwise comparison demonstrated no statistically significant differences in doses for every age group between scanners #2 and #3 from the same hospital

Hospital	Scanner		Collected data	< 1 year	1 – 5 years	6 – 10 years	11 – 15 years
1 (pediatric)	#1	Canon Aquilion Prime (2014)	Median $CTDI_{vol}$(mGy) Median DLP (mGy·cm)	30.9 496.8	31.4 575.8	34.9 699.3	41.8 795.2
2	#2	GE LightSpeed VCT (2010)	Median $CTDI_{vol}$(mGy) Median DLP (mGy·cm)	21.3 329.1	26.0 489.9	38.6 632.3	43.36 805.8
	#3	GE Optima 660 (2012)	Median $CTDI_{vol}$(mGy) Median DLP (mGy·cm)	21.8 335.8	28.9 537.1	40.4 729.3	40.5 748.7
3	#4	GE Optima 660 (2013)	Median $CTDI_{vol}$(mGy) Median DLP (mGy·cm)	24.3 400.4	26.9 574.6	43.8 887.5	43.9 871.9
	#5	Siemens Somatom Definition Edge (2022)	Median $CTDI_{vol}$(mGy) Median DLP (mGy·cm)	15.4 238.1	19.3 352.0	23.5 448.2	49.2 859.8
Provincial DRLs			$CTDI_{vol}$(mGy)	24.3	28.9	40.4	43.9
			DLP (mGy·cm)	404.1	574.6	729.3	871.9

RESULTS: DOSIMETRY

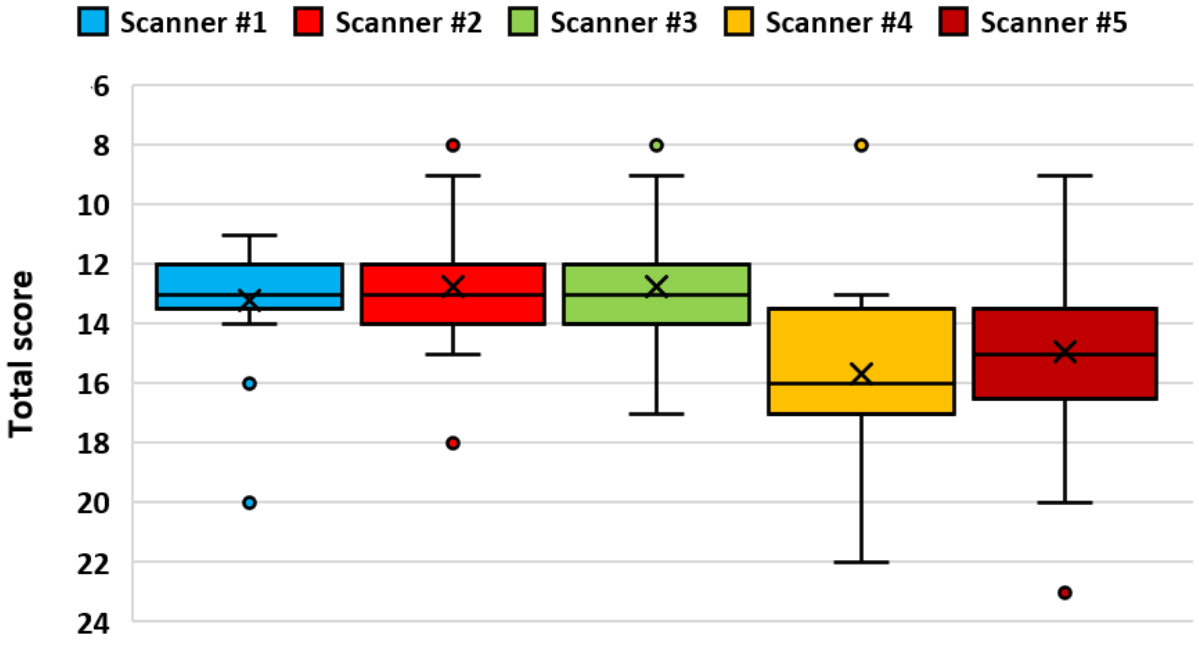




The figures show distributions of the DLP and $CTDI_{vol}$ values from each scanner in all age categories. **Scanner #1, located at the pediatric hospital, used fixed exposure parameters** for all pediatric CT head protocols, therefore all examinations in every age group resulted in the same $CTDI_{vol}$ value. The only differences were noted in the 11–15-year-old group because some patients of this age might be scanned with an adult protocol using a higher dose.

RESULTS: IMAGE QUALITY ASSESSMENT

Overall, 125 studies were evaluated by the pediatric neuroradiologist. Images were graded using **a 4-point scale: a score 1 indicated an excellent image, 2 – good, 3 – suboptimal but still diagnostic, 4 – unacceptable and non-diagnostic**.



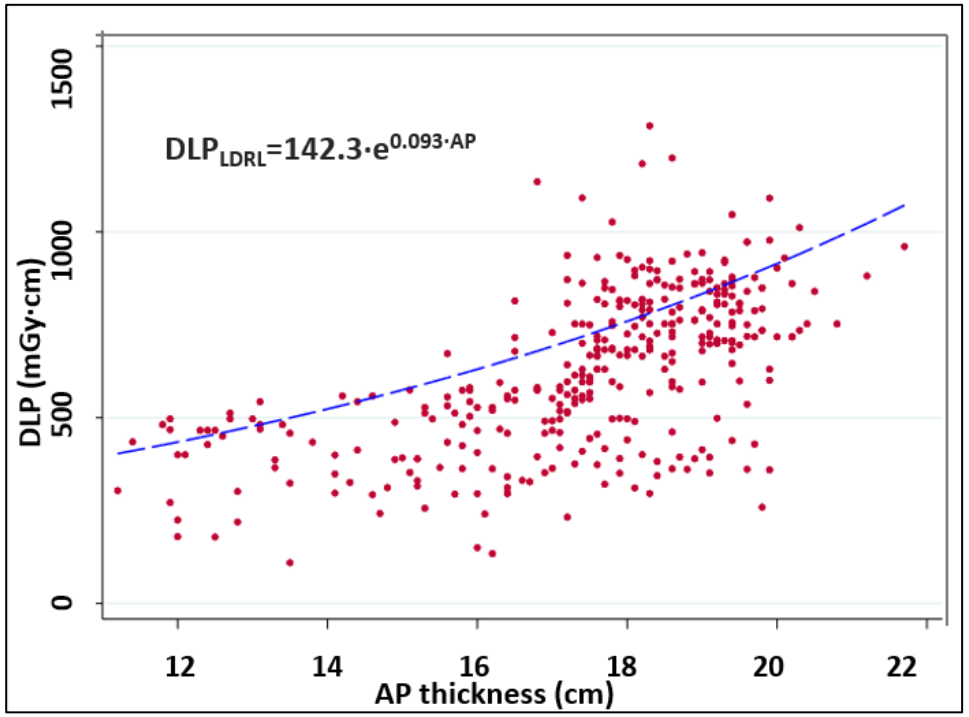
Scanner	#1	#2	#3	#4	#5
Total score	13.2±1.76	12.72±2.57	12.72±2.15	15.68±2.94	14.92±3.03

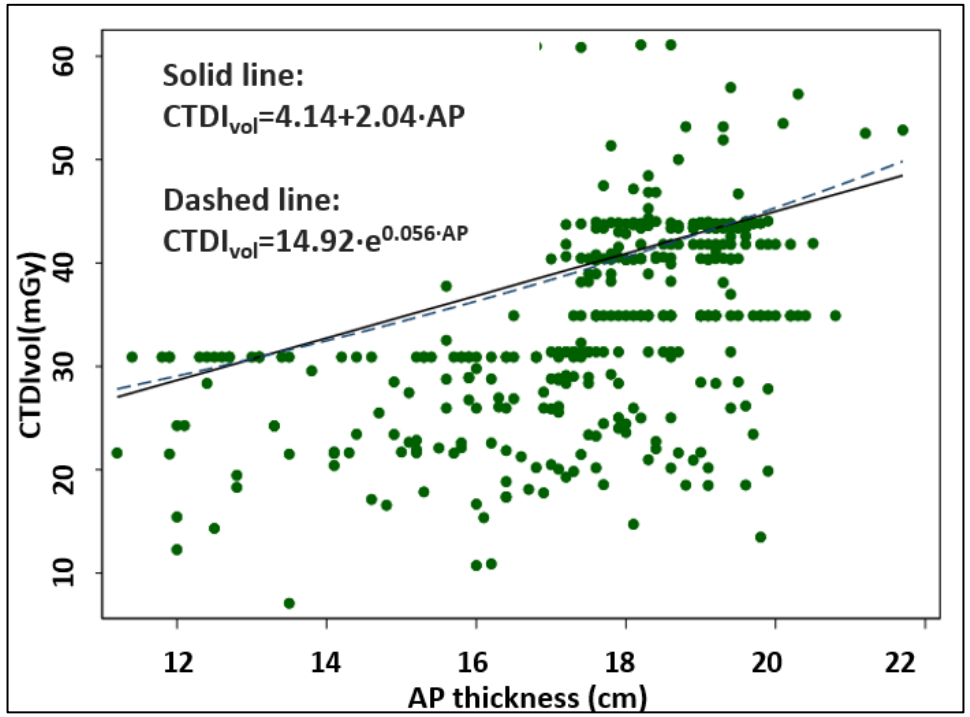
P-values from Pearson's chi-square test	All scanners	Scanners #1,#2,#3
Overall image quality	0.002	0.325
GM-WM sharp differentiation-Supratentorial	0.019	0.074
GM-WM sharp differentiation-Posterior fossa	0.202	0.575
Noise Reduction	0.000	0.324
Artifact Reduction	0.066	0.820
Sharpness of subarachnoid spaces	0.030	0.087
Bone	0.009	0.018
Total score	0.003	0.066

RESULTS: IMAGE QUALITY ASSESSMENT

- The total scores, as well as most individual scoring categories, **were significantly different (p-values <0.05) across scanners** when Pearson's chi-square test was performed for all five scanners
- There were no significant differences in total scores and all individual categories except bony detail when **only three scanners #1, #2, and #3** were compared
- **Pearson correlation coefficients demonstrated a weak correlation between radiation dose and the image quality total score across all scanners**
- Image quality was not correlated with patient age or AP thickness for all scanners, except #1; a total score from this scanner was strongly positively correlated with age and AP thickness (Pearson correlation coefficients were 0.46 and 0.55, respectively), as a result of fixed exposure parameters

RESULTS: DRL AS A CONTINUOUS FUNCTION





- To express local DRLs as continuous variables of patient age and AP thickness, we employed quantile regression analysis based on all 358 observations
- Patient age and AP thickness are highly correlated, the Pearson correlation coefficient is 0.78
- **An exponential function demonstrated the best fit for the 75th conditional quantile of DLP**
- For **the 75th quantile of $CTDI_{vol}$, a linear function of AP thickness** yields the predicted values similar to an exponential fit

DISCUSSION AND CONCLUSION

- Our study compared radiation dose and image quality from pediatric CT examinations performed at a dedicated pediatric facility and general practice hospitals located in the Canadian province of Nova Scotia
- **The differences in dose indices between scanners were statistically significant (p-values less than 0.05) for all age categories**
- Median $CTDI_{vol}$ and DLP values in the two **youngest patient groups of <1 and 1–5 years old were highest at the pediatric hospital,** indicating urgency for protocol optimization
- Provincial DRLs were determined as discrete values for each age category and as continuous functions of patient AP thickness
- **A weak correlation was found between radiation dose and image quality** scores across all scanners, suggesting potential for dose reduction without degrading image quality

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