DATA COLLECTION AND DOSE-INDEX METHODS

Study cohort and inclusion criteria

The source spreadsheet comprised 207 records. Thirteen non-target neck/chest/abdomen/pelvis examinations and one target-protocol record with conflicting label and acquisition characteristics were excluded, leaving 193 examinations for analysis. The count of 149 children contributing 194 target-protocol examinations was established using hospital identifiers before anonymisation. Patient identifiers and the linkage key are absent from the retained dataset, preventing confirmation of the unique-child count in the final 193 examinations or patient-clustered re-analysis. Examination dates were 15 March to 19 December 2019. Clinical and scanner-dose information was entered into Excel during 2019; individual dates of research-data abstraction were not recorded. Three pre-existing age-group labels were inconsistent with the numerical ages taken from hospital records; the analytical categories were corrected using those numerical ages. No scanner-recorded CTDIvol or DLP value was modified as part of these classification decisions.

Examination-level weighting and unlinked repeated scans

Before exclusion of the examination with uncertain protocol classification, 194 target-protocol examinations were attributed to 149 children using hospital identifiers. The final analytic file retained 193 examination records without a reliable identifier linking scans from the same child. P50 and P75 are therefore distributions of examination records, not child-weighted percentiles. A child scanned more than once could contribute more than one observation, with unknown influence on age- and protocol-specific percentiles. Non-parametric percentile bootstraps sampled examinations independently (50000 resamples per stratum). Within-child correlation could reduce effective independent information and make the reported 95% intervals too narrow; its magnitude and direction for each subgroup cannot be evaluated or corrected without patient linkage. No patient-level cumulative dose was estimated.

Data cleaning and quality-control procedures

The retrospective data-consistency assessment comprised: (1) 207 examination

records were screened, 13 neck/chest/abdomen/pelvis non-target records and one discordantly classified target record were excluded, leaving 193; (2) Ages were grouped from recorded numerical ages, correcting three discordant pre-existing age-category labels without changing the numerical age; (3) Scanner-reported CTDIvol and DLP were retained unchanged; (4) The uncertain protocol record was examined using alternative classifications in Supplementary Table 7; and (5) Scan-range plausibility was assessed by comparing the recorded field with 10 × DLP/CTDIvol in millimetres. Seven discrepancies exceeded 50 mm; none was corrected or removed from the primary analysis. Supplementary Table 10 lists these records and sensitivity checks. Original DICOM acquisition reports and a contemporaneous extraction log are unavailable. Independent re-abstraction, double-entry checking and comprehensive reconciliation with original scanner reports were not documented.

Protocol classification and acquisition variables

The protocol summaries below describe the variables retained in the study dataset. All four categories were identified from recorded protocol labels rather than from retrospectively inferred staging or follow-up indications. The underlying worksheets include broad contrast-use labels but not reliable phase-level metadata or a complete indication field. One DLP value was recorded per examination, but whether it represents an acquisition-specific or aggregated value in multiphase examinations could not be established.

Brain CT (*n* = 44): One record was labelled with intravenous contrast and 43 without contrast. Individual acquisition-phase counts and clinical indications are unavailable.

Chest CT (*n* = 33): All 33 records were labelled without contrast. Individual acquisition-phase counts and clinical indications are unavailable.

Abdomen CT without contrast (*n* = 65): All 65 records were labelled without contrast. Individual acquisition-phase counts and clinical indications are unavailable.

Chest/abdomen/pelvis CT (*n* = 51): 48 records were labelled with intravenous contrast and three without contrast. Exact phase structure, contrast timing and clinical indications are unavailable.

Dose-index measurement and reporting

CTDIvol was referenced to a 16-cm phantom for brain CT and a 32-cm phantom for body CT. Scanner-reported values were retained without phantom conversion. CARE Dose4D automatic tube-current modulation was active during the examinations. As a result, tube current could vary within acquisitions and examination-level entries are not evidence of fixed-current scanning. Scanner values came from post-acquisition dose reports rather than pre-scan estimates. Siemens' SOMATOM Emotion 6/16 Application Guide states that, under CARE Dose4D, the effective mAs shown after an examination reflects the mean actually applied across the scan range. Siemens' Emotion CT Examination Instructions describe an automatically generated post-acquisition dose report containing CTDIvol and DLP. The reported CTDIvol was interpreted as an acquisition-average value rather than a pre-acquisition maximum, consistent with the post-acquisition reporting described by Siemens. The software-specific averaging algorithm could not be independently verified because individual scanner dose-report objects were unavailable. Manufacturer documentation: https://www.meditegic.com/wp-content/uploads/pdfs/Siemens-SOMATOM.pdf (CARE Dose4D pp. 52, 56) and https://doclib.siemens-healthineers.com/rest/v1/view?document-id=262463 (dose report pp. 284–285; later software).

Exclusion of model-derived dose estimates with unavailable inputs

The analysis uses scanner-recorded CTDIvol and DLP measurements. The study documentation also contained secondary model-derived estimates, including SSDE, effective-dose and organ-dose outputs. The SSDE size-measurement method and conversion factors, together with the ImPACT scanner-matching, scan-region, reference-phantom, age-adjustment and tissue-weighting settings, were not recoverable from the retained study documentation. The available information is

therefore insufficient to validate or interpret the numerical SSDE, effective-dose or organ-dose values as paediatric results. Consequently, model-derived radiation-dose results were excluded, and the main and supplementary analyses were restricted to scanner-recorded CTDIvol and DLP. The analytical cohort contains 193 examinations.

Acquisition phase/clinical indication

Clinical information and post-acquisition dose indicators were abstracted from hospital records and scanner dose reports into Excel. Entries were checked for completeness and unusual values, with source records consulted where necessary; no independent second-person verification was documented. Recorded protocol names and anatomical coverage informed classification. The clinical worksheet contained a binary contrast label (with/without contrast); positive labels denoted intravenous contrast. For the 193 analysed examinations, the source entries were: brain CT 1 with contrast/43 without; chest CT 0/33; abdomen CT without contrast 0/65; and chest/abdomen/pelvis CT 48/3. These labels are not evidence of individual acquisition phase counts or the administration timing of contrast. The clinical examinations included single- and multiphase acquisitions, but phase counts could not be reconstructed by protocol category. Each clinical examination had one DLP entry in the retained worksheet; no additional acquisition phases from the same examination were separately entered or knowingly omitted. The original scanner dose-report objects were unavailable, so the exact reporting convention for a multiphase study (acquisition-specific versus scanner-aggregated DLP) cannot be independently established. The numerical DLP was retained as recorded without inferring summation of unknown phase contributions. No indication-level or diagnostic image-quality information was available.

Statistical precision

P50 is sample median. P75 uses Excel PERCENTILE.EXC/NumPy quantile(method="weibull"). Non-parametric P75 bootstrap percentile intervals used 50,000 resamples in each protocol-age group and seed 127030. Groups of $n < 4$ do not have reported quartiles; groups $n = 4$-9 are provisional. Patient-level dependence may

narrow nominal confidence limits; patient-level cluster bootstrap is not possible without identifiers.

Assessment of exploratory multivariable models

Exploratory multivariable models were not retained for interpretation because the available diagnostics indicated multicollinearity, heteroscedasticity, extreme non-normal residuals, model misspecification and influential observations. The principal local diagnostic reference levels do not depend on those regressions. Protocol correlations retained in S6 are descriptive and not multiplicity-adjusted.

Scan-range consistency and sensitivity analysis

Seven included examination records had scan-range versus 10 × DLP/CTDIvol-derived-length differences greater than 50 mm, including three exceeding 100 mm. The recorded values were preserved. Unusual entries were compared with source reports where available, although it could not be established whether the seven discrepant records had been individually checked during data extraction. The exact physical definition of the reported scan-range field was not recoverable. Secondary ImPACT-derived dose estimates with missing input provenance remained excluded. Patient identifiers, acquisition-phase counts and scanner dose-aggregation details were unavailable, and no dose values were retrospectively adjusted.

Supplementary Table 1 Overall volumetric computed tomography dose index and dose-length product values by computed tomography examination type, irrespective of age group

Examination	n	CTDIvol min	CTDIvol P25	CTDIvol mean	CTDIvol median	CTDIvol P75	CTDIvol max	DLP min	DLP P25	DLP mean	DLP median	DLP P75	DLP max
Brain CT	4	19.1	21.6	22.5	22.4	23.6	26.0	2	35	37	383	41	4

	4	2	2	0	5	9	0	90	6.25	7.48	.0	0.25	49
Chest CT	33	1.98	2.21	2.67	2.52	3.05	4.72	30	40.50	56.03	52.0	71.50	115
Abdomen CT without contrast	65	2.75	4.31	5.17	4.74	6.02	9.28	32	64.50	87.97	79.0	112.00	181
Chest/abdomen/pelvis CT	51	2.10	4.08	5.16	4.61	6.26	10.02	29	150.00	223.96	187.0	297.00	519

CTDIvol values are in mGy and DLP values in mGy·cm. The 2019 CT scanner used a 16-cm CTDI reference phantom for head CT and a 32-cm phantom for body CT. P75 is the pooled within-protocol 75th percentile from scanner-recorded values, rather than an independently validated regional reference level.

Supplementary Table 2 Number and percentage of examinations exceeding the proposed age-specific local diagnostic reference levels

Examination	**Age group**	**n**	**CTDIvol P75 LDRL**	**n > CTDIvol LDRL**	**% > CTDIvol LDRL**	**DLP P75 LDRL**	**n > DLP LDRL**	**% > DLP LDRL**	**n > either LDRL**	**% > either LDRL**
Brain CT	0–5 years	16	23.46	4	25.0	379.5	4	25.0	5	31.3
	6–10 years	23	23.73	5	21.7	411.0	5	21.7	8	34.8
	>10	5	23.70[1]	1	20.0	418.	0	0.0	1	20.0

	years					0[1]				
Chest CT	0–5 years	18	2.44	4	22.2	48.3	4	22.2	5	27.8
	6–10 years	12	3.15	3	25.0	76.3	3	25.0	6	50.0
	>10 years	3	NA	NA	NA	NA	NA	NA	NA	NA
Abdomen CT without contrast	0–5 years	31	4.68	7	22.6	72.0	6	19.4	11	35.5
	6–10 years	26	6.78	6	23.1	119.8	6	23.1	7	26.9
	>10 years	8	7.11[1]	2	25.0	142.0[1]	2	25.0	2	25.0
Chest/abdomen/pelvis CT	0–5 years	28	4.66	7	25.0	186.8	7	25.0	11	39.3
	6–10 years	18	7.50	4	22.2	352.8	4	22.2	5	27.8
	>10 years	5	8.62[1]	1	20.0	431.5[1]	1	20.0	2	40.0

rs

[1]Provisional local diagnostic reference levels (LDRLs) derived from subgroups containing four to nine examinations.

Exceedance was defined as a value greater than the age-specific P75 LDRL. NA indicates that no age-specific LDRL was proposed because the subgroup contained fewer than four examinations. LDRL: Local diagnostic reference level.

Supplementary Table 3 Scan-range indicators and association of dose-length product with scan range and volumetric computed tomography dose index

Protocol	***n***	**Median scan range, mm**	**P75 scan range, mm**	**Scan range, mm**	***Median DLP/CTDIvol, cm***	***r DLP vs scan range***	***P***	**r DLP *vs* CTDIvol**	***P***
Brain CT	44	167.5	172.8	132–191	16.8	0.68	< 0.001	0.63	< 0.001
Chest CT	33	201.0	230.0	125–261	20.9	0.70	< 0.001	0.91	< 0.001
Abdomen CT without contrast	65	170.0	190.5	64–405	16.7	0.65	< 0.001	0.82	< 0.001
Chest/abdomen/pelvis CT	51	430.0	522.0	142–660	41.2	0.73	< 0.001	0.79	< 0.001

DLP/CTDIvol approximates irradiated scan length in cm. Correlations are Pearson correlations. These findings identify scan range, particularly for chest/abdomen/pelvis CT, as a priority for clinically informed audit; they do not establish that anatomical coverage or radiation exposure was avoidable. The relationship of DLP to CTDIvol and scan length is partly mathematical and must not be interpreted causally. See the consistency assessment in Supplementary Table 10 for scan-length discrepancies.

Supplementary Table 4 Dose-size adaptation analysis using patient weight

Protocol	***n***	**CTDIvol *vs* DLP *vs* weight, ρ (*P*)**

		weight, ρ (*P*)	
Brain CT	44	0.21 (0.170)	0.54 (< 0.001)
Chest CT	33	0.69 (< 0.001)	0.76 (< 0.001)
Abdomen CT without contrast	65	0.68 (< 0.001)	0.85 (< 0.001)
Chest/abdomen/pelvis CT	51	0.69 (< 0.001)	0.82 (< 0.001)

ρ = Spearman rank correlation coefficient. All correlations in this table use patient weight and scanner-recorded CTDIvol or DLP; they are exploratory and do not identify causally independent influences on dose.

Supplementary Table 5 Dose variability and protocol optimisation indicators by computed tomography examination type

Protocol	***n***	**CTDIvol median**	**CTDIvol P75**	**CTDIvol CV, %**	**CTDIvol max/P75**	**DLP median**	**DLP P75**	**DLP CV, %**	**DLP max/P75**
Brain CT	44	22.45	23.69	7.3	1.10	383.0	410.3	9.7	1.09
Chest CT	33	2.52	3.05	23.1	1.55	52.0	71.5	33.7	1.61
Abdomen CT without contrast	65	4.74	6.02	25.1	1.54	79.0	112.0	36.0	1.62
Chest/abdomen/pelvis CT	51	4.61	6.26	33.2	1.60	187.0	297.0	49.6	1.75

Higher coefficient of variation and higher max/P75 ratios suggest greater protocol variability and greater potential for optimisation review. Chest/abdomen/pelvis CT showed the greatest DLP variability. CV: Coefficient of variation.

Supplementary Table 6 Pearson correlations between scan parameters and dose outcomes

Examination	Outcome	Tube current r (*P*)	Tube voltage r (*P*)	Pitch r (*P*)	Scan range r (*P*)	Age r (*P*)
Brain CT	CTDIvol	0.591 (< 0.001)	NC	NC	-0.057 (0.715)	0.197 (0.201)
	DLP	0.272 (0.074)	NC	NC	0.679 (< 0.001)	0.589 (< 0.001)
Chest CT	CTDIvol	0.342 (0.051)	-0.181 (0.314)	NC	0.446 (0.009)	0.572 (< 0.001)
	DLP	0.372 (0.033)	-0.133 (0.460)	NC	0.704 (< 0.001)	0.720 (< 0.001)
Abdomen CT without contrast	CTDIvol	0.959 (< 0.001)	-0.159 (0.207)	0.184 (0.143)	0.148 (0.240)	0.667 (< 0.001)
	DLP	0.729 (< 0.001)	0.147 (0.243)	0.099 (0.432)	0.648 (< 0.001)	0.842 (< 0.001)
Chest/abdomen/pelvis CT	CTDIvol	0.967 (< 0.001)	-0.050 (0.728)	0.141 (0.324)	0.482 (< 0.001)	0.734 (< 0.001)
	DLP	0.811 (< 0.001)	0.108 (0.449)	0.003 (0.986)	0.731 (< 0.001)	0.826 (< 0.001)

NC: Not calculated because at least one variable was constant within that examination group. Correlations are exploratory and should not be interpreted causally. Multiple exploratory correlations were reported without multiplicity adjustment.

Supplementary Table 7 Sensitivity analysis for the examination with uncertain

protocol classification

Scenario	Analysis *n*	Affected examinations	n in Category	CTDIvol P75, mGy	DLP P75, mGy·cm	Interpretation
Primary analysis: examination excluded	193	Brain CT, 6–10 years	23	23.73	411.0	Conservative primary approach
	193	Chest CT, 6–10 years	12	3.15	76.3	Conservative primary approach
Sensitivity A: examination retained as chest CT	194	Brain CT, 6–10 years	23	23.73	411.0	Brain CT unchanged
	194	Chest CT, 6–10 years	13	3.18	77.5	P75 changed only slightly
Sensitivity B: examination recoded as brain CT	194	Brain CT, 6–10 years	24	24.01	416.3	Brain CT P75 changed only slightly
	194	Chest CT, 6–10 years	12	3.15	76.3	Chest CT returned to the primary value

This sensitivity analysis examined the impact of one examination with uncertain protocol classification. The main LDRL estimates were not materially changed by alternative handling of this record.

Supplementary Table 8 Volumetric computed tomography dose index median, 75th percentile and 95% examination-level bootstrap interval (mGy)

Protocol	Age	*n*	P50	P75 (95%CI)	Status

Brain	0-5	16	21.87	23.46 (21.99-25.36)	principal
	6-10	23	23.21	23.73 (23.22-24.10)	principal
	> 10-15	5	23.11	23.70 (22.24-23.91)	provisional
Chest	0-5	18	2.25	2.44 (2.27-2.63)	principal
	6-10	12	3.00	3.15 (3.00-3.69)	principal
	> 10-15	3	3.21	Not reported	P75 withheld
Abdomen without contrast	0-5	31	4.40	4.68 (4.60-5.00)	principal
	6-10	26	5.63	6.78 (5.92-7.71)	principal
	> 10-15	8	6.37	7.11 (6.24-7.40)	provisional
Chest/abdomen/pelvis	0-5	28	4.32	4.66 (4.40-4.94)	principal
	6-10	18	6.19	7.50 (6.29-8.53)	principal
	> 10-15	5	6.80	8.62 (6.80-10.02)	provisional

Supplementary Table 9 Dose-length product median, 75% and 95% examination-level bootstrap interval (mGy·cm)

Protocol	**Age**	***n***	**P50**	**P75**	**Status**

				(95%CI)	
Brain	0-5	16	340.5	379.5 (341.0-418.0)	principal
	6-10	23	386.0	411.0 (389.0-421.0)	principal
	>10-15	5	405.0	418.0 (404.0-418.0)	provisional
Chest	0-5	18	41.5	48.3 (42.0-62.0)	principal
	6-10	12	69.5	76.3 (69.8-80.2)	principal
	>10-15	3	72.0	Not reported	P75 withheld
Abdomen without contrast	0-5	31	65.0	72.0 (67.0-80.0)	principal
	6-10	26	98.0	119.8 (102.8-142.2)	principal
	>10-15	8	117.5	142.0 (117.0-181.0)	provisional
Chest/abdomen/pelvis	0-5	28	159.5	186.8 (165.8-191.2)	principal
	6-10	18	293.5	352.8 (302.0-487.0)	principal
	>10-15	5	344.0	431.5	provisional

			(331.0-477.0)		

Bootstrap method: 50000 within-protocol-age resamples of the observed examination records. Each P75 was estimated using the exclusive/Weibull percentile definition (Excel PERCENTILE.EXC). Intervals are the 2.5% and 97.5% of resampled P75 values. Resampling assumes independent examinations, which could be violated by repeat scans of the same child; no patient identifiers were provided. Values from n = 4-9 are provisional and confidence limits in such groups should be interpreted very cautiously.

Supplementary Table 10 Examination-record consistency and sensitivity assessment

Record number	**Protocol**	**Recorded scan range (mm)**	**10×DLP/CTDIvol (mm)**	**Difference (mm)**	**Disposition**
5	Chest/abdomen/pelvis	575.0	169.7	+405.3	Included; acquisition-specific report unavailable
7	Chest/abdomen/pelvis	570.0	411.4	+158.6	Included; acquisition-specific report unavailable
32	Chest	197.0	250.0	-53.0	Included; acquisition-specific

					report unavailable
60	Chest/abdomen/pelvis	566.0	654.4	-88.4	Included; acquisition-specific report unavailable
67	Chest	183.0	246.0	-63.0	Included; acquisition-specific report unavailable
111	Chest/abdomen/pelvis	215.0	376.7	-161.7	Included; acquisition-specific report unavailable
147	Abdomen without contrast	64.0	148.5	-84.5	Included; acquisition-specific report unavailable

The quotient 10×DLP/CTDIvol was used as a plausibility check, not a correction formula. DLP may reflect irradiation length, over-ranging and/or acquisition structure differently from the recorded scan-range field. Among chest/abdomen/pelvis examinations, the Pearson correlation of DLP with recorded

scan range was $r = 0.731$ for all 51 records and $r = 0.780$ after excluding only the three records differing by more than 100 mm (three examination records). These exclusions are not adopted for the primary results. Within the provisional > 10-year chest/abdomen/pelvis subgroup, removing one outlying record alone changed the CTDIvol P75 from 8.625 mGy to 7.123 mGy ($n = 4$). These post hoc scenarios do not justify reclassifying or deleting examination records. The primary analysis retained the original scanner-reported values for all 193 examinations.