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Preliminary Age-Stratified Effective Dose for Pediatric Chest Radiography Using the American College of Radiology Dose Index Registry Data

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ABSTRACT

Purpose: Diagnostic medical physicists are often tasked with estimating effective dose (ED) for patient imaging procedures. As chest radiography is frequently performed in children, it is useful to know the general magnitudes of ED for various pediatric ages. The purpose of this study was to conduct a preliminary evaluation of ED magnitudes for common anatomical views of the chest for six age groups using dose index statistics from American College of Radiology Dose Index Registry (ACR-DIR).

Materials and Methods: From the ACR-DIR participant portal, median kerma-area product (KAP) values for the 2023–2025 period were exported for six age groups (0-1yr, 1-5yr, 5-10yr, 10-15yr, 15-18yr, adult) and three chest views: anteroposterior (AP), posteroanterior (PA) and lateral (LAT). Age-stratified KAP-to-ED conversion coefficients were obtained from Publications NRPB-R279 and NRPB-R262 for pediatric and adult patients, respectively. To apply these coefficients, typical tube potential (kVp) and total filtration were needed for each age group and view. Because national kVp statistics are not yet available, typical values at our institution for a representative radiographic system were used. Measured half-value layers were used to derive the appropriate total filtration used in the calculations.

Results: For adult patients, ED was estimated to be 0.045, 0.023, and 0.073 mSv for AP, PA, and lateral views, respectively, with the latter two values being consistent with previous literature. However, the highest ED values were found in teenage-age patients: 0.056 mSv (15-18 yr), 0.033 mSv (10-15 yr), and 0.073 mSv (10-15 yr) for AP, PA, and LAT views, respectively. Infants (0-1yr) were found to have higher ED than older children (1-5 yr and 5-10 yr).

Conclusions: Contrary to common knowledge, this preliminary analysis showed that a pediatric patient may receive a higher ED compared to an adult patient in chest radiography, suggesting the need for systematic technique optimization for the pediatric population.

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INTRODUCTION

Background
Effective dose (ED) estimation is a routine task for diagnostic medical physicists across various imaging modalities. Because chest radiography is frequently performed in children, establishing the general magnitudes of ED across different pediatric age groups is highly beneficial.

Purpose
To evaluate general magnitudes of effective dose for common pediatric chest radiographic views across six distinct age groups using dose index statistics from the ACR Dose Index Registry (ACR-DIR).

METHODS AND MATERIALS

National Statistics of Kerma-Area Product (KAP)

- ❑ Data Source: ACR-DIR Participant Portal
- ❑ Data Period: 2023–2025
- ❑ Dose Metric: registry median KAP
- ❑ Six Target Age Groups:
  - ✓ Infant (0-1 yr)
  - ✓ Toddler/Child (1-5 yr & 5-10 yr)
  - ✓ Adolescent (10-15 yr & 15-18 yr)
  - ✓ Adult Patient cohort
- ❑ Three Diagnostic Chest Views:
  - ✓ Anteroposterior (AP)
  - ✓ Posteroanterior (PA)
  - ✓ Lateral (LAT)

KAP-to-ED Conversion Coefficients

- ❑ Pediatric Reference:
  - ✓ Publication NRPB-R279
  - ✓ Geometric models of pediatric anatomy 0-18 yr
- ❑ Adult Reference:
  - ✓ Publication NRPB-R262
  - ✓ Geometric models of reference adult anatomy

Beam Quality Assumptions

- ❑ Required Inputs: Typical tube potential (kVp) & total filtration per age/view
- ❑ kVp Statistics:
  - ✓ National statistics not yet available
  - ✓ Substituted with typical values from a representative institutional DR system
- ❑ Filtration Determination:
  - ✓ Total filtration (mm Al) derived from measured half-value layer (HVL) at each kVp

Effective Dose Calculation

$$E = KAP * C$$

E (Effective Dose)→ Millisieverts (mSv)
KAP (Kerma-Area Product)→ Gy.cm^2
C (Conversion Coefficient) → mSv*Gy^{-1}*cm^{-2}

RESULTS

	Kerma-Area Product (mGy*cm^2)		
Age-Group	AP	PA	LAT
0-1 yr	19	N/A	26.6
1-5 yr	25.55	33.1	49.6
5-10 yr	33.4	49.9	78.9
10-15 yr	N/A	84	206.1
15-18 yr	154.3	89	280.4
Adult	161.25	110.1	447.4

Table 1: Registry median KAP values from ACR-DIR based on data submitted over a three-year period (2023-2025)

	Assumed kVp		
Age-Group	AP	PA	LAT
0-1 yr	60	60	60
1-5 yr	65	65	70
5-10 yr	80	80	85
10-15 yr	100	110	115
15-18 yr	100	120	125
Adult	100	120	125

Table 2: kVp assumed for each age group and anatomical view based on typical institutional techniques

kVp	MP report HVL (mmAl)	Inherent Filtration (mm Al)	Added filtration (mm Al)	Total filteration (mm Al)	Calculated HVL (mm Al)
60	2.56	1.6	2.05	3.65	2.56
65	2.77	1.6	2.09	3.69	2.77
70	2.97	1.6	2.09	3.69	2.97
80	3.39	1.6	2.12	3.72	3.39
85	3.62	1.6	2.17	3.77	3.62
100	4.25	1.6	2.2	3.8	4.25
110	4.65	1.6	2.18	3.78	4.65
115	4.83	1.6	2.16	3.76	4.84
120	5.01	1.6	2.12	3.72	5.01
125	5.2	1.6	2.2	3.8	5.26

Table 3: Measured HVL at each kVp

	Conversion-Coefficient (mSv*Gy^{-1}*cm^{-2})		
Age-Group	AP	PA	LAT
0-1 yr	2.141	1.431	1.541
1-5 yr	0.982	0.587	0.688
5-10 yr	0.679	0.474	0.468
10-15 yr	0.546	0.397	0.357
15-18 yr	0.362	0.253	0.223
Adult	0.278	0.212	0.163

Table 4: Conversion coefficients calculated by interpolating published data in NRPB-R279 and NRPB-R262 to match the total filtration and kVp in Tables 2 and 3.

	Effective Dose (mSv)			
Age-Group	AP	PA	LAT	PA+LAT
0-1	0.041	N/A	0.041	N/A
1-5	0.025	0.019	0.034	0.054
5-10	0.023	0.024	0.037	0.061
10-15	N/A	0.033	0.07348	0.107
15-18	0.056	0.022	0.063	0.085
Adult	0.045	0.023	0.0730	0.096

Table 5: Estimated effective dose for each age group and anatomical view

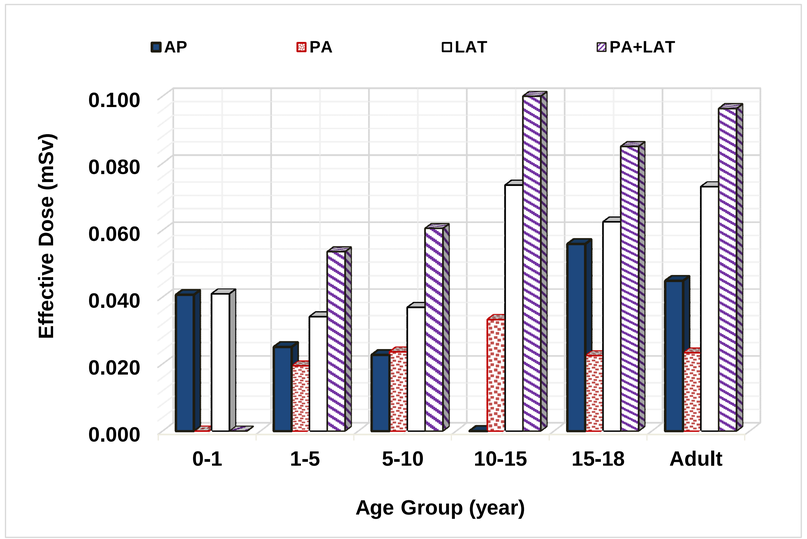

Figure : Effective dose estimated for six age groups and three chest anatomical views

DISCUSSION AND CONCLUSIONS

Contrary to common knowledge, this preliminary analysis shows that pediatric patients may receive higher effective dose than adults from common chest radiography examinations. The results suggest that clinical imaging techniques may not be properly scaled down or adapted to a child's smaller body size.

REFERENCES

1. Hart, D. et al. “Coefficients for estimating effective doses from pediatric x-ray examinations.” (1996).
2. Hart, D. et al. “Estimation of effective dose in diagnostic radiology from entrance surface dose and dose-area product measurements.” (1994).