Diagnostic Reference Levels for Paediatric Radiographic Procedures in Ireland

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Aims and objectives

There are two dedicated paediatric hospitals in the Republic of Ireland, Our Lady's Children's Hospital Crumlin (OLCHC) and Temple Street Children's University Hospital (TSCUH). In January 2019, TSCUH and OLCHC merged to become part of a new hospital group, Children's Health Ireland (CHI). CHI is committed to ensuring that paediatric healthcare services in Ireland continue to develop in line with international best practice standards.

Part of this standard of care is to ensure patients undergoing X-ray examinations receive radiation doses as low as reasonably achievable (ALARA), while ensuring adequate image quality is maintained. To aid in this, both hospitals are required to establish local diagnostic reference levels (DRLs). DRLs are defined in Irish Legislation (SI 478 of 2002 [1]) as dose levels which "*are expected not to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied*". These local DRLS can then be used as the benchmark for dose optimisation in paediatric radiology in Ireland. The recently published European RP 185 [2] document provides guidelines for establishing local and national paediatric DRLs. It also published European DRLs for comparison purposes. While Ireland contributed to this publication, the data used for radiographic exams was based on an audit published in 2004. To account for the technological improvements in imaging over the past 14 years, a new audit of patient doses is required.

OLCHC have established their local DRLs for general X-ray examinations using Digital Radiography (DR) systems. Recently, one of the main X-ray rooms in TSCUH was upgraded from a Computed Radiography (CR) system, to a Digital Radiography system. As a result, TSCUH began collating examination data for general radiography examinations to establish DRLs for those examinations. To achieve this, the radiology team at TSCUH, in conjunction with Medical Physics, have liaised with colleagues at OLCHC, on the appropriate exposure parameters and clinical set-ups using a DR system. A dose audit was carried out after the system was in use for a period of one month. This work presents the results of the TSCUH audit and compares the results with the DRLs established in OLCHC. Results are also compared with those published in RP 185 [2].

Methods and materials

Exposure factors and equipment technical parameters for all DR examinations, across both sites, closely followed the respective values that were recommended in the paper published by Knight *et al* [3] in conjunction with vendor recommendations.

Both sites carried out dose audits for a range of DR exams, which included chest, abdomen, pelvis and skull procedures. The age groups for each procedure were separated as followed, 0 - 4 weeks, 4 weeks - 1 year, 1 - 4 years, 4 - 10 years and 10 - 15 years.

Patient DAP values, given in $mGycm^2$, were collated for each procedure and age category. The 75^{th} percentile of each sample size was taken as the local DRL for the respective procedure and age category, as per recommended guidelines [2].

The resulting local DRLs were compared to aid both sites in the optimisation process.

Furthermore, the local DRLs for both sites were compared with the respective European DRLs established in RP 185 in order to verify if the DRLs for any the procedures need to be reduced in order to improve patient dose optimisation.

Results

Table 1 (a) and (b) display the DRLs for Chest & Pelvis X-ray exams respectively, for a range of different age groups. Both show that there is relatively good agreement, particularly at the older age groups 4 - < 10 years and 10 - < 15 years, between the respective values across both paediatric sites. The table also shows that the DAP values across both sites are significantly lower than the respective European DAP values outlined in RP 185. Figures 1 and 2 visually illustrate the values displayed in Table 1 for the Chest and Pelvis DRLs.

Table 1 (c) and Figure 3 provide a comparison between the DRLs for abdominal X-rays at the 4 - < 10 yrs age group, for both sites. There is good agreement across both paediatric sites and the respective DRLs are significantly lower than that given in RP 185. Due to the limited time frame of this study, patient numbers for TSCUH abdominal examinations are still small. A more comprehensive study will be performed at a later date

Table 2 provides the DRLs for the different spine and skull X-ray procedures over a range of age groups at OLCHC. TSCUH currently have insufficient numbers in these particular procedures in order to provide an adequate cross site comparison.

Follow up audits will be conducted at TSCUH for the different X-ray procedures in order to provide a more comprehensive cross site comparison and verify that the dose optimisation is appropriate across all paediatric sites.

Images for this section:

(a) Age Group	Chest DRL (mGy.cm²)		
	European[2]	OLCHC	TSCUH
1 m - < 1 Yrs	22	14	8.5
1 Yrs - < 4 Yrs	22	12	7.45
4 Yrs - < 10 Yrs	50	13	9.53
10 Yrs - < 15 Yrs	70	21	16.75

(b) Age Group	Pelvis DRL (mGy.cm²)		
	European[2]	OLCHC	TSCUH
1 m - < 1 Yrs	-	16	6.4
1 Yrs - < 4 Yrs	-	26	11.95
4 Yrs - < 10 Yrs	180	35	32.98
10 Yrs - < 15 Yrs	310	270	294.4

(c) Age Group	Abdomen DRL (mGy.cm²)		
	European[2]	OLCHC	TSCUH
4 Yrs - < 10 Yrs	250	66	55.5

Table 1: Comparison DRLs for (a) Chest, (b) Pelvis and (c) Abdomen X-rays

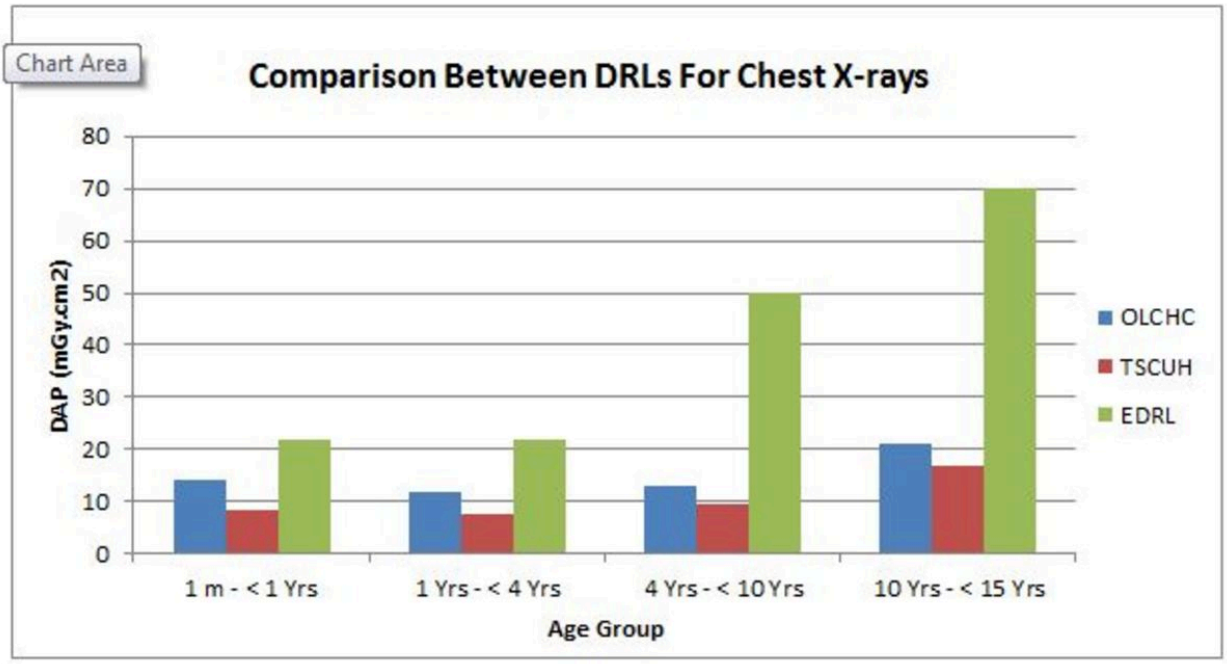

Fig. 1: Comparison between DRLs across Both Paediatric Sites and European DRLs for Chest X-rays

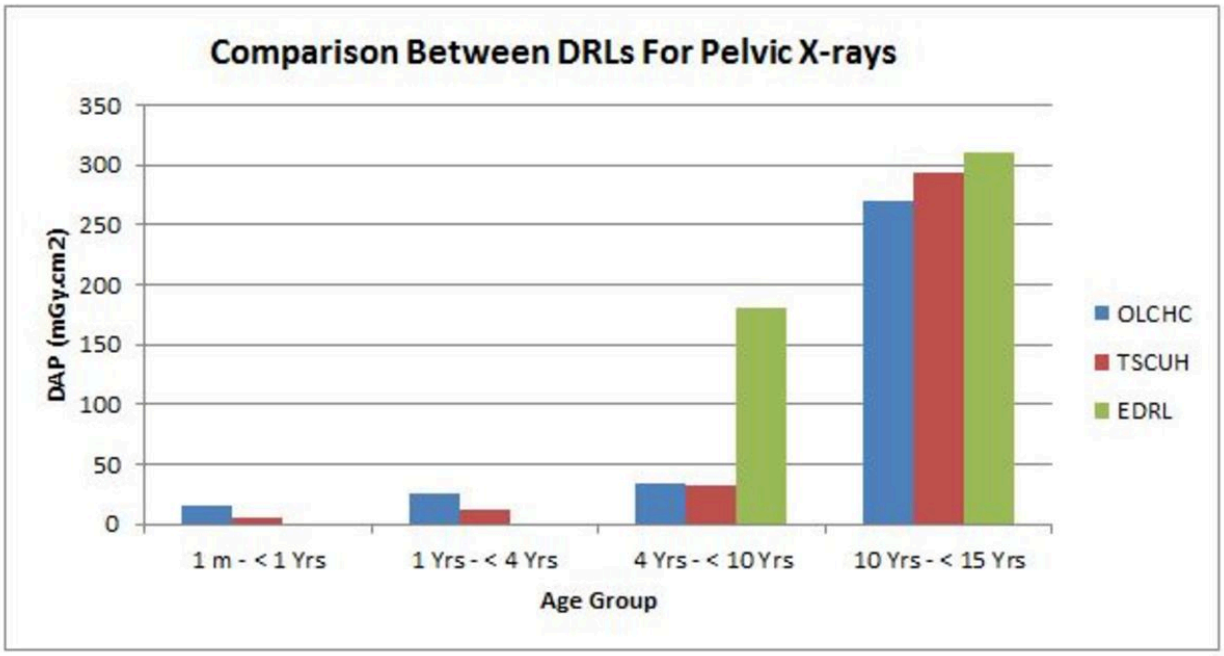

Fig. 2: Comparison between DRLs across Both Paediatric Sites and European Values for Pelvic X-rays

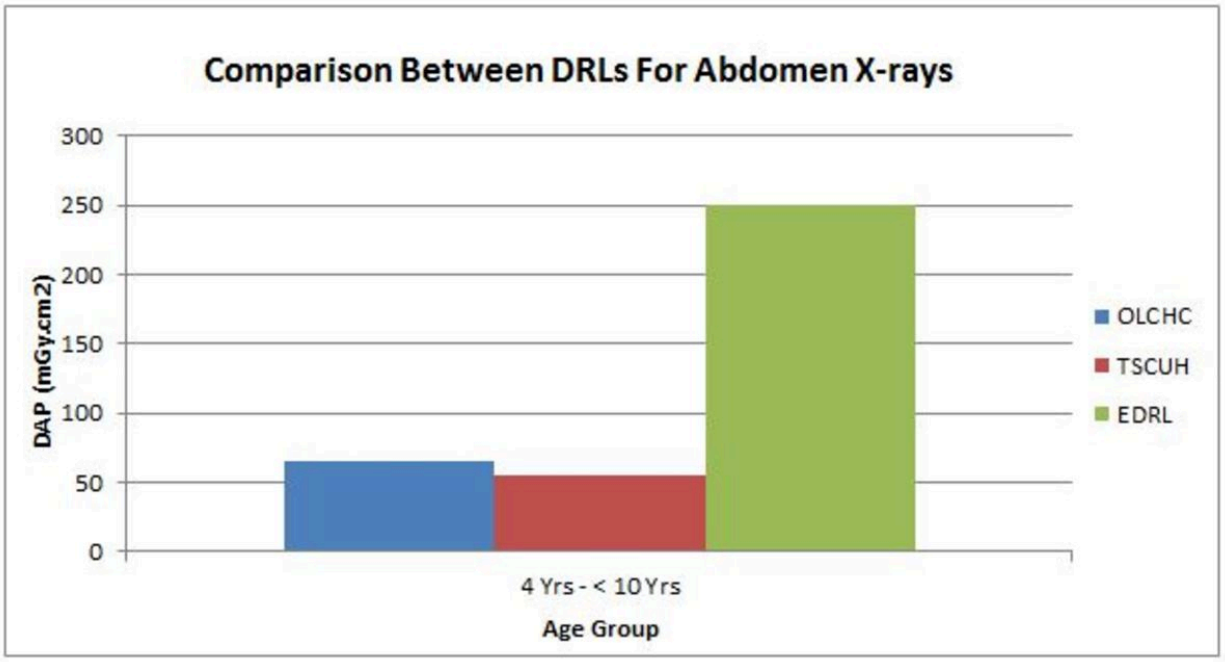

Fig. 3: Comparison between DRLs across Both Paediatric Sites and European Values for Abdominal X-rays

Exam	View	0 – < 1m	1 m - < 1yrs	1 - < 4yrs	4 - < 10yrs	10 - <15yrs	15 – 18yrs
L Spine	AP	-	16	19.8	48	162	452
	LAT	-	18	36.5	98.5	426	824
T Spine	AP	-	-	44.5	49.5	209.3	344.8
	LAT	-	-	33.5	81.8	352.5	488.5
C Spine	AP	7	23.8	11	16	33.3	48.5
	LAT	9	10.5	17.8	24	47.3	94.8
Skull	AP	55	63.5	74.5	104	214	184.5
	LAT	34.3	50	73.8	81	225	200.3

Table 2: DRLs (mGy.cm2) for Spine & Skull X-rays

Conclusion

Preliminary results suggest there is good agreement between the respective local DRLs across both paediatric hospitals. Further follow-up audits are required at TSCUH for the different X-ray procedures in order to provide a more comprehensive cross site comparison of dose optimisation. Once clinical and medical physics staff are satisfied that adequate dose optimisation has been achieved, the exposure factors will be applied across all future paediatric sites. This will ensure a high standard of care and dose optimisation for paediatric patients in Ireland.

Personal information

This work was a collaboration between Temple Street Children's University Hospital and Our Lady's Children's Hospital Crumlin, both part of the Children's Health Ireland Hospital Group.

Images for this section:

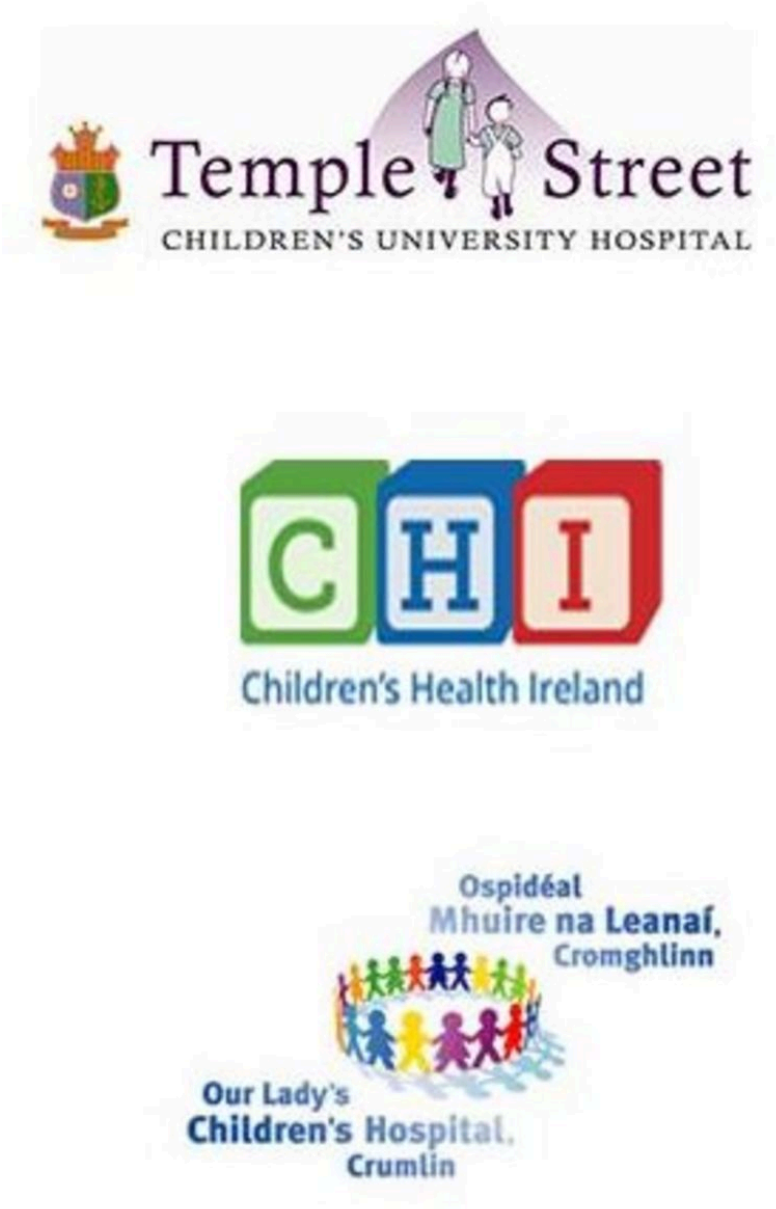

Fig. 4: This work was a collaboration between Temple Street Children's University Hospital and Our Lady's Children's Hospital Crumlin, both part of the Children's Health Ireland Hospital Group.

References

1. SI No. 478 of 2002. European Communities (Medical Ionising Radiation Protection) Regulations 2002.
2. RP 185, European Guidelines on Diagnostic Reference Levels for Paediatric Imaging, European Commission 2018
3. Journal of Medical Radiation Sciences, A Paediatric X-ray Exposure Chart, Knight et al, 2014