



Variations in CT Radiation Dose

- In 2011, the Joint Commission issued a Sentinel Event Alert to address factors that contribute to avoidable radiation dosing in medical procedures.
- In 2012, the American College of Radiology (ACR) initiated a Dose Index Registry (DIR) to create a database of radiation doses associated with CT examinations.
 - The DIR is a national database of radiation dose indices for various CT examinations at participating institutions.
 - The DIR provides quarterly reports showing data from a wide range of examinations.
 - Comparing radiation doses affords the opportunity for institutions to tailor their protocols and lower radiation exposure.

In the National Council on Radiation Protection and Measurements (NCRP) published the results of a comprehensive survey on radiation exposure from medical procedures and noted that the per capita exposure to radiation in 2006 had increased almost 6-fold since 1982, to 3 mSv. This level is approximately the same as the average American's annual exposure from background radiation. The survey found that CT scanning accounted for over half the per capita dose and revealed a 10-fold variation in radiation exposure from CT examinations.

Although no studies have conclusively demonstrated a risk of developing cancer from CT examinations, studies have extrapolated radiation risk data, which is derived from atomic bomb survivors and workers in the nuclear industry. These studies indicate that there is likely to be an extremely small but finite risk of developing cancer from a single CT examination, especially for children, although this risk is substantially smaller than the overall lifetime risk of developing cancer, which is one in three.

In 2011, in response to this concern, the Joint Commission issued a Sentinel Event Alert and the American College of Radiology (ACR) launched a national radiation dose data collection project, the Dose Index Registry (DIR). The goal of the Joint Commission is to address factors that can contribute to unnecessary radiation dosing through better education of health professionals on issues including potential risks, appropriate use of procedures and equipment, adequate training, and clear protocols. The Joint Commission has also issued several recommendations concerning the appropriateness of examinations, optimal dose and effective processes.

Radiation Dose Index Registry (DIR)

The DIR is a data registry that allows facilities to compare their CT dose indices to regional and national values. Information related to dose indices is collected, anonymized, and transmitted to the ACR, where it is stored in a database. As of February 2016, 1207 facilities have contributed data for 44.1 million CT scans to the DIR.

Participating facilities remove all patient identifying information and pseudo IDs are assigned before transmitting data to the DIR. In return, they receive periodic feedback in quarterly reports that compare their institutional results with those of other facilities for a wide range of body regions and examination types. The facilities can also assess their dose data at anytime on the ACR DIR website with secured password-protected access. From these reports, participating facilities can identify one or more exam type on which to base a practice quality improvement plan (PQI). Once that PQI has been implemented, a subsequent report can be used to assess the effectiveness of the plan.

As a subset to the DIR, the ACR has developed a Quality Improvement Registry for CT Scans in Children (QUIRCC). It involves a coalition of six children's hospitals and has the goal of developing a consensus on best practice for common pediatric CT examinations. The QUIRCC collects CT dose indices in relation to patient size, promotes practice transparency within the coalition, and has created a process of continuous improvement through the development of a quality team at each site. DIR participants receive a separate feedback report for pediatric patients that compares data from both pediatric and non-pediatric facilities.

Measuring CT Radiation Dose

The most widely used metrics for CT radiation dose are the volume CT dose index ($CTDI_{vol}$) and the dose length product (DLP). These indices describe the radiation dose emitted by the CT scanner based on measurements in acrylic cylinder phantoms. For safety reasons, the Food and Drug Administration mandates that all CT scanners display these metrics, which are automatically transmitted to radiology workstations. In general, the $CTDI_{vol}$ represents the average dose, in mGy, to the phantom in the central region of the scan. The DLP, in mGy.cm, is a surrogate of the total dose absorbed by the phantom over the entire scan. The $CTDI_{vol}$ and the DLP do not represent the actual dose absorbed by the patient. The American Association of Physicists in Medicine (AAPM) has proposed conversion factors that convert $CTDI_{vol}$ to patient size-specific dose estimates (SSDE).

DIR Reports

DIR reports include $CTDI_{vol}$, DLP, and SSDE data for specific CT examinations across the entire registry, as well as that for location, census division, and facility category. A sample page showing data for an abdominal CT with contrast in adult patients is shown in [Figure 1](#). Each facility receives an individualized report that shows the range and mean values of radiation exposure for each type of examination at their facility.

The most recent DIR report for Mass General indicates that radiation doses are below the national average for nearly all examinations, which reflect the considerable efforts to reduce radiation exposure in the past decade. These efforts are the result of investment in more dose efficient CT equipment as well as adjustment of radiation dose according to body region, clinical indication, and patient size with use of automatic exposure control, automatic tube potential selection, and/or iterative image reconstruction methods that can produce higher quality images at low radiation doses.

Interactive DIR reports are also available, which allow participants to drill down into the data. For example, "Dose Information by Exam" shows the $CTDI_{vol}$ values associated with every examination category performed at an institution over a specific period of time. Scatter plots can also plot the $CTDI_{vol}$ values for examinations over specific periods of time, which allows easy identification of any outliers as well as trends over time. Although all patient data are anonymized, the study date and time as well as the age and gender of the patient are recorded, together with the scanner type and study descriptions. These data can be used for technique assessment and protocol modifications for quality improvement purposes.

Scheduling

CT examinations are performed on the main Mass General campus, at Mass General West Imaging in Waltham, Mass General Imaging - Chelsea, and Mass General/North Shore Center for Outpatient Care. Appointments can be made through Epic (inside the Partners network) or [Physician Gateway](#) (outside the Partners network) or by calling 617-724-XRAY (9729).

Further Information

For further information on DIR, please contact [Bob Liu, PhD](#), Medical Physicist, or [Mannudeep K. Kalra, MD](#), Assistant Radiologist, Department of Radiology, Massachusetts General Hospital, at 617-643-4641.

We would like to thank Mannudeep Kalra, MD; Bob Liu, PhD; Sanjay Saini, MD, and James A. Brink, MD, for their advice and assistance in preparing this article.

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CT ABDOMEN PELVIS W IVCON, Age group Adult

Dose Index	Category	# Facilities	Mean	Min	25th %ile	Median	75th %ile	Max	Std Dev
CTDIvol per Scan	DIR	817	13	1	10	12	16	45	5
	Metropolitan	356	13	3	10	12	16	45	5
	New England	56	13	4	10	13	16	21	4
	Academic	90	12	4	10	11	14	27	4
SSDE per Scan	DIR	587	14	1	11	13	16	109	6
	Metropolitan	258	14	3	11	14	17	109	8
	New England	39	13	6	12	14	15	19	3
	Academic	72	13	6	11	13	15	25	4
DLP per Scan	DIR	817	631	17	470	603	765	1769	233
	Metropolitan	356	627	48	466	602	776	1769	236
	New England	56	624	194	482	643	776	948	171
	Academic	90	614	194	476	587	712	1407	206

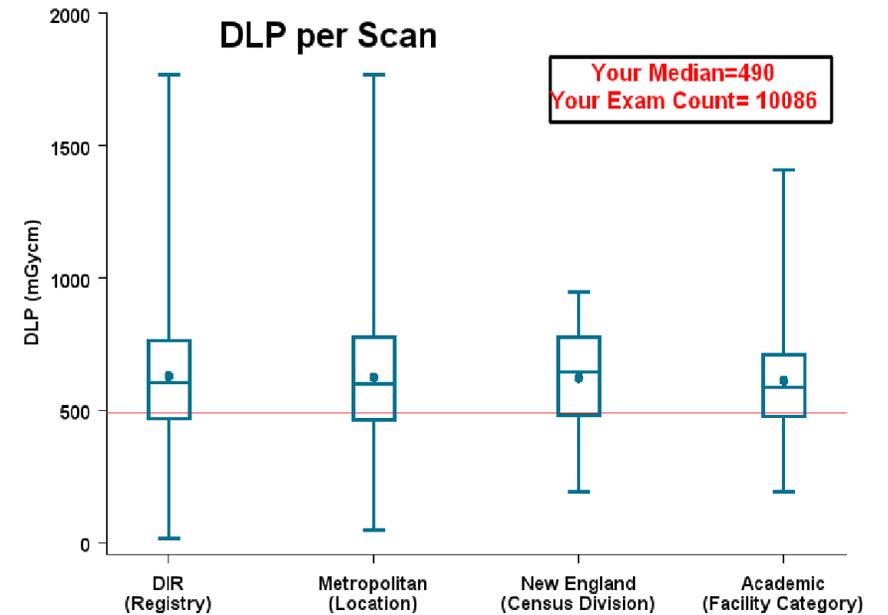
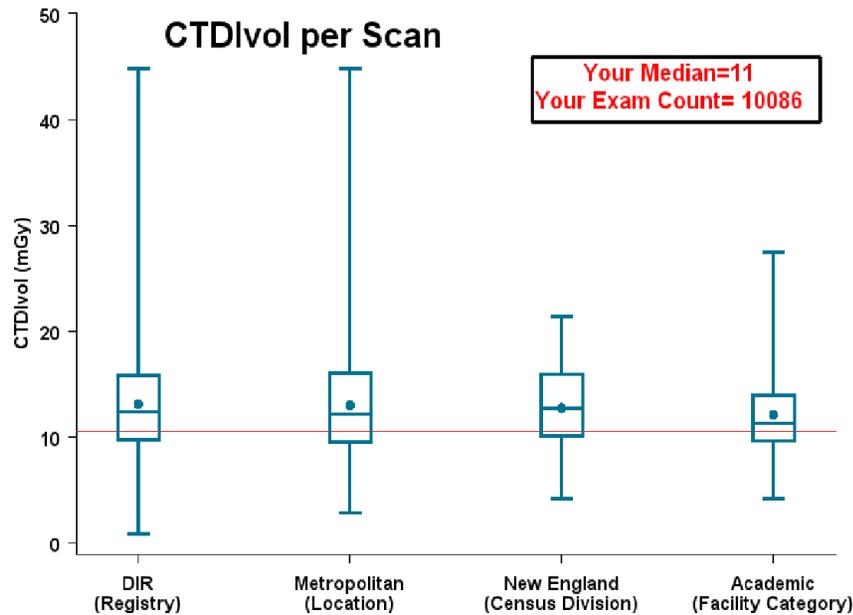
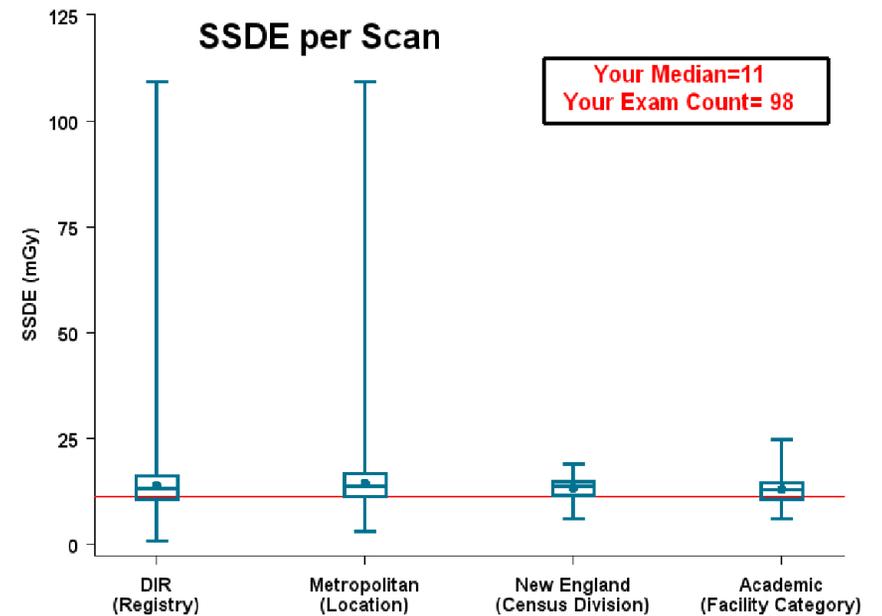


Figure 1. A sample page from a DIR report for the period July to December 2015. The box-whisker plots represent data collected across the national database (DIR) as well as the location, the census division, and the facility category. The vertical lines represents the range of vertical lines represents the range of CTDI_{vol} per scan. The upper limit of the box represents the 75th percentile and the lower limit represents the 25th percentile. The central line represents the mean and the dot represents the median. The red line represents the median for Mass General.