

**CBE ID**

2820

**Title**

Pediatric Computed Tomography (CT) Radiation Dose

**Project**

Patient Safety

**Endorsement Status**

Endorsed

**Is Under Review**

No

**Next Maintenance Cycle**

Fall 2027

**Previous Endorsement Cycle**

Spring 2022

**Initial Endorsement**

Wed, 05/04/2016 - 14:08

**Steward**

University of California, San Francisco

**1.0 New or Maintenance**

Maintenance

**1.1 Measure Structure**

Single Measure

**1.3 Electronic Clinical Quality Measure (eCQM)**

No

**1.6 Measure Description****2022 submission:**

Radiation dose is measured as the dose-length product for every diagnostic brain, skull, and abdomen and pelvis CT scan performed by a reporting facility on any child less than 18 years of age during the reporting period of 12 months. The dose associated with each scan is evaluated as "high" or "acceptable," relative to the 75<sup>th</sup> percentile benchmark for that type of scan and age of patient. Median doses are calculated at the facility level for each type of scan and age of patient stratum, and then compared with the same 75<sup>th</sup> percentile benchmark. The overall proportion of high dose exams is calculated including all CT scans.

### 2016 submission:

The measure requires hospitals and output facilities that conduct Computed Tomography (CT) examinations in children to: 1. Review their CT radiation dose metrics, 2. calculate the distribution of the results, and 3. compare their results to benchmarks. This would then imply a fourth step to investigate instances where results exceed a trigger value for underlying cause, such as issues with protocol, tech, equipment, patient, etc.

It is important to review doses of radiation used for CT, as the doses are far higher than conventional radiographs (x-rays), the doses are in the same range known to be carcinogenic (Pearce, Lancet, 2012; Ozasa, Radiation Research, 2012), and the higher the doses, the greater the risk of subsequent cancer (Miglioretti, JAMA Pediatrics, 2013) Thus the goal of the measure is to provide a framework where facilities can easily assess their doses, compare them to benchmarks, and take corrective action to lower their doses if they exceed threshold values, as per specifications in benchmarks.

The measure calls for assessment of doses for the most frequently conducted CT examination types, and compare these doses to published benchmarks. The measure calls for the assessment of radiation doses within four anatomic areas (CT's of the head, chest, abdomen/pelvis and combined chest/abdomen/pelvis.) The measure provides a simple framework for how facilities can assess their dose, compare their doses to published benchmarks (Smith-Bindman, Radiology, 2015) and identify opportunities to improve if their doses are higher than the benchmarks. For example, If a hospital finds their doses are higher than published benchmarks, they can review the processes and procedures they use for performance of CT in children and take corrective action, and follow published guidelines for how to lower doses (such as "child sizing" the doses, reducing multiple phase scans, and reducing scan lengths).

Published benchmarks for radiation dose in children exist (Smith-Bindman, Radiology, 2015) and additional benchmarks are under development and will be published within the year by us. (Kumar, 2015) Other groups have also published benchmarks (Goeske) or in the process of doing so.

Our work and that of others have shown that institutional review of dose metrics as outlined in this measure results in a significant lowering of average and outlier doses. (Demb, 2015; Greenwood, RadioGraphics, 2015; Miglioretti, JAMA Pediatrics, 2013; Keegan, JACR, 2104; Wilson, ARRS, 2015).

This measure is being proposed for diagnostic CT in children, but can also be used for CT in adults, and CT used in conjunction with radiation therapy for cancer. Whenever context the doses are used, the doses should be compared with appropriate benchmarks.

A similar measure (#0739) was previously endorsed by the NQF in 2011. The NQF did not provide ongoing endorsement when the measure was up for renewal in 2015, primarily because there was no evidence that assessing doses as called for in the measure would result in an improvement in outcomes (i.e. patient dose). Since that time, there has been additional research that has shown

that assessing doses using the format outlined in the measure does indeed result in lower doses, and thus we are re-submitting a similar although updated measure.

Of note, the surrogate measure we are using for outcomes is radiation dose. The true outcome of interest is the number of cancers that result from imaging. Because of the lag time between exposure to radiation and cancer development (years to decades) it is not feasible to use cancer cases as the outcome of a quality improvement effort. Thus while there is ample evidence that radiation causes cancer (sited below), and evidenced that cancer risk is proportional to dose, there are no direct data that suggest that lowering doses lowers cancer risk. However, we have used mathematical modeling to try to understand the relationship between lowering doses and cancers and estimated that if the top quartile of doses were reduced in children (i.e. the very high doses are brought down the average doses), the number of cancer cases would be reduced by approximately 43%, the equivalent to preventing 4,350 cancer cases / year in the US among children (Miglioretti, JAMA Pediatrics 2013).

Cited in this section:

Demb J, Chu P, Nelson T, Hall D, Seibert A, Lamba R, Boone J, Krishnam M, Cagnon C, Bostani M, Gould R, Miglioretti D, Smith-Bindman R. Optimizing Radiation Doses for Computed Tomography Across Institutions: Dose Auditing and Best Practices. JAMA Intern Med. 2017 Jun 1;177(6):810-817. doi: 10.1001/jamainternmed.2017.0445. PMID: 28395000; PMCID: PMC5818828.

Greenwood T, Lopez-Costa R, Rhoades P, et al. CT Dose Optimization in Pediatric Radiology: A Multiyear Effort to Preserve the Benefits of Imaging While Reducing the Risks. RadioGraphics. Jan 2015;35(5):1539-1554

“This systematic approach involving education, streamlining access to magnetic resonance imaging and ultrasonography, auditing with comparison with benchmarks, applying modern CT technology, and revising CT protocols has led to a more than twofold reduction in CT radiation exposure between 2005 and 2012...” – Conclusion statement from Abstract

Keegan J, Miglioretti DL, Gould R, Donnelly LF, Wilson ND, Smith-Bindman R. Radiation Dose Metrics in CT: Assessing Dose Using the National Quality Forum CT Patient Safety Measure. Journal of the American College of Radiology: JACR; 11(3):309-315.

<http://download.journals.elsevierhealth.com/pdfs/journals/1546-1440/PII...> Mar 2014

Looking at dose metrics as per compliance with the previously endorsed #0739 NQF measure results in reasonably timed acquisition of CT doses, and seeing such doses resulted in 30-50% dose reduction.

Remove, this was never published: Kumar K, manuscript under preparation. Radiation Dose Benchmarks in Children.

This paper will describe dose metrics among 29,000 children within age strata <1, 1-4 years, 5-9 years, 10-14 years, and 15-19 years. 2015.

Miglioretti D, Johnson E, Vanneman N, Smith-Bindman R, et al. Use of Computed Tomography and Associated Radiation Exposure and Leukemia Risk in Children and Young Adults across Seven Integrated Healthcare Systems from 1994 - 2010. JAMA Pediatrics Published online June 10, 2013 joi:10.1001/jamapediatrics2013311, 2013.

Radiation-induced cancers in children could be dramatically reduced if the highest quartile of CT radiation doses were lowered.

Miglioretti, YX Zhang, E Johnson, N Vanneman, R Smith-Bindman. Personalized Technologist Dose Audit Feedback for Reducing Patient Radiation Exposure from Computed Tomography. Journal of the American College of Radiology: JACR 2014.

“Personalized audit feedback and education can change technologists’ attitudes about, and awareness of, radiation and can lower patient radiation exposure from CT imaging.” - Conclusion statement from Abstract

Ozasa K, Shimizu Y, Suyama A, et al. Studies of the mortality of atomic bomb survivors, Report 14, 1950-2003: an overview of cancer and noncancer diseases. Radiation Research; 177(3):229-243. Mar 2012

Fourteenth follow-up report on the lifetime health effects from radiation on atomic bomb survivor showing that: 58% of the 86,611 LSS cohort members with DS02 dose estimates have died, 17% more cancer deaths especially among those under age 10 at exposure (58% more deaths).

Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study.

Lancet;380(9840):499-505. Aug 4 2012

“Use of CT scans in children to deliver cumulative doses of about 50 mGy might almost triple the risk of leukaemia and doses of about 60 mGy might triple the risk of brain cancer... although clinical benefits should outweigh the small absolute risks, radiation doses from CT scans ought to be kept as low as possible” - Conclusion statement from Abstract

Smith-Bindman R, Moghadassi M, Wilson N, et al. Radiation Doses in Consecutive CT Examinations from Five University of California Centers. Radiology 2015;277: 134-141

“These summary dose data provide a starting point for institutional evaluation of CT radiation doses.” - Conclusion statement from Abstract

Wilson N. CT Radiation Dose Standardization Across the Five University of California Medical Centers. ARRS: Annual Toronto Meeting presentation. April 19-24, 2015

Understanding the reasons for variation in commonly performed CT procedures, and figuring out how to standardize them.

## 1.7 Measure Type

Intermediate Outcome

## 1.8 Level of Analysis

Facility, Integrated Delivery System

## 1.9 Care Setting

Inpatient/Hospital, Outpatient Services

## 1.14 Numerator

Radiation Dose metrics among consecutive patients, who have undergone CT of the head, chest,

abdomen/pelvis, or chest/abdomen/pelvis. The metrics are 1) mean dose as measured using DLP, CTDIvol, and SSDE: within age strata. And 2) the proportion of exams with doses greater than the 75th percentile of the benchmark you are comparing with for the same anatomic area strata (Kumar, 2015; Smith-Bindman, Radiology, 2015; Goske, Radiology, 2013)The CTDIvol and DLP are directly reported by the scanner using an “industry wide” standardized dose report (DICOM Radiation Dose Structured Report). The data should be assembled for the entire CT examination. If there are several series, the CTDIvol values should be averaged, and the DLP values should be added.SSDE can be calculated using any dose monitoring software product, or using published multiplier coefficients which are highly valid. These different metrics are highly correlated, but nonetheless reveal important differences regarding radiology practice and performance and are thus complimentary. However, if a practice only assesses data from a single metric, there is substantial opportunity for data-driven improvement.CTDIvol reflects the average dose per small scan length. Modern CT scanners directly generate this.DLP reflects the CTDIvol x scan length, and is directly generated by modern CT scanners.SSDE is a modified measure of CTDIvol that takes into account the size of the patient scanned and is useful for scaling dose to patient size. Several current radiation tracking software tools directly report SSDE.Cited in this sectionGoske MJ, Strauss KJ, Coombs LP, et al. Diagnostic reference ranges for pediatric abdominal CT. Radiology. Jul 2013;268(1):208-218.“Calculation of reference doses as a function of BW (body weight) for an individual practice provides a tool to help develop site-specific CT protocols that help manage pediatric patient radiation doses.” - Conclusion statement from AbstractKumar K, manuscript under preparation. Radiation Dose Benchmarks in Children. This paper will describe dose metrics among 29,000 children within age strata <1, 1-4 years, 5-9 years, 10-14 years, and 15-19 years. 2015.Smith-Bindman R, Moghadassi M, Wilson N, et al. Radiation Doses in Consecutive CT Examinations from Five University of California Centers. Radiology 2015:277: 134-141“These summary dose data provide a starting point for institutional evaluation of CT radiation doses.” - Conclusion statement from AbstractSmith-Bindman R, Miglioretti DL. CTDIvol, DLP, and Effective Dose are excellent measures for use in CT quality improvement. Radiology. Dec 2011;261(3):999; author reply 999-1000.An explanation as to why these radiation dose metrics are useful in calculating a patient’s absorbed doses.Huda W, Ogden KM, Khorasani MR. Converting dose-length product to effective dose at CT. Radiology. Sep 2008;248(3):995-1003.“This article describes a method of providing CT users with a practical and reliable estimate of adult patient EDs by using the DLP displayed on the CT console at the end of any given examination.” - Conclusion statement from Abstract

## 1.15 Denominator

2022 submission:The denominator is the total number of diagnostic CT scans within an eligible anatomic region and age stratum (infant (<1 year); small child (1-4); medium child (5-9); large child (10-14) and adolescent (15-17)) that were performed during the reporting period. These totals are summed to generate the total number of diagnostic CT scans within all eligible anatomic regions and age strata. 2016 submission:Consecutive sample of CTs conducted in the head, chest, abdomen/pelvis and chest/abdomen/pelvis. No examinations should be excluded

## 1.20 Types of Data Sources

Electronic Health Data, Electronic Health Records, Other, Registry data

### 6.1.2 Current or Planned Use(s)

Public Reporting, Quality Improvement (Internal to the specific organization), Quality

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Improvement with Benchmarking (external benchmarking to multiple organizations)

### **6.1.3 Current Use(s)**

Public Reporting, Quality Improvement (Internal to the specific organization), Quality Improvement with Benchmarking (external benchmarking to multiple organizations)

### **Exclusions**

CT examinations conducted in anatomic areas not included above (such as CTs of the extremities or lumbar spine) or that combine several areas (head and chest) should not be included. In children, these four included categories will reflect approximately 80% of CT scans.

Examinations performed as part of diagnostic procedures - such as biopsy procedures - should not be included. CT examinations performed as part of surgical planning or radiation therapy should not be included.

Examinations that are considered "limited abdomen" or "limited pelvis" studies should be included in the abdomen and pelvis category. Any examinations that include any parts of the abdomen and or pelvis should count in the abdomen/pelvis category.

### **Measure Disclaimer**

N/A

### **Planned Use**

Public Reporting, Quality Improvement (Internal to the specific organization), Quality Improvement with Benchmarking (external benchmarking to multiple organizations)

### **Risk Adjustment**

No risk adjustment or risk stratification

### **Target Population**

Children (Age < 18)

### **Steward Organization**

University of California, San Francisco

### **Steward POC email**

rebecca.smith-bindman@ucsf.edu