CT Dose: Are we really giving people cancer?

Timothy P. Szczykutowicz Ph.D., DABR

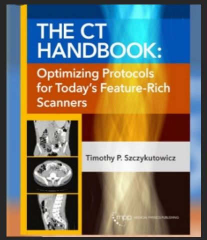
Professor

University of Wisconsin Madison Departments of Radiology[1], Medica[illegible]ysics[illegible]d Biomedical Engineering[3]

No

- Tim Stick’s Disclosures
  - Funds or equipment to UW-Madison
    - Supplies CT protocols to GE Healthcare under a licensing agreement
    - Research support from GE Healthcare
    - Receives research support from Canon Medical Systems USA
  - Personal
    - Medical Advisory Board of iMALOGIX LLC
    - Consult to ALARA Imaging LLC.
    - Licensing Patent US10957444B2 (repeat rates) to Qaelum.
    - Royalties from Medical Physics Publishing
    - Founder of RadUnity Corp.

RadUnity



No personal $ from GE/Canon

LNT and stochastic effects

"…there has not been any data on this, but personally…"

abcNEWS / Health

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CT Scan Radiation May Lead to 29,000 Cancers, Researchers Warn

Popular Diagnostic Scans May Be Overused, Some Worry

Cancer on msnbc.com

15,000 will die from CT scans done in 1 year

Scans have higher levels of radiation than thought, researchers say

REUTERS | EDITION: U.S. | News & Markets | Sectors & Industries | Analysis & Opinio

(Reuters) - Radiation from CT scans done in 2007 will cause 29,000 cancers and kill nearly 15,000 Americans, researchers said on Monday.

By Julie Steenhuysen

CHICAGO | Mon Dec 14, 2009 4:30pm EST

Will You Be one of the 15,000 That Are Killed By CT Scans Next Year?

This is the question being asked as 2009 drew to a close.

Cancercare.com

“Boy I’m lucky I never had one of these done! I was always skeptical of this procedure. It was my intuition that told me don’t go there!”
....USA Today

https://www.youtube.com/watch?v=j60vm-LL8hY&t=3s

Axial was slow then came spiral
According to Smith-Bindman these x-rays gone viral
At these low doses what conclusions can we make?
So what if a few photons cause DNA to break?
Mix public fear and psuedo science and let it ferment
Drunk on that you won't ask where the high dose FBP images went

Smith-Bindman, R., Lipson, J., Marcus, R., Kim, K. P., Mahesh, M., Gould, R., ... & Miglioretti, D. L. (2009). Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. Archives of internal medicine, 169(22), 2078-2086.

Sacks, B., Meyerson, G., & Siegel, J. A. (2016). Epidemiology without biology: false paradigms, unfounded assumptions, and specious statistics in radiation science (with commentaries by Inge Schmitz-Feuerhake and Christopher Busby and a reply by the authors). Biological theory, 11(2), 69-101.

Disaster Medicine and Public Health Preparedness

Article contents

Long-term Radiation-Related Health Effects in a Unique Human Population: Lessons Learned from the Atomic Bomb Survivors of Hiroshima and Nagasaki

Published online by Cambridge University Press: **08 April 2013**

Evan B. Douple, Kiyohiko Mabuchi, Harry M. Cullings, Dale L. Preston, Kazunori Kodama, Yukiko Shimizu, Saeko Fujiwara and Roy E. Shore

Article Figures Metrics

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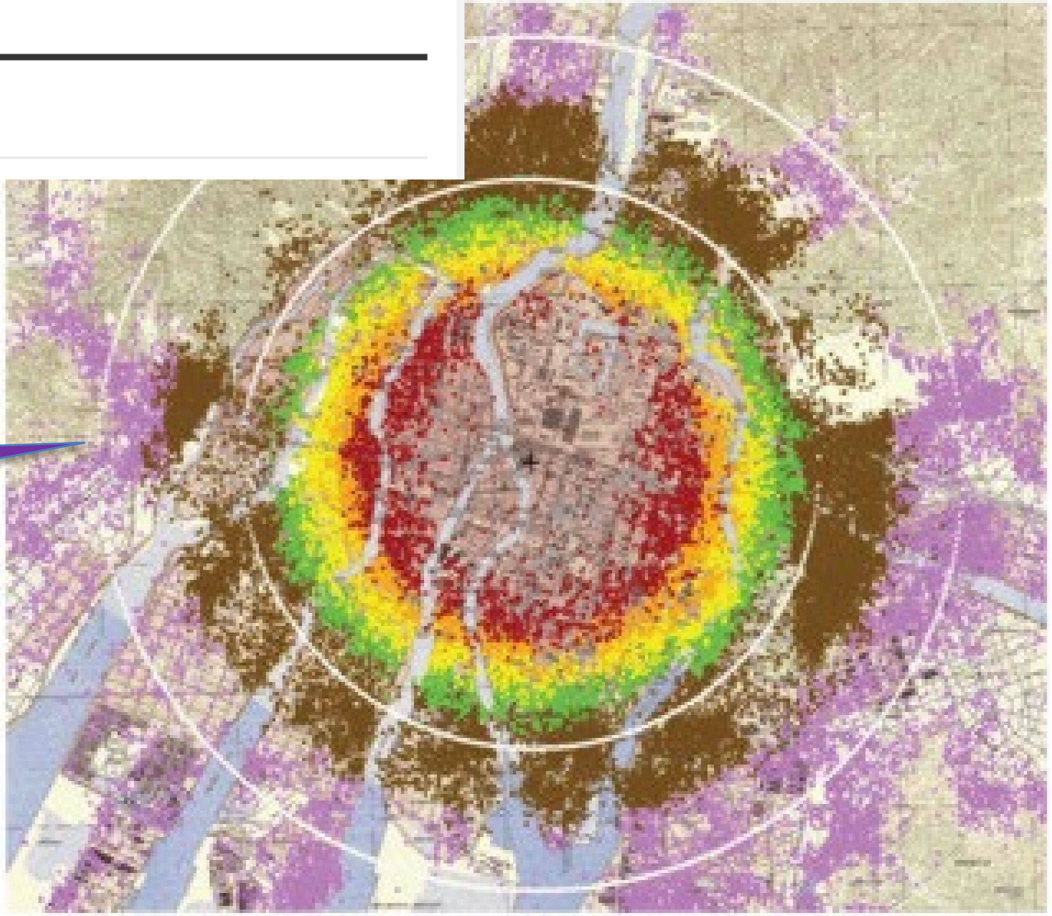
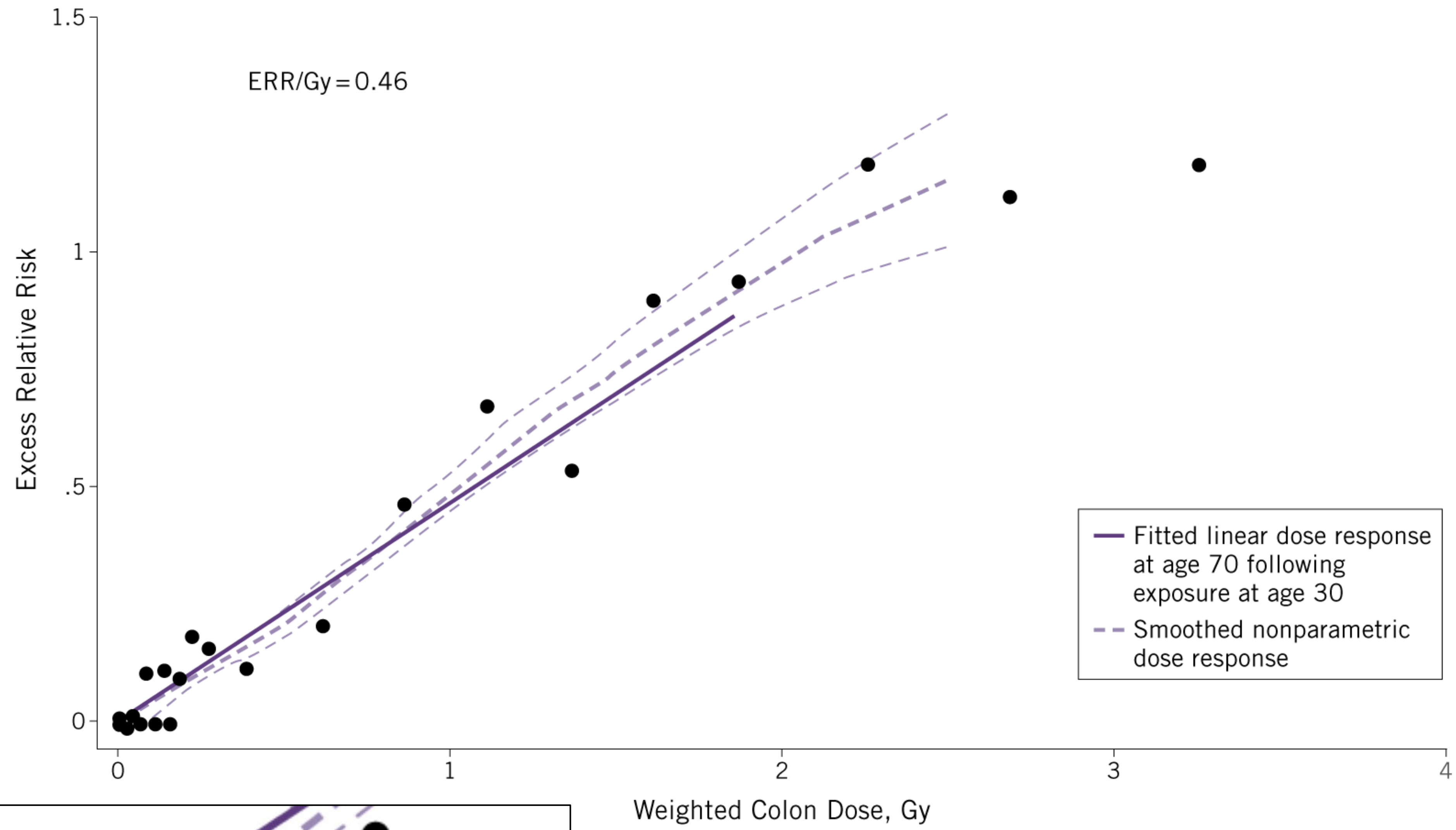
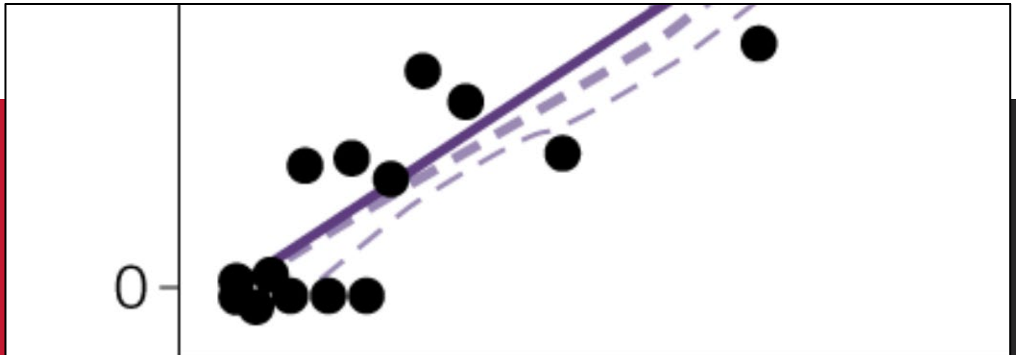


Each colored dot is a person


ERR/Gy = 0.46
Excess Relative Risk
1.5
1
.5
0
Weighted Colon Dose, Gy
0
1
2
3
4
Fitted linear dose response at age 70 following exposure at age 30
Smoothed nonparametric dose response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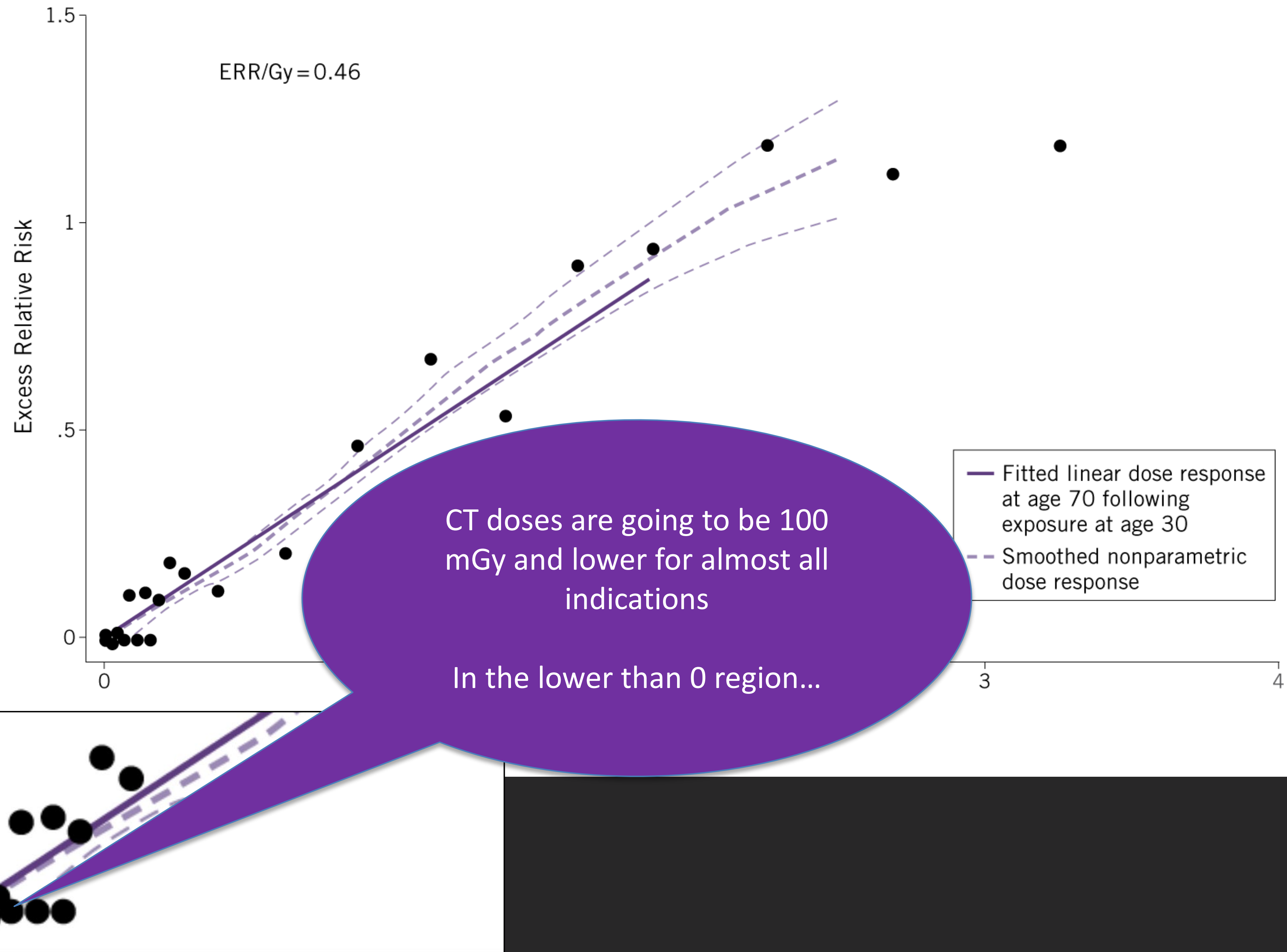
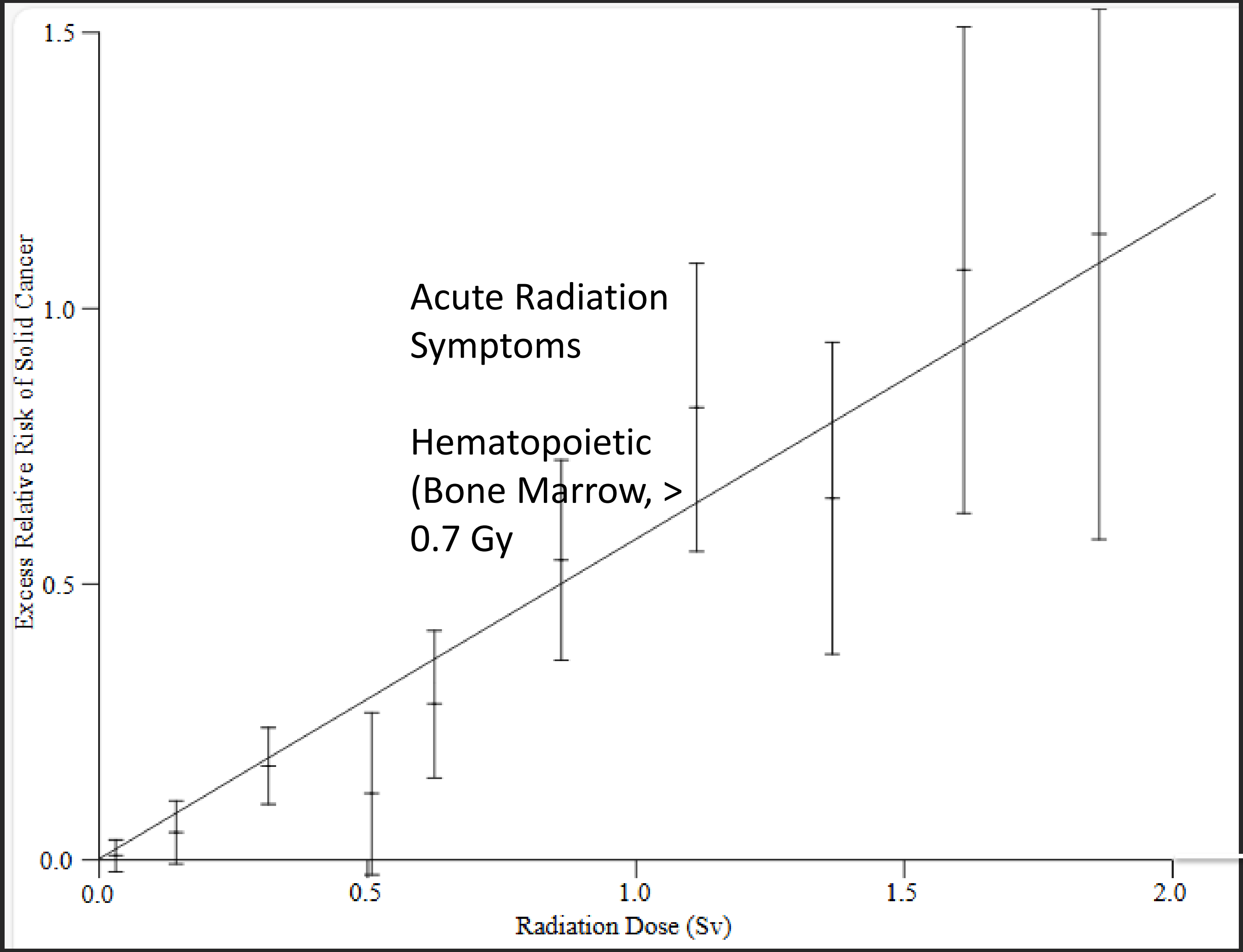


CT doses are going to be 100 mGy and lower for almost all indications

In the lower than 0 region…

"deterministic effects" in text over stochastic cancer risk plot"



Acute Radiation Symptoms

Hematopoietic (Bone Marrow, > 0.7 Gy

Acute Radiation Symptoms

Gastrointestinal (GI), > 10 Gy

Acute Radiation Symptoms

Cardiovascular (CV)/ Central Nervous System (CNS), > 50 Gy

The NEW ENGLAND JOURNAL of MEDICINE

CURRENT ISSUE SPECIALTIES TOPICS

REVIEW ARTICLE | CURRENT CONCEPTS

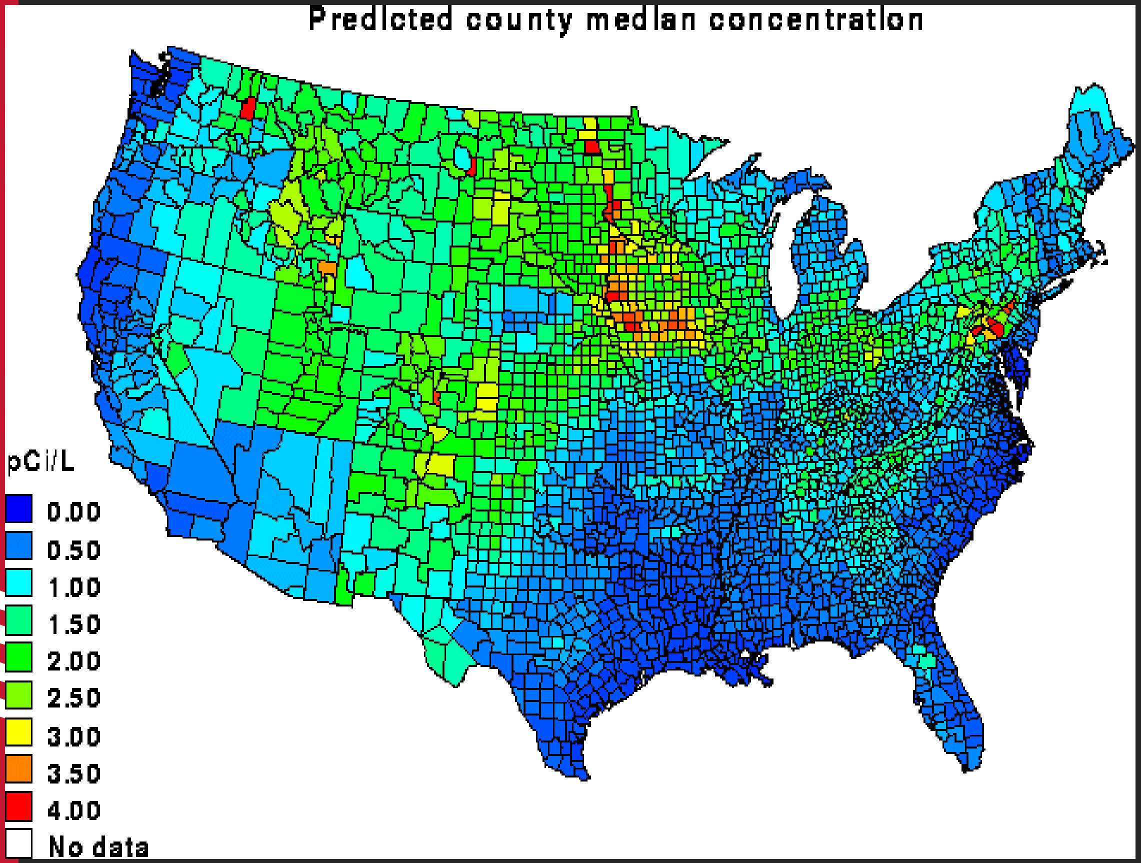
Computed Tomography — An Increasing Source of Radiation Exposure

Authors: David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phil., D.Sc. Author Info & Affiliations

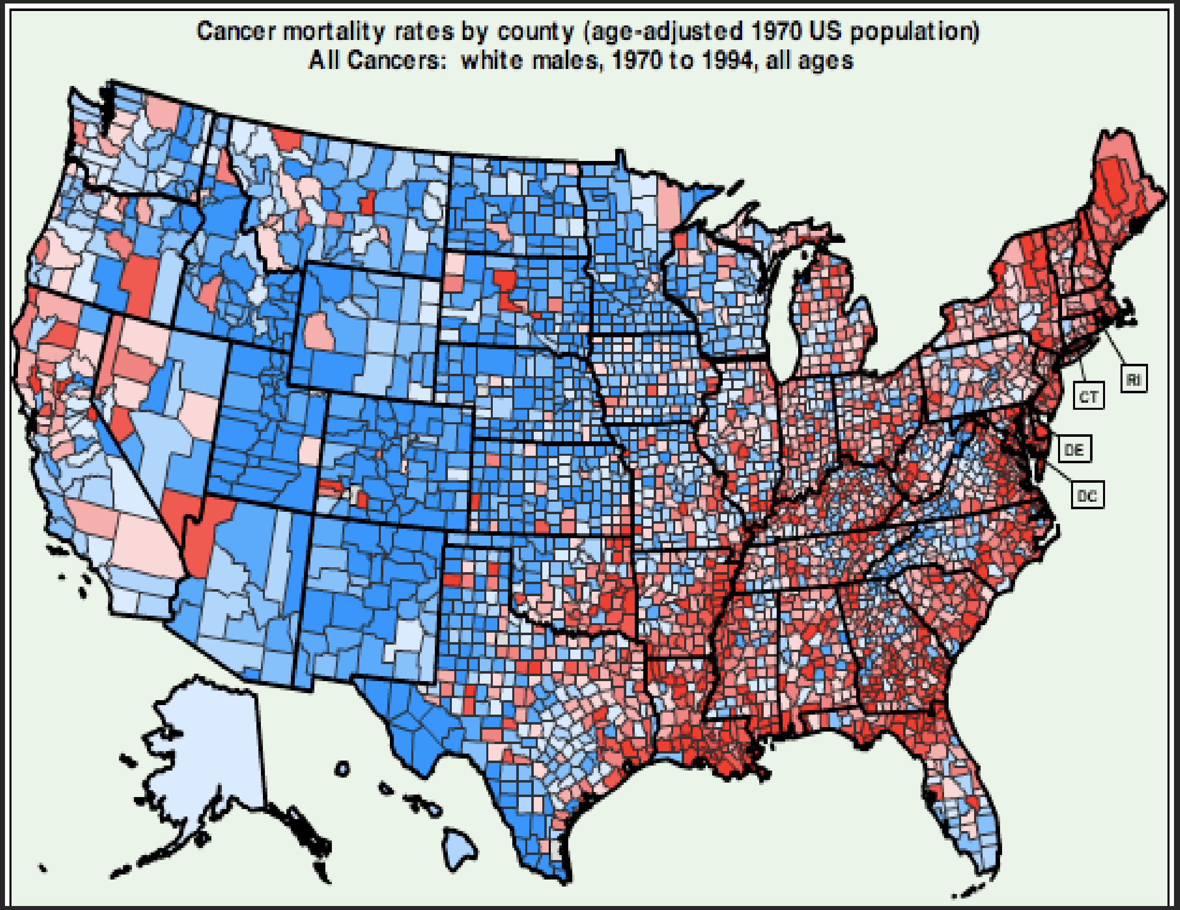
Published November 29, 2007 | N Engl J Med 2007;357:2277-2284 | DOI: 10.1056/NEJMra072149
VOL. 357 NO. 22 | Copyright © 2007

This is sus, Brenner and Hall 2007 (the most famous of all papers in CT community discussing radiation risk and CT) say there is real data supporting low dose causes cancer. But the LSS has real data points under zero on excess cancer plots for CT dose levels....

The increase in CT use and in the CT-derived radiation dose in the population is occurring just as our understanding of the carcinogenic potential of low doses of x-ray radiation has improved substantially, particularly for children. This improved confidence in our understanding of the lifetime cancer risks from low doses of ionizing radiation has come about largely because of the length of follow-up of the atomic-bomb survivors — now more than 50 years — and because of the consistency of the risk estimates with those from other large-scale epidemiologic studies. These considerations suggest that the estimated risks associated with CT are not hypothetical — that is, they are not based on models or major extrapolations in dose. Rather, they are based directly on measured excess radiation-related cancer rates among adults and children who in the past were exposed to the same range of organ doses as those delivered during CT studies.



Just for fun, see how this plot of radon gas naturally seeping into our basements (causes dose increases like CT doses) correlated with cancer mortality....



Learning Objectives

- Understand the linear no-threshold (LNT) model and other common frameworks for radiation risk.

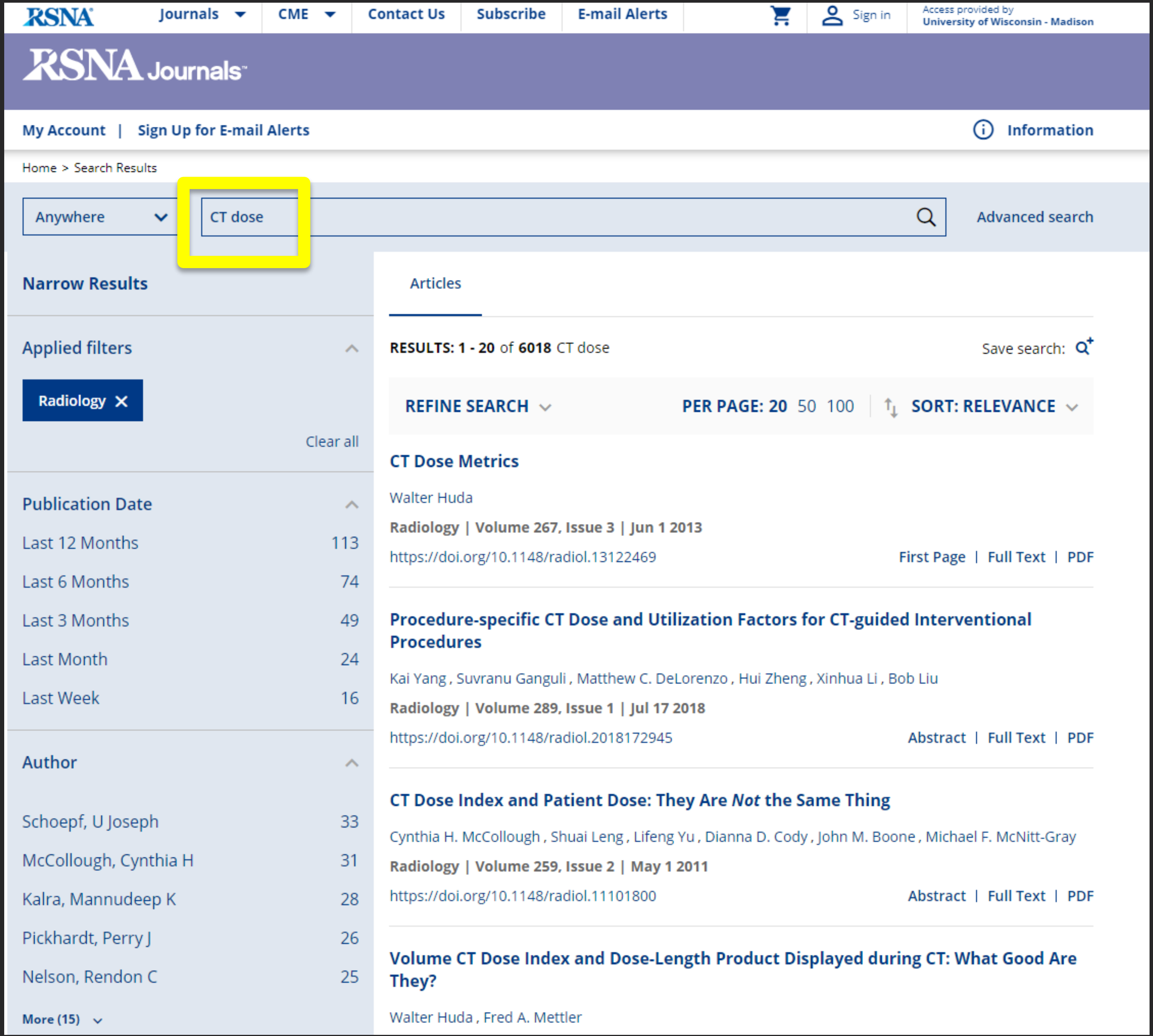
- Review basic CT dosimetry metrics: CTDIvol, DLP, SSDE, ED

- Learn what cumulative effective dose is and why its clinical relevance is debated.

- Explore modern models that weigh the risks of under-dosing (missed diagnoses) against overexposure.

Confusing terminology

Confusing Terminology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RESULTS: 1 - 20 of **6018** CT dose

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CT Dose Metrics

Walter Huda

Radiology | Volume 267, Issue 3 | Jun 1 2013

https://doi.org/10.1148/radiol.13122469

First Page | Full Text | PDF

Procedure-specific CT Dose and Utilization Factors for CT-guided Interventional Procedures

Kai Yang , Suvranu Ganguli , Matthew C. DeLorenzo , Hui Zheng , Xinhua Li , Bob Liu

Radiology | Volume 289, Issue 1 | Jul 17 2018

https://doi.org/10.1148/radiol.2018172945

Abstract | Full Text | PDF

CT Dose Index and Patient Dose: They Are *Not* the Same Thing

Cynthia H. McCollough , Shuai Leng , Lifeng Yu , Dianna D. Cody , John M. Boone , Michael F. McNitt-Gray

Radiology | Volume 259, Issue 2 | May 1 2011

https://doi.org/10.1148/radiol.11101800

Abstract | Full Text | PDF

Volume CT Dose Index and Dose-Length Product Displayed during CT: What Good Are They?

Walter Huda , Fred A. Mettler

Confusing Terminology

Original Research
Medical Physics

Free Access

Procedure-specific CT Dose and Utilization Factors for CT-guided Interventional Procedures

Kai Yang, Suvranu Ganguli, Matthew C. DeLorenzo, Hui Zheng, Xinhua Li, Bob Liu

Author Affiliations

Published Online: Jul 17 2018 | https://doi.org/10.1148/radiol.2018172945

See editorial by Shuai Leng

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Results

Interventional CT scans have distinctly different dose metric characteristics from diagnostic CT scans. Wide variations of dose metrics were observed among subcategories, even within the same major category. For the most frequently performed CT-guided interventional procedures within each major category, liver ablation, chest aspiration, liver biopsy, and single abdominal drainage, the median dose-length product was 2351, 657, 1175, and 1125 mGy · cm, respectively. Procedure-specific CT utilization factors ranged between 0.6 and 3.6.

Therefore, we focused on DLP for patient dose consideration, similar to the concept of kinetic energy
;–area product (known as KAP) in fluoroscopy-guided interventional procedures.
-length-weighted $CTDI_{vol}$ and SSDE were included for complete reporting. For this
: reported single-value CTDI and SSDE with *sw* in the following equations. If we
ınt (*AC*) as the total number of CT series occurring in one procedure and use *i* as the
es, we can have

$$Scan\ Length_{total} = \sum_{i=1}^{AC} Scan\ length(i),$$

$$CTDIsw = \frac{\sum_{i=1}^{AC} CTDIvol(i) \times Scan\ length(i)}{Scan\ Length_{total}},$$

$$SSDEsw = \frac{\sum_{i=1}^{AC} SSDE(i) \times Scan\ length(i)}{Scan\ Length_{total}},$$

and

$$DLP = \sum_{i=1}^{AC} DLP(i) = \sum_{i=1}^{AC} CTDIvol(i) \times Scan\ length(i) = CTDIsw \times Scan\ Length_{total}.$$

Original Research
Medical Physics

Dose Performance of a 64-Channel Dual-Source CT Scanner

Cynthia H. McCollough, Andrew N. Primak, Osama Saba, Herbert Bruder, Karl Stierstorfer, Rainer Raupach, Christoph Suess, Bernhard Schmidt, Bernd M. Ohnesorge, Thomas G. Flohr

Author Affiliations

Published Online: Jun 1 2007 | https://doi.org/10.1148/radiol.2433061165

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Results: For the multi–detector row and dual-source CT systems, respectively, weighted CT dose index per 100 mAs was 14.2 and 12.2 mGy (head CT), 6.8 and 6.4 mGy (body CT), and 6.8 and 5.3 mGy (cardiac CT). In the spiral cardiac mode (no electrocardiographically based tube current modulation, 0.2 pitch), equivalent noise occurred at volume CT dose index values of 23.7 and 35.0 mGy (coronary artery calcium CT) and 58.9 and 61.2 mGy (coronary CT angiography) for multi–detector row CT and dual-source CT, respectively. The use of heart rate–dependent pitch values reduced volume CT dose index to 46.2 mGy (0.265 pitch), 34.0 mGy (0.36 pitch), and 26.6 mGy (0.46 pitch) compared with 61.2 mGy for 0.2 pitch. The use of electrocardiographically based tube current–modulation and temporal windows of 110, 210, and 310 msec further reduced volume CT dose index to 9.1–25.1 mGy, dependent on the heart rate.

ORIGINAL RESEARCH
THORACIC IMAGING

Free Access

Optimal Scan Parameters for CT Fluoroscopy in Lung Interventional Radiologic Procedures: Relationship between Radiation Dose and Image Quality

Yoshikazu Yamao, Koichiro Yamakado, Haruyuki Takaki, Tomomi Yamada, Shuichi Murashima, Junji Uraki, Hiroshi Kodama, Naoki Nagasawa, Kan Takeda

Author Affiliations

Published Online: Mar 10 2010 | https://doi.org/10.1148/radiol.09090733

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Results

Both the SNR and the CNR improved as the radiation dose increased, leading to improvement in the image quality. Acceptable image quality was achieved in 94% (30 of 32) of patients when the radiation dose was 1.18 mGy/sec (120 kV, 10 mA) and in all patients when it was greater than 1.48 mGy/sec (135 kV, 10 mA). The piecewise linear curve showed rapid improvement in image quality until the radiation dose increased to 1.48 mGy/sec (135 kV, 10 mA). When the radiation dose was increased greater than 1.48 mGy/sec, improvement in the image quality became more gradual.

Medical Physics

Radiation Effective Doses to Patients Undergoing Abdominal CT Examinations

Dan E. Ware1, Walter Huda1, Patricia J. Mergo1, Anthony L. Litwiller1

Author Affiliations

Published Online: Mar 1 1999 | https://doi.org/10.1148/radiology.210.3.r99mr05645

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RESULTS: All abdominal CT examinations were performed at 120 kVp with a section thickness of approximately 7 mm for all sizes of patients. The mean number of CT sections increased from 22.0 for children to [illegible]1.5 for adults, and the mean quantity of x radiation in milliampere-seconds increased from 22[illegible] mAs for children to 290 mAs for adults. The mean values (± SD) of energy imparted were 72.1 mJ ± 24.[illegible] for children, 183.5 mJ ± 44.8 for young adults, and 234.7 mJ ± 89.4 for adults. The corresponding mean values of patient effective dose were 6.[illegible] mSv ± 1.4 for children, 4.4 mSv ± 1.0 for young adults, and 3.9 mSv ± 1.1 for adults.

Original Research
Medical Physics

Free Access

U.S. Diagnostic Reference Levels and Achievable Doses for 10 Adult CT Examinations

Kalpana M. Kanal, Priscilla F. Butler, Debapriya Sengupta, Mythreyi Bhargavan-Chatfield, Laura P. Coombs, Richard L. Morin

Author Affiliations

Published Online: Feb 21 20

Sections PDF

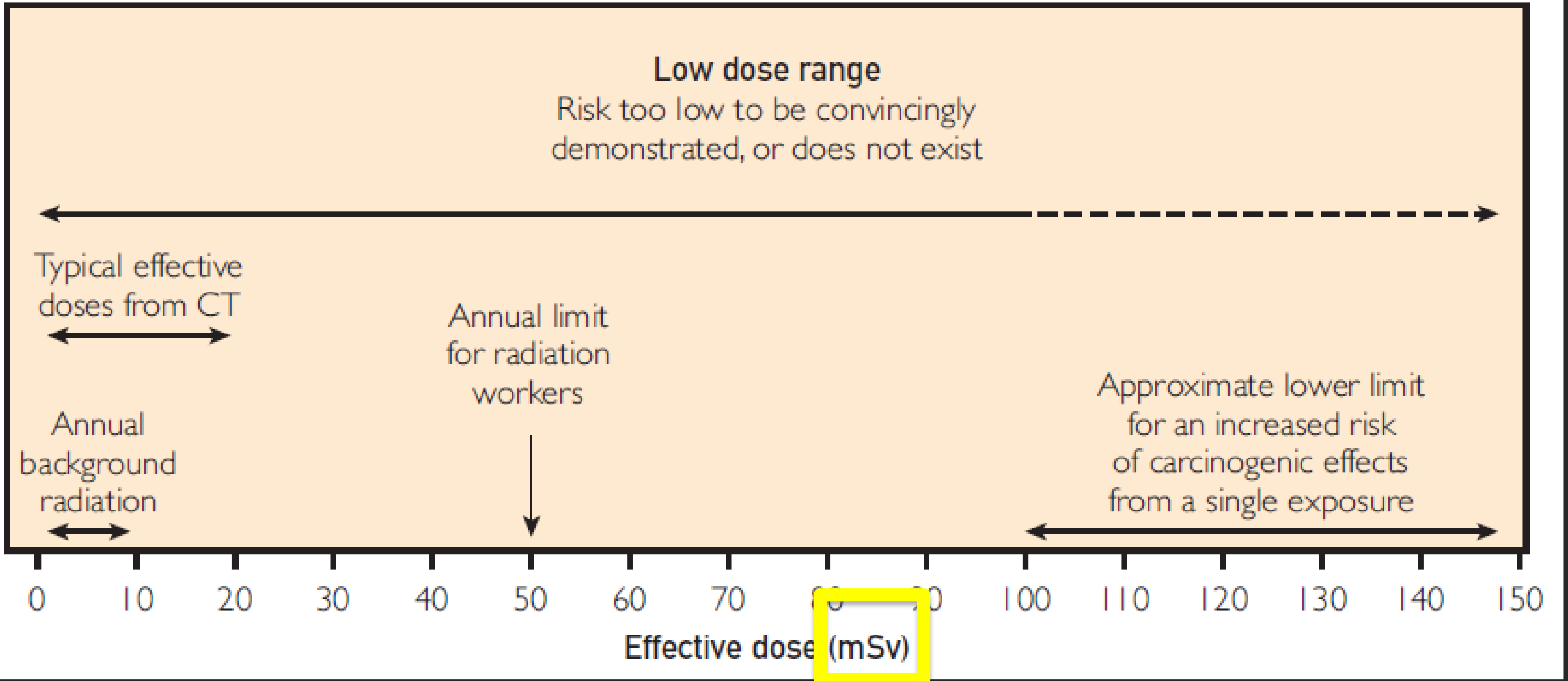
Examination and Median Size (Diameter)	Size (cm)	No. of Facilities	No. of Patients	$CTDI_{vol}$ (mGy) AD (50th Percentile)	$CTDI_{vol}$ (mGy) DRL (75th Percentile)	SSDE (mGy) AD (50th Percentile)	SSDE (mGy) DRL (75th Percentile)	DLP (mGy-cm) AD (50th Percentile)	DLP (mGy-cm) DRL (75th Percentile)
Abdomen and pelvis without contrast material*	21–25	353	14 667	7	9	11	14	318	422
	25–29	390	43 185	9	12	13	16	443	545
	29–33	415	64 317	13	16	15	19	639	781
	33–37	403	51 133	17	21	18	22	865	1048
	37–41	365	21 901	21	25	19	22	1071	1306
	All[†]	446[†]	201 754	13	20	15	19	657	1004
Abdomen and pelvis with contrast material*	21–25	397	29 691	7	9	10	13	300	394
	25–29	443	82 822	9	11	12	15	409	524
	29–33	448	108 921	12	15	15	18	608	755
	33–37	434	76 681	17	21	18	21	887	1056
	37–41	392	30 640	21	24	19	22	1072	1266
	All[†]	492[†]	338 056	13	19	15	19	615	995
Abdomen, pelvis, and kidney without contrast material*	21–25	137	4173	7	9	10	15	291	408
	25–29	165	10 640	8	12	12	16	380	526
	29–33	170	14 622	12	15	14	19	576	705
	33–37	164	11 440	16	20	17	20	788	943
	37–41	148	5111	19	22	17	20	901	1092
	All[†]	202[†]	47 748	12	18	14	19	586	877

SPECIAL ARTICLE

MAYO CLINIC

Answers to Common Questions About the Use and Safety of CT Scans

Cynthia H. McCollough, PhD; Jerrold T. Bushberg, PhD; Joel G. Fletcher, MD; and Laurence J. Eckel, MD



Region or Organ	Dose Limit	Comments
Skin	<2 Gy	No observable negative effects.
Skin	5 Gy	Transient erythema occurring within 2 weeks followed by hair loss, no lasting effects.
Skin	10 Gy	Transient erythema occurring within 2 weeks followed by hair loss, some lasting hair loss, possible lasting dermal atrophy.
Skin	15 Gy	Transient erythema occurring within 2 weeks followed by prolonged erythema and permanent hair loss. Lasting dermal atrophy, Telangiectasia, and lasting weak skin.
Skin	>15 Gy	Within 2 weeks, ulceration, transient erythema, edema. Surgical intervention likely to be needed. Lasting dermal atrophy, Telangiectasia, and persistent deep wound.
Eye Lens	0.5 Gy	The cataract induction dose limit is 0.5 Gy [26]. To safely work in a radiation environment, the ICRP statement recommends limiting eye absorbed dose to a 5-year average of 20 mSv (i.e., mGy for MDCT photons) with no single year over 50 mSv (i.e., mGy for MDCT photons) [26]. At the time of this writing, the European Atomic Energy Community (via COUNCIL DIRECTIVE 2013/59/EURATOM) has issued a directive that limits the equivalent dose for the lens of the eye to 20 mSv in a single year or 100 mSv in any five consecutive years, slightly different than the ICRP recommendation.

“The CT Handbook: Optimizing Protocols for Today’s feature-rich scanners”
By Tim Szczykutowicz. Medical Physics Publishing 2020

http://blogs.wsj.com/health/2009/10/13/hospital-mistake-gives-patients-radiation-overdose/
http://www.nytimes.com/2009/10/16/us/16radiation.html?_r=0

Radiation quantities	CT specific radiation quantities
Organ dose (eye lens dose, colon dose, fetal dose, etc.), effective dose, absorbed dose, equivalent dose	CTDIvol, DLP, SSDE

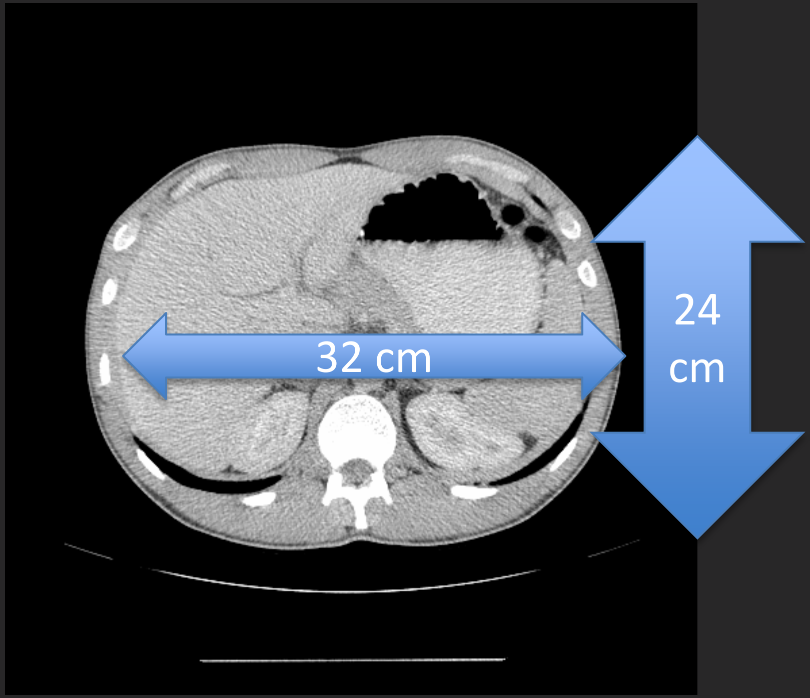
@Prof_TimStick's Actionable information

- When comparing your dose to your colleague's down the street, I would think in terms of CTDIvol, DLP, and SSDE.
  - Forget organ doses, what are you really going to do with them…?
  - DO NOT think in terms of mA, mAs, or effective mAs. These don't translate within a single scanner or across scanners.
- When comparing CT to other modalities, I would think in terms of mSv

Effective dose, CTDIvol, DLP, SSDE

- CT scanner’s output
  - CTDIvol (Volume Computed Tomography Dose Index)
    - Average dose a 16 or 32 cm plastic phantom receives

- CT scanner's output
  - CTDIvol (Volume Computed Tomography Dose Index)
    - Average dose a 16 or 32 cm plastic phantom receives



Patient Name: [redacted] Exam no: [redacted]
Accession Number: UWHC[redacted]
Patient ID: [redacted] LightSpeed16
Exam Description: CT ABDOMEN PELVIS W IV

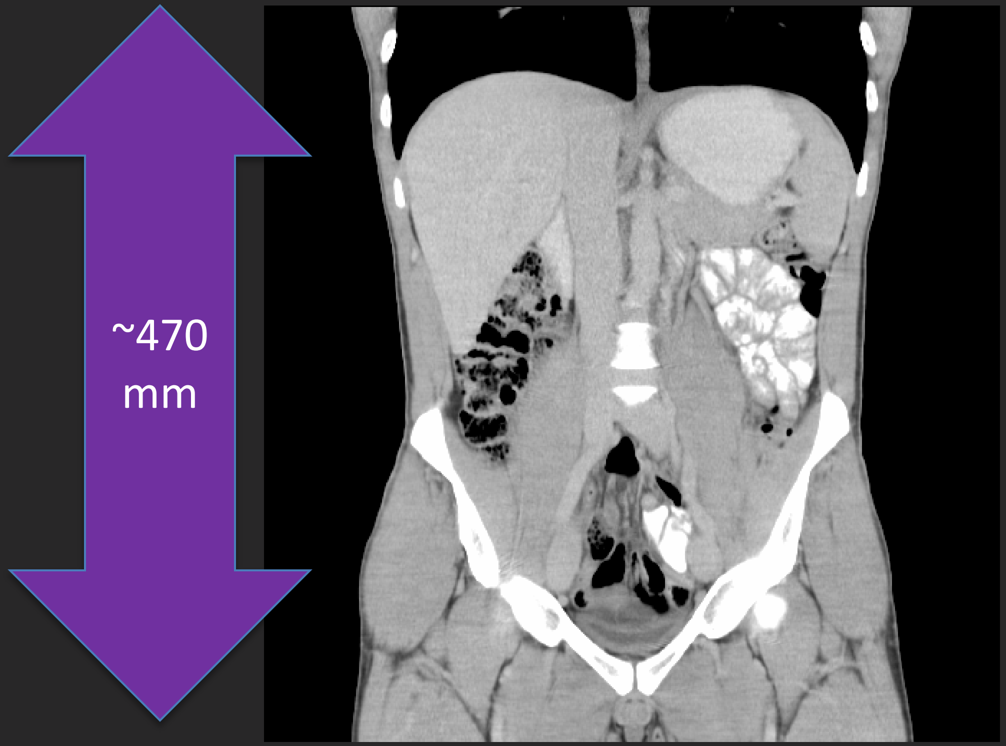
Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
200	Axial	I168.750-I168.750	20.83	20.80	Body 32
2	Helical	I14.500-I475.125	17.57	879.96	Body 32
			Total Exam DLP:	900.76	

1/1

- CT scanner's output
  - CTDIvol (Volume Computed Tomography Dose Index)
    - Average dose a 16 or 32 cm plastic phantom receives
    - Units of mGy
    - Measured using cylindrical phantom with center and periphery holes where we put in a dose measurement device

- Dose Length Product (DLP)
  - CTDIvol times the scan length in centimeters
  - Units of mGy*cm



Patient Name: [redacted] Exam no: [redacted]
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Exam Description: CT ABDOMEN PELVIS W IV

Dose Report

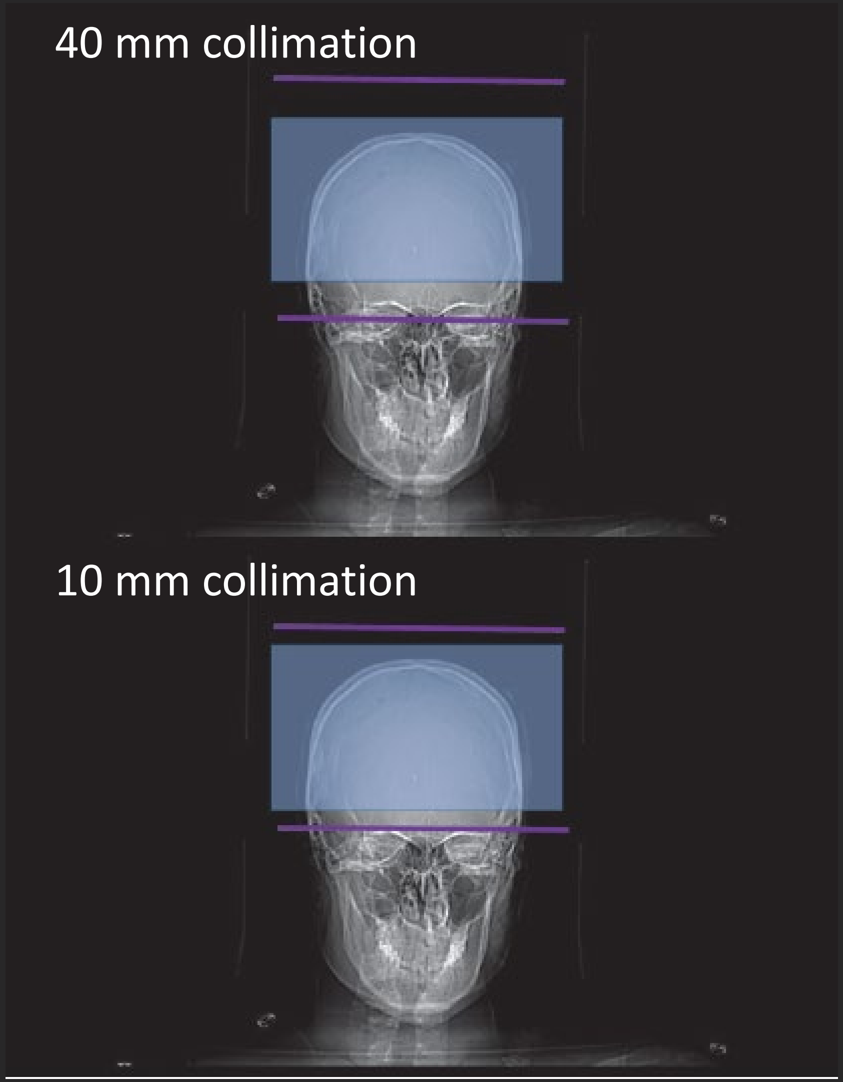
Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
200	Axial	I68.750-I68.750	20.83	20.80	Body 32
2	Helical	I4.500-I475.125	17.57	879.96	Body 32
			Total Exam DLP:	900.76	

1/1

DLP = CTDIvol*range
= 17.57 mGy * 47 cm
= 826 mGy*cm

I get 50 cm range if I divide DLP by CTDIvol

- Overranging is the collection of slightly more data than is needed (in helical/spiral mode)
- Increases with higher beam collimations



Radiology. 2011 May;259(2):311–316. doi: 10.1148/radiol.11101800

CT Dose Index and Patient Dose: They Are *Not* the Same Thing

Cynthia H McCollough [1,✉], Shuai Leng [1], Lifeng Yu [1], Dianna D Cody [1], John M Boone [1], Michael F McNitt-Gray [1]

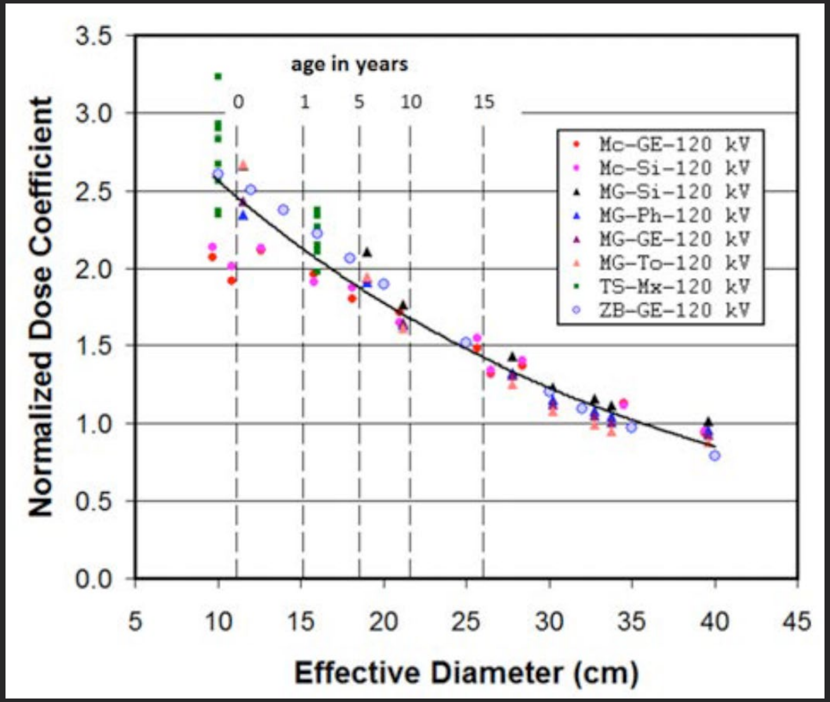
▸ Author information ▸ Article notes ▸ Copyright and License information

PMCID: PMC3079120 PMID: 21502387

- CTDIvol isn't patient dose, it is scanner output
  - As car RPM (output) is to car speed (patient dose)
    - High RPM can go really fast with little drag and high gear
    - High RPM can go really slow pulling huge load up a hill in low gear

Size specific dose estimate (SSDE)

- Modulates scanner report 16 or 32 cm dose to actual patient size
- Small patients get more dose than phantom (usually)
- Large patients get less dose than phantom (usually)



Values we multiply CTDIvol by to make CTDIvol patient size specific

SSDE = CTDIvol * value from this curve

- SSDE example

Patient Name: [redacted]
Exam no: [redacted]
Accession Number: UWHC[redacted]
Patient ID: [redacted]
LightSpeed16
Exam Description: CT ABDOMEN PELVIS W IV

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
200	Axial	I68.750-I68.750	20.83	20.80	Body 32
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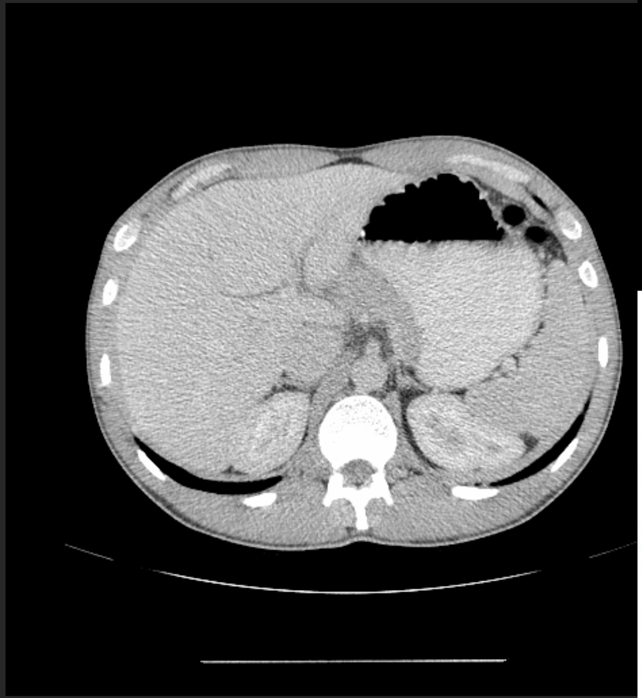
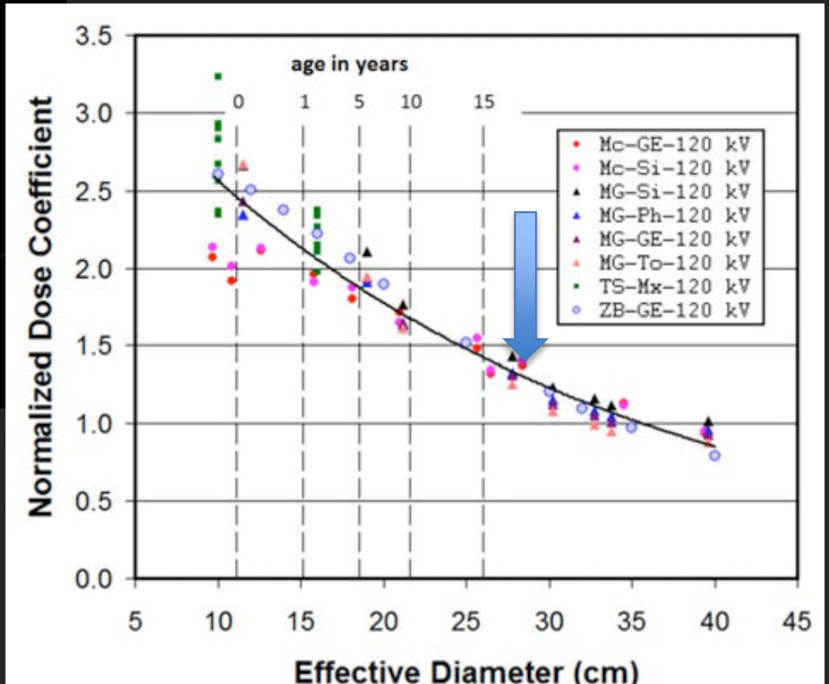
1/1

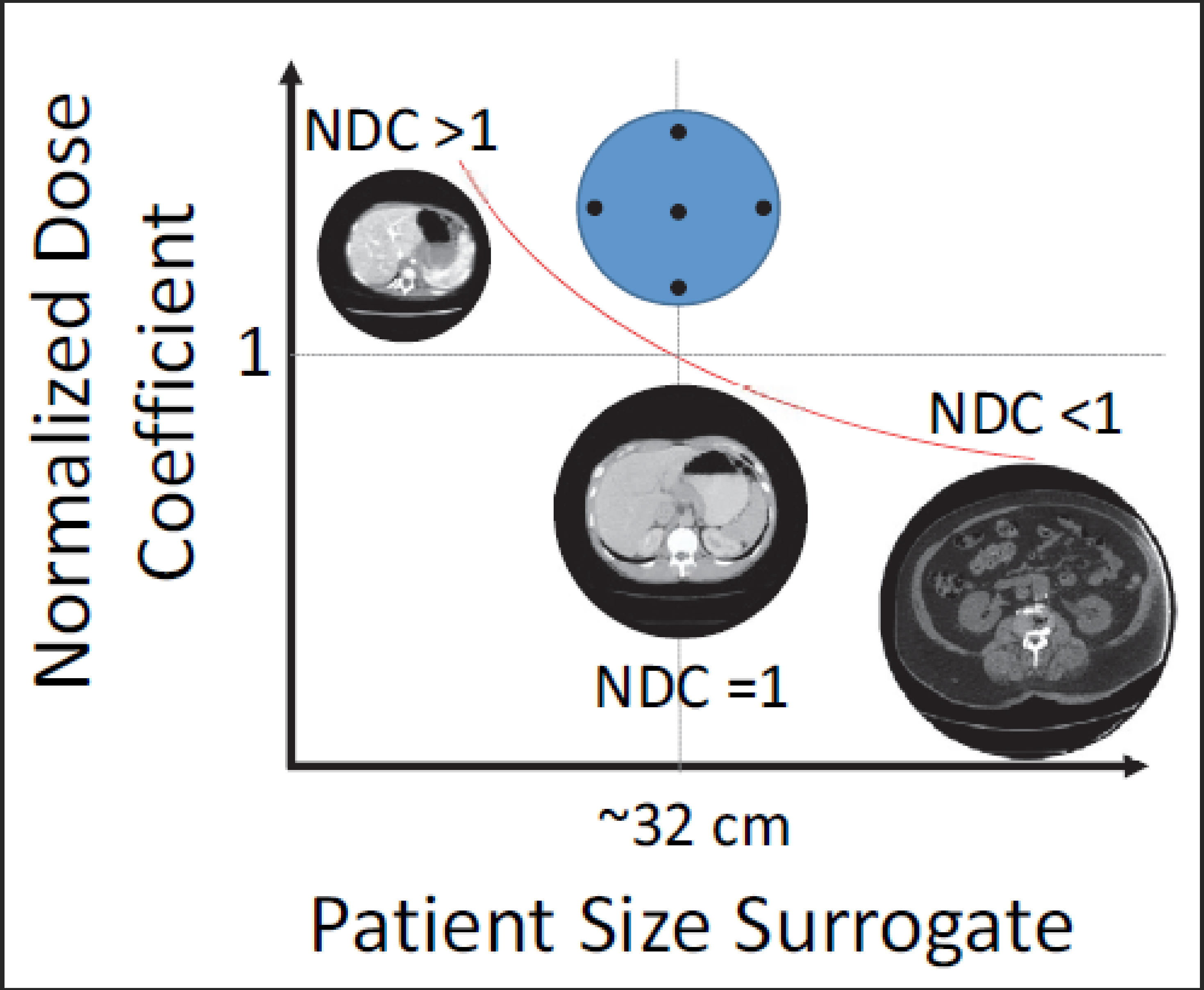


ED = 28 cm



SSDE multiplier here is like 1.3. so SSDE = 1.3*17.57 mGy = 22.8 mGy

- CTDIvol will depend on if it is reported in a 16 or 32 cm phantom
- Most torso scans use 32 cm phantom to report dose
- Head and some peds use 16 cm phantom to report dose
- SSDE goes up for small people
- SSDE goes smaller for larger people



SSDE modulation of CTDIvol in graph form

- Effective dose
  - DLP * “k factor”. Super simple formula to get effective dose.
  - “k factor” is a number specific to a body region which calculates how much dose specific organs receive and sums them, to derive a total effective dose.
  - CTDIvol, DLP, SSDE are specific to CT
  - Effective dose is modality neutral

Table 4.11 A comparison of organ dose coefficients. Blank spaces for a column correspond to that organ being counted in the remainder category.

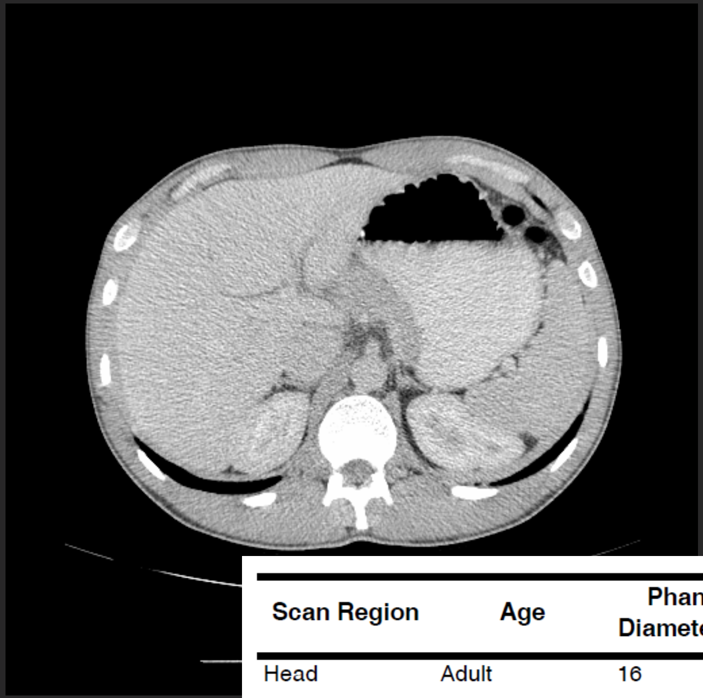
Organ	ICRP 26 (1977)	ICRP 60 (1991)	ICRP 103 (2007)
Brain			0.01
Salivary Glands			0.01
Thyroid	0.03	0.05	0.04
Esophagus		0.05	0.04
Breast	0.15	0.05	0.12
Lung	0.12	0.12	0.12
Stomach		0.12	0.12
Liver		0.05	0.04
Colon		0.12	0.12
Bladder		0.05	0.04
Gonads	0.25	0.20	0.08
Bone Surfaces	0.03	0.01	0.01
Bone Marrow	0.12	0.12	0.12
Skin		0.01	0.01
Remainder	0.30	0.05	0.12

Organ weights

Scan Region	Age	Phantom Diameter (cm)	Huda 2011 [47]	Jessen 1999 [48]	EUR 2004 [49]	Deak 2010 [46]
Head	Adult	16	0.0024	0.0021	0.0023	0.0019
Head and Neck	Adult	16/32	0.0045/0.009			
Neck	Adult	16/32	0.0053/0.0107	0.0048/ n/a	0.0054	0.0051/ n/a
Chest	Adult	32	0.0204	0.014	0.019	0.0145
Abdomen	Adult	32	0.0163	0.012	0.017	0.0153
Pelvis	Adult	32	0.0143	0.016	0.017	0.0129
CAP (Trunk)	Adult	32	0.0186			
Legs	Adult	32			0.0008	
Whole Body	Adult	16/32	0.0077/0.0154			

K factors

Effective Dose example



Patient Name: [redacted]
Exam no: [redacted]
Accession Number: UWHC[redacted]
Patient ID: [redacted]
LightSpeed16
Exam Description: CT ABDOMEN PELVIS W IV

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
200	Axial	I68.750-I68.750	20.83	20.80	Body 32
2	Helical	I4.500-I475.125	17.57	879.96	Body 32
		Total Exam DLP:		900.76	

1/1

Scan Region	Age	Phantom Diameter (cm)	Huda 2011 [47]	Jessen 1999 [48]	EUR 2004 [49]	Deak 2010 [46]
Head	Adult	16	0.0024	0.0021	0.0023	0.0019
Head and Neck	Adult	16/32	0.0045/0.009			
Neck	Adult	16/32	0.0053/0.0107	0.0048/ n/a	0.0054	0.0051/ n/a
Chest	Adult	32	0.0204	0.014	0.019	0.0145
Abdomen	Adult	32	0.0163	0.012	0.017	0.0153
Pelvis	Adult	32	0.0143	0.016	0.017	0.0129
CAP (Trunk)	Adult	32	0.0186			
Legs	Adult	32			0.0008	
Whole Body	Adult	16/32	0.0077/0.0154			

These change by non-trivial amounts…

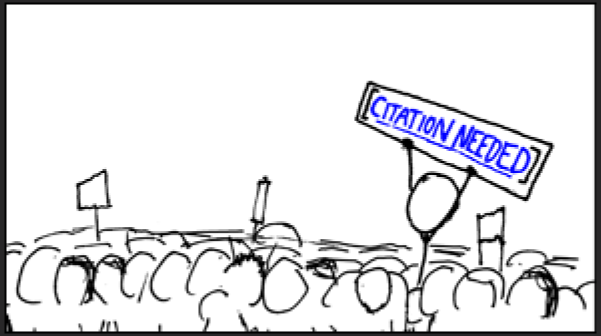
My effective dose was 900.76(mGy*cm)*0.0163(mSv/mGy/cm) = 14.3 mSv

900.76(mGy*cm)*0.012(mSv/mGy/cm) = 10.6 mSv

… vendors and academics play these games

@Prof_TimStick's Actionable information

- If someone gives you an effective dose, ask for k factor reference



https://xkcd.com/

Organ dose: skin

Region or Organ	Dose Limit	Comments
Skin	<2 Gy	No observable negative effects.
Skin	5 Gy	Transient erythema occurring within 2 weeks followed by hair loss, no lasting effects.
Skin	10 Gy	Transient erythema occurring within 2 weeks followed by hair loss, some lasting hair loss, possible lasting dermal atrophy.
Skin	15 Gy	Transient erythema occurring within 2 weeks followed by prolonged erythema and permanent hair loss. Lasting dermal atrophy, Telangiectasia, and lasting weak skin.
Skin	>15 Gy	Within 2 weeks, ulceration, transient erythema, edema. Surgical intervention likely to be needed. Lasting dermal atrophy, Telangiectasia, and persistent deep wound.
Eye Lens	0.5 Gy	The cataract induction dose limit is 0.5 Gy [26]. To safely work in a radiation environment, the ICRP statement recommends limiting eye absorbed dose to a 5-year average of 20 mSv (i.e., mGy for MDCT photons) with no single year over 50 mSv (i.e., mGy for MDCT photons) [26]. At the time of this writing, the European Atomic Energy Community (via COUNCIL DIRECTIVE 2013/59/ EURATOM) has issued a directive that limits the equivalent dose for the lens of the eye to 20 mSv in a single year or 100 mSv in any five consecutive years, slightly different than the ICRP recommendation.

"The CT Handbook: Optimizing Protocols for Today's feature-rich scanners"
By Tim Szczykutowicz. Medical Physics Publishing 2020

http://blogs.wsj.com/health/2009/10/13/hospital-mistake-gives-patients-radiation-overdose/
http://www.nytimes.com/2009/10/16/us/16radiation.html?_r=0

Table 4.3 Head, neck, and cervical spine doses from Kanal et al. 2017 [41]

Examination and Median Size (Thickness or Diameter)	Size (cm)	No. of Facilities	No. of Patients	$CTDI_{vol}$ (mGy)		DLP (mGy-cm)	
				AD (50th Percentile)	DRL (75th Percentile)	AD (50th Percentile)	DRL (75th Percentile)
Head and brain without contrast material*	12–14	227	19,993	47	56	767	936
	14–16	290	137,755	49	56	811	962
	16–18	256	57,292	52	60	902	1,020
	18–20	160	5,390	51	60	926	1,069
	All†	347†	223,908	49	57	849	1,011
Neck with contrast material‡	14–18	352	9,458	14	18	377	509
	18–22	350	8,723	15	19	429	563
	22–26	334	5,717	15	19	423	560
	26–30	307	5,012	16	20	457	572
	30–34	259	2,655	17	23	494	656
	All†	417†	33,740	15	20	431	572
Cervical spine without contrast material§	13–17	350	22,739	18	24	362	495
	17–21	375	36,711	20	28	421	562
	21–25	346	18,600	21	28	438	575
	25–29	326	11,640	22	29	450	609
	29–33	265	5,477	25	33	551	703
	All†	434†	97,586	21	28	432	602

NOTE: The AD is the 50th percentile of the distribution of median values (the 50th percentile) of all participating facilities, and the DRL is the 75th percentile of the distribution of median values of all participating facilities.

* Only lateral thickness (cm) was used. The median lateral thickness was 15 cm.

† "All" includes data beyond lowest- and highest-size bins. "No. of facilities" is the total number of facilities submitting data for any size patient.

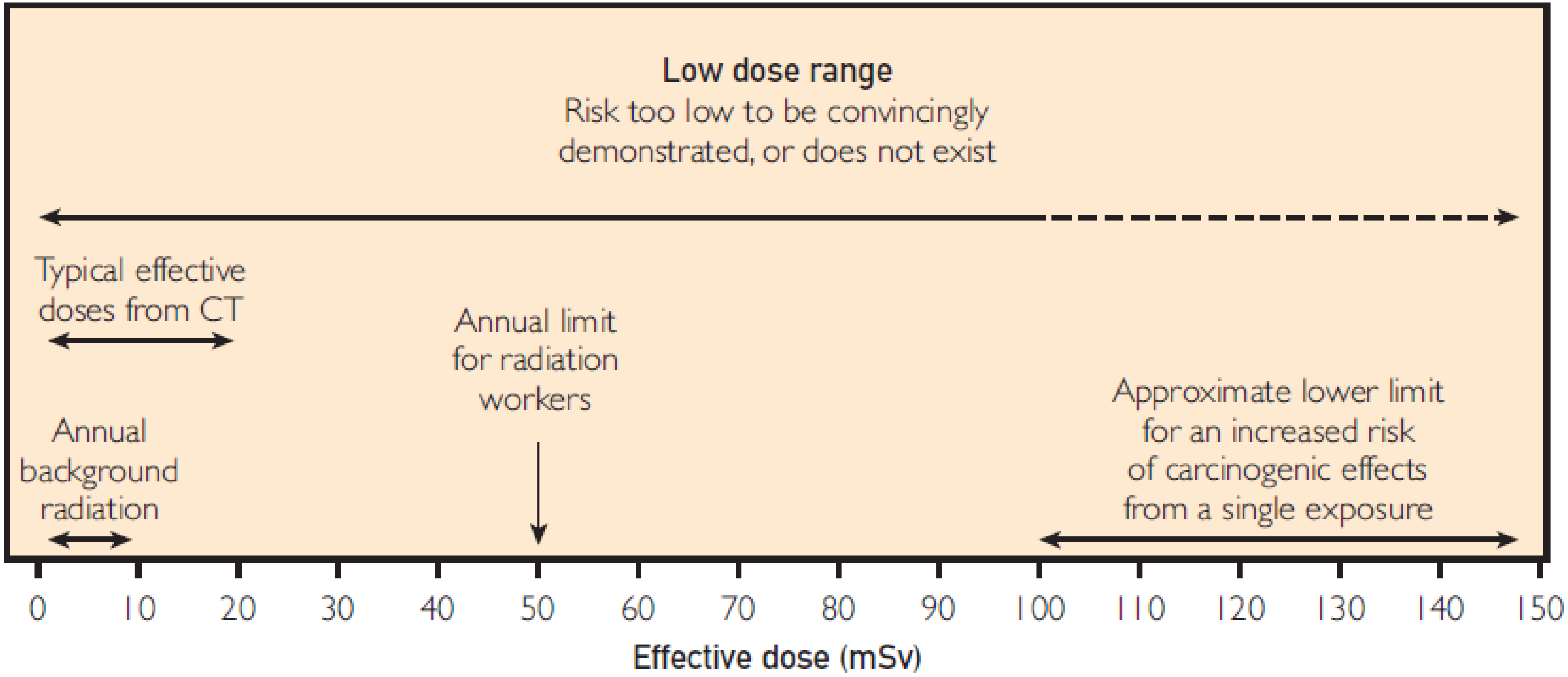
‡ Water-equivalent diameter (cm) was used. The median diameter was 20 cm.

§ Water-equivalent diameter (cm) was used. The median diameter was 19 cm.

SPECIAL ARTICLE

Answers to Common Questions About the Use and Safety of CT Scans

Cynthia H. McCollough, PhD; Jerrold T. Bushberg, PhD; Joel G. Fletcher, MD; and Laurence J. Eckel, MD

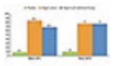


Current CT doses are below the level at which, according to widely accepted data, radiation induced effects occur. The AAPM policy on this topic states *"…epidemiological evidence supporting increased cancer incidence or mortality from radiation doses below 100 mSv is inconclusive."* Diagnostic CT dose levels range from less than 1 mSv to ~20 mSv (e.g., multiphase torso exams) depending on indication.

https://www.aapm.org/org/policies/details.asp?id=318&type=PP&current=true

One of the 12 "Recommended Research Needs" of the BEIR VII report makes it clear there is no consensus on the validity of summing CT dose: "*In vitro and in vivo data are needed for delivery of low doses over several weeks or months at very low dose rates or with fractionated exposures. The cumulative effect of multiple low doses of less than 10 mGy delivered over extended periods has to be explored further.*"

The NEW ENGLAND JOURNAL of MEDICINE



REVIEW ARTICLE CURRENT CONCEPTS

Computed Tomography — An Increasing Source of Radiation Exposure

David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phil., D.Sc.

Article Figures/Media

46 References 4867 Citing Articles Letters

November 29, 2007
N Engl J Med 2007; 357:2277-2284
DOI: 10.1056/NEJMra072149

a public health issue some years in the future. On the basis of such risk estimates and data on CT use from 1991 through 1996, it has been estimated that about 0.4% of all cancers in the United States may be attributable to the radiation from CT studies.[2,34] By adjusting this estimate for current CT use (Figure 2), this estimate might now be in the range of 1.5 to 2.0%.

Citation report for 769 results from Web of Science Core Collection between 1900 and 2019 Go

You searched for: **TITLE:** (ct dose reduction) **...More**

This report reflects citations to source items indexed within Web of Science Core Collection. Perform a Cited Reference Search to include citations to items not indexed within Web of Science Core Collection.

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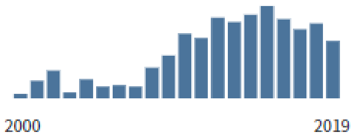


h-index

62

Average citations per item

18.11

Sum of Times Cited

13,924

Without self citations

12,606

Citing articles

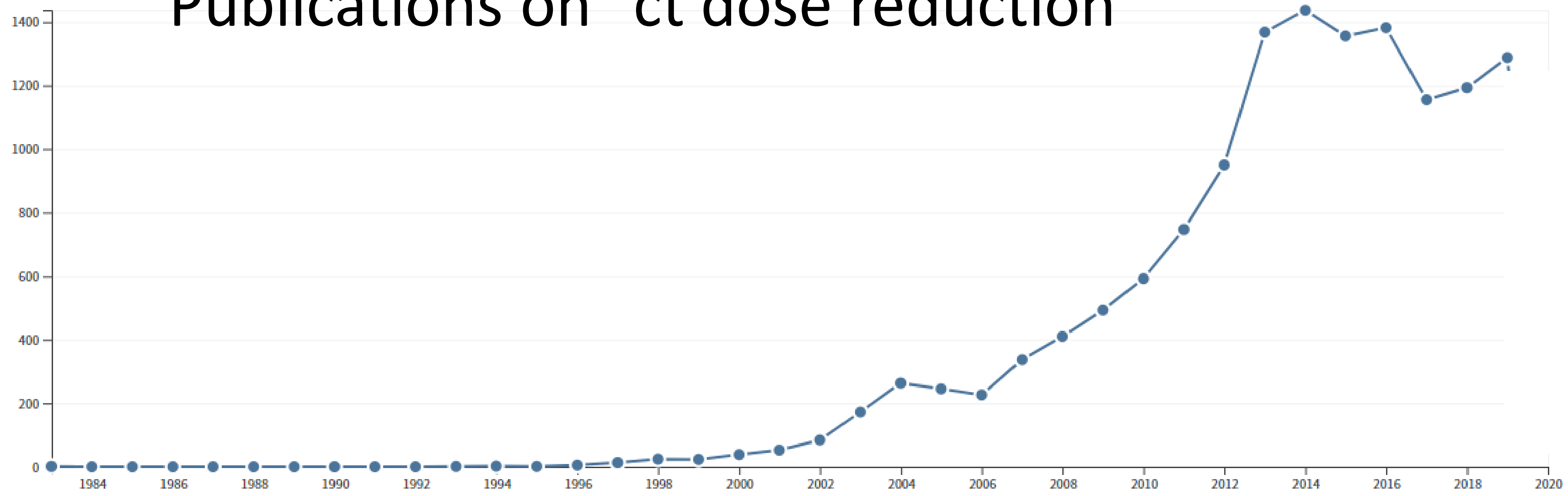
7,434 Analyze

Without self citations

7,022 Analyze

Sum of Times Cited per Year

Publications on “ct dose reduction”



Original Investigation

April 14, 2025

Projected Lifetime Cancer Risks From Current Computed Tomography Imaging

Rebecca Smith-Bindman, MD[1,2,3]; Philip W. Chu, MS[1]; Hana Azman Firdaus, MPH

» Author Affiliations | Article Information

JAMA Intern Med. Published online April 14, 2025. doi:10.1001/jamainternmed.2

~20 years later, you can still publish and get headlines on this

ct radiation dose

All Images Videos News Short videos Shopping Forums ⋮ More Tools

Verywell Health

Study Says CT Scan Could Account for 5% of All Cancer Cases. What Do Radiologists Think?

Cancer risk from a single CT scan is low, but repeated exposure could increase the risk of radiation-induced cancer.

1 hour ago

NPR

Study highlights cancer risk from millions of CT scans performed annually

They can be life-saving but radiation from the scans also contributes to cancer risk. The authors of a new study estimate overuse of CT...

1 week ago

Hematology Advisor

CT Exams in 2023 Projected to Result in 103,000 Future Cancers

Hemato ADVISOR

(HealthDay News) — At current utilization and radiation dose levels, computed tomography (CT) examinations in 2023 were projected to result...

17 hours ago

Novel study in that they did more accurate organ dose calculations for individual patients (by size and gender and CT technique parameters)

Not novel in that they then went against all major professional societies recommended use of atomic bomb survivor data and estimated cancer rates from this data

Do I have to worry about a pt getting a lot of scans over their life?

Suggestions for topics suitable for these Point/Counterpoint debates should be addressed to Habib Zaidi, Geneva University Hospital, Geneva, Switzerland: habib.zaidi@hcuge.ch; Jing Cai, The Hong Kong Polytechnic University, Hong Kong: jing.cai@polyu.edu.hk; and/or Gerald White, Colorado Associates in Medical Physics: gerald.white@mindspring.com. Persons participating in Point/Counterpoint discussions are selected for their knowledge and communicative skill. Their positions for or against a proposition may or may not reflect their personal opinions or the positions of their employers.

CT is still not a low-dose imaging modality

Madan M. Rehani, Ph.D.
Radiology Department, Massachusetts General Hospital, 175 Cambridge Str., Suite 244, Boston, MA 02114, USA,
(Tel. Tel: 608-263-5729; E-mail: mrehani@mgh.harvard.edu)

Timothy P. Szczykutowicz, Ph.D.
Departments of Radiology, Medical Physics, and Biomedical Engineering, University of Wisconsin-Madison, Madison, WI, USA,
(Tel. Tel: 608-263-5729; E-mail: tszczykutowicz@uwhealth.org)

Habib Zaidi, Ph.D., Moderator

(Received 17 December 2019; revised 20 December 2019; accepted for publication 23 December 2019; published 20 January 2020)

[https://doi.org/10.1002/mp.14000]

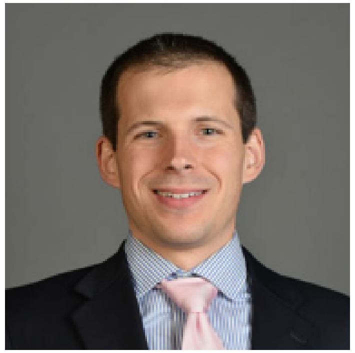
OVERVIEW

Clinical diagnosis of a number of diseases is seldom performed without resorting to multimodality imaging technology in the era of personalized and precision medicine. Among the existing plethora of imaging techniques, computed tomography (CT) plays a pivotal role in the clinical setting owing to widespread availability of equipment and expertise as well as acceptance of this technology. Yet, medical radiation exposure of patients has become an important public health concern worldwide. Significant efforts by the vendors to improve CT scanner technology and by medical physicists and radiologists to optimize acquisition protocols have significantly reduced the radiation dose from CT examinations to address the concerns of patients and general public

driven by unp... hysteria.

Although t... patients from ... ports contradi... dose is declin... multinational ... lative doses. E... and dose redu... the clinic, son... dose imaging ... of "low dose" ... increase unjus... decline CT ex... ease or even ... this month's P...

Arguing fo... Dr. Rehani rec... of Medical Sc... ious faculty po... Physics at the... 2001 to Vien... Agency (IAE... moved in 20... Hospital (MG... Director, Glo... MGH and Pr... Medical Physi... International Commission on Radiological Protection (ICRP) for almost two decades and has authored eight Annals of ICRP, four of which as the Chair of the group. He is the Senior Editor of the British Journal of Radiology, acts as Associate Editor for Medical Physics and was Assistant Editor for the American Journal of Radiology for many years.



...ditorials in the ...nal of Cardiol-... ...y P. Szczyku-... ...te Professor of ...dison. He spe-... reconstruction ...ocol optimiza-... ...rations for the ...date, protocols ...ore than 2,000 ...editorial board ...phy and Radio-... ...33 papers, two ...t in 2020. Dr. ...are and on the

...HANI, PH.D.

...nformation has ... have assessed ...ave helped to ...ile maintaining ...nd how much ...e CT examina-... where one can ...The concept of low or high is always relative and is related to use and risks. The risk depends on how recurrent the use is. Most medicines require recurrent use. Does one just talk about risk of a single dose or one needs to also talk about the dose in a collective manner? If a surgery is performed only once, one will obviously talk about the risk of a single surgery. If it is to be performed many times, one cannot simply talk about risks of individual surgery in isolation. Three papers published recently[6–8] covering data of 3.2 million patients undergoing CT examinations in 344 hospitals in 20 countries have shown that 0.64% to 3.4% of the patients undergoing CT examinations reach cumulative effective doses (CED) of ≥100 mSv in a 1- to 5-year period. The papers estimated that about 0.9 million patients probably reach a CED ≥100 mSv every year globally through recurrent CT examinations alone.

About every fifth patient (nearly 20%, 13.4–28% in the whole sample) who was exposed to more than 100 mSv in this study was ≤50 years old. Further, these papers identified patients in this cohort who are < 40 years of age and with no malignant disease. One of these three papers assessed imaging appropriateness in a subset of patients.[7] While previous studies documented overuse of CT or unoptimized techniques, neither of these was the case in the above cohort.

Can we tell millions of these patients that CT is a low-dose imaging modality? This is reasonable only if medical physicists consider their responsibility to be limited to single CT examinations and excludes managing the patient's overall history of medical radiation exposure. Medical physicists have responsibility toward patient radiation safety and that is what creates requirements in national regulations for their appointment at first place.

Why have we missed identifying the magnitude of cumulative CT doses so long? Perhaps because we have been guided by "fear" of misuse of cumulative dose. We often say that radiation is not as harmful as the fear of radiation. Much as we preach avoidance of fear, we are ourselves affected by fears, otherwise we would have identified the issue much earlier. Assessing calories in a single item of food as well as the whole meal and full daily intake of food all go together. If we stop at a single examination, we are missing the very purpose for which we assess the radiation dose.

AGAINST THE PROPOSITION: TIMOTHY P. SZCZYKUTOWICZ, PH.D.

Opening Statement

The label "low dose" is arbitrary and implies there exists "high-dose" imaging modalities. It is a label misused by our community to assuage patient fear over CT screening examinations and by researchers and vendors to advertise their technical improvements. Here follows my arguments for why the label "low dose" is flawed and why CT must not be considered "high dose."

1. Current CT doses are below the level at which, according to widely accepted data, radiation-induced effects occur. The AAPM policy on this topic states "…epidemiological evidence supporting increased cancer incidence or mortality from radiation doses below 100 mSv is inconclusive."[9] Diagnostic CT dose levels range from less than 1 mSv to ~20 mSv (e.g., multiphase torso examinations) depending on indication.[10]
2. **The lack of a definition for "low dose" has resulted in the term "low" corresponding to a continuously decreasing and therefore unobtainable goal which**

Yes, I clearly have an opinion on this. The logistics of implementing of a CED based alarm scare me those most, even if CED induced stochastic cancer induction is is true.

Published in final edited form as:
AJR Am J Roentgenol. 2013 June ; 200(6): 1275–1283. doi:10.2214/AJR.12.10011.

HOW RADIATION EXPOSURE HISTORIES INFLUENCE PHYSICIAN IMAGING DECISIONS: A MULTICENTER RADIOLOGIST SURVEY STUDY

Pari V. Pandharipande, MD, MPH[1,2,3], **Jonathan D. Eisenberg, BA**[1,2,6], **Laura L. Avery, MD**[2,3], **Martin L. Gunn, MD**[4], **Stella K. Kang, MD**[2,5], **Alec J. Megibow, MD, MPH**[5], **Ekin A. Turan, BA**[1,2], **H. Benjamin Harvey, MD, JD**[1,3], **Chung Yin Kong, PhD**[1,2,3], **Emily C. Dowling, MHS**[1,2], **Elkan F. Halpern, PhD**[1,2,3], **Karen Donelan, ScD**[1,3,7], and **G. Scott Gazelle, MD, MPH, PhD**[1,2,3]

[1]Massachusetts General Hospital Institute for Technology A

[2]Department of Radiology, Massachusetts General Hospital

[3]Harvard Medical School

[4]University of Washington Department of Radiology, Harbor

[5]Department of Radiology, NYU Langone Medical Center

[6]University of Massachusetts Medical School

[7]Mongan Institute for Health Policy at Massachusetts Gener

Abstract

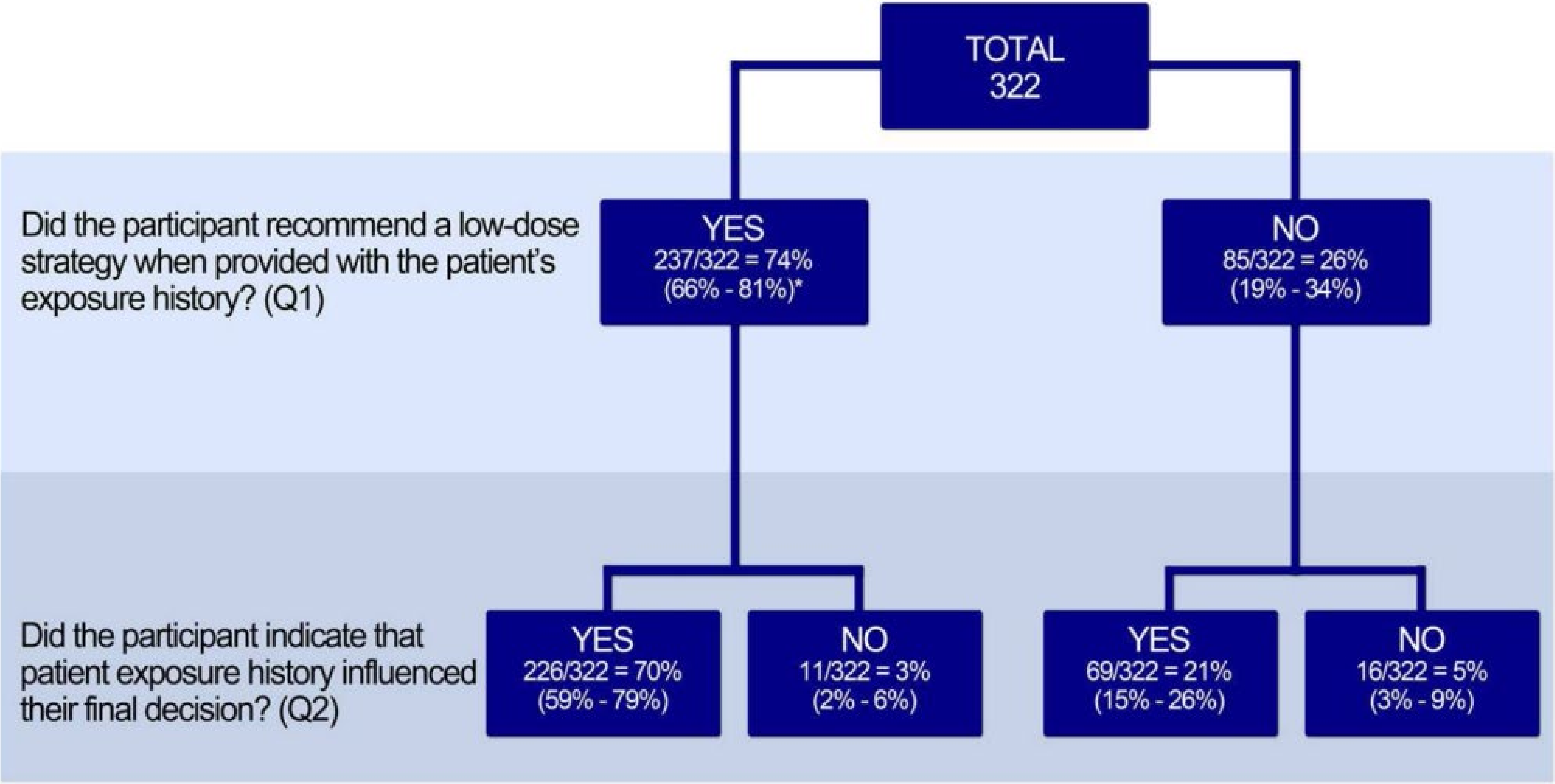
Patient Vignette

The survey began with the following vignette: "A PCP (Primary Care Provider) calls you, a radiologist, to discuss imaging options for a patient that he recently saw in clinic. The patient is a 35-year-old man with non-specific abdominal pain.

After discussing the nature of the patient's pain and presentation, and after weighing the risks and benefits of all possible imaging options, you recommend a standard abdominopelvic CT. You determine that in this patient's case, its net benefit is likely to be superior – albeit only slightly – to all other imaging options.

As you are about to hang up, the PCP remembers some additional information. He states that the patient has had 15 prior CT scans, totaling 150-mSv. These took place after a car accident 10 years ago. Initial scans were performed routinely as part of a trauma protocol – no abdominal injuries were detected, and the patient did not undergo surgery. Subsequent scanning was for follow-up of incidental findings, all benign. You and the PCP agree that the patient's accident and incidental findings are not related to his current abdominal pain.

The PCP asks for your final recommendation, in light of the patient's prior radiation exposure history."



*Beneath all multicenter percentages, percentages are provided (in parentheses) which reflect the ranges of the three individual, participating institutions.

- Facts on cumulative effective dose
  - Easy to calculate, you just sum up effective dose in a patient's history
    - No studies have been performed relating integration period with negative stochastic cancer effects.
  - Denying CT based on CED means we are weighing current need for CT lower than future potential cancer risks
    - No studies have been performed or guidance given from advocates of CED on age/indication based CED limits

- Facts on cumulative effective dose
  - Easy to calculate, you just sum up effective dose in a patient’s history
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  - Denying CT based on CED means we are weighing current need for CT lower than future potential cancer risks
    - No studies have been performed or guidance given from advocates of CED on age/indication based CED limits

“Repeat customers” to your CT clinic will likely die within a few years. Using CED to keep them from getting a CT isn’t supported by the literature.

ORIGINAL RESEARCH ■ HEALTH POLICY AND PRACTICE

Body CT Scanning in Young Adults: Examination Indications, Patient Outcomes, and Risk of Radiation-induced Cancer[1]

Radiology

Robert L. Zondervan, BA
Peter F. Hahn, MD, PhD
Cheryl A. Sadow, MD
Bob Liu, PhD
Susanna I. Lee, MD, PhD

Purpose: To quantify patient outcome and predicted cancer risk from body computed tomography (CT) in young adults and identify common indications for the imaging examination.

Materials and Methods: This retrospective multicenter study was HIPAA compliant and approved by the institutional review boards of three institutions, with waiver of informed consent. The

Conclusion: Among young adults undergoing body CT, risk of death from underlying morbidity is more than an order of magnitude greater than death from long-term radiation-induced cancer.

Outcome and Predicted CT-induced Cancer Risk for Patients Undergoing Chest CT without a Known Cancer Diagnosis

Frequency of Scanning	No. of Patients	No. Dead	Percentage Dead	No. of CT Cancer Cases	No. of CT Cancer Deaths	Percentage of CT Cancer Deaths
Very rarely, 1–2 scans	5914	215	3.6	5	3	0
Rarely, 3–5 scans	418	51	12.2	1	1	0.1
Moderately, 6–14 scans	95	28	29.5	0	0	0.3
Frequently, > 15 scans	12	6	50.0	0	0	0.6
Overall	6439	300	4.7	6	4	0.1

Note.—For all comparisons, $P < .001$.

Table 8

Outcome and Predicted CT-induced Cancer Risk for Patients Undergoing Abdominopelvic CT without a Known Cancer Diagnosis

Frequency of Scanning	No. of Patients	No. Dead	Percentage Dead	No. of CT Cancer Cases	No. of CT Cancer Deaths	Percentage of CT Cancer Deaths
Very rarely, 1–2 scans	11 291	219	1.9	12	6	0.1
Rarely, 3–5 scans	952	66	6.9	3	1	0.2
Moderately, 6–14 scans	219	21	9.6	1	1	0.4
Frequently, > 15 scans	10	3	30.0	0	0	0.8
Overall	12 472	309	2.5	16	8	0.1

Note.—For all comparisons, $P < .001$.

Real data

LNT model

Our findings demonstrate that young adults undergoing body CT are at a higher risk of dying of radiation-induced cancer than the general population. The average risk of an American man or woman between the ages of 18 and 35 dying within a 5-year window is 1.1% (23). In contrast, the observed mortality rate over the 5.5-year follow-up period in our study was 7.1% and 3.9% in the chest and abdominopelvic CT cohorts, respectively; even among very rarely scanned noncancer patients, in whom the lowest death rates were observed, mortality was still higher than in the general population at 3.6% and 1.9%, respectively. In this context, the added 0.1% death risk attributable to radiation from CT scanning, while not negligible, is tiny in comparison.

Moreover, for the radiologist advising a patient or referring physician about radiation concerns, our results define the patient's underlying medical morbidity, rather than CT-induced cancer, as the dominant factor driving a potentially adverse outcome.

Radiology

Impact of Reduced Patient Life Expectancy on Potential Cancer Risks from Radiologic Imaging[1]

David J. Brenner, PhD, DSc
Igor Shuryak, MD, PhD
Andrew J. Einstein, MD, PhD

ORIGINAL RESEARCH ■ MEDICAL PHYSICS

Purpose: To quantify the effect of reduced life expectancy on cancer risk by comparing estimated lifetime risks of lung cancer attributable to radiation from commonly used computed tomographic (CT) examinations in patients with and those without cancer or cardiac disease.

Conclusion: The importance of radiation exposure in determining optimal imaging usage is much reduced for patients with markedly reduced life expectancies: Imaging justification and optimization criteria for patients with substantially reduced life expectancies should not necessarily be the same as for those with normal life expectancies.

- Recently, Rehani *et al.* have revisited cumulative effective dose
  - Need for caution here, as
    - No studies have linked CED to increases in cancer risks
    - There is no consensus on the time periods over which CED may be summed
    - The almost ubiquitous use of informatics solutions to track/monitor CT dose makes implementing “CT CED alarms” trivial. Without science to back up length of CED summing or CED values for specific patient indications/ages/clinical scenarios, how do we use a “CT CED alarm”?
    - Proponents of CED need to address the question “For what patients does the ~1% increase over baseline risk of cancer motivate refusing CT in the setting of trauma”

Physica Medica 76 (2020) 173–176

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/ejmp

Technical note

Estimates of the number of patients with high cumulative doses through recurrent CT exams in 35 OECD countries

Madan M. Rehani[a,*], Michael Hauptmann[b]

[a] Massachusetts General Hospital, Boston, MA 02114, USA
[b] Institute of Biostatistics and Registry Research, Brandenburg Medical School, 16816 Neuruppin, Germany

European Radiology (2020) 30:2493–2501
https://doi.org/10.1007/s00330-019-06528-7

COMPUTED TOMOGRAPHY

Multinational data on cumulative radiation exposure of patients from recurrent radiological procedures: call for action

Marco Brambilla[1] · Jenia Vassileva[2] · Agnieszka Kuchcinska[3] · Madan M. Rehani[4]

Received: 21 July 2019 / Revised: 15 September 2019 / Accepted: 17 October 2019 / Published online: 2 December 2019

Abstract
Objectives To have a global picture of the recurrent use of CT imaging to a level where cumulative effective dose (CED) to individual patients may be exceeding 100 mSv at which organ doses typically are in a range at which radiation effects are of concern

My AAPM
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- Position Statements & Policies
- Association Governance
- Committees
- Committee Classifieds
- Individual Appointments
- History & Heritage
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GOVERNANCE

This Policy is No Longer Active.

POLICY NUMBER	POLICY NAME	POLICY DATE	SUNSET DATE
PP 35-A	AAPM/ACR/HPS Joint Statement on Proper Use of Radiation Dose Metric Tracking for Patients Undergoing Medical Imaging Exams	8/6/2021	12/31/2026

Section
No section assigned

Policy source

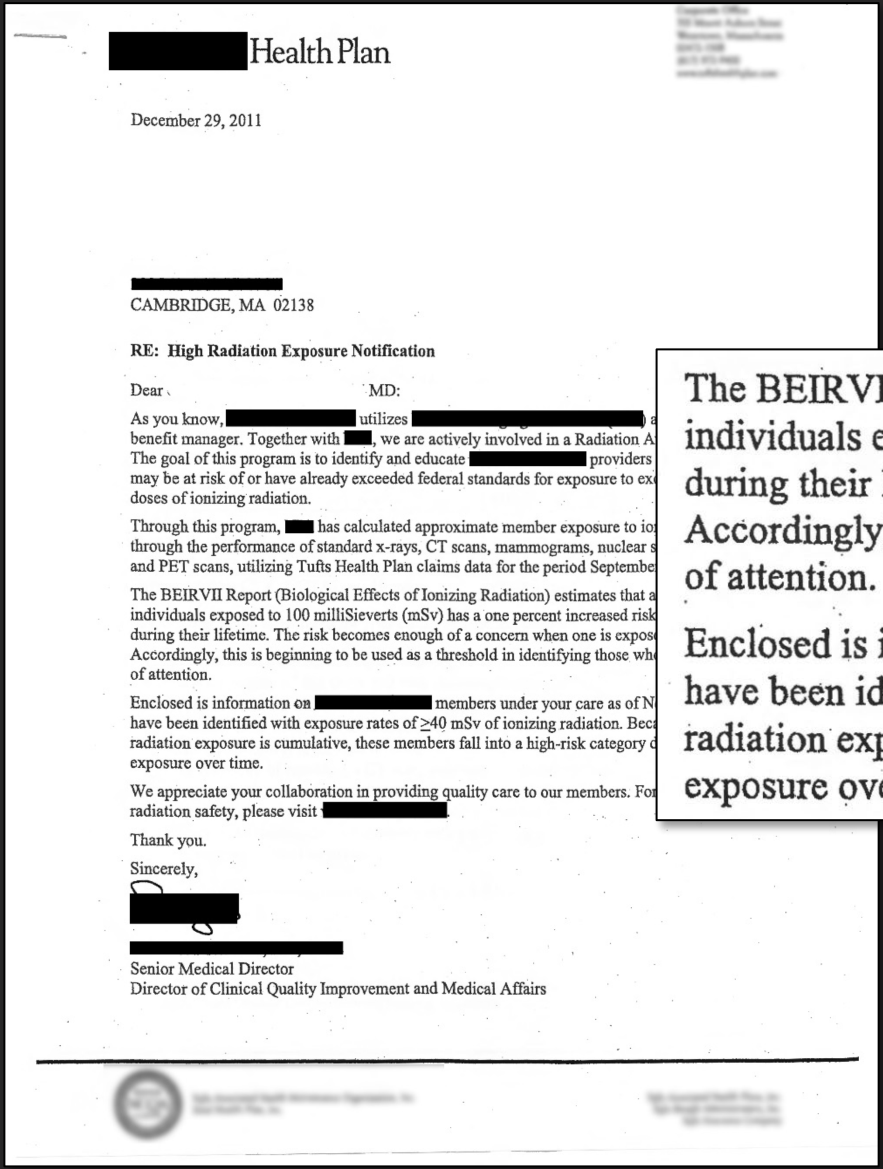
August 6-7, 2021 Board of Directors Meeting Minutes

Policy text

It is the position of the American Association of Physicists in Medicine (AAPM), the American College of Radiology (ACR), and the Health Physics Society (HPS) that the decision to perform a medical imaging exam should be based on clinical grounds, including the information available from prior imaging results, and not on the dose from prior imaging-related radiation exposures.

AAPM has long advised, as recommended by the International Commission on Radiological Protection (ICRP), that justification of potential patient benefit and subsequent optimization of medical imaging exposures are the most appropriate actions to take to protect patients from unnecessary medical exposures. This is consistent with the foundational principles of radiation protection in medicine, namely that patient radiation dose limits are inappropriate for medical imaging exposures. Therefore, the AAPM recommends against using dose values, including effective dose, from a patient's prior imaging exams for the purposes of medical decision making. Using quantities such as cumulative effective dose may, unintentionally or by institutional or regulatory policy, negatively impact medical decisions and patient care.

This position statement applies to the use of metrics to longitudinally track a patient's dose from medical radiation exposures and infer potential stochastic risk from them. It does not apply to the use of organ-specific doses for purposes of evaluating the onset of deterministic effects (e.g., absorbed dose to the eye lens or skin) or performing epidemiological research.



[redacted] Health Plan

December 29, 2011

[redacted]
CAMBRIDGE, MA 02138

RE: High Radiation Exposure Notification

Dear MD:

As you know, [redacted] utilizes [redacted] a
benefit manager. Together with [redacted], we are actively involved in a Radiation A
The goal of this program is to identify and educate [redacted] providers
may be at risk of or have already exceeded federal standards for exposure to ex
doses of ionizing radiation.

Through this program, [redacted] has calculated approximate member exposure to io
through the performance of standard x-rays, CT scans, mammograms, nuclear s
and PET scans, utilizing Tufts Health Plan claims data for the period Septembe

The BEIRVII Report (Biological Effects of Ionizing Radiation) estimates that a
individuals exposed to 100 milliSieverts (mSv) has a one percent increased risk
during their lifetime. The risk becomes enough of a concern when one is expos
Accordingly, this is beginning to be used as a threshold in identifying those wh
of attention.

Enclosed is information on [redacted] members under your care as of N
have been identified with exposure rates of ≥40 mSv of ionizing radiation. Beca
radiation exposure is cumulative, these members fall into a high-risk category d
exposure over time.

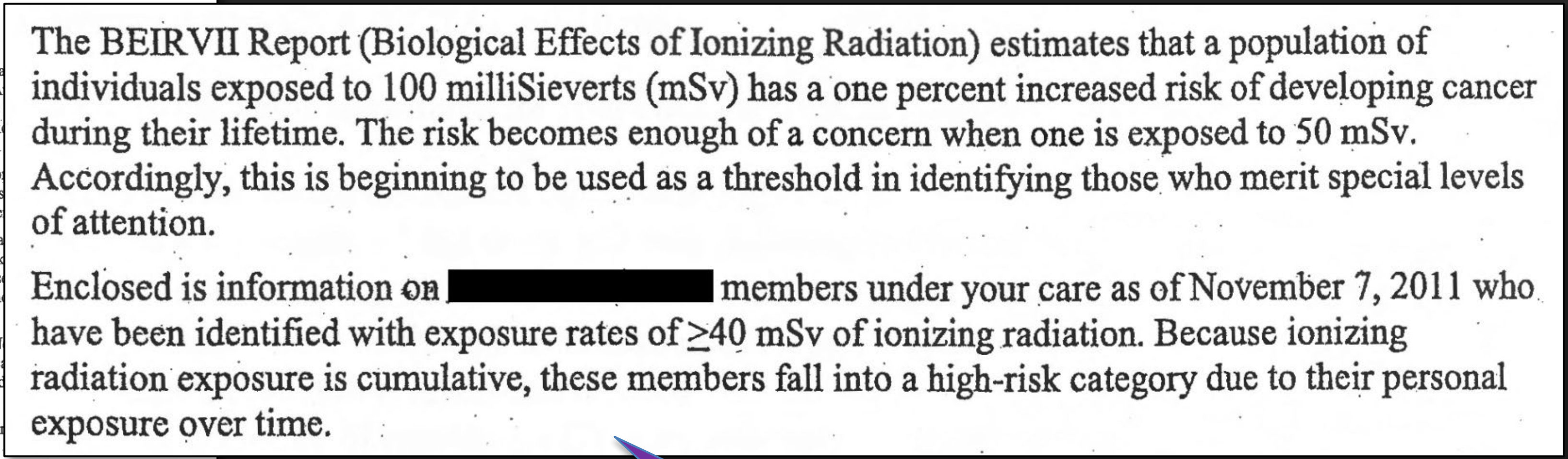
We appreciate your collaboration in providing quality care to our members. For
radiation safety, please visit [redacted].

Thank you.

Sincerely,

[redacted]

Senior Medical Director
Director of Clinical Quality Improvement and Medical Affairs



The BEIRVII Report (Biological Effects of Ionizing Radiation) estimates that a population of individuals exposed to 100 milliSieverts (mSv) has a one percent increased risk of developing cancer during their lifetime. The risk becomes enough of a concern when one is exposed to 50 mSv. Accordingly, this is beginning to be used as a threshold in identifying those who merit special levels of attention.

Enclosed is information on [redacted] members under your care as of November 7, 2011 who have been identified with exposure rates of ≥40 mSv of ionizing radiation. Because ionizing radiation exposure is cumulative, these members fall into a high-risk category due to their personal exposure over time.

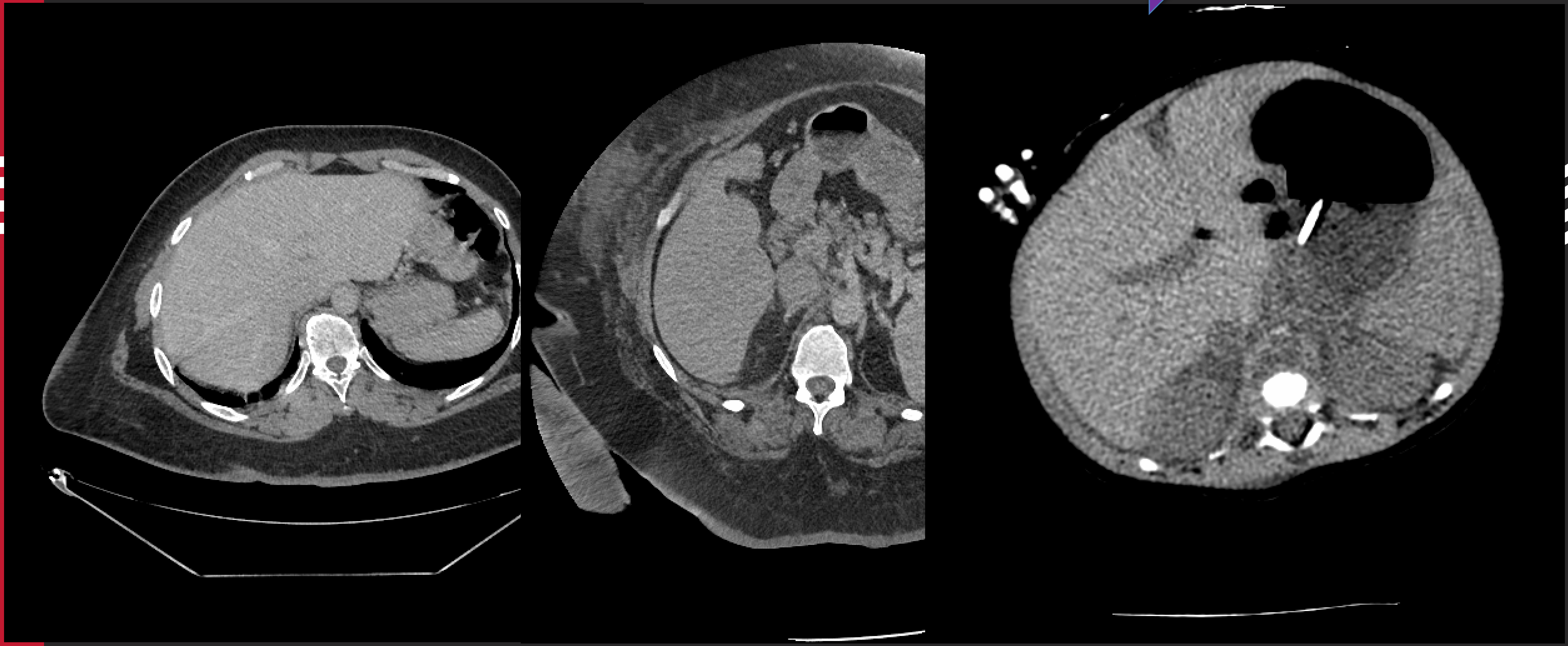
This gets real quick. This crap science is giving another reason for insurance companies to deny claims.

@Prof_TimStick's Actionable information

- Evidence to date demonstrates the theoretical risks of cancer incidence and cancer death to be orders of magnitude smaller than our patients underlying morbidity → don't let past radiation exposures impact your decision to order present or future studies, advocates of CED don't have data to guide us on how or when to apply CED in the clinic

Crappy image risk vs radiation risk

noise



- Noise
  - Standard deviation of pixels in a uniform ROI (def used in practice)
    - All PACS workstations will let you measure this, don't confuse it with the mean/max/min which are also commonly displayed

Parameter	Affect on noise
Beam energy ↑	↓
Slice thickness ↑	↓
Dose ↑	↓
Bone/lung switch to brain/soft tissue kernel/algorithm	↓
Pitch ↑	No effect is using AEC, if manual then ↑
Tube current ↑	↓

Makes more photons

Lets more photons go into image

Makes more photons

Blurs image, so noise goes down

Makes more photons

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  - Standard deviation of pixels in a uniform ROI (def used in practice)
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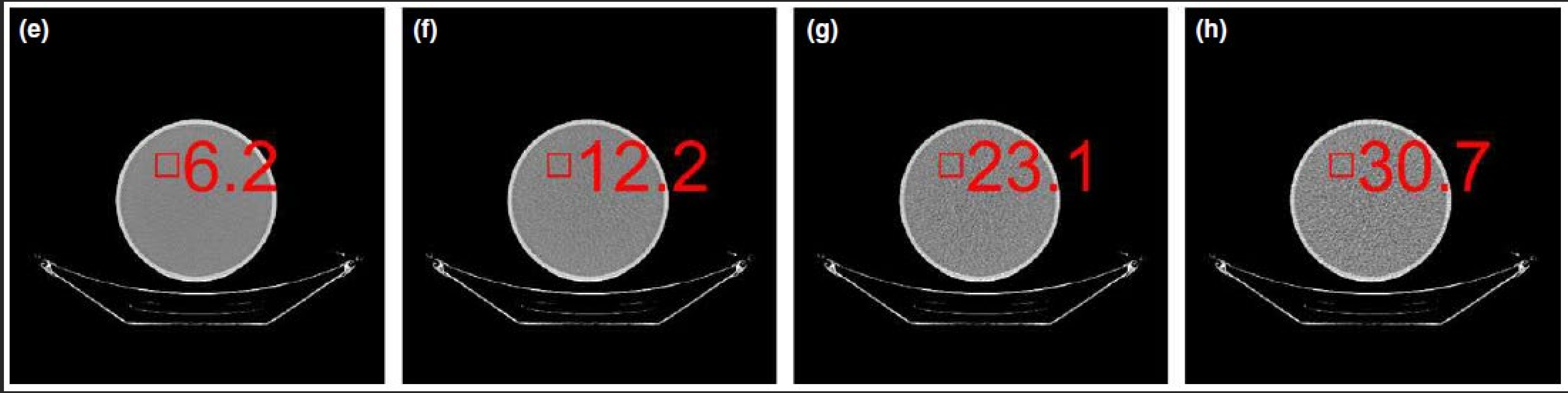
Pitch ↑	No effect is using AEC, if manual then ↑
Tube current ↑	↓

- Noise $\propto \frac{1}{\sqrt{\text{Dose}}}$



280 mAs | 70 mAs | 20 mAs | 10 mAs

- So the exponent on dose is -0.5
  - Noise $= c(\text{Dose})^n$

Image from: A method to extract image noise level from patient images in CT, Malkus and Szcz… Med. Physics 2017

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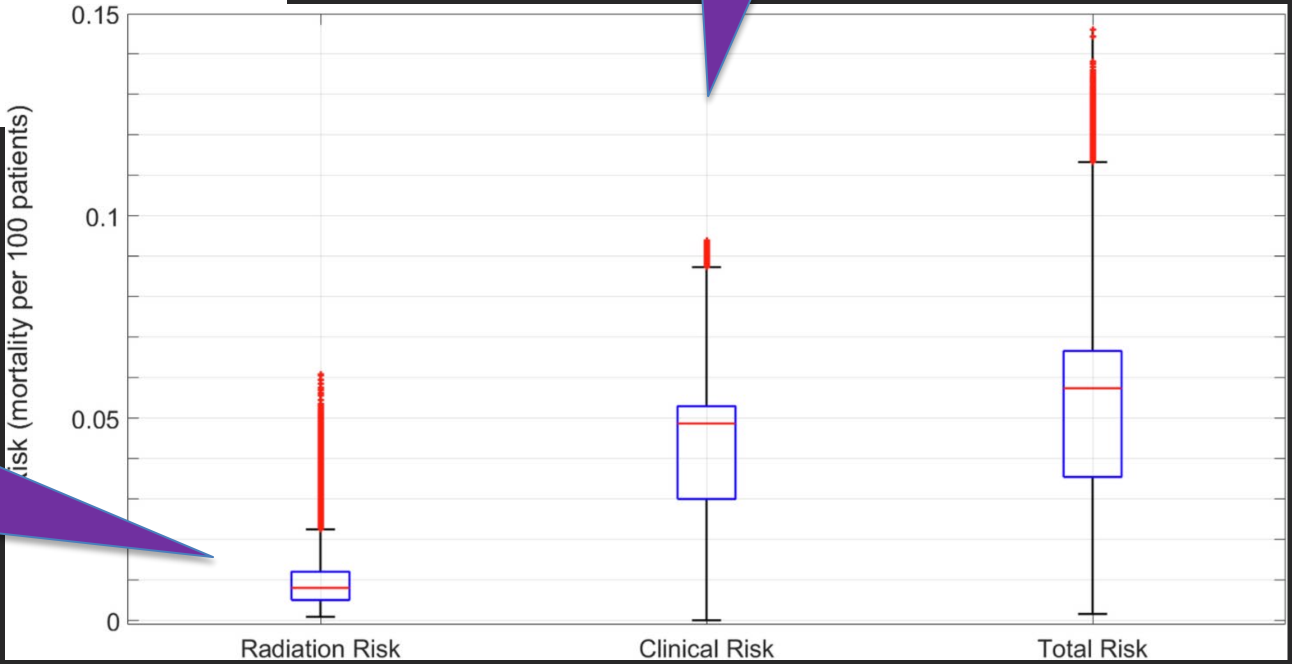
Optimization of abdominal CT based on a model of total risk minimization by putting radiation risk in perspective with imaging benefit

Francesco Ria, Anru R. Zhang, Reginald Lerebours, Alaattin Erkanli, Ehsan Abadi, Daniele Marin & Ehsan Samei

Communications Medicine **4**, Article number: 272 (2024) | Cite this article

Model missing cancer due to images that are noisy

BEIR VII report based risk using linear no threshold model



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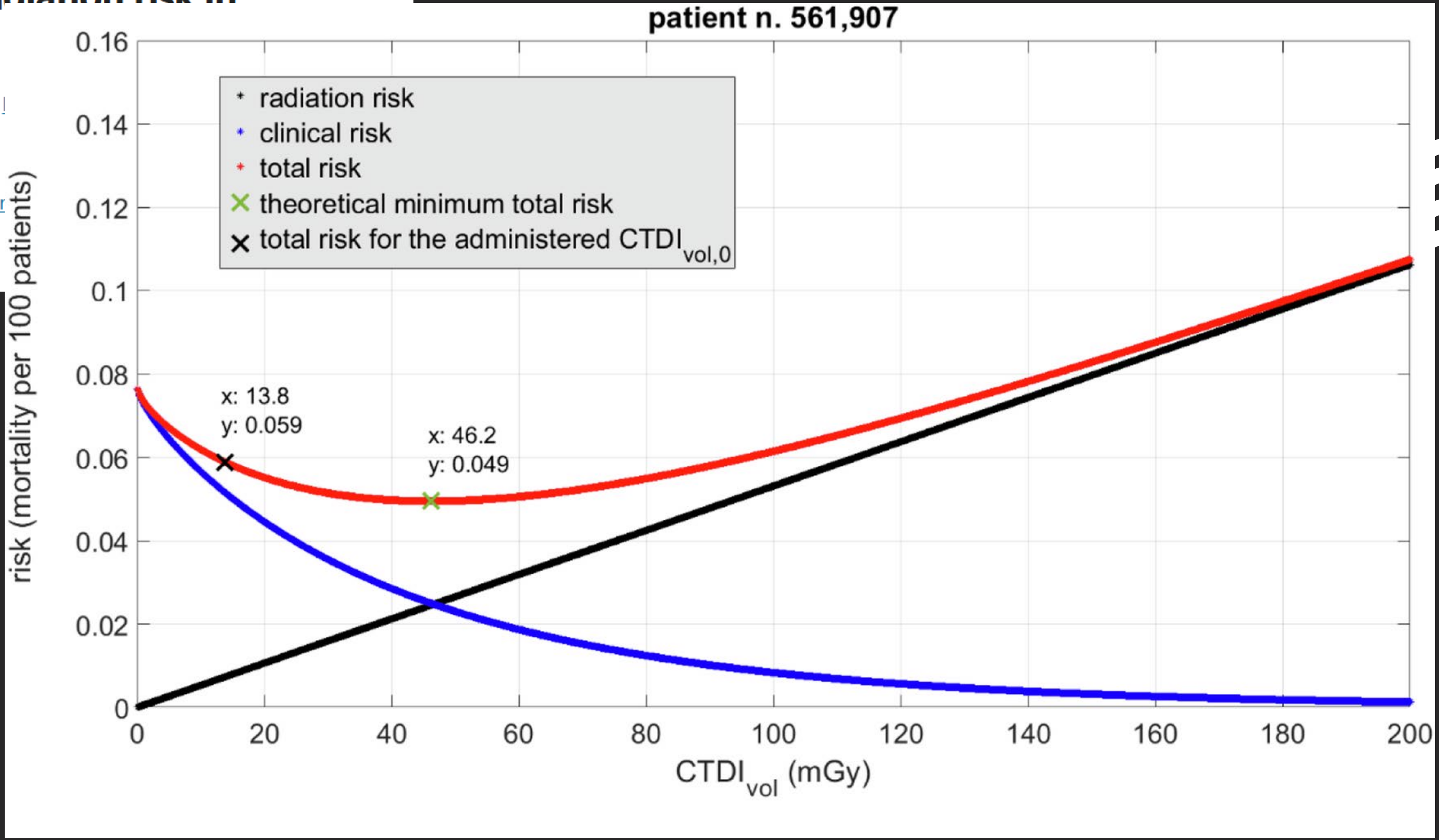

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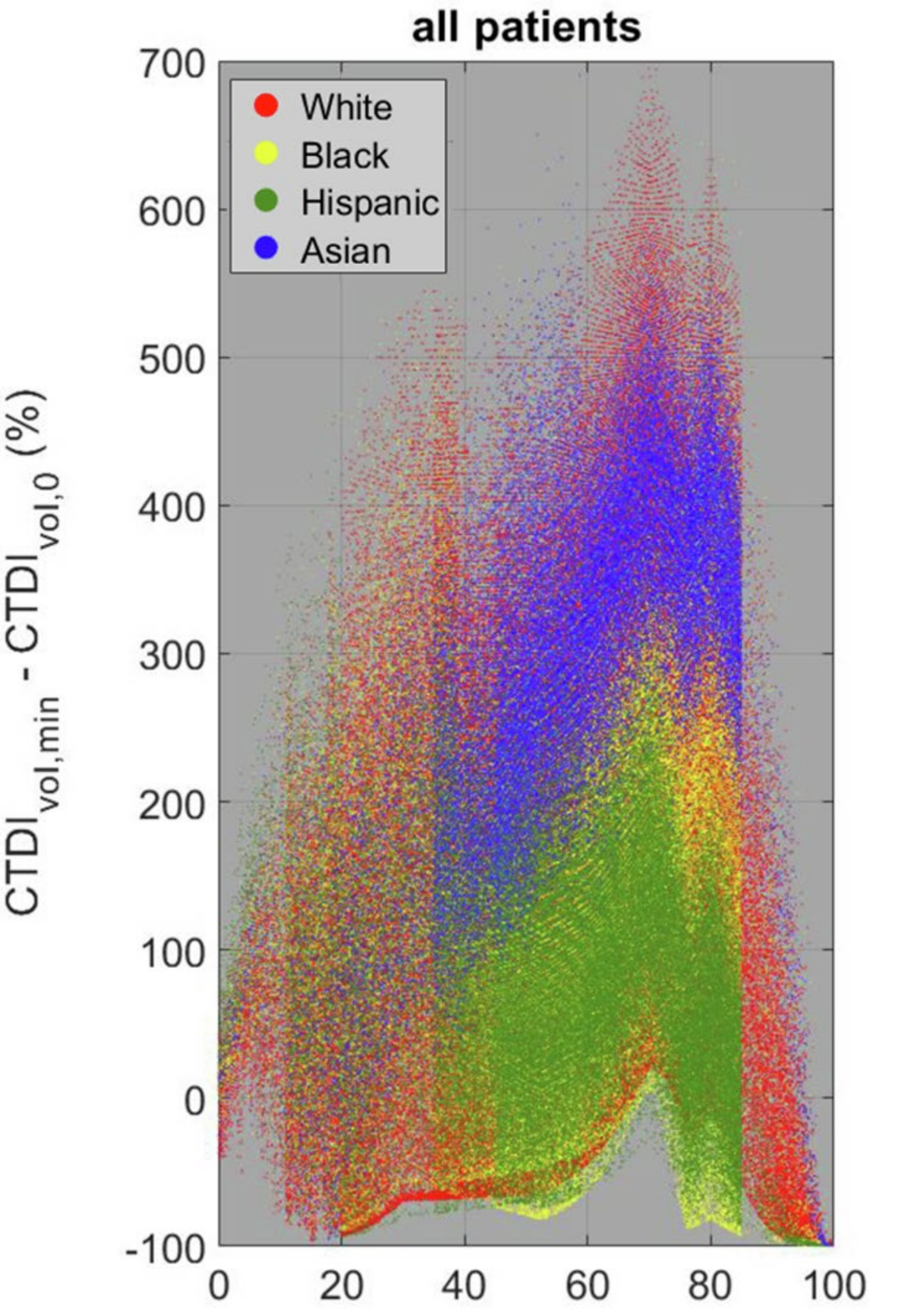
Interesting, so most patients would have had less total risk with higher radiation doses.

And this study doesn’t include added “negative risk” from non indicated findings



Thanks!

Feel free to contact me at tszczykutowicz@uwhealth.org