



# Medical Perspectives

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## Disclosure

I am the PI of a UCSF contract with CMS to develop a quality measure focused on computed tomography that can be incorporated into CMS quality payment programs.

I am a co-founder of Alara Imaging, a company focused on collecting and reporting radiation dose information and image quality for CT as part of CMS reporting.



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# Overview

Medical Radiation Exposures

Risks of Medical Radiation

Risk Communication

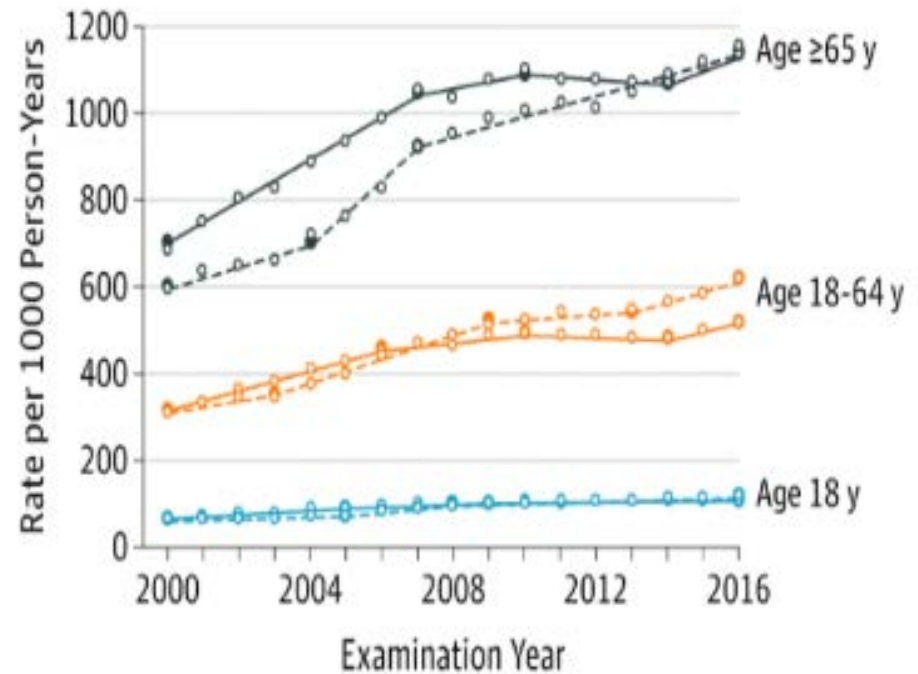
High Priority Research Areas



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- Medical imaging is the largest source of exposure to ionizing radiation in U.S.- and growing
- Around half of U.S. exposures from imaging (3 mSv / 6 mSv)
- Wide range in doses per exam (<1 mSv to >100 mSv)
- Computed tomography (CT) contributes the lion's share of the radiation dose

Annual Rate of Imaging  
U.S. (solid) and Ontario (dotted)



Smith-Bindman, JAMA 2019



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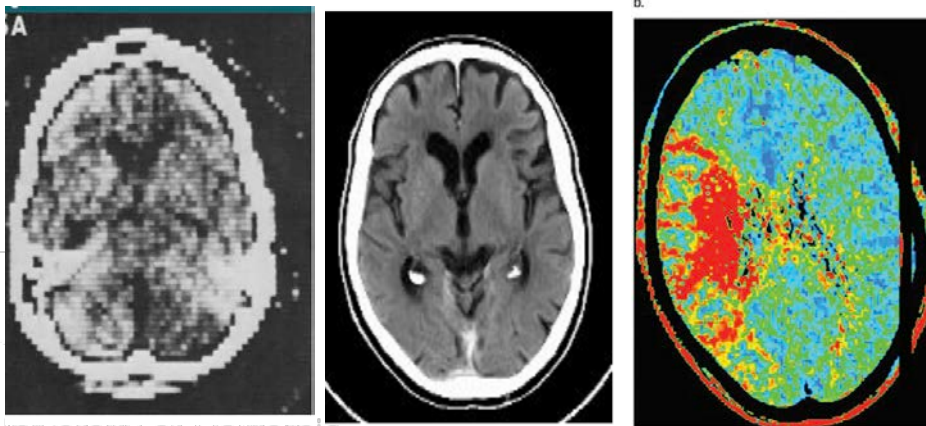
Additional Research

# History of CT

- **1967:** Drs. Hounsfield & Cormack: Nobel Prize in 1979
- **1971:** First patient scanned in London
- **1980:** 3 million exams per year in US
- **2019:** 90 million exams per year in US



## Drivers of Growth in CT



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- Improvements in CT technology
- High profitability
- Loved by patients and physicians
- By 2010, growth in CT surpassed all other health care services

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The New York Times

## *Radiation Overdoses Point Up Dangers of CT Scans*

By WALT BOGDANICH OCT. 15, 2009

- Radiation overdoses from CT occurred across many hospitals
- A single child irradiated 15 times in California
- Publication showing doses highly variable

Thousands of patients received doses of 2-20 Gray



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- Radiation in medicine is used for direct patient benefit - contrasting to other exposures that have societal but not direct patient benefit
- Nonetheless, there are guiding principals for using radiation in medicine to ensure it is used safely and judiciously



# Justification

*The expected benefit of the imaging should exceed any expected harm*

- Imaging is overused  
30-50% of exams unnecessary
- Standing orders frequent
- Growth in CT steepest for exams least likely to be beneficial
- Efforts to reduce overuse unsuccessful
- When there is no justification, the assumption that imaging is providing benefit may not be true and harms become far more important to consider



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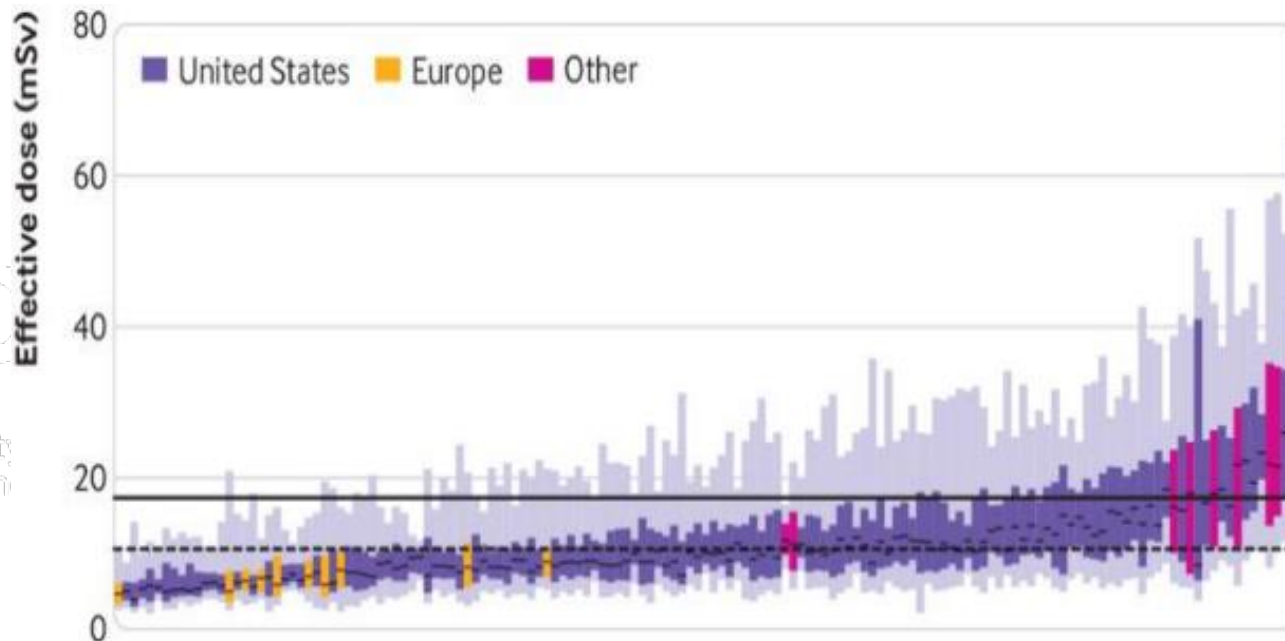
Additional Research

# Optimization

*Exams should use the  
lowest dose possible  
ALARA*

- Few guidelines exist
- Doses are highly variable
- Only exception is mammography

International variation in radiation dose for computed tomography examinations:  
prospective cohort study



UC

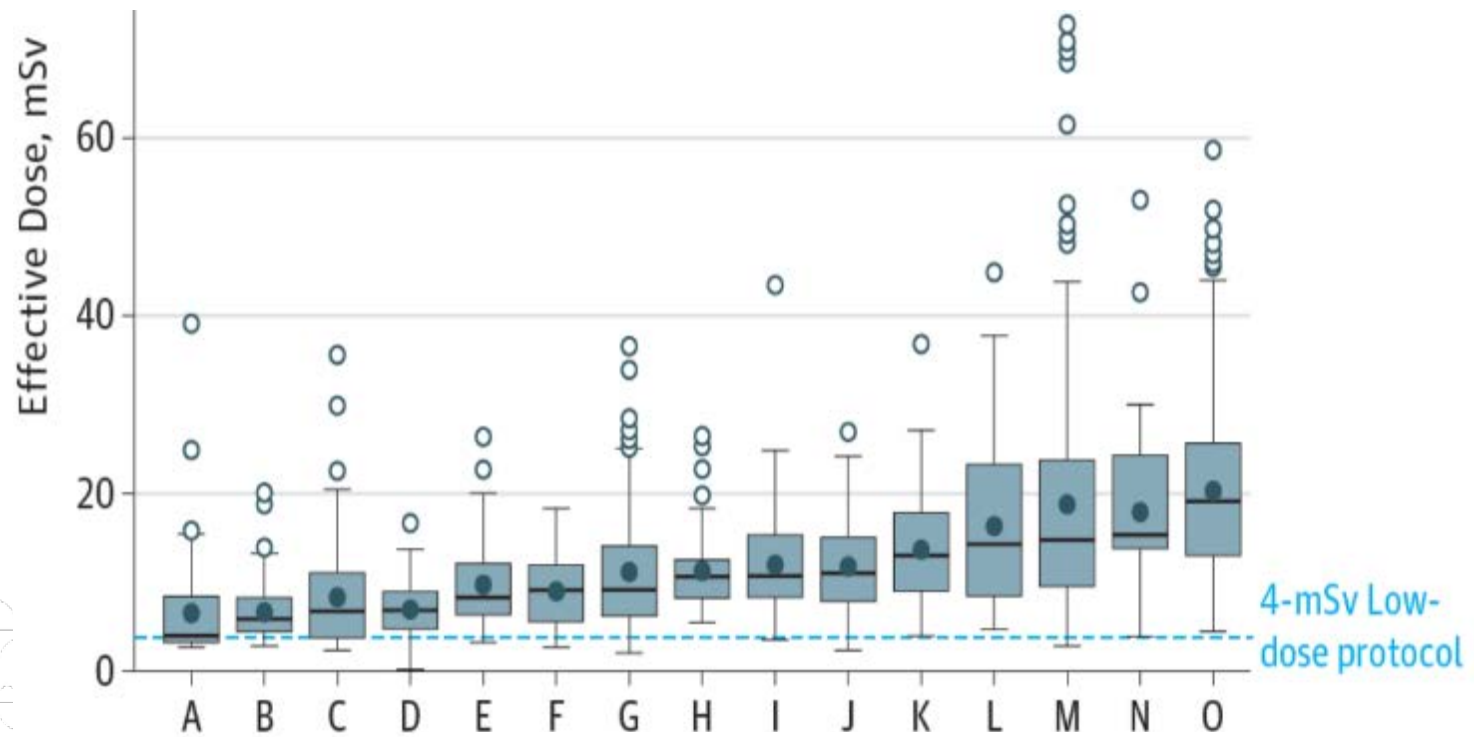
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RSmith-Bindman 2019

thebmj

# CT Doses are Far Higher Than Needed

Radiation doses for suspected renal stone CT within a randomized controlled trial



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Smith-Bindman NEJM 2014  
JAMA IM 2015

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# Cancer Risks

- **BEIR VII** Report summarized cancer risks pre-CT
- **Abalo**, Systematic Review, Pediatric Radiology, 2021:  
Pooled data 11 million children and 11 studies confirmed ↑ risks of leukemia and brain cancer associated with CT
- **Hauptmann**: Systematic Review, JNCI, 2020:  
↑ risks of leukemia and brain cancer associated with CT  
Cancer risks from CT statistically compatible with radiation-dose related cancer risks of atomic bomb survivors; bias does not explain results
- No direct studies of cancer risks in adults, but modelling suggests 2-5% of cancer results from imaging

*For a CT scan delivering:*

*10 mGy to red bone marrow, the risk of leukemia increased around 27% over background*

*10 mGy to the brain, the risk of brain cancer increased around 9% over background*

*Abalo, 2021*



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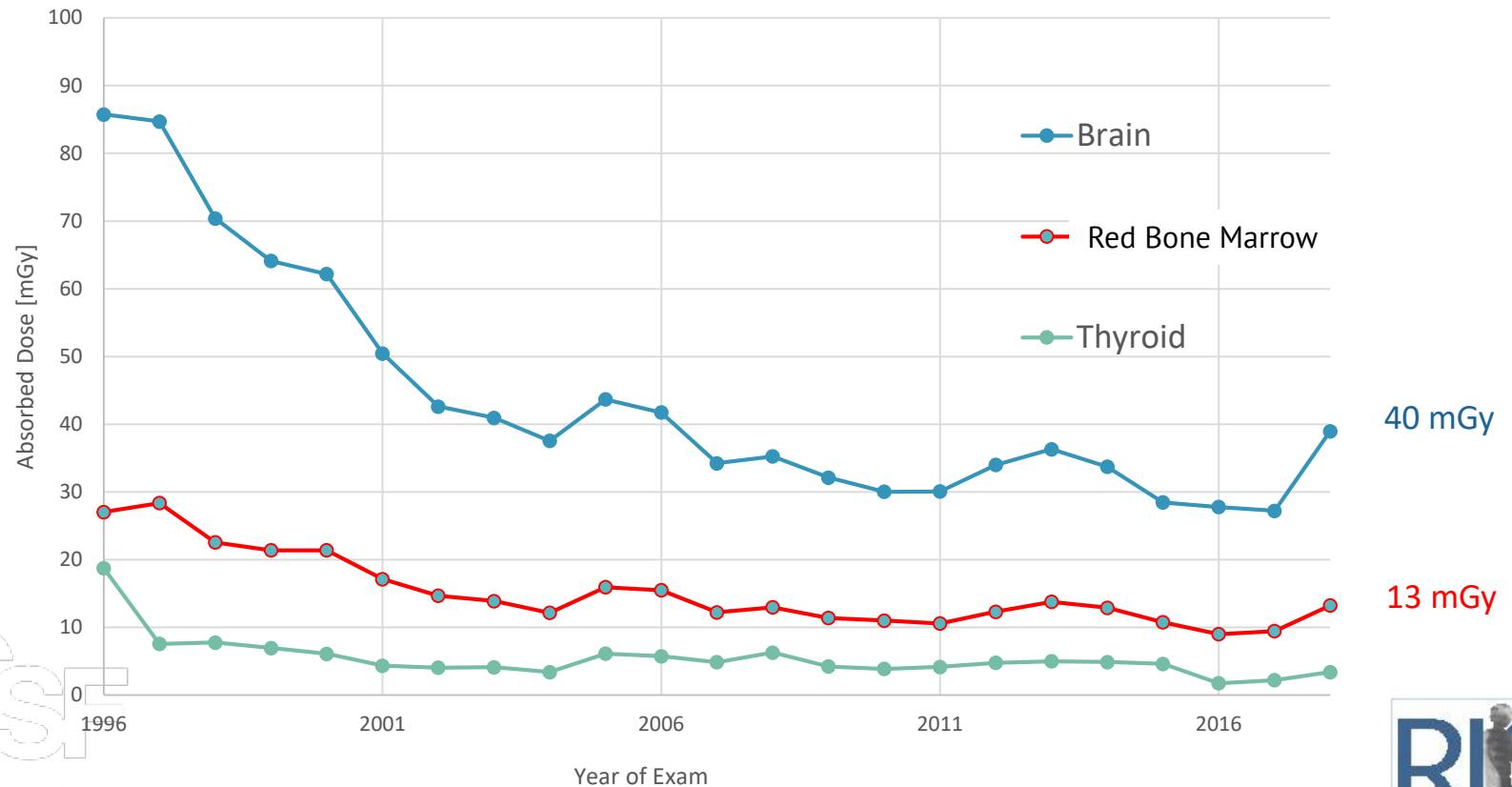
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# Typical Observed Organ Doses for CT in Children

## Organ Doses for Head CT in Children Ages 0-4 years



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# Immediate Biologic Effects : DNA, RNA, Proteins

- 67 adult patients underwent cardiac CT (mean 30 mSv)
- Full DNA gene sequencing, RNA signaling for metabolic pathways, immuno-histochemistry and diverse markers of DNA damage, cell death, repair
- Significant changes in expression of every measurement of cellular damage known to be associated with carcinogenesis
- Changes persisted at least 30 days



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Nguyen, JACC Cardiovasc Imaging, 2015

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# Patients Rarely Informed of Any Potential Harms

Original Investigation | Imaging



October 13, 2021

## Patient Perceptions and Knowledge of Ionizing Radiation From Medical Imaging

Luca Bastiani, PhD<sup>1</sup>; Fabio Paolicchi, RT<sup>2</sup>; Lorenzo Faggioni, MD, PhD<sup>2</sup>; [et al](#)

Invited Commentary | Imaging

October 13, 2021

## It Is Time to Inform Patients of Medical Imaging Risks

Carly Stewart, MHA<sup>1</sup>; Rebecca Smith-Bindman, MD<sup>1,2,3</sup>



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# Risk Communication

- Physicians who order tests uniformed

They don't understand exposures, risks, or how to communicate them

*Primary Care physician colleague underwent a screening cardiac CT*

- Radiologists who may better understand exposures and risks are rarely involved in communication and often deny risks exist

*Three follow up CTs recommended for incidental findings (20-30 mSv each)*

*When she sought advice from radiologists / technologists, she was informed the exams now use so little radiation there is no risk of cancer and that she should undergo all three exams*

- What is communicated is usually wrong or actively misleading



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# Risk Communication, Radiology

*Based on what is known, a CT study could carry a small risk for cancer, have no detectable cancer risk, or carry a potential benefit of cancer prevention [ due to hormesis]*

*If we were to impose a requirement of informed consent a practitioner would have to state that there is an unproven possibility that the CT study could increase the risk for cancer and then state that there is an unproven possibility that it may decrease the risk for cancer.*



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Head of the Board of Chancellors,  
American College of Radiology  
2015

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# Summary

- The risks associated with low dose radiation used in medicine warrant communication
- Patients want and are entitled to know about these risks
- Understanding these risks could contribute to a reduction in the inappropriate and widespread overuse of imaging
- Several small studies have shown informed patients make reasonable decisions (reasonable from perspective of MDs)
- Studies are needed to understand how to address the large education gaps in providers who must communicate



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# High Priority Research Areas

- Studies quantifying cancer risks of imaging in adults
- Studies to understand how to optimize doses for medical imaging
- Studies to understand policy solutions to lowering exposures
- Studies on appropriate strategies to communicate risks to patients that balances the potential risks and benefits it entails



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