

RISKS OF MEDICAL IMAGING

OVERVIEW OF EFFECTS OF RADIATION EXPOSURE

William Hendee

What I Believe In

- ALARA – Doses As Low As Reasonably Achievable
- ASARA – Procedures As Safe As Reasonably Achievable
- AHARA – Benefits As High As Reasonably Achievable

Deterministic (Non-Stochastic) Effects

- Hematopoietic Syndrome (>1 Gy)
- Gastrointestinal Syndrome (>5 Gy)
- Neurovascular Syndrome (>20-30 Gy)
- Cutaneous Syndrome
- Eye Lens – 5 Gy limit protracted, 2 Gy brief
- Fetus

Hematopoietic Syndrome ($>1\text{ Gy}$)

- Decreased WBCs - - susceptibility to infection
- Decreased platelets - - propensity to bleeding
- Decreased RBCs - - anemia

Gastrointestinal Syndrome (>5 Gy)

- Nausea, vomiting, anorexia, abdominal pain
- Time of onset depends on dose
- Usually fatal, due to infection

Neurovascular Syndrome ($>20\text{-}30\text{ Gy}$)

- Confusion, seizures, dizziness, loss of consciousness
- Immediate onset
- Invariably fatal

Probabilistic (Stochastic) Effects

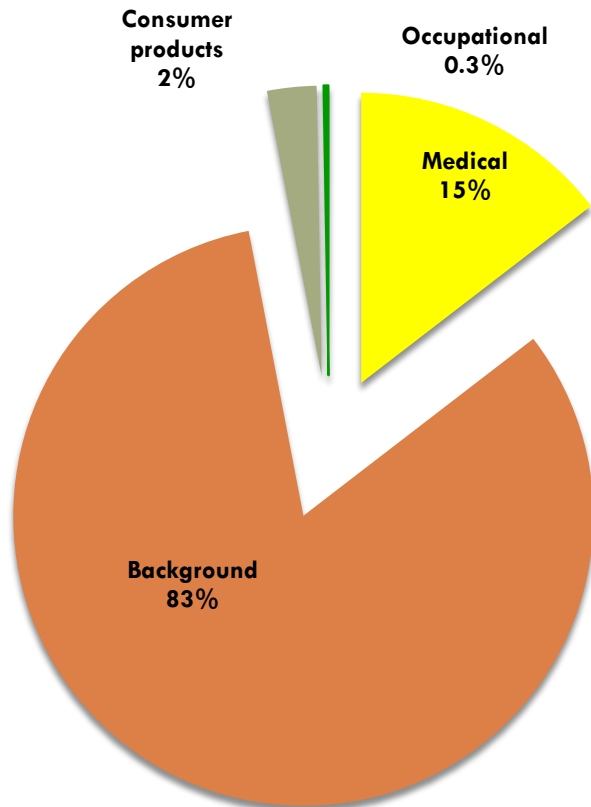
- Mutagenesis
- Carcinogenesis
- Other
- S. Weart, The Rise of Nuclear Fear (2012)

RISKS OF MEDICAL IMAGING CANCER INCIDENCE AND DEATH CLAIMS

William Hendee

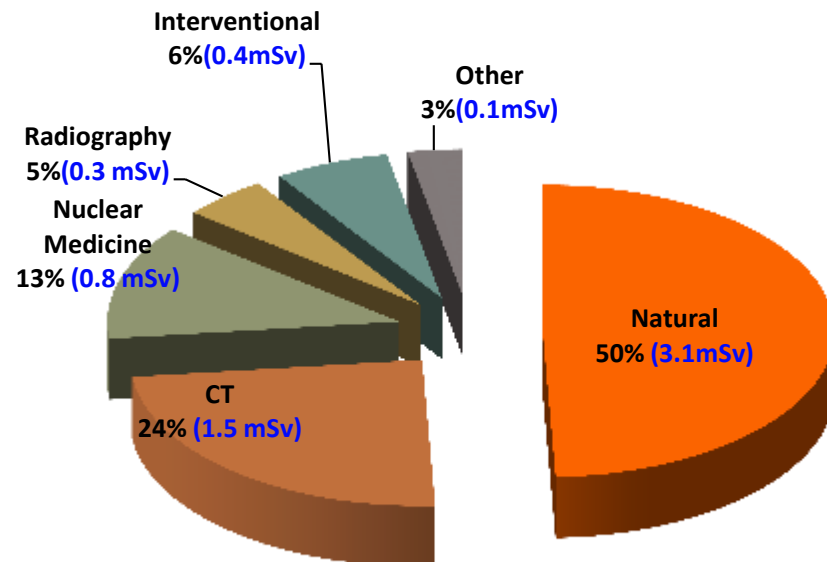
Radiation Exposure to US Population from all Sources

US 1982 (NCRP 93)



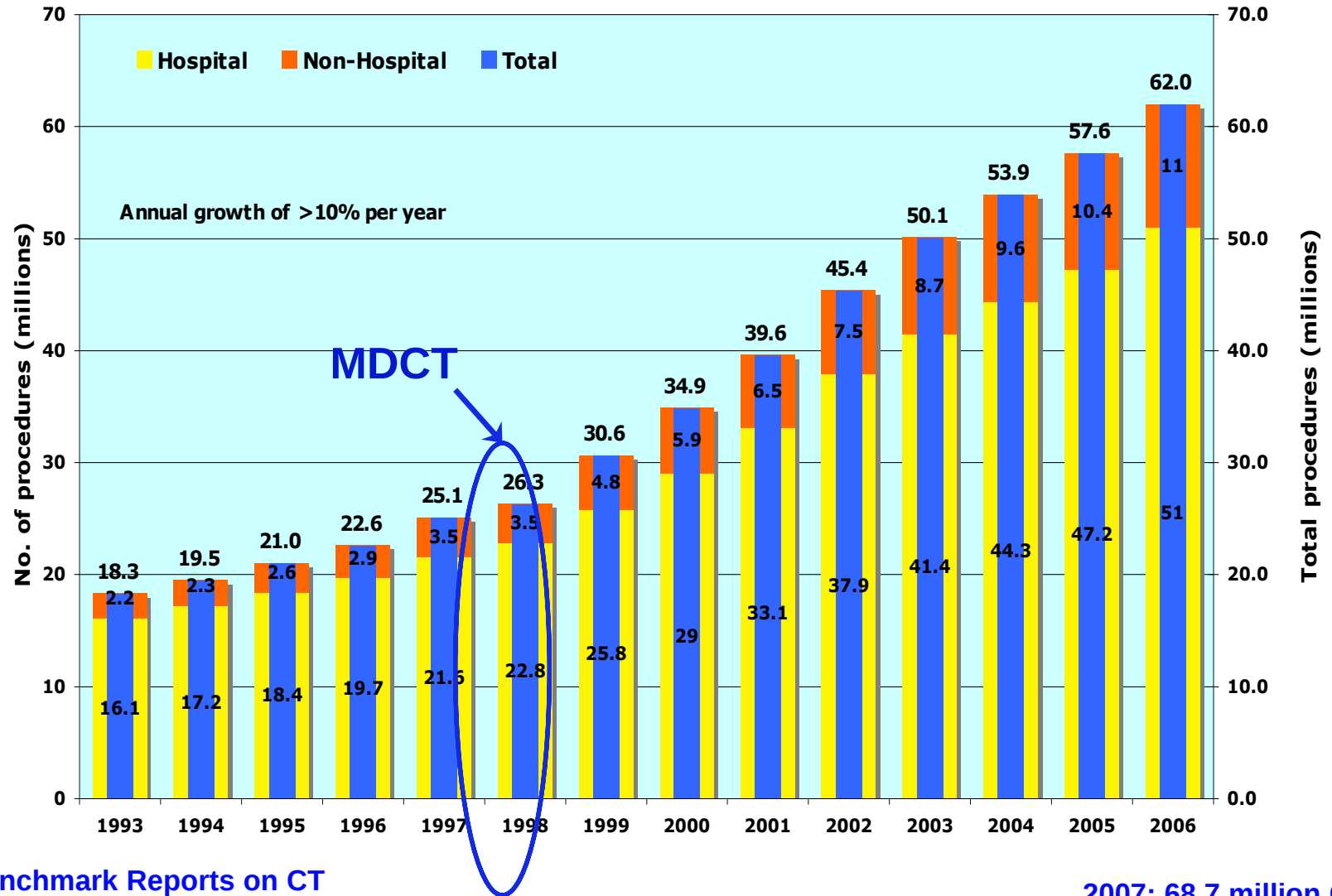
Medical 0.54 mSv per capita
Total 3.6 mSv per capita

US 2006 (NCRP 160)

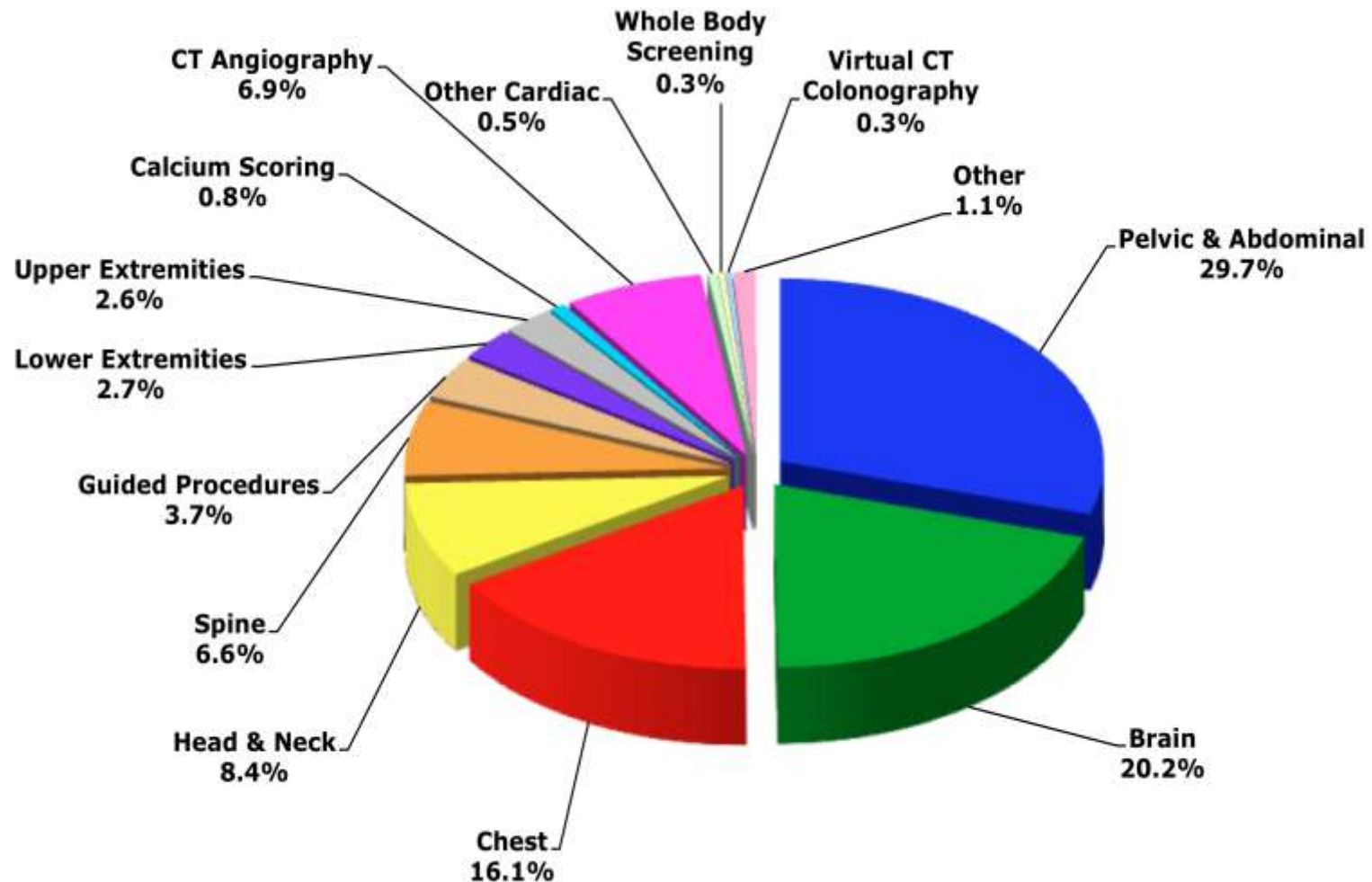


Medical 3.0 mSv per capita
Total 6.2 mSv per capita

Number of CT Procedures in US



Categories of CT Procedures (62.0 million in 2006)



HCAP: ~80% of all CT procedures

IMV 2006

ORIGINAL INVESTIGATION

Projected Cancer Risks From Computed Tomographic Scans Performed in the United States in 2007

Amy Berrington de González, DPhil; Mahadevappa Mahesh, MS, PhD; Kwang-Pyo Kim, PhD; Mythreyi Bhargavan, PhD; Rebecca Lewis, MPH; Fred Mettler, MD; Charles Land, PhD

Estimates that 29,000 future cancers and 14,500 deaths are related to CT scans performed in the U.S. in 2007.

Arch Intern Med. 2009;169(22):2078-2086

Radiation Dose Associated With Common Computed Tomography Examinations and the Associated Lifetime Attributable Risk of Cancer

Rebecca Smith-Bindman, MD; Jafi Lipson, MD; Ralph Marcus, BA; Kwang-Pyo Kim, PhD;
Mahadevappa Mahesh, MS, PhD; Robert Gould, ScD; Amy Berrington de González, DPhil; Diana L. Miglioretti, PhD

Estimates one in 270 women (1 in 600 men) who undergo CT coronary angiography will develop cancer from the CT scan.

Arch Intern Med. 2009;169(22):2078-2086



Computed Tomography — An Increasing Source of Radiation Exposure

David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phil., D.Sc. N Engl J Med 2007; 357:2277-2284, November 29, 2007

1.5 – 2 % all cancers in United States caused by CT exams



Breast Cancer Risk Estimates Increased with Repeated
Prior CT and Nuclear Imaging, Ginger Merry and
Rebecca Smith-Bindman, RSNA, 2012.

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

Popular Diagnostic Scans May Be Overused, Some Worry



REUTERS

EDITION:

U.S.

News
& Markets ▼

Sectors
& Industries ▼

Analysis
& Opinion

(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 Steenhuisen](#)

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



What is the origin of these estimates of
cancer incidence and death from
medical imaging?

[Small “estimated” cancer risk]
Multiplied by
[Large patient population]
Yields
[Many hypothetical cancers]

FOR EXAMPLE

$[60 \times 10^6 \text{ patients}] \times [0.01 \text{ Sv/patient}] \times [.05 \text{ cancers/Sv}]$
yields

30,000 cancers (1/2 estimated to be fatal)

RISKS OF MEDICAL IMAGING

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Health Physics Society Position

- Recommends against quantitative estimation of health risks below an individual dose of 5 rem (50 mSv) in one year or a lifetime dose of 10 rem (100 mSv) above that received from natural sources
- For doses below 5-10 rem (50-100 mSv) risks of health effects are either too small to be observed or are nonexistent

POSITION STATEMENT ON RADIATION RISKS FROM MEDICAL IMAGING PROCEDURES

The American Association of Physicists in Medicine (AAPM) acknowledges that medical imaging procedures should be appropriate and conducted at the lowest radiation dose consistent with acquisition of the desired information. Discussion of risks related to radiation dose from medical imaging procedures should be accompanied by acknowledgement of the benefits of the procedures. Risks of medical imaging at patient doses below 50 mSv for single procedures or 100 mSv for multiple procedures over short time periods are too low to be detectable and may be nonexistent. Predictions of hypothetical cancer incidence and deaths in patient populations exposed to such low doses are highly speculative and should be discouraged. These predictions are harmful because they lead to sensationalistic articles in the public media that cause some patients and parents to refuse medical imaging procedures, placing them at substantial risk by not receiving the clinical benefits of the prescribed procedures.

IOMP Policy Statement

□ Prospective estimates of cancers and cancer deaths induced by medical radiation should include a statement that the estimates are highly speculative because of various random and systematic uncertainties embedded in them. These uncertainties include dosimetric uncertainties; epidemiological and methodological uncertainties; uncertainties from low statistical power and precision in epidemiology studies of radiation risk; uncertainties in modeling radiation risk data; generalization of risk estimates across different populations; and reliance of epidemiological studies on observational rather than experimental data. Such uncertainties cause predictions of radiation-induced cancers and cancer deaths to be susceptible to biases and confounding influences that are unidentifiable.

IOMP Policy Statement (cont'd)

□ Paragraph A86 of Report 103 of the International Commission on Radiological Protection (ICRP) states that “There is, however, general agreement that epidemiological methods used for the estimation of cancer risk do not have the power to directly reveal cancer risks in the dose range up to around 100 mSv.” Further, UNSCEAR Report A-67-46, approved in May, 2012, states that “The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) does not recommend multiplying very low doses by large numbers of individuals to estimate numbers of radiation-induced health effects within a population exposed to incremental doses at levels equivalent to or lower than natural background levels.”

IOMP Policy Statement (cont'd)

- Predictions of radiation-induced cancers and cancer deaths from medical imaging procedures should be accompanied by estimates of reductions in patient morbidity, mortality and cost resulting from the same medical imaging procedures.

IOMP Policy Statement (cont'd)

□ If effective dose is used to generate predictions of cancers and cancer deaths, a statement should be included that the ICRP has expressed caution in the use of effective dose for purposes of estimating risks to individuals or populations exposed to ionizing radiation. Paragraph 151 of ICRP Report 103 states: “The use of effective dose for assessing the exposure of patients has severe limitations that must be considered when quantifying medical exposure,” and “The assessment and interpretation of effective dose from medical exposure of patients is very problematic when organs and tissues receive only partial exposure or a very heterogeneous exposure which is the case especially with x-ray diagnostics.”

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