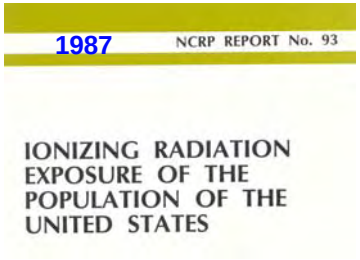
Medical Radiation Exposure of the US Population: Preliminary Results from NCRP Scientific Committee 6-2 & Other Related Issues

David A. Schauer
Executive Director

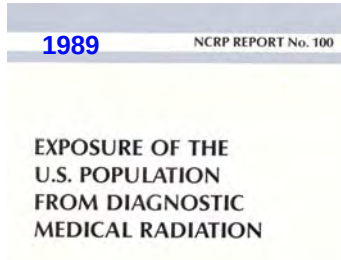
Outline

- **NCRP SC 6-2, “Radiation Exposure of the US Population”**
  - **Purpose and Goals**
  - **Data Sources**
  - **Preliminary Results and Conclusions***
- **Radiation Protection Philosophy**
  - **Justification**
    - **Appropriateness (ACR Criteria)**
  - **Optimization**
    - **Manufacturers**
- **Major Planned NCRP Activity**
  - **Potential Effects of Low Dose and Dose-Rate Radiation**

*These results have not been reviewed and approved by Council.
Not to be disseminated or referenced



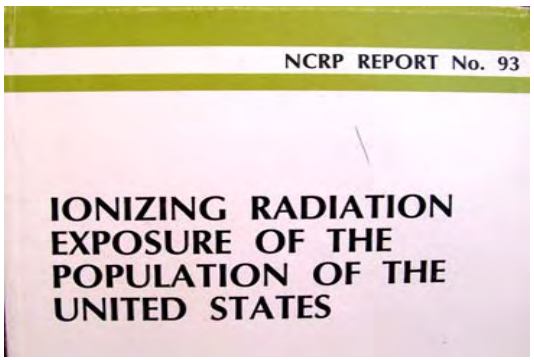
NCRP SC 6-2: Purpose



- **To update NCRP Report No. 93 published in 1987 and NCRP Report No. 100 published in 1989.**
  - **Last major medical data used in these reports are from 1982 or earlier.**
- **Evaluate average annual effective dose to members of US public from:**
  - **Medical Sources**
  - **Radon**
  - **Cosmic and Terrestrial Radiation**
  - **Consumer Products and**
  - **Other Radiation Sources (occupational, nuclear fuel cycle, radioactive fallout and miscellaneous sources)**

NCRP SC 6-2:
Radiation Exposure of US population

Medical



Published in 1987

Occupational

Natural

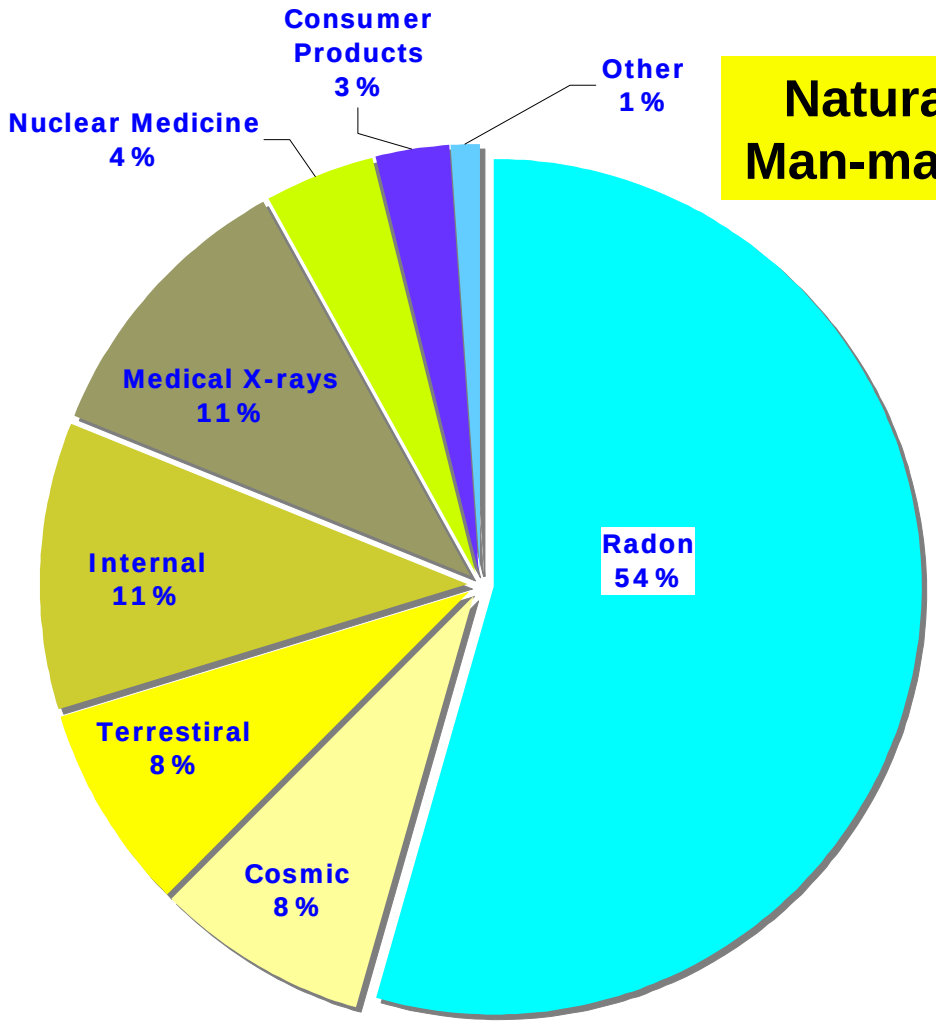
Technologically enhanced

New report expected to be published in 2008

NCRP Report No. 93:
Annual effective dose equivalent to US population circa 1980-82

- **Natural Sources 3.0 mSv**
  - Radon 2.0 mSv
  - Other 1.0 mSv
- **Man-made Sources 0.6 mSv**
  - Occupational, Consumer products, nuclear fuel cycle and other miscellaneous products 0.07 mSv

- Medical 0.53 mSv
  - X-rays 0.39 mSv
  - NM 0.14 mSv



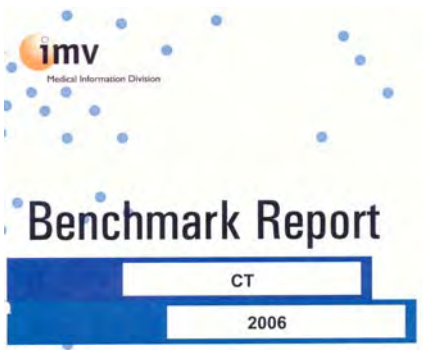
Natural 82%
Man-made 18%

Goals

- **Estimate current radiation exposure to US population**
  - **Number and types of medical procedures**
  - **Effective dose per procedure**
- **Modalities**
  - **CT**
  - **Nuclear Medicine**
  - **Interventional**
  - **Radiography, Fluoroscopy, Mammography, Dental, Chiropractic, Bone Densitometry**
  - **Radiation Therapy**

Major and Minor Data Sources

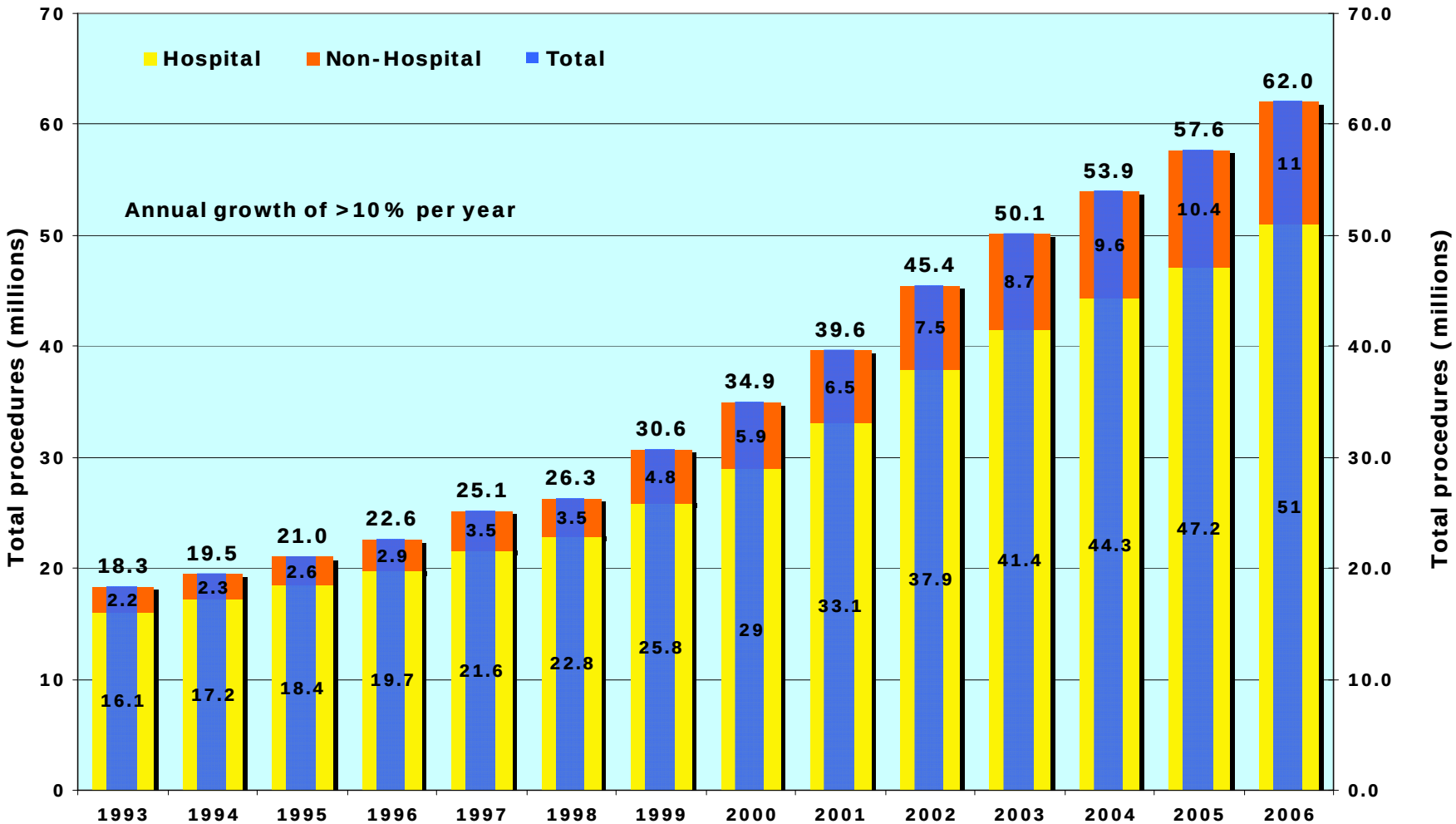
- Commercial (IMV Benchmark)
- Medicare payment data (2003-2005)
- VA Health Care System
- Claims data from large national employer plan
- US FDA
- CRCPD
- State radiation programs
- Large hospitals
- American College of Radiology
- Literature



Computed Tomography (CT)

- **Annual growth over 1993-2006:**
  - **CT Procedures > 10 % vs US population < 1 %**
- **Nearly 62 million CT procedures in US in 2006**
- **Data correlated to nearly 7,649 hospitals in US**
- **Pediatric CT ~10 % of total procedures**

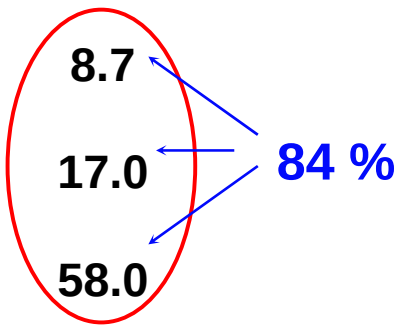
Number of CT procedures in US



IMV Benchmark Report on CT, 2006

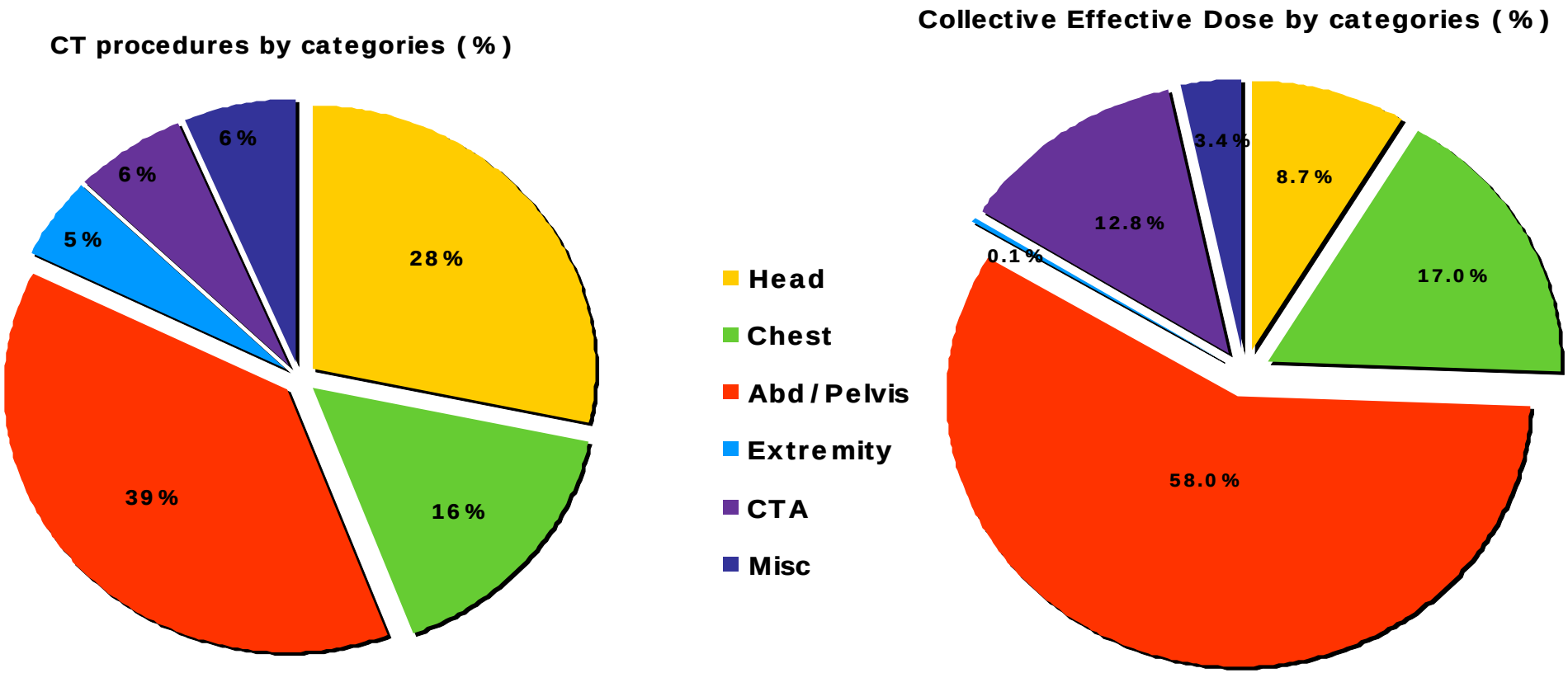
Preliminary Results for CT (2006)

	Number (millions)	%	Collective Effective Dose (person Sv)	%
Head	19.0	28	38,000	8.7
Chest	10.6	16	74,000	17.0
Abd/Pelvis	25.4	39	254,000	58.0
Extremity	3.5	5	500	0.1
CT Angiogram	4.3	6	56,000	12.8
Miscellaneous	4.2	6	15,000	3.4
TOTAL	67*		438,000	



* Number of scans - accounting for multiple scans within a procedure

CT: Procedures & Collective Effective Dose



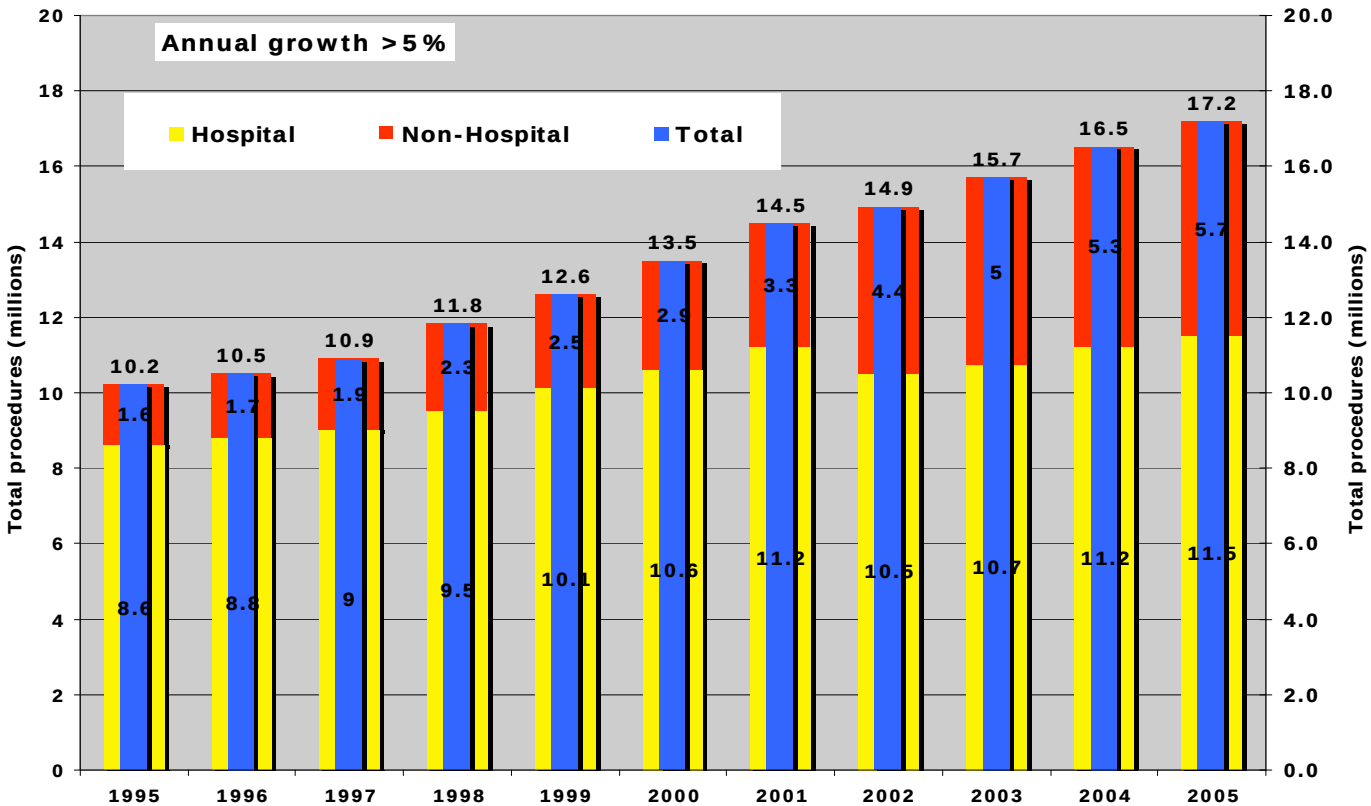
Collective effective dose **~438,000 person Sv**

Effective dose per capita **~1.5 mSv**

Nuclear Medicine

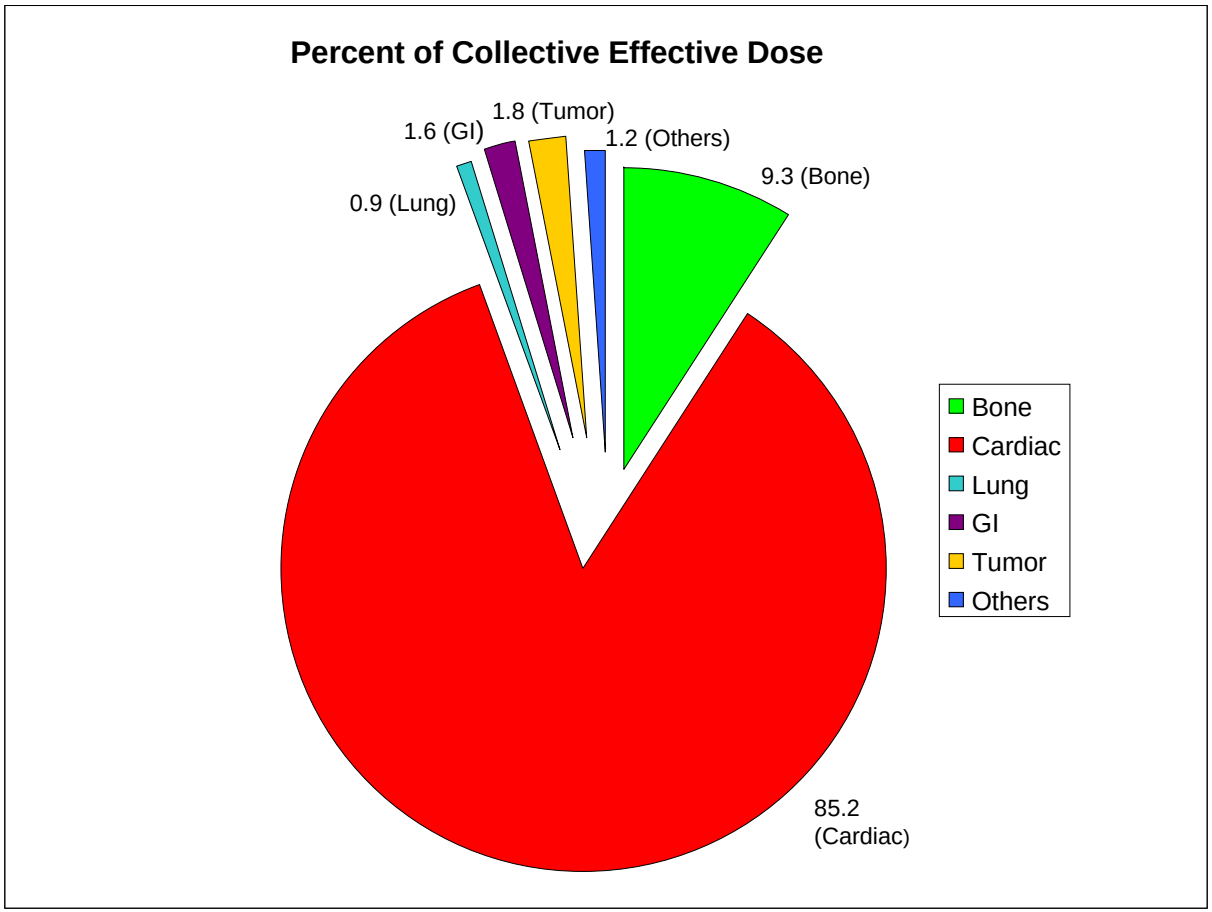
- **Annual growth over 1995-2005:**
  - **Nuclear Medicine Procedures > 5 % vs US population < 1 %**
- **Nearly 17 million nuclear medicine visits in US in 2005**
- **Data correlated to nearly 7,200 hospitals in US**
- **Largest increases in cardiac procedures**
  - **1 % in 1973 to 57 % in 2005**

Nuclear Medicine Visits in US



IMV Benchmark Report on NM, 2005

Nuclear Medicine: Collective Effective Dose



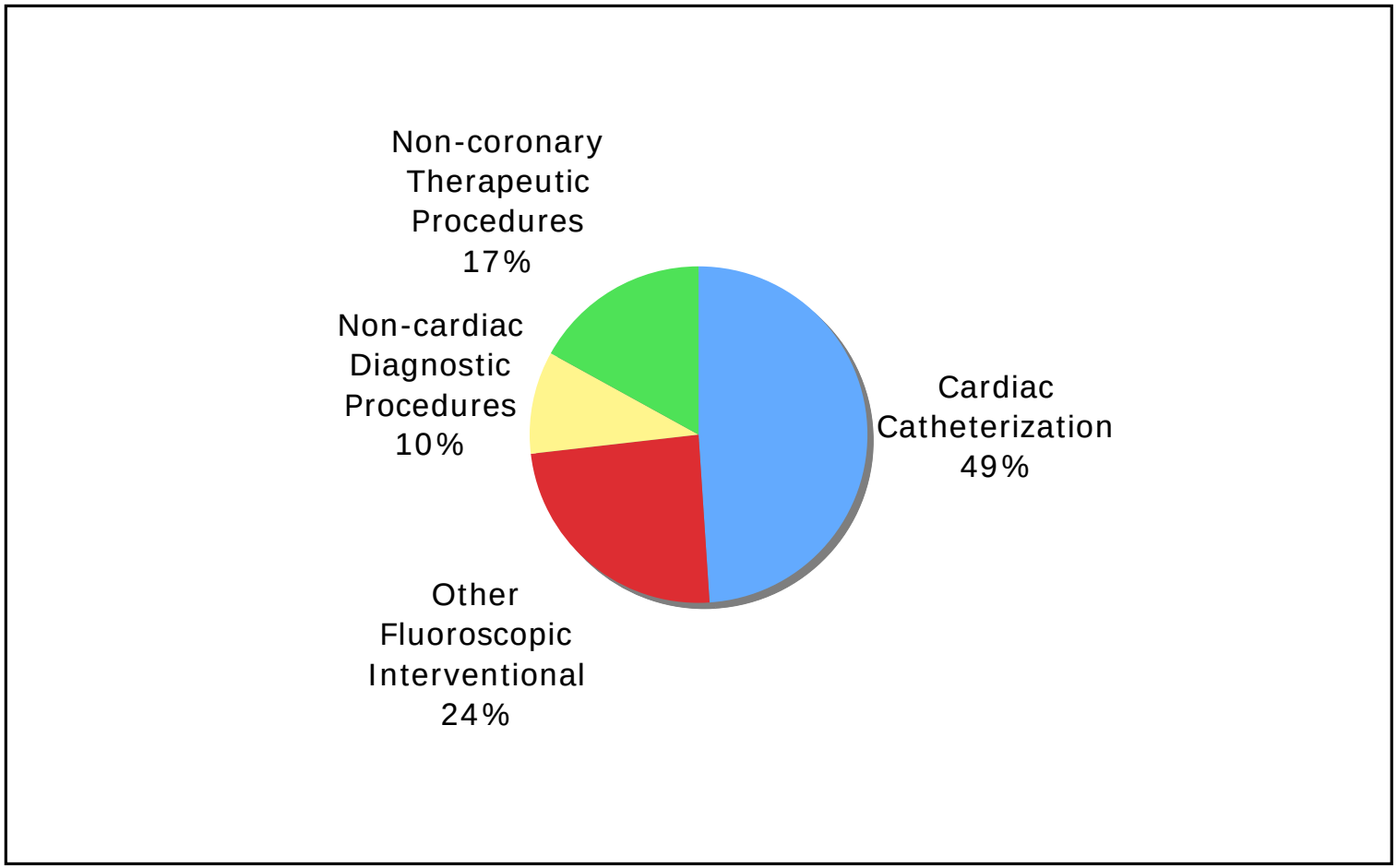
Collective effective dose **~231,000 person Sv**

Effective dose per capita **~0.8 mSv**

Interventional Fluoroscopy

- **Procedures considered**
  - **Non-coronary angiography diagnostic and therapeutic procedures**
  - **Cardiac catheterization procedures**
  - **Other interventional fluoroscopy procedures such as ERCP, urinary studies.**

Interventional: Collective Effective Dose



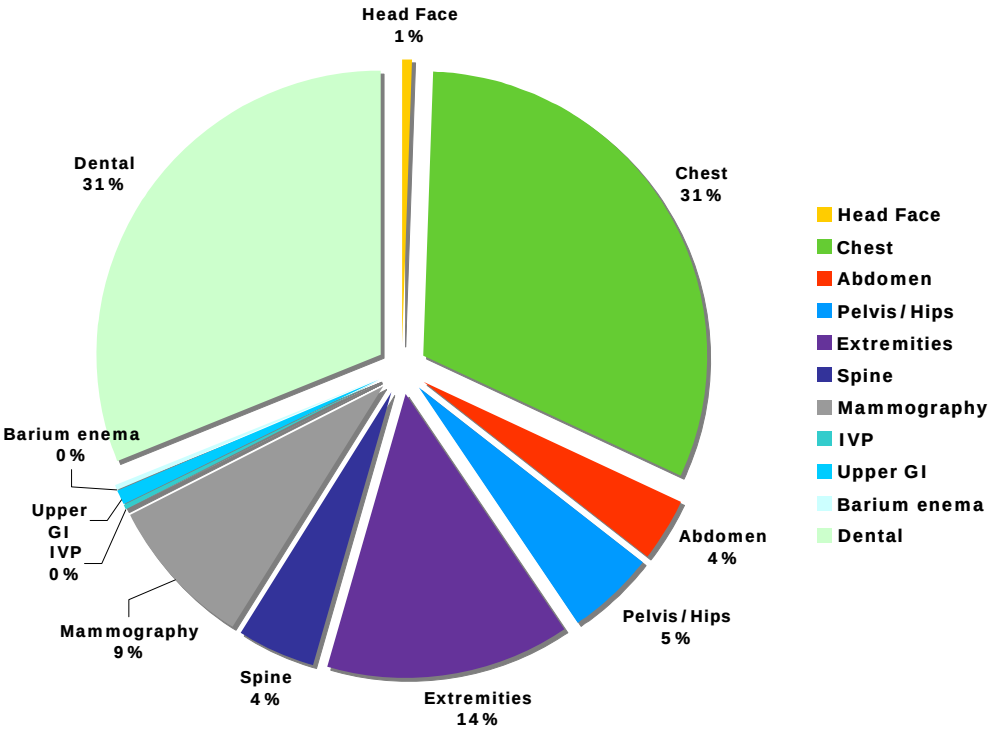
Collective effective dose	**~129,000 person Sv**
Effective dose per capita	**~0.4 mSv**

Radiography & Fluoroscopy (R & F)

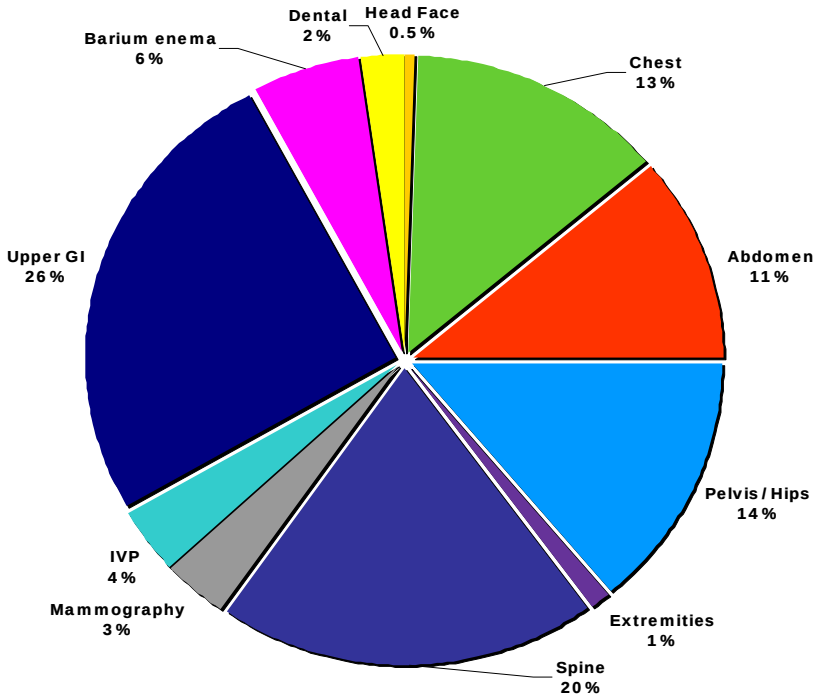
- Data include mammography, dental, chiropractic radiographic procedures, bone densitometry & certain fluoroscopy procedures
- Limited data available for dental and chiropractic procedures

R & F: Procedures and Collective Effective Dose

Procedures by categories (%)



Collective effective dose by categories (%)



Collective effective dose **~99,000 person Sv**

Effective dose per capita **~0.30 mSv**

Preliminary Estimate of Radiation Exposure to US Population - Medical Exposures

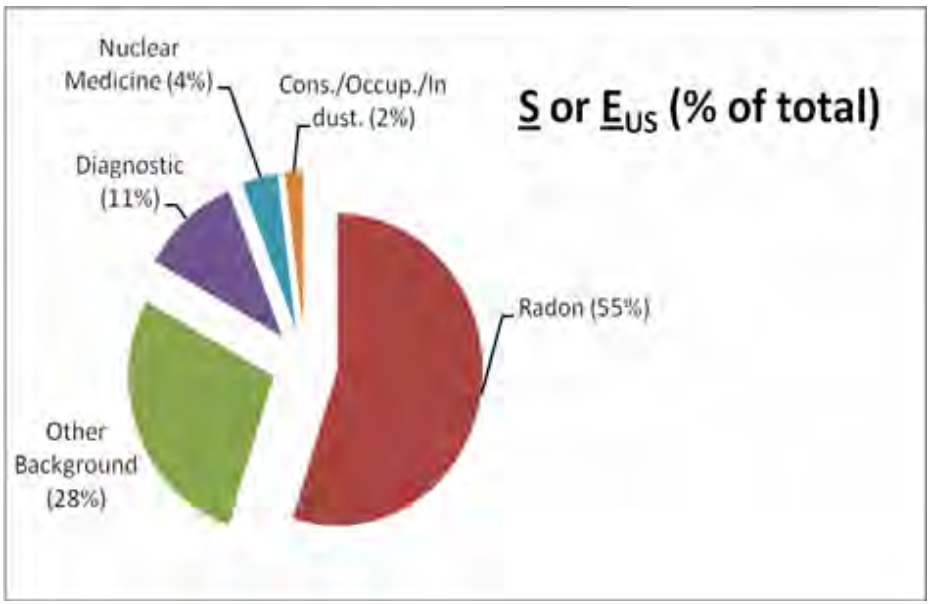
	Number of Procedures (millions)	%	Collective Effective Dose (person Sv)	%	$\underline{E}_{US}$ (mSv)
Computed Tomography	67	16	438,000	49	1.5
Nuclear Medicine	18	4	231,000	26	0.8
Interventional	17	4	129,000	14	0.4
Radiography and Fluoroscopy	324	76	99,000	11	0.3
TOTALS	**426**	**100**	**897,000**	**100**	**~3**

(600 % increase)

*Data in NCRP publications are considered preliminary until reviewed and approved by Council.

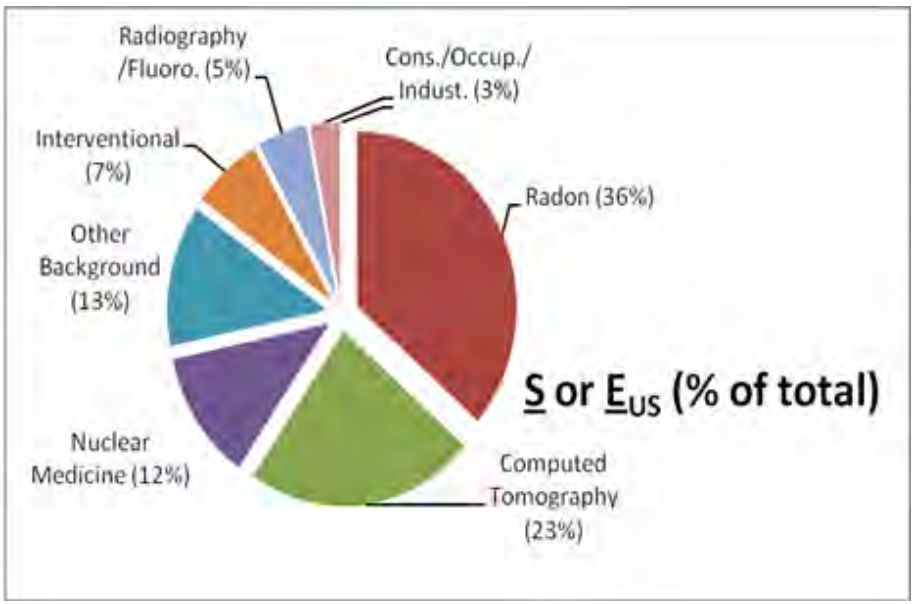
Preliminary Estimate of Changes in Radiation Exposure to US Population: All Exposures

US 1982*



Medical 0.53 mSv per capita
Total 3.6 mSv per capita

US 2005-2006



Medical ~3 mSv per capita
Total ~6 mSv per capita

*** NCRP Report No. 93**

These results have not been reviewed and approved by Council.
Not to be disseminated or referenced

Is the Increase in Medical Imaging Justified?

[Part 1 – Editorial by V. Ho in Medical Care: 46(5) May 2008*]

- Noninvasive imaging has revolutionized medical practice by leading to early, more precise, and much less morbid diagnosis.
- CT and MRI have replaced exploratory laporotomy, a very expensive and morbid operation required for diagnosing abdominal problems.
- Computed tomography angiogram (CTA) is much less invasive than coronary angiography.
- PET scans enable oncologists to identify tumors and metastases at earlier stages than would be otherwise possible.

*“Advanced Diagnostic Imaging - Benefit or Burden”

Is the Increase in Medical Imaging Justified?

[Part 2 – Article by Levin and Rao in JACR: 1(5) Mar 2004*]

- As much as $16 billion (*US dollars*) per year is spent by our health care system to cover the cost of **unnecessary** self-referred noninvasive diagnostic imaging.
- This does not include the costs of image-guided invasive procedures.
- The level of waste resulting from self referral in imaging is indeed staggering.

*"Turf Wars in Radiology: The Overutilization of Imaging Resulting from Self-Referral"

Is the Increase in Medical Imaging Justified?

(Part 3 – Article by Hadley *et. al*. and Winslow *et. al*.)

- *Potential Impact of the American College of Radiology Appropriateness Criteria on CT for Trauma*, Hadley, *et al*., *AJR*; 186:937–942 (2006)
  - RESULTS. **Overall, application of the ACR criteria was found to have the potential to reduce imaging costs by 39 % and the estimated radiation dose by 44 %.**
  - CONCLUSION. **The ACR appropriateness criteria have the potential to have a strong positive impact on the overall cost of imaging and radiation dose received for patients in the setting of trauma. These criteria should be emphasized to clinicians to help guide their imaging decisions.**
- *Quantitative Assessment of Diagnostic Radiation Doses in Adult Blunt Trauma Patients,* Winslow, *et al*., *Annals of Emerg. Med*. (2008) in press.
  - Approaches to decreasing ionizing radiation exposure may include:
    - reducing repeated imaging studies;
    - using lower-dose radiologic imaging techniques;
    - using alternative imaging methods that do not use ionizing radiation (ultrasonography, magnetic resonance imaging); and
    - **returning to an increased reliance on clinical examinations.**

Justification (Appropriateness)

- ACR Appropriateness Criteria®
  - Presently address over 160 clinical conditions with over 700 variants.
  - New topics are added to reflect changes in technology and clinical practice.
  - It is believed that this systematic process of criteria development provides credible guidelines for radiology decision-making based on scientific analysis and broad-based consensus techniques.

It is hoped that the end result will be the cost-effective practice of high quality radiology.

Justification (Appropriateness) and Optimization

- "American College of Radiology White Paper on Radiation Dose in Medicine", *JACR* 4:272.284; (2007).
- Medical Imaging and Technology Alliance. "How Innovations in Medical Imaging Have Reduced Radiation Dosage".
  - www.medicalimaging.org
- The Alliance for Radiation Safety in Pediatric Imaging – the Image Gently Alliance.
  - www.imagegently.org
  - The primary objective of the Alliance is to raise awareness in the imaging community of the need to adjust radiation dose when imaging children.
  - The ultimate goal of the Alliance is to change practice.

Major Planned NCRP Activity

(Potential Effects of Low Dose and Dose-Rate Radiation)

ICRP Publication 99 (2004)

- while the existence of a low-dose threshold did not seem unlikely for radiation related cancers in certain tissues, **the evidence did not favor the existence of a universal threshold.**
- **the LNT hypothesis**, combined with an uncertain DDREF for extrapolation from high doses **remained a prudent basis for radiation protection at low doses and low dose rates.**

French Academy of Sciences Report (2005)

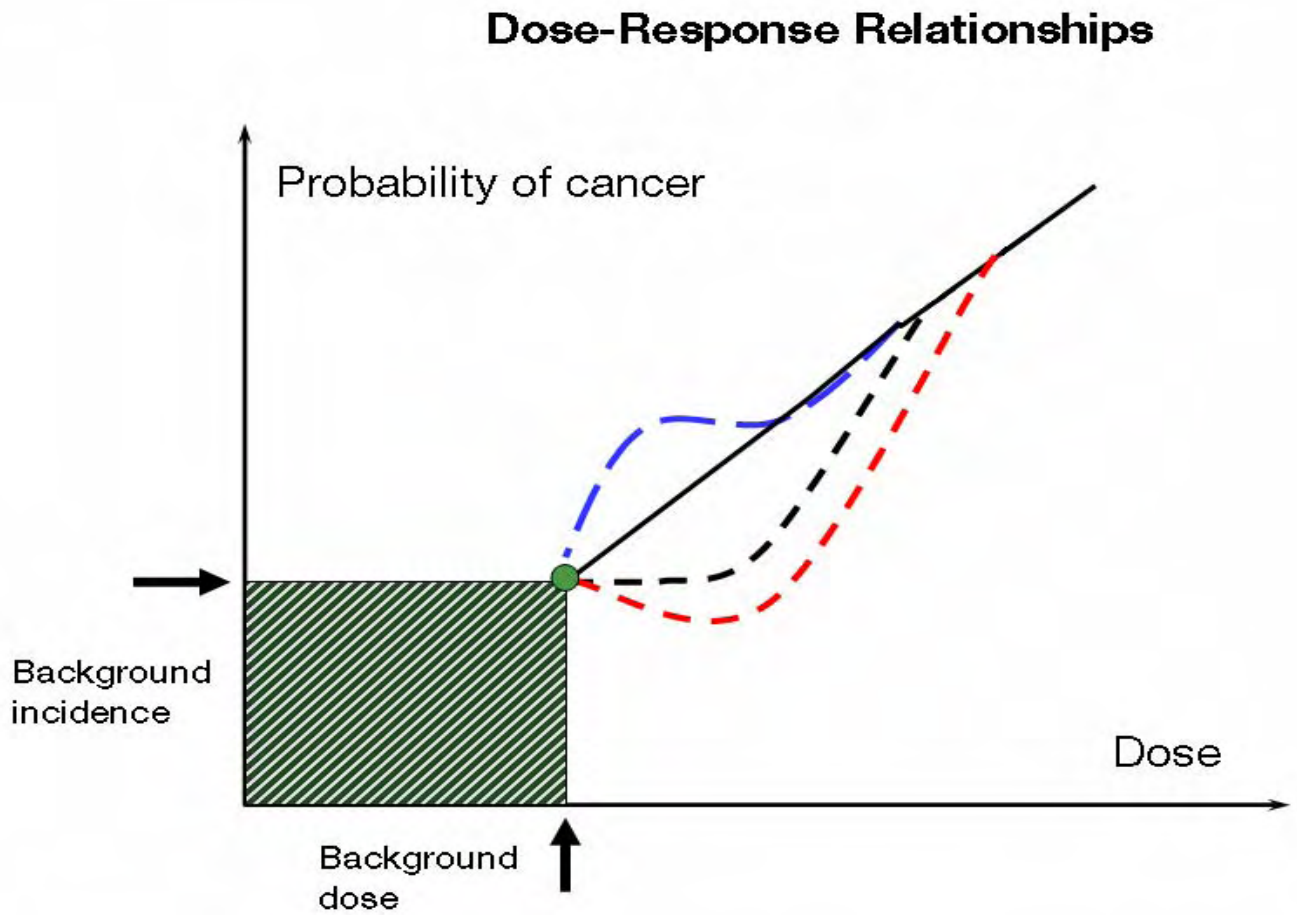
- **raised doubts about the validity of using LNT for evaluating carcinogenic risks at low doses.**
- significant credence was given to cellular responses following irradiation including scavenging reactive oxygen species (ROS), activation of DNA repair systems, and the elimination of damaged cells by apoptosis or mitotic linked cell death.

U.S. National Academy of Sciences Report (2006)

- objective of this study was to develop the best possible risk estimate for exposure to low-dose, low LET radiation in human subjects.
- concluded that the **available biological and biophysical data support an LNT risk model** (*i.e.*, that the risk of cancer proceeds in a linear fashion at lower doses without a threshold).
  - Thus the smallest dose of radiation has the potential to cause a small increase in risk to humans.

Major Planned NCRP Activity

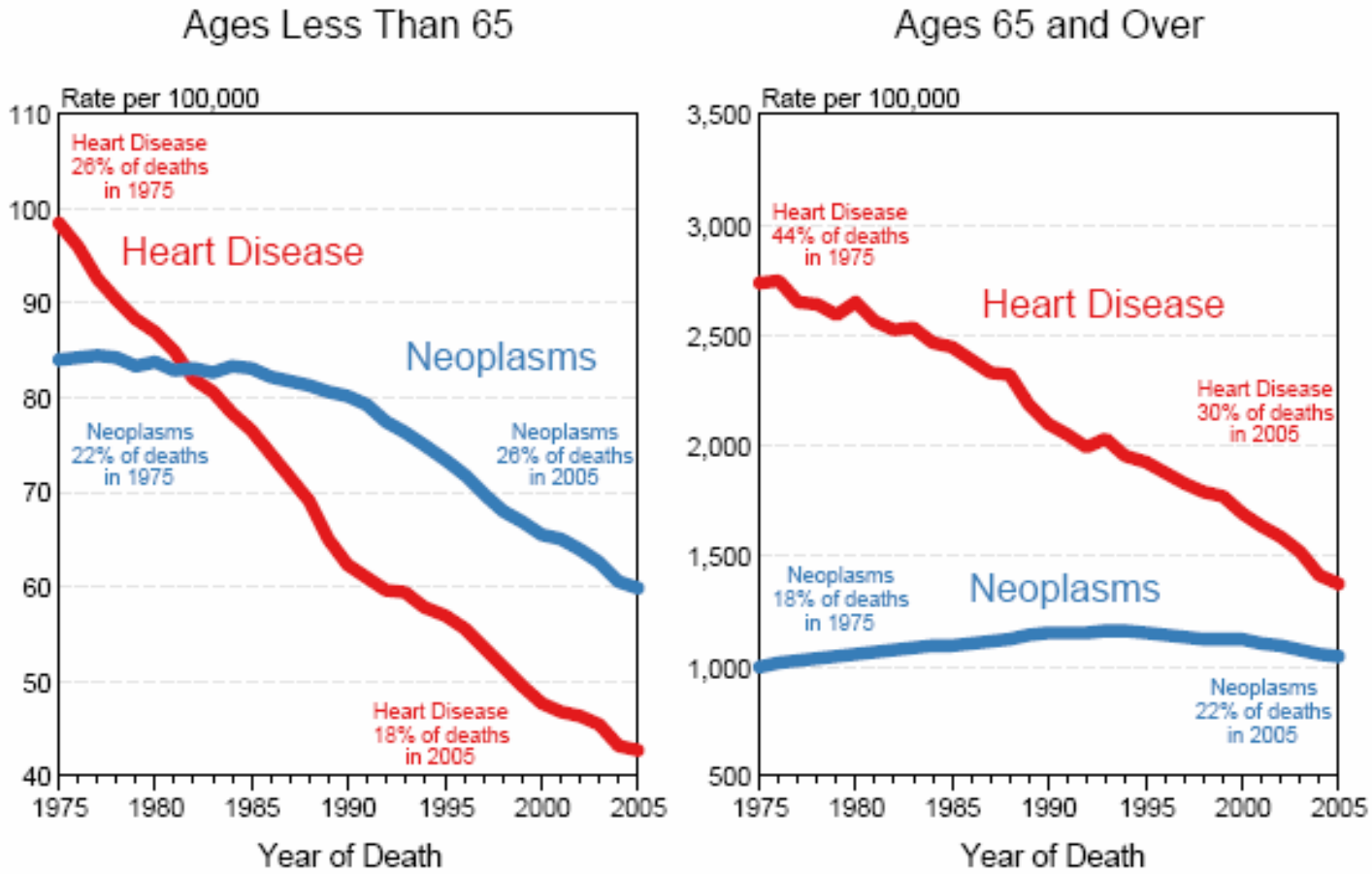
(Potential Effects of Low Dose and Dose-Rate Radiation)



See NCRP Report No. 136 (2001) for a detailed description of the contrasting types of dose-response relationships.

Major Planned NCRP Activity

(Potential Effects of Low Dose and Dose-Rate Radiation)



Source: US Mortality Files, National Center for Health Statistics, Centers for Disease Control and Prevention.
Rates are per 100,000 and age-adjusted to the 2000 US Std Population (19 age groups - Census P25-1103).