Diagnostic Radiation Exposure
Radiation Exposure in the U.S.

1980
- CT scans: 3 million, 0.5 mSv
- Nuclear medicine: 6 million, <0.1 mSv

2006
- CT scans: 70 million, <0.1 mSv
- Nuclear medicine: 18 million, 3 mSv
- Natural: 3 mSv
- Medical: 3.2 mSv
- Other: <0.1 mSv

NCRP report 160 (2009)
Diagnostic Radiation Exposure in the U.S.

- Great medical benefits but rapid increase public health concern
- 1991-95 Attributable Risk $\approx$ 1% of US cancers
  - Impact of increase on attributable risk?
- Observational studies often not feasible
- Projection models provide timely estimates of potential risks

Berrington de Gonzalez & Darby (*Lancet* 2004)
Radiation Risk Projection Research

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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

Circulation

Myocardial Perfusion Scans

Projected Population Cancer Risks From Current Levels of Use in the United States

Amy Berrington de Gonzalez, DPhil; Kwang-Pyo Kim, PhD; Rebecca Smith-Bindman, MD; Dorothea McAreavey, MD
70 Million CT Scans U.S. 2007

- Head (22 million)
- Abd/pelvis (24 million)
- Chest (11 million)
- Spine (4 million)
- CTA chest (2.5 million)
- Other (6.5 million)

Mettler et al (Radiology 2008); IMV 2008
Projected Cancers from CT Scans (U.S. 2007)

29,000 cancers (95% Uncertainty limits: 15,000 – 45,000)
Cardiac Stress Tests

- 9 million tests annually in US - 1 million 1982
- 85% collective dose from nuclear medicine tests
- Average doses higher than CT

7 mSv  Chest CT
15 mSv  Technetium-99m
35 mSv  Dual Isotope
Projected Cancers from Cardiac Stress Tests (U.S. 2008)

7,400 cancers (95% Uncertainty limits: 3,300 – 13,700)

Berrington de González et al (Circulation 2010)
Implications for Future Attributable Risk

• Levels of Use 1991-95 Attributable Risk ~ 1%
  – Radiography 0.5%
  – CT scans 0.5%
  – Nuclear medicine <0.1%

• Levels of Use 2007-8 Attributable Risk ~ 3.0%
  – CT scans 2.0%
  – Nuclear medicine 0.5%
  – Radiography 0.5%

Berrington de González & Darby (Lancet 2004); Berrington de González et al (Arch Int Med, 2009); Berrington de González et al (Circulation, 2010)
Recent Campaigns to Mitigate Risks

- NIH Clinical Center Radiation Dose Tracking

- FDA white paper “Initiative to reduce unnecessary radiation exposure”

- Image Gently & Image Wisely Campaigns
Summary of Recommendations

If test clinically justifiable then benefits > risks

Reduce use
- Use Appropriateness criteria
  - American College of Radiology CT scans
- Seek Alternatives
  - eg MRI, ultrasound

Reduce doses
- Standardize protocols
- Monitor doses
Therapeutic Radiation Exposure
Subsequent Malignancies in Cancer Survivors

• 12 million cancer survivors living in US
• 14% higher risk of subsequent malignancy than general population

SEER prevalence database 2010; Curtis et al (SEER monograph 2006)
SEER Study of Adult Cancer Survivors

- What proportion of second cancers are related to radiotherapy?

- SEER cancer registries (1973-2007)

- 15 cancers routinely treated with radiotherapy

- $N \approx 1.3$ million

- Poisson regression analysis
Excess Cancers Related to Radiotherapy

- 42,000 (9%) RT patients developed 2\textsuperscript{nd} cancer
- 3300 excess cancers (95% CI 2900-3700)
  - 8\% of second cancers (95% CI 7\%-9\%)
  - 1 excess cancer for every 150 treated
- Risks higher for younger age & pelvic radiation
- Benefits should generally outweigh risks

Berrington de Gonzalez et al (in preparation)
Newer Radiotherapy Modalities

- Intensity modulated radiotherapy (IMRT) & proton therapy
- Aim to reduce high-dose exposures
  - Acute toxicities (e.g., bladder damage)
- Second cancer risks?
Radiation Epidemiology Branch Strategic Plan
- Medical Radiation Exposure

• **Monitor use of existing and emerging medical technologies**
  – Conduct studies of questions of public health & clinical concern

• **Assess the radiation dose-response relationship**
  – Low & high-dose range
  – Fractionated vs acute exposures
  – Identify radiosensitive sub-groups
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