Diagnostic Radiation Exposure and Cancer Risk

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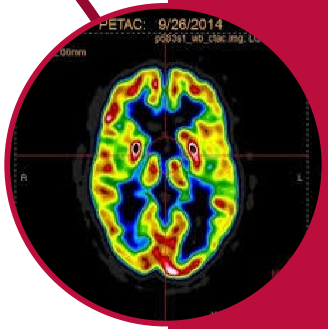
DCEG Radiation Epidemiology and Dosimetry Course 2019

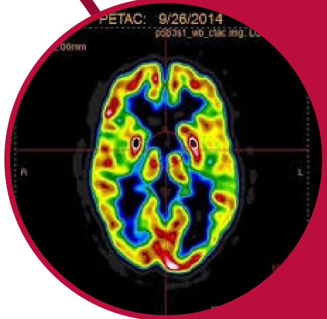
Why Study Cancer Risks from Medical Diagnostic Radiation?



Exposures increasing & evolving

- Quantify risks from current exposures
- Emerging exposures eg PET-CT
- Public heath concern – is it safe?

Why Study Cancer Risks from Medical Diagnostic Radiation? (2)



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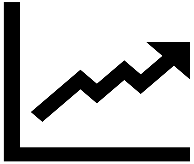

Inform low-dose radiation carcinogenesis

- Understand risks from low-dose, fractionated, non-uniform exposure
- Risk in women & children (complement worker studies)

Diagnostic Imaging Procedures for Selected Years in the United States

Type of Procedure	1950*	1964†	1970‡	1980–1982§	2006‖
Radiologic procedures#	. . .	. . .	. . .	180	377
Radiographic and fluoroscopic studies	25	109	136	177	293
CT scanning	. . .	. . .	. . .	3.3 (2–3.5)**	67
Interventional procedures	. . .	. . .	. . .	. . .	17
Dental radiographic examinations	. . .	54	67	101††	500‡‡
Nuclear medicine studies	. . .	. . .	. . .	7	18

Number of procedures in millions

Mettler, 2009 (Radiology)

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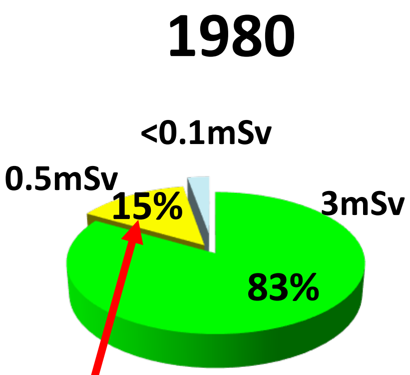
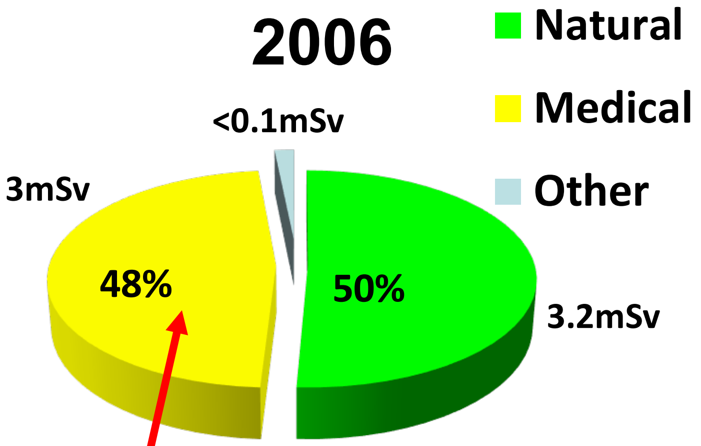
Dramatic Increase in Medical Exposures in the U.S.



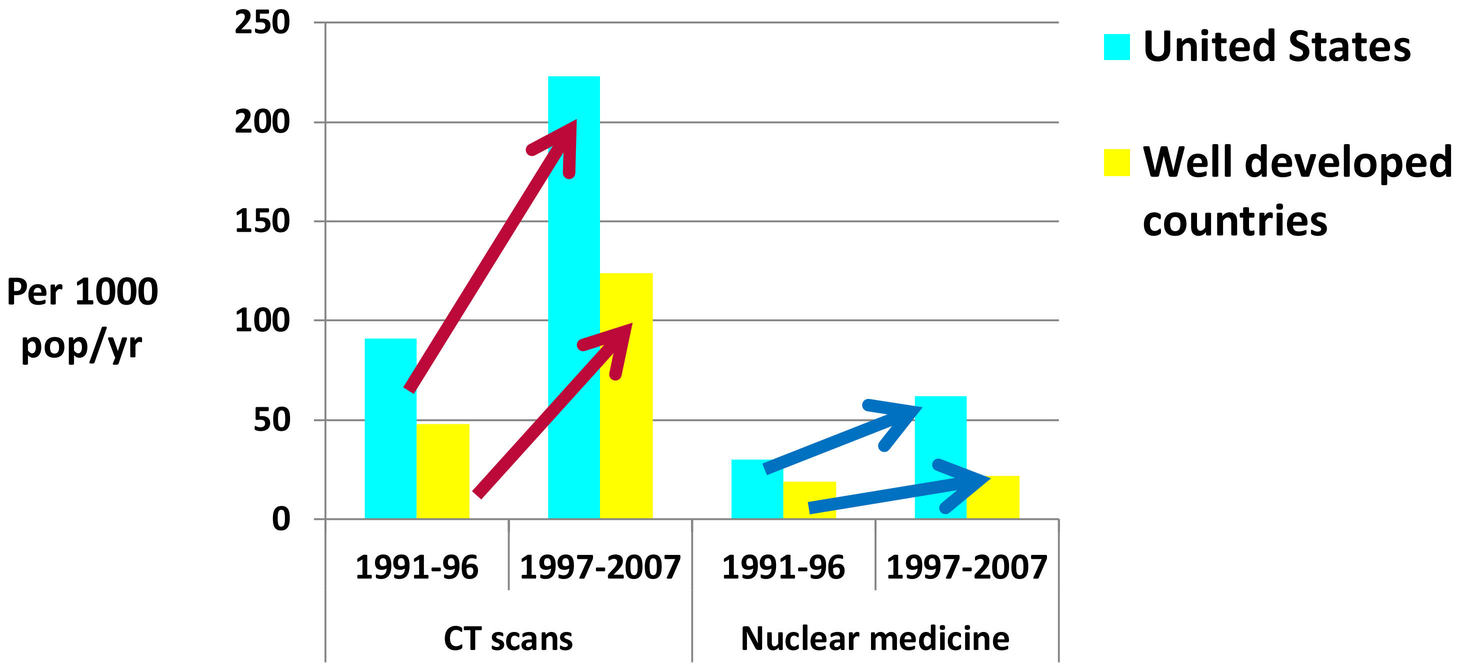


CT scans - 3 million
Nuclear medicine - 6 million

CT scans - 70 million
Nuclear medicine - 18 million

NCRP report 160 (2009)

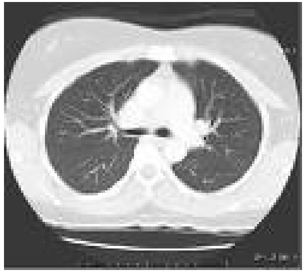
International Trends in Diagnostic Imaging



Mettler et al (Radiology 2009)

Diagnostic Imaging - Effective & Organ Doses

Procedure	X-ray	CT scan
Skull	0.1 mSv	2 mSv
Chest	0.1 mSv	7 mSv
Abdomen	0.7 mSv	8 mSv



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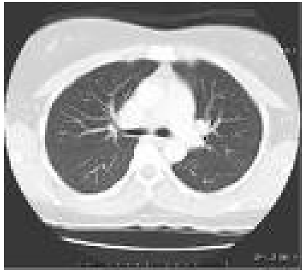


CT scan	Brain	Lung	Stomach
Skull	$\boxed{40\ \text{mGy}}$	0 mGy	0 mGy
Chest	0 mGy	20 mGy	6 mGy
Abdomen	0 mGy	3 mGy	20 mGy

Mettler et al (Radiology 2009)

Radiation Protection Principles

- Justification
- Optimization
- Dose limit

Radiation Protection Principles (2)

- Justification → Do more good than harm
- Optimization → ALARA
- Dose limit →

⇨ Medical exposure

Radiation Protection Principles (3)

- Justification → Do more good than harm
- Optimization → ALARA

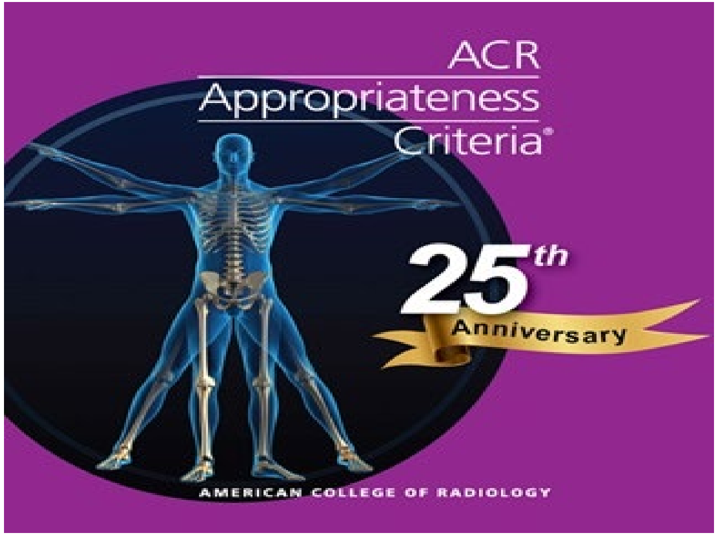
⇨ Medical exposure

- Dose limit → Not Applicable for medical exposure
  - Intentional and for the direct benefit of the patient.
  - Limit may compromise patient care.

❖ Diagnostic Reference Level (DRL) – investigation level

Optimization and Justification in medical diagnostic imaging

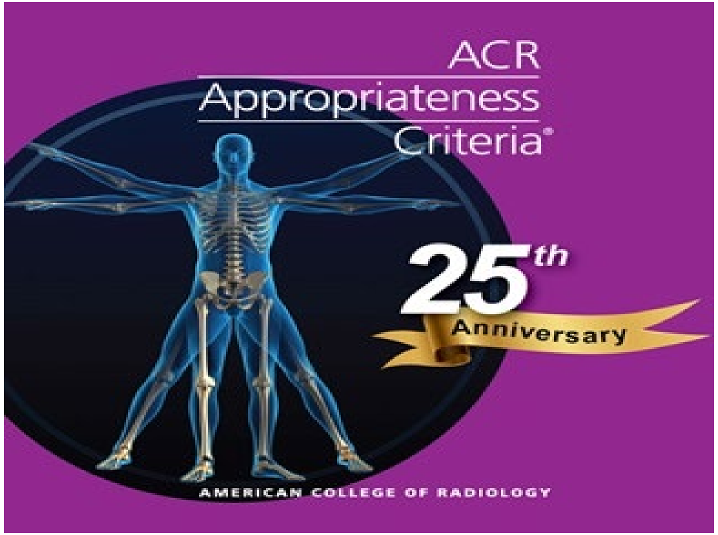
- Appropriateness use criteria



Optimization and Justification in medical diagnostic imaging (2)

- Appropriateness use criteria

Guidelines funded by the ACR to assist physicians on which imaging tests they should, or should not, order for different patient symptoms, medical histories, and health status



Optimization and Justification in medical diagnostic imaging (3)

- Appropriateness use criteria
- Campaigns to reduce unnecessary use

World Health Organization

Global Initiative on Radiation Safety in Healthcare Settings

image gently®

Canada Safe Imaging

ESR EUROSAFE IMAGING

LATIN SAFE PEDIATRIA

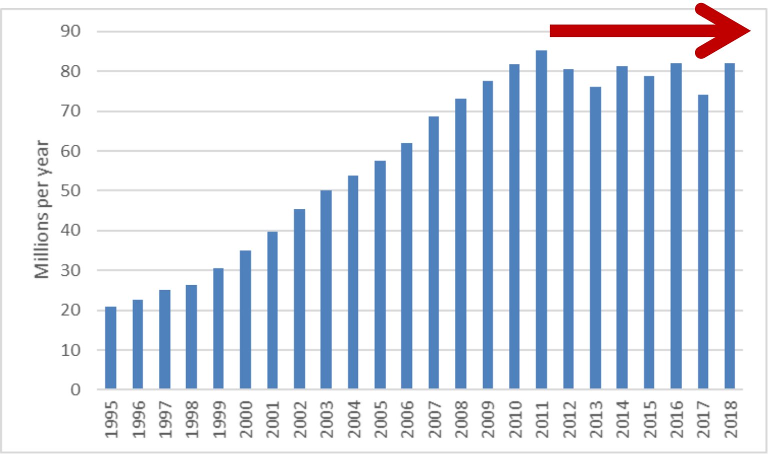
Optimization and Justification in medical diagnostic imaging (4)

- Appropriateness use criteria
- Campaigns to reduce unnecessary use
- Doses optimization

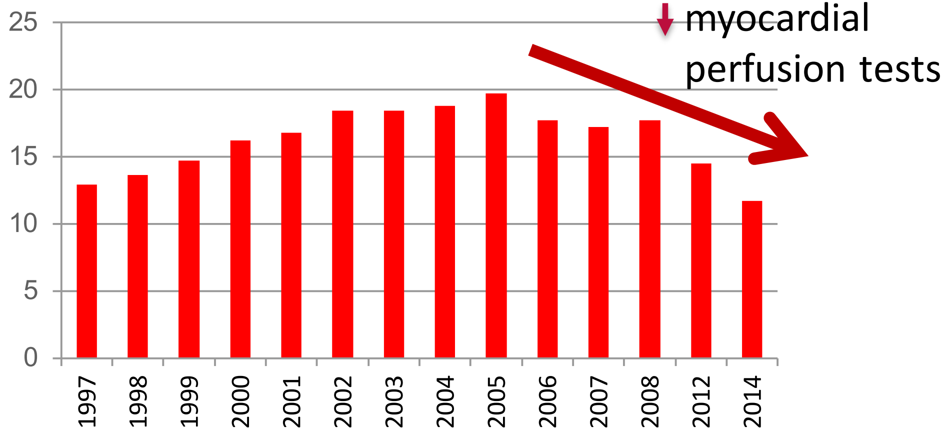
Part of the Image Gently campaign to reduce doses from pediatric CTs.
→Adjust CT parameters to child size

Recent Trends in the United States

CT procedures
(millions per year)



Nuclear medicine procedures
(millions per year)



IMV Market Research Reports

Studies on Diagnostic Radiation and Cancer Risk

PUBLIC HEALTH CONCERN

LOW-DOSE RADIATION CARCINOGENESIS

CLINICAL DECISION MAKING

Studies on Diagnostic Radiation and Cancer Risk
Methodological Issues

Case-control vs cohort design

Sample size

Exposure assessment

Confounding by indication

Studies on Diagnostic Radiation and Cancer Risk
Methodological Issues (2)

Case-control vs cohort design

- Recall bias in case-control studies.
- Loss to follow-up and incomplete ascertainment in cohort studies

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Sample size

- Maximize power by studying highly radiosensitive cancers & childhood exposure

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Case-control vs cohort design

- Recall bias in case-control studies.
- Long follow-up for cohort studies

Sample size

- Maximize power by studying highly radiosensitive cancers & childhood exposure

Exposure assessment

- Medical records

vs Self-reported

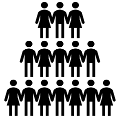
- Information for dose reconstruction
- Organ doses

Confounding by indication

Studies on Diagnostic Radiation and Cancer Risk Methodological Issues (5)

Case-control vs cohort design

- Recall bias in case-control studies.
- Long follow-up for cohort studies



Sample size

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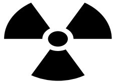


Exposure assessment

- Medical records

vs Self-reported

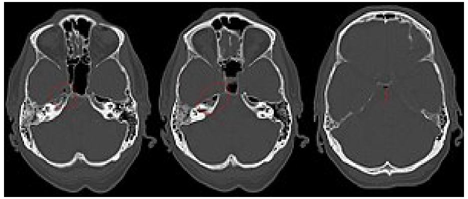
- Dose reconstruction
- Organ doses

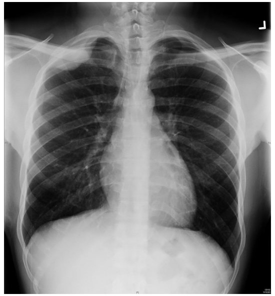
Confounding by indication

- Underlying conditions related to the outcome and the exposure

Evidences from Main Studies on Diagnostic Radiation and Cancer Risk

- **Diagnostic X-rays**
  - ✓ In-utero exposure
  - ✓ Adult and childhood exposure
  - ✓ BRCA mutation carriers





- **Pediatric CT**

- **Screening examinations**

Diagnostic X-Ray and Cancer Risk
In utero exposures

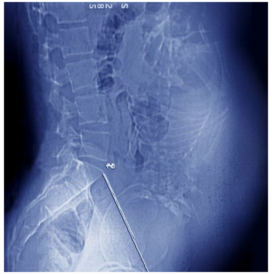
Oxford Survey of Childhood Cancer Mortality, 1953-1972

- ✓ Study on leukemia and childhood cancer mortality associated with radiation exposure due to abdominal and pelvis X-rays during pregnancy
- ✓ Nationwide survey -15,300 deaths (cases), 1:1 paired controls (age, sex & local of residence)
- ✓ X-rays exposure - Self-reported from mother of cases and controls

Doll and Wakeford (Br J Radiology 1997); Wakeford (Radiat Prot Dosimetry 2008)

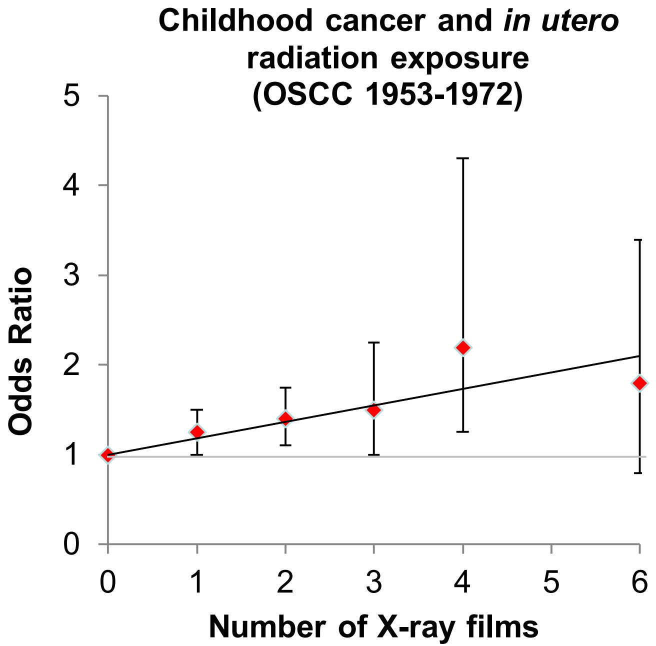
Diagnostic X-Ray and Cancer Risk

In Utero Exposures (2)



Oxford Survey of Childhood Cancer Mortality, 1953-1972

- ✓ OR=1.39 (1.30-1.49) childhood cancer
- ✓ OR=1.49 (1.33-1.67) childhood leukaemia
- ✓ Decline in risk by birth cohort
- ✓ Dose per film
  - 15mGy 1940s
  - 3mGy 1960s
- ❖ Recall bias ?



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Diagnostic X-Ray and Cancer Risk

In Utero Exposures (3)

Other studies on leukaemia and in utero radiation exposure:

- Northeastern US case-control study (medical record-based)
  - ✓ OR=1.48 (1.18-1.85)

(Monson & MacMahon, 1984, JNCI)

Diagnostic X-Ray and Cancer Risk

In Utero Exposures (4)

Other studies on leukaemia and in utero radiation exposure:

- Northeastern US case-control study (medical record-based)
  - ✓ OR=1.48 (1.18-1.85)
- Meta-analysis of 32 case-control studies
  - ✓ RR=1.32 (1.19-1.42)

(Monson & MacMahon, 1984, JNCI)

Diagnostic X-Ray and Cancer Risk

In Utero Exposures (5)

Other studies on leukaemia and in utero radiation exposure:

- Northeastern US case-control study (medical record-based)
  - ✓OR=1.48 (1.18-1.85)
- Meta-analysis of 32 case-control studies
  - ✓ RR=1.32 (1.19-1.42)
- UKCCS case-control study (medical-record-based)
  - ✓All childhood cancers, OR=1.14 (0.90-1.45)
  - ✓Leukemia, OR=1.36 (0.91-2.02)

(Monson & MacMahon, 1984, JNCI)

Diagnostic X-Ray and Cancer Risk

Childhood and young adult exposures

Breast cancer risk & Multiple Spine X-rays
US Scoliosis Cohort Study

- 3,010 Scoliosis patients
- Mean age: 12 (0-19) years
- 36 years follow-up, 78 breast cancer
- Repeated spine X-ray (medical records):
  - ✓ Mean: 27 (range: 0-332)
- Breast dose:
  - ✓ Mean: 120 mGy (range: 0-1110)

Ronckers et al (Cancer Epidemiol Biomarkers Prev 2008)

Diagnostic X-Ray and Cancer Risk

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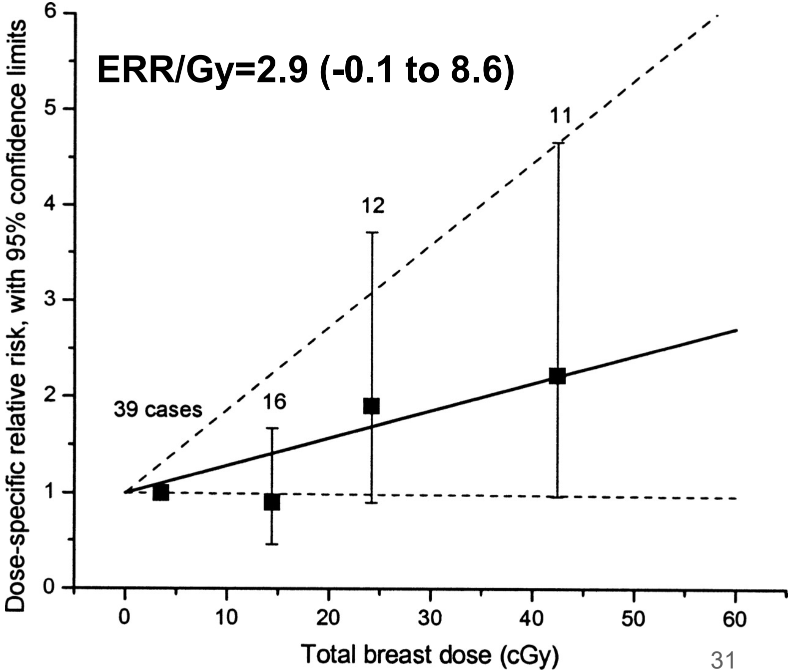

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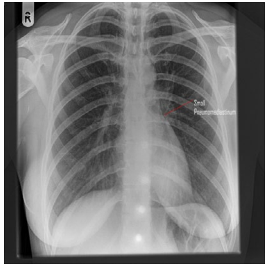
Diagnostic X-Ray and Cancer Risk

Adult Exposures



Multiple fluoroscopies among Tuberculosis patients

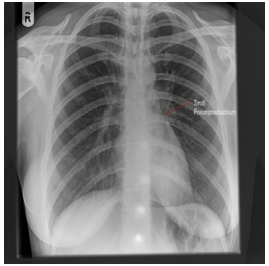
Breast Cancer

- Massachusetts TB 4,940 women (1925-54)
- Canadian TB 31,710 women (1930-1952)

Boice et al (Radiat Res 1991); Howe and McLaughlin (Radiat Res 1996); Howe (Radiat Res 1995) ;

Diagnostic X-Ray and Cancer Risk

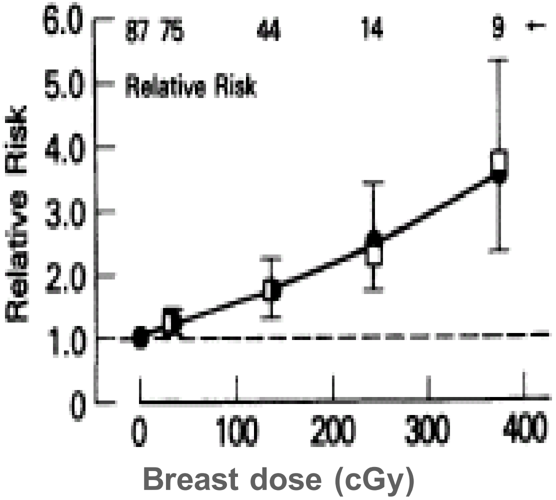
Adult Exposures (2)



Multiple fluoroscopies among Tuberculosis patients

Breast Cancer

- Massachusetts TB 4,940 women (1925-54)
  - ✓ Mean breast dose 0.8Gy (88 exposures)
  - ✓ 234 breast cancers cases
  - ✓ RR=1.61 (1.30-2.01) at 1Gy



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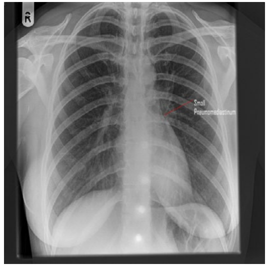

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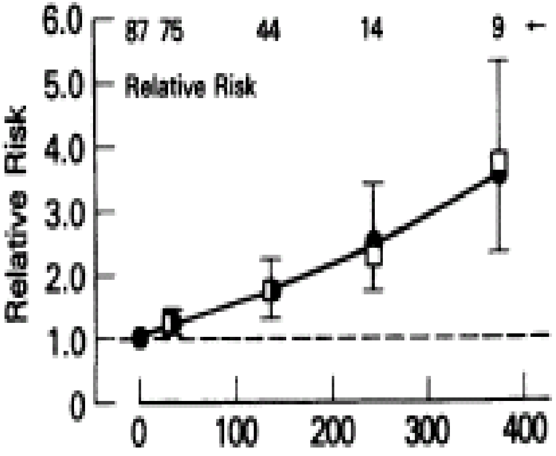
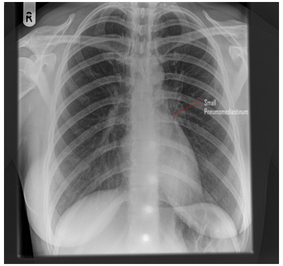


- Canadian TB 31,710 women (1930-1952)
  - ✓ 688 breast cancer deaths
  - ✓ RR=1.36 (1.11-1.67) at 1Gy

Boice et al (Radiat Res 1991); Howe and McLaughlin (Radiat Res 1996); Howe (Radiat Res 1995) ;

Diagnostic X-Ray and Cancer Risk

Adult Exposures (4)



Multiple fluoroscopies among Tuberculosis patients

Lung Cancer

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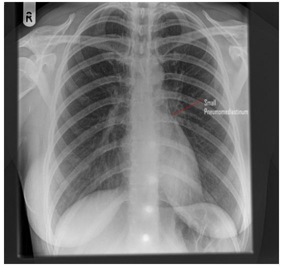
- Canadian 64,172 TB (Mean dose 1Gy)

Howe (Radiat Res 1995) ; Davis et al (Cancer Research 1989)

Diagnostic X-Ray and Cancer Risk

Adult Exposures (5)



Multiple fluoroscopies among Tuberculosis patients

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- Massachusetts 13,572 TB patients (Mean dose 0.8Gy)
  - ✓357 lung cancer deaths
  - ✓RR at 1 Gy 0.96 (0.89 to 1.14)

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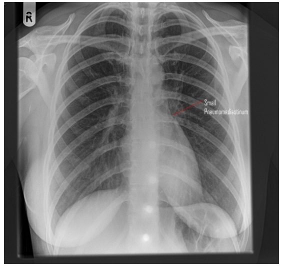
Diagnostic X-Ray and Cancer Risk

Adult Exposures (6)



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❖ **No excesses of lung cancer**

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Diagnostic X-Ray and Cancer Risk

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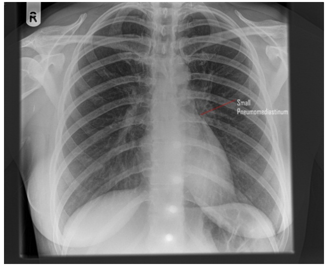

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- Canadian 64,172 TB (Mean dose 1Gy)
  - ✓1,178 lung cancer deaths
  - ✓ RR at 1 Gy 1.00 (0.94 to 1.07)

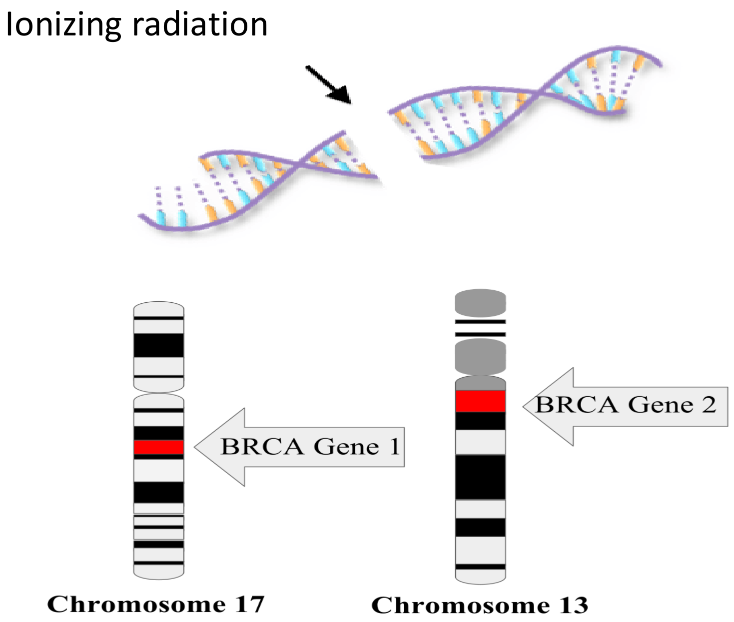
❖ **No excesses of lung cancer**

- Confounding by indication?
- TB risk factor for lung cancer
- Misclassification of cause of death (lung cancer vs tuberculosis)

Howe (Radiat Res 1995) ; Davis et al (Cancer Research 1989)

Diagnostic X-Ray and Cancer Risk

Breast cancer & Chest X-rays among BRCA carriers



Radiosensitive population – carries of BRCA 1/2 mutation

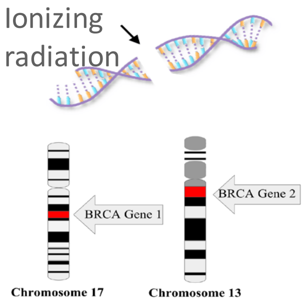
✓ greater risk of developing breast cancer

BRCA 1/2 genes → DNA repair process, including double-strand breaks caused by ionizing radiation

Andrieu et al (JCO 2006); Narod et al (Lancet Oncol 2006), Pijpe et al (BMJ 2012)

Diagnostic X-Ray and Cancer Risk
Breast cancer & Chest X-rays among BRCA carriers (2)

- **Cohort study n=1993 BRCA 1/2 mutation carriers, 2006-2009**
  - Three nationwide studies in France, UK and the Netherlands
  - Cumulative breast dose - self-reported diagnostic procedures



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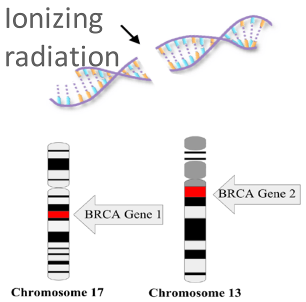
  - Any diagnostic radiation, HR=1.65 (1.11-2.46)
  - Exposure <age 30
    - ✓HR=1.90 (1.20-3.00), with dose–response pattern
    - ✓Breast dose>17 mGy, HR=3.84 (1.67-8.79)



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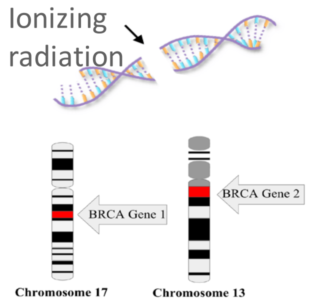
  - Exposure >age 30
    - ✓HR=1.06 (0.66-1.71)



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Diagnostic X-Ray and Cancer Risk

Breast cancer & Chest X-rays among BRCA carriers (5)

- Increased risk in dose levels lower than other cohorts exposed to radiation
- Recall bias ?
  - Two methodological studies in the Dutch cohort → extent of the misclassification was small and mainly non-differential by disease status.

Andrieu et al (JCO 2006); Narod et al (Lancet Oncol 2006), Pijpe et al (BMJ 2012)

Diagnostic X-Ray and Cancer Risk

Thyroid Cancer & Diagnostic X-rays

- Swedish medical records study
- 484 thyroid cancer cases and matched population controls (1980-1992)
- Generic thyroid dose estimates

Inskip et al (JNCI 1995)

Diagnostic X-Ray and Cancer Risk

Thyroid Cancer & Diagnostic X-rays (2)

- Swedish medical records study
- 484 thyroid cancer cases and matched population controls (1980-1992)
- Generic thyroid dose estimates

- No risk associated with past X-rays
  - ✓Similar results <age 20 exposure
  - ✓But small number of X-rays among children and adolescents.

Cumulative thyroid dose (mGy)	Cases / Controls	RR	95%CI
0	133/137	1.00	Ref.
>0-1.6	116/114	1.05	(0.73-1.52)
1.7-6.8	114/114	1.04	(0.70-1.55)
7.0-75.3	121/119	1.05	(0.73-1.52)
P-trend		0.80	

Inskip et al (JNCI 1995)

Diagnostic X-Ray and Cancer Risk

Thyroid Cancer & Diagnostic X-rays (3)

USRT Cohort study, n=76,415 and 414 thyroid cancer cases

- Self-reported personal medical diagnostic procedures
- Estimated radiation thyroid dose (questionnaire and literature review)
- Assuming Rad Technologists report their medical radiation more accurate than general population

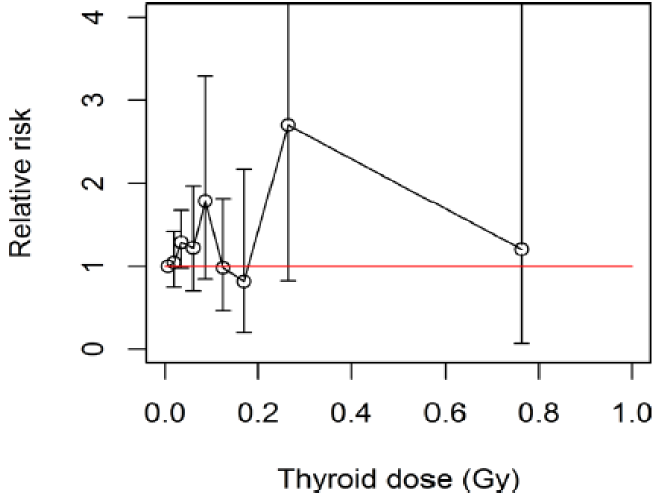
Little et al (BMJ 2018)

Diagnostic X-Ray and Cancer Risk

Thyroid Cancer & Diagnostic X-rays (3)

USRT Cohort study, n=76,415 and 414 thyroid cancer cases

- Self-reported personal medical diagnostic procedures
- Estimated radiation thyroid dose (questionnaire and literature review)
- Assuming Rad Technologists report their medical radiation more accurate than general population
- Weak evidence of association of diagnostic X-rays and thyroid cancer



Little et al (BMJ 2018)

Diagnostic X-Ray and Cancer Risk

Thyroid Cancer & Diagnostic X-rays (4)

Comparison of documented and recalled histories of diagnostic X-rays

- 123 cases & controls - Sweden study
- 50 cases & controls - US Kaiser NW health plan
- Medical records vs Telephone interview
- Discrepancy score: N per interview - N per medical record
  - ✓ Negative →underreporting
  - ✓ Positive →overreporting

Berrington de Gonzalez et al (AJE 2003)

Diagnostic X-Ray and Cancer Risk

Thyroid Cancer & Diagnostic X-rays (5)

Comparison of documented and recalled histories of diagnostic X-rays

- 123 cases & controls - Sweden study
- 50 cases & controls - US Kaiser NW health plan
- Medical records vs Telephone interview
- Discrepancy score: N per interview - N per medical record
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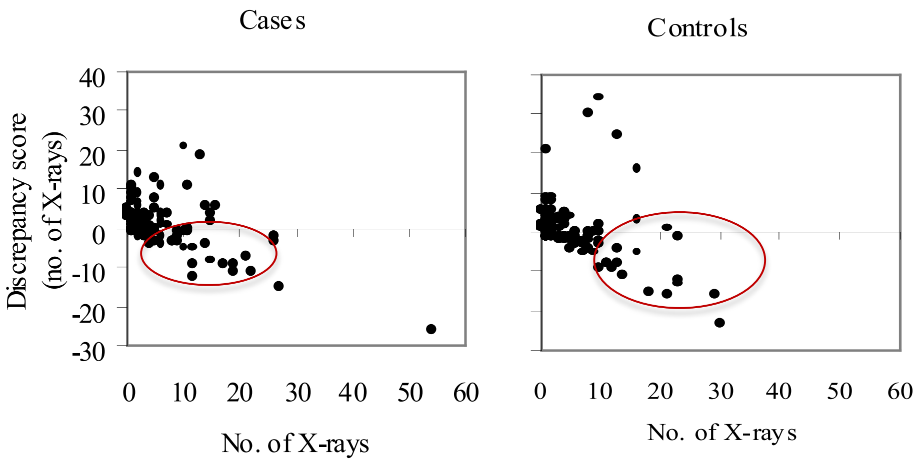
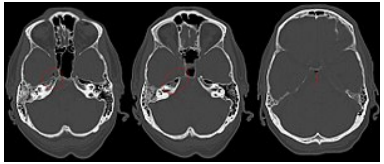


Berrington de Gonzalez et al (AJE 2003)

Pediatric CT Scans & Cancer Risk

- Higher doses & risks for children
  - ✓Adult settings in past (<2000)

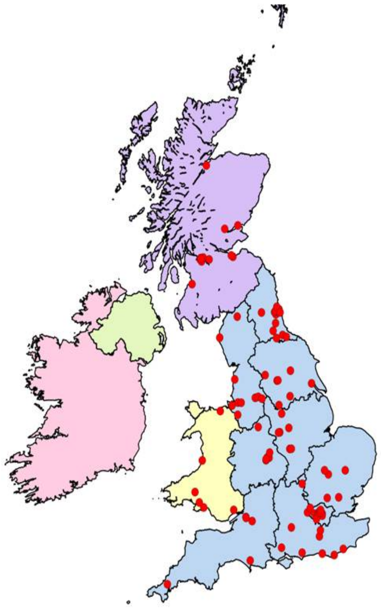
	Head CT	Chest CT
Organ	Brain	Lung/Breast
<1990	60mGy	30mGy
2000+	30mGy	5mGy



✓Children have a long life expectancy → increase risk over lifetime

NCI-UK Pediatric CT scan Cohort

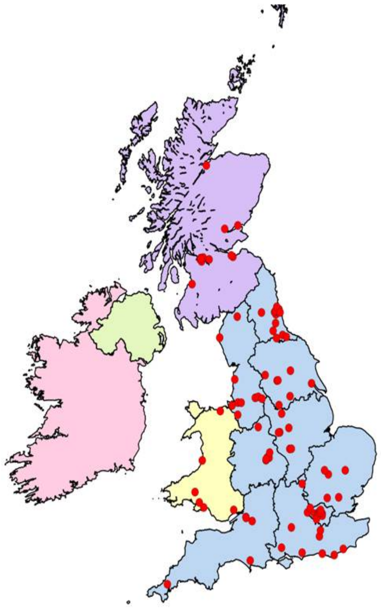
- Record linkage study of brain and leukemia
  - ✓ Cancer incidence following CT scans to 178,000 persons (1985-2002) at ages 0-21
  - ✓ Historical data from RIS, paper of film records



Pearce et al (Lancet 2012); Kim et al (Radiat Prot Dosimetry 2012)

NCI-UK Pediatric CT scan Cohort (2)

- Record linkage study of brain and leukemia
  - ✓ Cancer incidence following CT scans to 178,000 persons (1985-2002) at ages 0-21.
  - ✓ Historical data from RIS, paper of film records
- Organ dose estimates
  - ✓ Generic dosimetry based on average machine settings.



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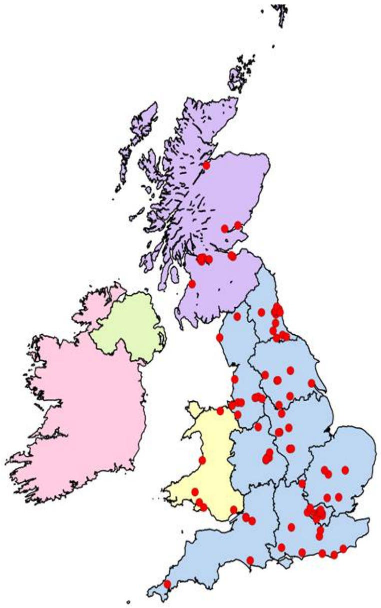
- Record linkage study of brain and leukemia
  - ✓ Cancer incidence following CT scans to 178,000 persons (1985-2002) at ages 0-21
  - ✓ Historical data from RIS, paper of film records
- Organ dose estimates
  - ✓ Generic dosimetry based on average machine settings.
- Avoid CT scans related to cancer diagnosis:
  - ✓ Leukemia - Follow-up begun 2 years after the first CT
  - ✓ Brain tumors - Follow-up begun 5 years after the first CT

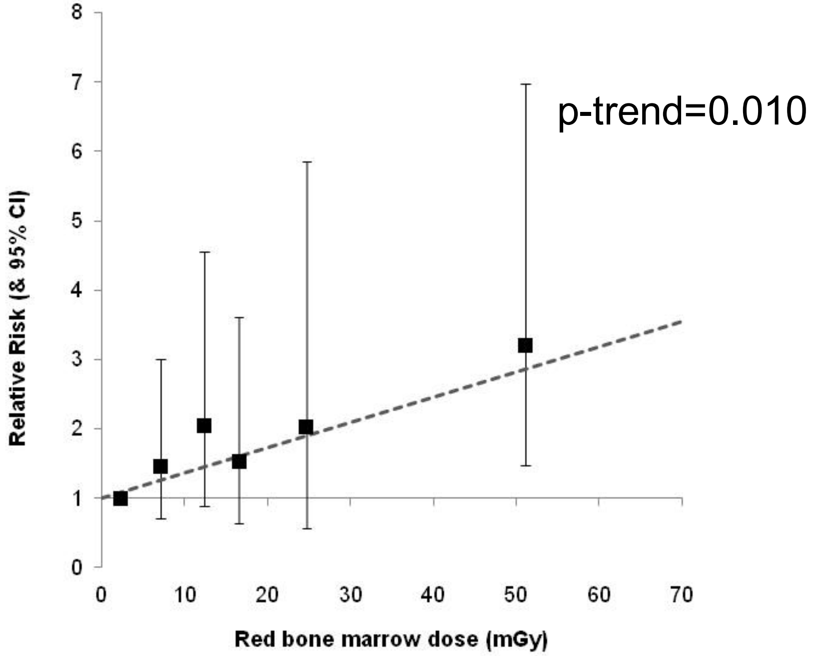


Pearce et al (Lancet 2012); Kim et al (Radiat Prot Dosimetry 2012)

Leukaemia/MDS and brain tumors dose-response

Leukaemia & MDS (n=74)

Excess relative risk per mGy=0.036



Pearce et al, Lancet 2012

Leukaemia/MDS and brain tumors dose-response (2)

Leukaemia & MDS (n=74)

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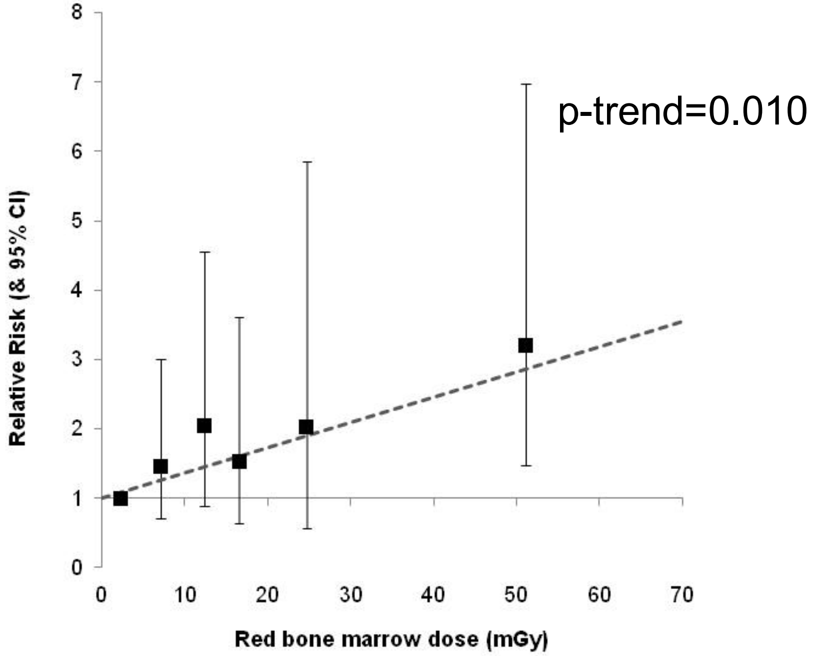
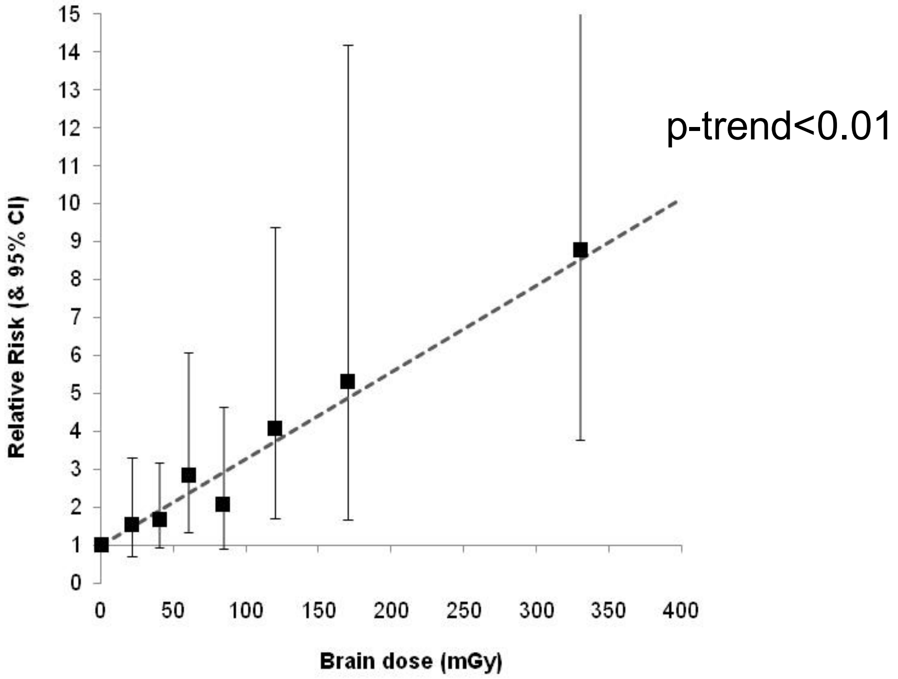


Brain (n=135)

Excess relative risk per mGy=0.023



Pearce et al, Lancet 2012

Comparison with the Life Span Study*

	UK CT Study	Life Span Study*
	ERR/mGy (95%CI)	
Leukemia	0.036 (0.005-0.12)	0.045 (0.016-0.188)

*Restricted to similar dose range, age at exposure and follow-up time

Pearce et al, Lancet 2012

Comparison with the Life Span Study*

	UK CT Study	Life Span Study*
	ERR/mGy (95%CI)	
Leukemia	0.036 (0.005-0.12)	0.045 (0.016-0.188)
Brain tumors	0.023 (0.010-0.049)	0.006 (0.0001-0.063)

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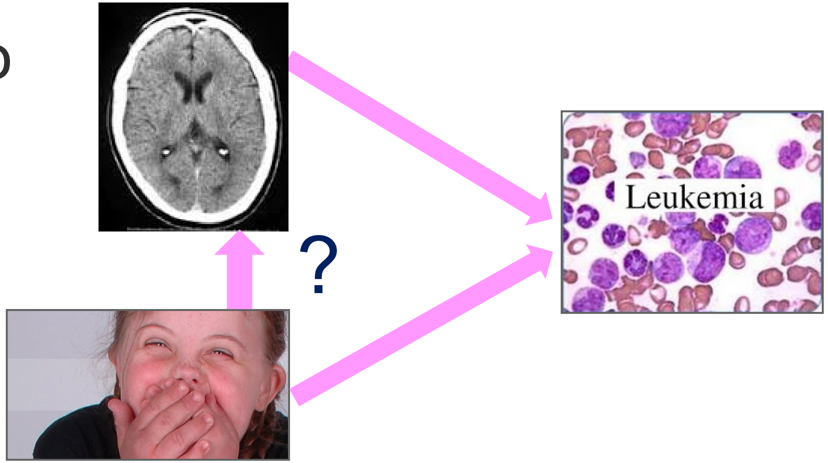
Pearce et al, Lancet 2012

Confounding by Indication?

Underlying condition related to cancer & the condition related to CT scan frequency



Brain tumors

CT scan may have been performed because of a preexisting or unreported brain cancer

Impact of Underlying Conditions

Relevant clinical information were collected and reviewed:

- **<u>Predisposing conditions for Leukemia and Brain tumors:</u>**
  - ✓ Down syndrome, LFS, Fanconi anemia, bone marrow transplants, neurofibromatosis type 1 and 2, and others.

Berrington de Gonzalez et al (BJC 2016)

Impact of Underlying Conditions (2)

Relevant clinical information were collected and reviewed:

- **Predisposing conditions for Leukemia and Brain tumors:**
  - ✓ Down syndrome, LFS, Fanconi anemia, bone marrow transplants, neurofibromatosis type 1 and 2, and others.

- **Previous cancer or possible previous cancer:**
  - ✓ Previous cancer not in the UK cancer registry
  - ✓ Possible previous cancer – Possible undiagnosed cancer or if the CT could have been performed due to cancer-related symptoms.

Berrington de Gonzalez et al (BJC 2016)

Impact of Excluding Underlying Conditions and Possible Previous Cancer

ERR/mGy	UK CT Study	UK CT Study (after exclusions)	Life Span Study
Leukemia	0.036 (0.005-0.12) (n=74)	0.031 (0.003, 0.109) (n=70)	0.045 (0.016-0.188)

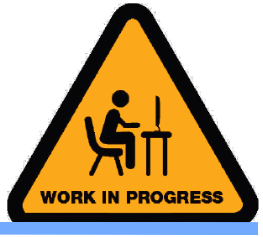
Berrington de Gonzalez et al (BJC 2016)

Impact of Excluding Underlying Conditions and Possible Previous Cancer (2)

ERR/mGy	UK CT Study	UK CT Study (after exclusions)	Life Span Study
Leukemia	0.036 (0.005-0.12) (n=74)	0.031 (0.003, 0.109) (n=70)	0.045 (0.016-0.188)
Brain tumors	0.023 (0.010-0.049) (n=135)	0.012 (0.004, 0.031) (n=112)	0.006 (0.0001-0.063)

Berrington de Gonzalez et al (BJC 2016)

NCI-UK Pediatric CT Scan Cohort study



- Extended cohort follow-up
- Case-control study (detailed dosimetry)
- Collection of CT films to improve dosimetry/uncertainty

Ongoing Pediatric CT Scans Cohorts

- Canada (n=400k)
- Israel (n=70k)
- French (n=60k)
- German (n=45k)
- Australian Cohort (n=680k)
- Taiwan (n=24k)
- The Netherlands (n=45k)

Ongoing Pediatric CT Scans Cohorts (2)

- Canada (n=400k)
- Israel (n=70k)
- French (n=60)
- German (n=45k)
- Australian Cohort (n=680k)
- Taiwan (n=24k)
- The Netherlands (n=45k)

- **Statistically significant dose-response between brain dose and brain tumors**
- **No statistically significant dose-response between bone marrow dose and leukemia**

Journy et al (JRP 2016); Krille et al (Rad Envi Bioph 2015), Melleupas et al (JNCI 2019)

Ongoing Pediatric CT Scans Cohorts (3)

❖ **European Study EPI-CT – 9 countries, ~ 1 million**

- Belgium, Denmark, France, Germany, The Netherlands, Norway, Spain, Sweden and UK.
- CT scans aged 0-22 yrs
- Organ dose reconstruction – RIS and PACS - NCICT
- Underlying diseases collected from various source (hospital database and rare disease registries)
- First results – SMR
- Dose-response analysis underway

(Bernier et al, IJE 2019)

EPI-CT study – First results

SMR according to the time since first CT (1-year exclusion period)

- **<u>1-5 years since 1st CT</u>**

All causes of mortality → SMR=4.2 (4.1-4.3)

All cancer mortality → SMR=3.3 (3.0-3.7)

Non-cancer mortality → SMR=3.7 (3.6-3.8)

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- **<u>5+ years since 1st CT</u>**

All causes of mortality → SMR=2.2 (2.2-2.3)
All cancer mortality → SMR=1.1 (1.0-1.2)
Non-cancer mortality →SMR=2.3 (2.3-2.4)

(Bernier et al, IJE 2019)

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Suggested that CT performed because of a suspicious of cancer

(Bernier et al, IJE 2019)

Diagnostic X-Ray and Cancer Risk

On-going studies

US Kaiser Pediatric Imaging Case-Control Study

In utero & childhood exposures

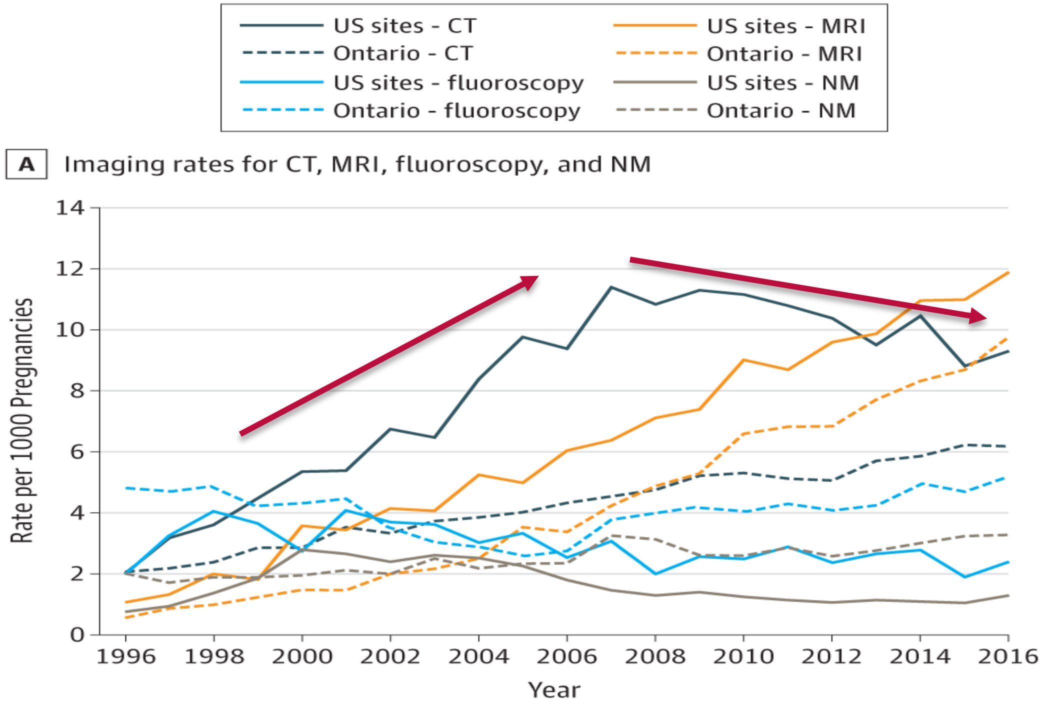
4 Kaiser HMOs

- 750 leukemias (estimated)
- Controls matched on age & time in health plan

Imaging data from PACs

PIs: Smith-Bindman, Miglioretti, Kwan

Trends in Medical Imaging during Pregnancies in US and Canada, 1996-2016



Kwan et al (JAMA 2019)

Pooled Analysis of 9 Cohorts and Thyroid Cancer/Leukemia

9 cohorts of childhood exposure

- 394 thyroid cancers
- 221 leukemias

Diagnostic/therapeutic radiation & A-bomb

- Restricted to <200 or <100mGy

Lubin,…, Veiga (JCEM 2017)   Little,…,Berrington (Lancet Haematology, 2018)

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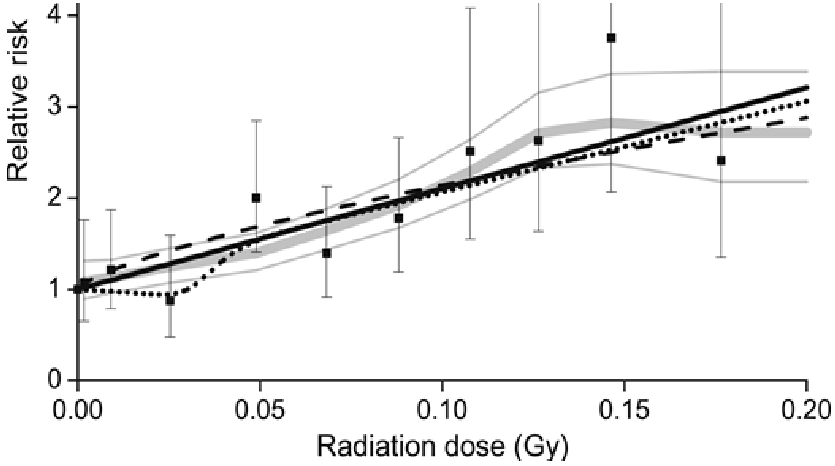
ERR/Gy = 11.1 (95% CI: 6.6 to 19.7)



Thyroid dose (Gy)

Lubin,…, Veiga (JCEM 2017) Little,…,Berrington (Lancet Haematology, 2018)

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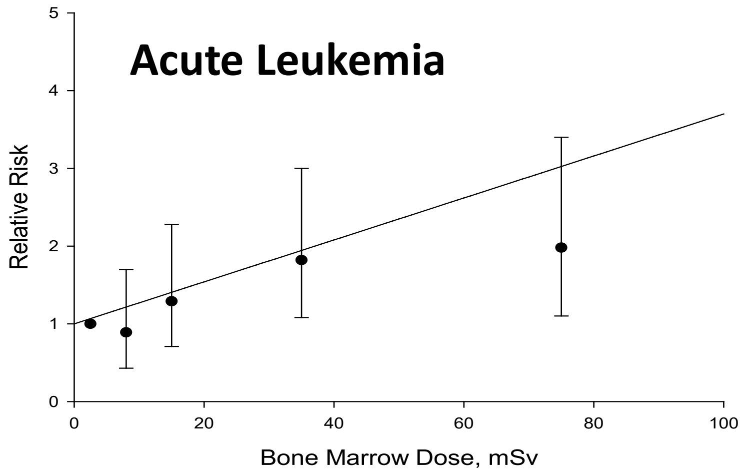

Significant dose-response for:
Acute myeloid leukemia (p-trend=0.03)
Acute lymphoblastic leukemia (p-trend=0.02)

Lubin,…, Veiga (JCEM 2017) Little,…,Berrington (Lancet Haematology, 2018)

Screening Tests & Cancer Risk

- Screening – Testing for a disease in a population with no symptoms
  - Doses lower than diagnostic
  - Large numbers of healthy individuals → will not develop the disease
  - Benefits (reducing mortality) >>>> Risks
  - Very low doses → large sample size
  - Risk projection rather than direct studies

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Screening Examinations: Risk Projection

- Younger screening ages
  - ✓Lower cancer incidence rates → lower absolute mortality reduction
- Mortality reduction from screening >>radiation induced mortality
  - ✓Mammography BRCA carriers > age 35
  - ✓Lung CT smokers > age 50
  - ✓CT colonography > age 50

Berrington de González et al (J Natl Can Inst 2009) Berrington de González (J Med Screen 2007) Berrington de González et al (J Med Screen 2008)

Summary of Key Results

Repeated low-dose medical exposures related to increased cancer risk….but absolute risks generally small

Summary of Key Results (2)

Repeated low-dose medical exposures related to increased cancer risk….but absolute risks generally small

Absolute excess risk from CT:

1 Head CT before age 10 → 1 excess case of leukemia and one excess case of brain tumor per 10,000 patients

Summary of Key Results (3)

Repeated low-dose medical exposures related to increased cancer risk….but absolute risks generally small

Evidence of excess risks from cumulative doses <100mGy for childhood leukemia & thyroid cancer

Summary of Key Results (4)

Repeated low-dose medical exposures related to increased cancer risk….but absolute risks generally small

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Risk estimates for non-uniform exposures and children and women

Summary of Key Results (5)

Repeated low-dose medical exposures related to increased cancer risk....but absolute risks generally small

Evidence of excess risks from cumulative doses <100mGy for childhood leukemia & thyroid cancer

Risk estimates for non-uniform exposures and children and women

ERR/Gy generally compatible with A-bomb Life Span Study (DDREF = 1?)

Future Opportunities

Diagnostic medical radiation exposure continues to expand and evolve

Future Opportunities (2)

Diagnostic medical radiation exposure continues to expand and evolve

Expansion of electronic medical records and digital imaging facilitates studies

Future Opportunities (3)

Diagnostic medical radiation exposure continues to expand and evolve

Expansion of electronic medical records and digital imaging facilitates studies

Opportunities to study non-cancer outcomes from low doses eg CVD & cataracts

Why is it important to study diagnostic radiation exposure and cancer risk?

A. Public health concern

B. Implications for clinical decision making

C. Learn about radiation risk in low-dose fractionated exposure

D. All above

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C. Learn about radiation risk in low-dose fractionated exposure

D. All above

Medical diagnostic radiation exposure should be clinically justified and dose optimized.

A. True

B. False

Medical diagnostic radiation exposure should be clinically justified and dose optimized.

A. True

B. False

U.S. Department of Health & Human Services

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dceg.cancer.gov/

1-800-4-CANCER

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