Table 2.1. Cohort studies of X-ray exposure and cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/ deaths	Relative risk (95% CI)*	Adjustment for potential confounders	Comments
Andrieu *et al.* (2006) Europe & Canada	1601 female BRCA1 + BRCA2 carriers, aged 18+; disease ascertainment via questionnaire, 1997–2002	Interviewer-administered standardized questionnaire: ever vs never	Female breast cancer	Number of X-ray exposures (for UK & Ireland only ever vs never)	853 cases	Never exposed 1.0 1-4 X-rays 1.09 (95% CI 0.7-1.7) 5+ X-rays 1.92 (95% CI 1.2-3.0)	Year of birth, country, parity, oophorectomy	Poor ascertainment of radiation exposure and disease; potential for recall bias
Carr *et al.* (2002) US cohort receiving X-rays for treatment of peptic ulcers	3997 treated for peptic ulcers at University of Chicago between 1937-1965, followed up for mortality to 12/1997	Dose assessed via treatment records for 1852 patients, supplemented with phantom measurements	All cancers, with particular emphasis on all cancers (ICD8 140-209), stomach (ICD8 151), pancreas (ICD8 157), lung (ICD8 162)	Mean stomach dose 1-10 Gy received by 19.7% of irradiated subjects, 11-20 Gy received by 63.8% of irradiated subjects, >20 Gy received by 16.5% of irradiated subjects	All cancer deaths 750, stomach cancer deaths 75, pancreatic cancer deaths 59, lung cancer deaths 209	Stomach ERR /Gy =0.05 (95% CI -0.03 – 0.13)(1-tailed p=0.231); pancreas ERR /Gy =-0.03 (95% CI -0.10 – 0.05)(1-tailed p=0.453); lung ERR /Gy =0.24 (95% CI -0.08 – 0.68)(1-tailed p=0.166)	Cox models using time after treatment as time variable (starting 1 y after exposure), with adjustment for age at exposure, gender, smoking status, surgery type, ulcer type	Generally good radiation exposure assessment

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Damber *et al.* (2002) treated in three hospitals in Northern Sweden	8144 persons given X-ray exposures of cervical spine + 19271 controls given similar treatment but with no dose to thyroid, at ages >15 for benign conditions (mainly arthrosis, sponylosis); case ascertainment via Swedish Cancer Registry, treated 1950-1964, followed up 1958-1995	None (but estimated thyroid dose of ~1 Gy)	Thyroid cancer	Exposed (~1 Gy) vs unexposed	6 male cases, 16 female cases	Exposed men SIR 1.44 (95% CI 0.52 –3.12) Exposed women SIR 1.67 (0.75– 2.71) Unexposed SIR 0.96 Relative risk (relative to unexposed) 1.64 (95% CI 0.94 – 2.85)	None	No radiation exposure assessment
Guibout *et al.* (2005) French-British childhood cancer cohort	1814 3-year female survivors treated for first primary cancer in childhood in 8 French and English centres between 1946-1986, followed up for incidence to 1/1/1993 (France) and 1/1/1991 (UK)	Dose assessed via treatment records for patients, supplemented with phantom measurements	Female breast cancer	Mean breast dose 5.06 Gy (range 0.0 – 88.0)	16 cases	ERR /Gy =0.13 (95% CI <0 – 0.75)(1-tailed p=0.231)	Poisson models adjusted for first cancer type, chemotherapy	Generally good radiation exposure and chemotherapy assessment

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Mohan et al. (2003) US radiologic technologists	146,022 US radiologic technologists, 90305 responding to questionnaire during 1983-1989, followed up for mortality to 1997	None	All cancers, with particular emphasis on all cancers (ICD8 140-209), breast cancer (ICD8 174), lung cancer (ICD8 162), leukaemia (ICD8 204-207)	None	3695 all cancers, 703 female breast cancers, 781 lung cancers, 158 leukaemias	Generally no significant trends among any calendar periods ≥1950. For those working <1950 significant trends by years worked for breast cancer (p=0.018), leukaemia (p=0.05)	Poisson risk models stratified by age, calendar year of follow-up, race, gender and adjusted for employment in various time periods; breast cancer adjusted for age at menopause, age at first birth and family history of breast cancer; lung cancer and all cancers adjusted for duration of smoking and amount smoked	No radiation exposure assessment
Rajaraman *et al.* (2006) US radiologic technologists	146,022 US radiologic technologists, 71894 responding to baseline questionnaire (1983-1989) and free of cancer (other than non-melanoma skin), followed up for mortality to 8/1998	None	Lung cancer	None	66 incident lung cancers, 221 lung cancer deaths	RR (adjusted for smoking) for number of times held patients for X-rays <10 =1, 10-24 =1.7 (95% CI 1.0 – 2.7), 25-49 =1.5 (95% CI 0.9 – 2.4), 50+ =1.5 (95% CI 1.0 – 2.2) (trend p=0.2), generally no significant trends by calendar periods first worked, number of years worked, age first worked etc	Cox models using age as time scale, stratified by birth cohort, adjusted for ethnicity and smoking (never/former/current, and amount smoked (pack years))	No radiation exposure assessment, limited confirmation of lung cancer diagnoses (medical records obtained for 68% of cases, of which 87% confirmed reported diagnosis)

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Ronckers *et al.* (2008) US cohort receiving diagnostic X-rays for scoliosis	3012 women diagnosed with spinal curvature between 1912-1965, followed up by mail and telephone, alive 1992 and participated in health survey	Dose assessed via radiographs from pediatric orthopedic centres	Female breast cancer	Mean dose 9 mGy, 99% centile 37 mGy	78 incident cancers (68 medically confirmed)	ERR /Gy =2.86 (95% CI -0.07 – 8.62)(1-tailed p=0.029)	Poisson models stratified by age, menopausal status, age at first birth, household income, family history of breast cancer	Generally good radiation exposure assessment, not all cases medically confirmed
Sadetzki *et al.* (2005) Israeli cohort receiving therapeutic X-rays for tinea capitis	10834 irradiated patients, and a matched sample of 10834 persons without radiation exposure selected from national population and individually matched by age (±2 years), gender, country of birth and year of immigration, also 5392 non-irradiated siblings, followed up via Israel Cancer Registry to 12/1996	Dose assessed via treatment records	Brain cancer	Maximal dose 6 Gy, median dose 1.38 Gy	81 benign meningiomas, 44 malignant brain tumours	Benign meningioma ERR /Gy =4.63 (95% CI 2.43 – 9.12), malignant brain tumour ERR /Gy =1.98 (95% CI 0.73 – 4.69)	Poisson models stratified by age, gender, ethnic origin	Generally good radiation exposure assessment, diagnostic confirmation

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Shore *et al.* (2002) New York cohort receiving therapeutic X-rays for tinea capitis 1940-1959	2224 irradiated patients aged 1-15 at exposure, 1380 controls in same age range treated for tinea capitis without radiation exposure, followed up via four surveys (last 1988-1993)	Dose assessed via treatment records	Skin cancer	Average dose/treatment =4.75 Gy	128 non-melanomas skin cancers (NMSC) in irradiated group, 21 NMSCs in control group, 0 melanomas in either group	Caucasian ERR /Gy =0.6 (95% CI 0.3 – 1.1), EAR /10^4 PY Gy = 1.9 (95% CI 0.5 – 3.3)	Cox regression + Poisson models stratified by age at irradiation (and for Poisson models stratified by attained age)	Generally good radiation exposure assessment, reasonable diagnostic confirmation (94.4% confirmation via physicians' notes of NMSCs in irradiated group)
Shore *et al.* (2003) New York cohort receiving therapeutic X-rays for tinea capitis 1940-1959	2224 irradiated patients aged 1-15 at exposure, 1380 controls in same age range treated for tinea capitis without radiation exposure, followed up via four surveys (last 1988-1993)	Dose assessed via treatment records	All cancers, with particular emphasis on leukaemia, brain, thyroid, salivary cancers	Average dose/treatment brain =1.4 Gy, thyroid 0.05 Gy, skull bone marrow 4 Gy	8 leukaemias (6 non-CLL) in exposed group vs 1 (0 non-CLL) in control, 7 brain tumours in exposed vs 0 in control, 2 thyroid tumours in exposed group vs 0 in control, 11 thyroid adenomas in exposed group vs 1 in control, 6 salivary gland tumours in exposed group vs 2 in control	n.a.	Poisson and Cox models stratified by age at irradiation (and for Poisson models stratified by attained age)	Generally good radiation exposure assessment, reasonable diagnostic confirmation (all but three tumours (2 thyroid, 1 benign salivary) confirmed via physicians' notes)

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Travis *et al.* (2005) international testicular cancer cohort	40,576 1-year survivors of testicular cancer in 14 population-based registries in Denmark, Finland, Sweden, Norway, Ontario, US, followed up for incidence to 12/2002	None	All cancers	n.a.	2285 second solid cancer cases	n.a.	Poisson models adjusted for age at testicular cancer	No individual radiation or chemotherapy exposure assessments