Supplementary File

Appendix A

Supplementary Methods

Algorithm used to determine individual time distribution of medical diagnostic radiation doses by diagnostic procedure

Appendix A Table A1 gives the dose per procedure derived from the paper of Chang *et al* [1]. Table A2 is derived from information given in the second questionnaire, specifically the number of procedures (0, 1, 2-4, 5+) by procedure and by calendar year period, y (<1980, 1980-1989, ≥1990). For dental and chest X-rays a similar question was asked, but with number of procedure groups 0, 1-9, 10-24, 25+. We assigned mean numbers of procedures of 0, 1, 3, 7 and 0, 5, 17, 35 to these two sets of procedure-number groupings and estimated mean numbers of procedures using these mean values per group, resulting in estimates, $N_{i,y,m}$, of the mean number of each type of medical diagnostic procedure, m (skull, other head and neck, ribs, etc), for each individual i associated with each calendar period y (<1980, 1980-1989, ≥1990). For each individual i, and for each calendar period y, and age group, a (0-29, 30-39, 40-49, 50-59, 60-69, ≥70), we determined the number of years of follow-up from birth to the date of the first questionnaire, $PY_{i,y,a}$ in that combination of age and calendar year intervals. For each calendar period, y, and medical diagnostic exam group, m, we assumed a linear model in which the mean number of exams is given by:

$$\begin{aligned} N_{i,y,m} &= \beta_{y,m,0-29} PY_{i,y,0-29} + \beta_{y,m,30-39} PY_{i,y,30-39} + \beta_{y,m,40-49} PY_{i,y,40-49} \\ &+ \beta_{y,m,50-59} PY_{i,y,50-59} + \beta_{y,m,60-69} PY_{i,y,60-69} + \beta_{y,m,70+} PY_{i,y,70+} + \varepsilon_{i,y,m} \end{aligned} \quad \text{(A1)}$$

for some mutually independent Normal random errors $\varepsilon_{i,y,m} \sim N(0,\sigma_{y,m}{}^2)$. Therefore if this model is valid we can interpret each of $\beta_{y,m,0-29}, \beta_{y,m,30-39}, \beta_{y,m,40-49}, \beta_{y,m,50-59}, \beta_{y,m,60-69}, \beta_{y,m,70+}$ as the rates (per year) of the diagnostic procedure m in calendar year period y for the age groups <30, 30-39, 40-49, 50-59, 60-69, ≥70, respectively. We estimate these diagnostic procedure rate coefficients $\beta_{y,m,a}$ in expression (A1) by ordinary least squares in R [2], using the **lm** procedure, with constant term constrained to be 0. These coefficients, the rates per year of administration of each type of procedure, are given in Table A2. All estimated coefficients for the calendar period 1980-1989 were positive, but occasionally in other calendar periods, <1980, ≥1990, the coefficients took negative values, and in these cases the value for the corresponding medical procedure and age group for 1980-1989 was used.

Given the mean first year of use of a given procedure and individual determined from the first questionnaire, the mean number of procedures per age group and calendar year period derived above (Table A2) were used to determine a distribution across time of procedures for a given individual by calendar year from this initial year to the year of response to the first questionnaire. The only exception was if a single diagnostic exam was recorded, in which case this was assumed to take place at the date of first exam. The distribution was normalised to the total number of this type of procedure determined from the first questionnaire, yielding an expected number of the given type of procedure per calendar year for the individual. Finally, the expected number of procedures in a given calendar year for the individual was multiplied by the thyroid dose for the procedure and calendar year given in Table A1 to determine the dose in that calendar year.

We illustrate with a hypothetical example. Suppose an individual born in 1945 has indicated in 1990 (aged 45) that they have had 2 chest X-rays with the first in 1975. Appendix A Table A2 indicates that from ages 30-34 there are 0.0761 chest X-rays per year expected, from ages 35-39

0.46765 X-rays per year expected and for ages 40-44 0.51399 X-rays per year expected. The sum of these 15 expected numbers of X-rays is 5.2887. If we now normalise these expected numbers so that their sum is now 2 (the total number of chest X-rays), we get that from ages 30-34 there are 0.02878 chest X-rays per year expected, from ages 35-39 0.17685 chest X-rays per year expected and from ages 40-44 0.19437 chest X-rays per year expected. If we now multiply these expected numbers of chest X-rays by the doses per chest X-ray from Appendix A Table A1, namely 1.8 mGy per chest X-ray up to 1980, 1.2 mGy per chest X-rays from 1980 onwards, this suggests that from ages 30-34 there is 0.05180 mGy chest X-ray dose per year expected, from ages 35-39 0.21222 mGy chest X-ray dose per year expected and from ages 40-44 0.23325 mGy chest X-ray dose per year expected, totaling 2.48634 mGy for ages 30-44.

Table A1. Estimated mean radiation doses to the thyroid gland (mGy) from specific diagnostic examinations by year of procedure, taken from Chang *et al* [1]. Procedures other than these were deemed to give minimal dose to the thyroid.

Diagnostic exam	Calendar period					
	1900-1939	1940-1949	1950-1959	1960-1969	1970-1979	≥1980
Skull X-ray	23	16	9.6	3.6	3.6	1.5
Neck (soft tissue) X-ray [other head and neck X-ray]	6.5	6.5	4.8	1.5	1.5	1.1
Ribs X-ray	0.53	0.53	1	1.7	1.8	1.2
Chest X-ray	0.19	0.23	0.23	0.16	0.16	0.22
Cervical spine X-ray	49	49	49	7.8	7.8	4.1
Thoracic spine X-ray	3.1	2	4.4	0.96	1.2	0.62
Collar bone (clavicle) X-ray	0.26	0.26	0.15	0.09	0.09	0.06
Shoulder X-ray	0.07	0.07	0.04	0. 25	0.31	0.05
Dental X-ray (bitewing)	3.1	2	0.49	0.39	0.01	0.01
Mammogram (5 cm CBT)	0[a]	0[a]	0[a]	0.29	0.18	0.07
Upper gastrointestinal series	4.6	4.6	3.7	0.29	0.29	0.35
Esophagram (barium swallow)	140	140	110	25	25	14
Thyroid scan[b]	0[a]	0[a]	0[a]	630	290	170
Thyroid uptake[b]	0[a]	0[a]	0[a]	64	58	51

[a]These procedures were thought to be uncommon before 1960, so doses of 0 are assigned.
[b]The first questionnaire data did not specify the type of radionuclide thyroid procedure (thyroid uptake vs thyroid scan) – we assumed all such procedures were thyroid scans.

Table A2. Estimated number of procedures (rates per year) by age group, derived from second questionnaire data. See Methods of Appendix A for more details on the methods used to derive these rates. Where a rate was negative (generally only for the <1990 and ≥1990 calendar year groups), the value is replaced by estimates derived for 1980-1989.

Diagnostic exam	Calendar year	Age (years)					
		0-29	30-39	40-49	50-59	60-69	>70
Skull X-ray	<1980	0.01155	0.00566	0.02125	0.02896	0.03195[a]	0.01948 [a]
	1980-1989	0.01407	0.01600	0.01884	0.02721	0.03195	0.01948
	≥1990	0.01407[a]	0.01159	0.01450	0.02010	0.02369	0.02561
Other head & neck X-ray	<1980	0.00397	0.00383	0.01433	0.01599	0.01864[a]	0.00492[a]
	1980-1989	0.00946	0.00781	0.01019	0.01376	0.01864	0.00492
	≥1990	0.00946[a]	0.00990	0.01046	0.01352	0.01683	0.01008
Ribs X-ray	<1980	0.00506	0.01146	0.02652	0.03144	0.03276[a]	0.02463[a]
	1980-1989	0.00898	0.01258	0.01705	0.02698	0.03276	0.02463
	≥1990	0.00965	0.01126	0.01564	0.02362	0.02995	0.02402
Chest X-ray	<1980	0.19239	0.07610	0.24823	0.30971	0.63754[a]	0.07857
	1980-1989	0.43380	0.46765	0.51399	0.58993	0.63754	0.53617
	≥1990	0.33366	0.50773	0.59615	0.70198	0.75589	0.77845
Cervical spine X-ray	<1980	0.01275	0.02734	0.02728	0.03872	0.06120[a]	0.02516[a]
	1980-1989	0.02994	0.03802	0.05193	0.05706	0.06120	0.02516
	≥1990	0.01553	0.04293	0.05308	0.06278	0.05650	0.04410
Thoracic spine X-ray	<1980	0.00753	0.01312	0.03400	0.03210	0.01586	0.03503[a]
	1980-1989	0.01517	0.01979	0.02682	0.03920	0.04733	0.03503
	≥1990	0.00732	0.01877	0.02495	0.03394	0.04176	0.04429
Collar bone X-ray	<1980	0.00463	0.00010	0.01518	0.01069	0.00278	0.00745[a]
	1980-1989	0.00569	0.00579	0.00728	0.01304	0.01489	0.00745
	≥1990	0.00569[a]	0.00787	0.01365	0.01799	0.02225	0.01756
Shoulder X-ray	<1980	0.00627	0.01414	0.03313	0.04069	0.04913[a]	0.03384[a]
	1980-1989	0.01313	0.01957	0.03076	0.04840	0.04913	0.03384
	≥1990	0.01313[a]	0.02321	0.03675	0.05053	0.05902	0.03937
Dental X-ray	<1980	0.27782	0.61769[a]	0.03765	0.57425	0.07952	0.49539
	1980-1989	0.63674	0.61769	0.60697	0.57425	0.52473	0.49539
	≥1990	0.97786	0.87190	0.83185	0.79869	0.77211	0.70479
Mammogram	<1980	0.00833	0.07544	0.00732	0.00031	0.14081[a]	0.11062
	1980-1989	0.00837	0.14633	0.26037	0.22230	0.14081	0.11146
	≥1990	0.00837[a]	0.19508	0.35913	0.43679	0.31292	0.22000
Upper GI series	<1980	0.01763	0.03731	0.03908	0.04839	0.01206	0.06904[a]
	1980-1989	0.03080	0.03426	0.04939	0.06444	0.07613	0.06904
	≥1990	0.01942	0.02280	0.03160	0.04367	0.05532	0.06594
Esophagram [Barium swallow]	<1980	0.00714	0.01828	0.03859	0.04981	0.01153	0.03038
	1980-1989	0.01190	0.01371	0.02172	0.03562	0.04799	0.04615
	≥1990	0.01190[a]	0.01118	0.01557	0.02437	0.03418	0.04103
Thyroid scan [other head/neck X-ray]	<1980	0.00397	0.00383	0.01433	0.01599	0.01864[a]	0.00492[a]
	1980-1989	0.00946	0.00781	0.01019	0.01376	0.01864	0.00492

≥1990	0.00946[a]	0.00990	0.01046	0.01352	0.01683	0.01008

[a]estimate from regression was negative: value replaced by that for 1980-1989.

Appendix B

Table B1. Numbers of persons with either number of personal diagnostic radiation procedures or year of first procedure missing

Procedure type	Numbers of persons with partially missing information on number of diagnostic procedures or year of first procedure
Skull	916
Other head & neck	501
Ribs	333
Chest	3362
Cervical spine	1008
Thoracic spine	406
Collar bone	145
Shoulder	567
Dental X-ray	3985
Mammogram	336
Upper gastrointestinal series	663
Esophagram (Barium swallow)	420
Thyroid scan	195

Table B2. Index of sensitivity analyses, with reasons

Table number	Table title	Reason for sensitivity analysis
Table B3	Thyroid cancer, by time since exposure and exposure age, using cumulative diagnostic thyroid radiation dose, assuming all procedures are within the first 10 years after the initial procedure of each type.	The main point of this analysis was to assess the effect on radiation risk of the variant assumption whereby all diagnostic procedures are concentrated in the first 10 years after the first, rather than being spread out over the period between year of first procedure and the date of first questionnaire, as conceivably diagnostic procedures could be concentrated in this way.
Table B4	Thyroid cancer, by time since exposure and exposure age, using cumulative diagnostic thyroid radiation dose, assuming all procedures occur at a constant rate (by age and time period) rather than varying according to the rates of Table A2.	The main point of this analysis was to assess the effect on radiation risk of the variant assumption whereby diagnostic procedures are spread out at a constant rate over time after the first such procedure, rather than being distributed over the period between year of first procedure and the date of first questionnaire according to the rates given by Table A2 – just in case these rates did not increase with age in the way suggested by our analysis.
Table B5	Thyroid cancer, by time since exposure and exposure age, in relation to cumulative diagnostic thyroid radiation dose excluding both thyroid scan and dental dose.	The main point of the analysis was to assess the effect of excluding dental dose, because of the uncertainties surrounding the precise type of dental diagnostic procedure. We assumed the indicated procedures were mostly bitewing doses, but conceivably they might have been something else.
Table B6	Effect of excluding all non-malignant thyroid conditions assayed at first questionnaire from the data.	The main point of the analysis was to exclude conditions that conceivably might have been precursors to thyroid cancer, to assess if doing so might affect risk. This is a means of assessing reverse causation resulting from diagnostic procedures being part of the diagnosis of indolent thyroid cancer. However, as we discuss, there is a danger that doing so may weaken an underlying dose response, by removing the intermediate radiation-associated phenotype.
Table B7	Fit of model allowing for simultaneous occupational and personal diagnostic thyroid radiation doses.	The main point of the analysis was to assess the possible confounding effect of occupational radiation dose on the dose response from medical diagnostic dose – conceivably diagnostic dose could, conditional on age, have been correlated with occupational dose, leading to the possibility of bias due to uncontrolled confounding.

Table B3. Thyroid cancer, by time since exposure and exposure age, using cumulative diagnostic thyroid radiation dose, assuming all procedures are within the first 10 years after the initial procedure of each type. Thyroid scan is not used, and stratification is by sex and year of birth (<1900, 1900-1909, 1910-1919, 1920-1929, 1930-1939, 1940-1949, 1950-1959, 1960+)

Model number	**Statistical model**	ERR/Gy (+95% CI)
1	Linear thyroid dose	0.95 (-0.76, 3.81)
	p-value	0.356[a]
2	Time since exposure 5-9 years	-7.05 (-27.61, 29.51)
	Time since exposure 10-14 years	-10.59 (-24.86, 11.36)
	Time since exposure 15+ years	1.22 (-0.57, 4.15)
	Heterogeneity *p*-value	0.363[b]
3	Exposure age 0-19 years	0.46 (-2.53, 5.43)
	Exposure age 20-39 years	1.32 (-0.80, 5.06)
	Exposure age 40-59 years	-2.18 (-8.85, 15.00)
	Exposure age 60+ years	<-100 (<-100, >100)
	Heterogeneity *p*-value	0.847[b]

[a]*p*-value for improvement in fit compared with null model, i.e., significance of the departure of the ERR/Gy from 0.
[b]*p*-value for improvement in fit compared with simple linear model 1

Table B4. Thyroid cancer, by time since exposure and exposure age, using cumulative diagnostic thyroid radiation dose, assuming all procedures occur at a constant rate (by age and time period) rather than varying according to the rates of Table A2. Thyroid scan is not used, and stratification is by sex and year of birth (<1900, 1900-1909, 1910-1919, 1920-1929, 1930-1939, 1940-1949, 1950-1959, 1960+)

Model number	**Statistical model**	ERR/Gy (+95% CI)
1	Linear thyroid dose	1.86 (-0.91, 5.99)
	p-value	0.226[a]
2	Time since exposure 5-9 years	-1.94 (-24.78, 37.63)
	Time since exposure 10-14 years	-10.14 (-24.76, 12.07)
	Time since exposure 15+ years	2.95 (-0.41, >100)
	Heterogeneity *p*-value	0.400[b]
3	Exposure age 0-19 years	3.20 (-3.48, 13.37)
	Exposure age 20-39 years	0.60 (-3.06, 5.79)
	Exposure age 40-59 years	7.90 (-3.30, 31.70)
	Exposure age 60+ years	-60.81 (<-100, >100)
	Heterogeneity *p*-value	0.801[b]

[a]*p*-value for improvement in fit compared with null model, i.e., significance of the departure of the ERR/Gy from 0.
[b]*p*-value for improvement in fit compared with simple linear model 1.

Table B5. Thyroid cancer, by time since exposure and exposure age, in relation to cumulative diagnostic thyroid radiation dose excluding both thyroid scan and dental dose. Stratification is by sex and year of birth (<1900, 1900-1909, 1910-1919, 1920-1929, 1930-1939, 1940-1949, 1950-1959, 1960+)

Model number	**Statistical model**	ERR/Gy (+95% CI)
1	Linear thyroid dose	2.09 (-1.08, 6.68)
	p-value	0.231[a]
2	Time since exposure 5-9 years	0.03 (-24.33, 41.12)
	Time since exposure 10-14 years	-7.17 (-24.70, 16.23)
	Time since exposure 15+ years	3.26 (<-100, 8.72)
	Heterogeneity *p*-value	0.590[b]
3	Exposure age 0-19 years	3.80 (<-100, 15.25)
	Exposure age 20-39 years	0.12 (-3.96, 6.04)
	Exposure age 40-59 years	8.10 (-2.43, 27.79)
	Exposure age 60+ years	-35.45 (<-100, >100)
	Heterogeneity *p*-value	0.740[b]

[a]*p*-value for improvement in fit compared with null model, i.e., significance of the departure of the ERR/Gy from 0.
[b]*p*-value for improvement in fit compared with simple linear model 1.

Table B6. Effect of excluding all non-malignant thyroid conditions assayed at first questionnaire from the data. Stratification is by sex, year of birth (<1900, 1900-1909, 1910-1919, 1920-1929, 1930-1939, 1940-1949, 1950-1959, 1960+).

Non-malignant thyroid condition excluded	All thyroid cancer			Papillary thyroid cancer		
	ERR/Gy (+95% CI)	Thyroid cancer cases	*p*-value[a]	ERR/Gy (+95% CI)	Thyroid cancer cases	*p*-value[a]
No exclusions	2.29 (-0.91, 7.01)	414	0.191	4.15 (-0.39, 11.27)	275	0.080
Hyperthyroidism	1.45 (-1.53, 6.00)	405	0.403	2.60 (-1.49, 9.20)	269	0.264
Hypothyroidism	3.37 (-0.35, 8.86)	388	0.082	5.17 (0.05, 13.27)	257	0.047
Thyroiditis	2.55 (-0.77, 7.45)	404	0.154	4.46 (-0.23, 11.81)	269	0.066
Goiter	2.07 (-1.25, 7.02)	399	0.266	3.75 (-0.98, 11.26)	263	0.144
Any other non-malignant thyroid condition	1.66 (-1.47, 6.49)	382	0.360	3.20 (-1.21, 10.37)	250	0.192
All non-malignant thyroid conditions	1.62 (-1.89, 7.32)	336	0.445	1.80 (-2.59, 9.61)	219	0.519

.[a]*p*-value for improvement in fit compared with null model, i.e., significance of the departure of the ERR/Gy from 0.

Table B7. Fit of model allowing for simultaneous occupational and personal diagnostic thyroid radiation doses. In each case a dose lag of 5 years is assumed.

Dose source	ERR/ Gy (+95% CI)	*p*-value
	All thyroid cancers	
Medical diagnostic dose	2.24 (-0.90, 7.05)	0.188[a]
Occupational dose	-0.39 (-3.01, 4.05)	0.827[b]
	Papillary thyroid cancers	
Medical diagnostic dose	3.91 (-0.33, 11.13)	0.077[a]
Occupational dose	-1.02 (-4.69[c], 4.70)	0.651[b]

[a]*p*-value for improvement in fit compared with model adjusting only for occupational dose, i.e., significance of the departure of the medical diagnostic ERR/Gy from 0, adjusted for the occupational ERR/Gy.
[b]*p*-value for improvement in fit compared with model adjusting only for medical diagnostic dose, i.e., significance of the departure of the occupational ERR/Gy from 0, adjusted for the medical diagnostic ERR/Gy.
[c]Wald-based confidence limit.

Table B8. Risk estimates for thyroid cancer incidence from studies of radiation exposure in adulthood

Study	Mean exposure age (range)	Incident cases	Mean thyroid dose (Sv)	Person-years	Excess relative risk / Sv (+95% CI)
Present study (all thyroid cancers, diagnostic doses)	38.06 (22.22, 86.37)[n]	414	0.0261	1,694,960	2.29 (-0.91, 7.01)
Present study (papillary thyroid cancers, diagnostic doses)	38.06 (22.22, 86.37)[n]	275	0.0261	1,694,960	4.15 (-0.39, 11.27)
Japanese atomic-bomb survivors Life Span Study [3]					
Males, exposure age >15[a]	33.5 (15-85+)	60	0.16	391,047	0.23 (<0, 1.55)
Females, exposure age >15[a]	31.8 (15-85+)	237	0.13	904,579	0.70 (0.14, 1.56)
All, exposure age >15[a]	32.3 (15-85+)	297	0.14	1,295,630	0.57 (0.12, 1.25)
Japanese atomic-bomb survivors Life Span Study [4]					
Males, exposure age ≥20	n.a.	21	n.a.	n.a.	-0.18 (-0.24, 1.8)[o]
Females, exposure age ≥20	n.a.	159	n.a.	n.a.	0.34 (-0.18, 1.3)[o]
All, exposure age ≥20	n.a.	180	n.a.	n.a.	0.27 (<0, 1.07)[o]
Japanese atomic-bomb survivors Adult Health Study, exposure age >20 [5]	>20 (n.a.)	n.a.	n.a.	1042[b]	0.25 (-0.28, 1.96)
Medically-exposed groups (predominantly exposed in adulthood) – treatment for benign conditions					
New York cervical tuberculous adenitis screening [6]: exposure age >20	n.a. (>20)	7	8.20[c]	3,786	1.2 (0.2, 3.7)[c, d]
Pennsylvania head & neck irradiation cohort [7]	19.1 (n.a.)	3	7.11[e]	n.a.	-0.06 (-0.14, 0.70)[f]
Dutch cervical tubercular adenitis +hyperthyroidism +hemangioma +enlarged tonsils +other [8]	25 (n.a.)	7	10.68	n.a.	0.5 (0.1, 1.0)[c, d]
Swedish cervical tubercular adenitis [9]	19 (SD 8)	25	7.3	n.a.	1.34 (>0, 8.86)[f]
Swedish diagnostic exposure to ^{131}I [10][g]	43 (0-74)[g]	36[g]	0.94	n.a.	1.38 (-0.02, 12.59)[g, h]
Medically exposed groups (predominantly exposed in adulthood) – treatment for cancer					

Study	Mean exposure age (range)	Incident cases	Mean thyroid dose (Sv)	Person-years	Excess relative risk / Sv (+95% CI)
Present study (all thyroid cancers, diagnostic doses)	38.06 (22.22, 86.37)[n]	414	0.0261	1,694,960	2.29 (-0.91, 7.01)
Present study (papillary thyroid cancers, diagnostic doses)	38.06 (22.22, 86.37)[n]	275	0.0261	1,694,960	4.15 (-0.39, 11.27)
Cervical cancer case-control [11]	52 (<45 - >65)	43	0.11	n.a.	12.30 (-1.00, 76.0) [d]
Stanford Hodgkin's disease [12]	28 (2 - 82)	6	39.6	17,500	0.35 (0.13, 0.75)
Occupationally exposed groups					
Canadian National Dose Registry [13]	n.a. (<20 - >85)	129	0.0066	2,667,903	5.9 (2.5, 9.9)[d, i]
Chinese X-ray technologists [14]					
Employed<1970	26[j]	13	0.551	357,753	1.9 (0.3, 4.4)[d, i]
First employed 1970-1980		1	0.082	337,133	<0[i]
Russian Chernobyl liquidators [15]					
Latent period 4 years	34[k] (<20 - >50)	80	0.168, 0.033[l]	100,997[b]	-0.21 (-3.23, 3.43)[d]
Latent period 10 years					0.48 (-1.93, 5.69)[d]
National Registry for Radiation Workers [16]	>30 (15-84)	54	0.0249	3.9 x 10^6	3.24 (-0.48, 17.51)
Belarus-Russian-Baltic Chernobyl liquidators [17]	37[k] (n.a.)	107	0.069	423[m]	3.8 (1.0, 10.9)
USRT [occupational dose] [18]	n.a. (<20 - >60)	476	0.057	~1.9 x 10^6	-0.5 (<-1.0, 3.4)
Environmentally exposed groups					
Bryansk Chernobyl-exposed [19]	n.a. (15-69)	769	n.a.	n.a.	0.0 (-1.4, 1.7)

[a]fitted by Poisson maximum-likelihood [20] using a linear relative risk model with semi-parametric stratified model, with stratification by city, AHS status, gender, exposure age and attained age
[b]numbers of persons;
[c]estimate reproduced from Shore [21];
[d]90% CI;
[e]mean dose to tonsils and nasopharynx;
[f]fitted by binomial maximum-likelihood [20] using a linear relative risk model;
[g]among persons with no previous history of X-ray exposure of the head or neck, and referred for diagnosis without a suspicion of thyroid cancer;
[h]fitted by Poisson maximum-likelihood [20] using a linear relative risk model;
[i]estimate reproduced from UNSCEAR [22];

[j]age at first employment;
[k]age at first arrival at Chernobyl;
[l]mean external gamma dose for those working at Chernobyl in 1986 and 1988-90 respectively;
[m]number of matched controls.
[n]age at entry to study.
[o]adjusted to attained age 60 years.

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