

RESEARCH

Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians

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Abstract

**Objective** To assess the cancer risk in children and adolescents following exposure to low dose ionising radiation from diagnostic computed tomography (CT) scans.

**Design** Population based, cohort, data linkage study in Australia.

**Cohort members** 10.9 million people identified from Australian Medicare records, aged 0-19 years on 1 January 1985 or born between 1 January 1985 and 31 December 2005; all exposures to CT scans funded by Medicare during 1985-2005 were identified for this cohort. Cancers diagnosed in cohort members up to 31 December 2007 were obtained through linkage to national cancer records.

**Main outcome** Cancer incidence rates in individuals exposed to a CT scan more than one year before any cancer diagnosis, compared with cancer incidence rates in unexposed individuals.

**Results** 60 674 cancers were recorded, including 3150 in 680 211 people exposed to a CT scan at least one year before any cancer diagnosis. The mean duration of follow-up after exposure was 9.5 years. Overall cancer incidence was 24% greater for exposed than for unexposed people, after accounting for age, sex, and year of birth (incidence rate ratio (IRR) 1.24 (95% confidence interval 1.20 to 1.29); P<0.001). We saw a dose-response relation, and the IRR increased by 0.16 (0.13 to 0.19) for each additional CT scan. The IRR was greater after exposure

at younger ages (P<0.001 for trend). At 1-4, 5-9, 10-14, and 15 or more years since first exposure, IRRs were 1.35 (1.25 to 1.45), 1.25 (1.17 to 1.34), 1.14 (1.06 to 1.22), and 1.24 (1.14 to 1.34), respectively. The IRR increased significantly for many types of solid cancer (digestive organs, melanoma, soft tissue, female genital, urinary tract, brain, and thyroid); leukaemia, myelodysplasia, and some other lymphoid cancers. There was an excess of 608 cancers in people exposed to CT scans (147 brain, 356 other solid, 48 leukaemia or myelodysplasia, and 57 other lymphoid). The absolute excess incidence rate for all cancers combined was 9.38 per 100 000 person years at risk, as of 31 December 2007. The average effective radiation dose per scan was estimated as 4.5 mSv.

**Conclusions** The increased incidence of cancer after CT scan exposure in this cohort was mostly due to irradiation. Because the cancer excess was still continuing at the end of follow-up, the eventual lifetime risk from CT scans cannot yet be determined. Radiation doses from contemporary CT scans are likely to be lower than those in 1985-2005, but some increase in cancer risk is still likely from current scans. Future CT scans should be limited to situations where there is a definite clinical indication, with every scan optimised to provide a diagnostic CT image at the lowest possible radiation dose.

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Table 1 | Characteristics of study population by final exposure status, based on a one year lag period

Characteristic	No (%) of people exposed*	Total no of people in study
<b>Sex</b>		
Male	357 119 (6.4)	5 563 185
Female	323 082 (6.0)	5 376 575
<b>Age at entry to study (years)</b>		
0-4	450 346 (6.8)	6 652 654
5-9	120 957 (9.0)	1 339 527
10-14	88 731 (5.4)	1 488 524
15-19	28 177 (1.9)	1 457 975
<b>Calendar year of entry to study</b>		
1985-89	526 488 (8.6)	6 156 422
1990-94	99 466 (6.5)	1 539 278
1995-99	40 931 (2.8)	1 467 602
2000-05	13 326 (0.8)	1 776 378
<b>Socioeconomic group</b>		
1 (lowest status)	92 332 (5.3)	1 557 545
2	97 236 (6.2)	1 556 448
3	95 547 (6.1)	1 557 331
4	101 154 (6.5)	1 556 311
5	103 454 (6.6)	1 558 887
6	102 449 (6.6)	1 557 562
7 (highest status)	87 392 (6.3)	1 554 273
Unknown status	647 (1.6)	41 323
<b>Total no of people in study</b>	<b>680 211 (6.2)†</b>	<b>10 939 690</b>

\*Exposure status at end of study. All study members were classified as unexposed on entry to the study. Those exposed to a CT scan continued to be classified as unexposed for the duration of the lag period (taken to be one year here and in most analyses, but five or 10 years in some analyses). They were then transferred to the exposed group, provided that the date of transfer was before the date of exit from the study (fig 1).

†The total no of CT scans received by these individuals at least one year before date of exit was 866 580.

Table 2 | Characteristics of cohort members whose final status was exposed, based on a one year lag period

Characteristic	No (%) of people exposed
<b>Sex</b>	
Male	357 119 (52.5)
Female	323 082 (47.5)
<b>Age at first CT scan (years)</b>	
0-4	42 798 (6.3)
5-9	104 618 (15.4)
10-14	202 420 (29.8)
15-19	330 375 (48.5)
<b>Calendar year of first CT scan</b>	
1985-89	95 249 (14.0)
1990-94	133 528 (19.6)
1995-99	184 463 (27.1)
2000-05	286 971 (39.3)
<b>Final no of CT scans</b>	
1	557 877 (82.0)
2	86 109 (12.7)
3	23 740 (3.5)
4	6763 (1.0)
≥5	5722 (8.8)
<b>Site of first CT scan</b>	
Brain*	404 105 (59.4)
Facial bones	89 133 (13.1)
Chest	11 381 (1.7)
Extremities	64 940 (9.5)
Abdomen or pelvis†	33 870 (5.0)
Spine or neck	58 677 (8.6)
Other or unknown	18 105 (2.7)
<b>Total no (%) of people exposed</b>	<b>680 211 (100.0)</b>

\*Includes brain in combination with other sites such as the chest.

†Includes combined scans of the chest, abdomen, and pelvis.

Table 3 | Number of cancers of all types and incidence rate ratios (IRR), exposed v unexposed, for various lag periods

	Lag period		
	1 year	5 years	10 years
<b>Exposed group</b>			
Observed no of cancers	3150	2365	1405
No of person years	6 486 548	3 971 641	1 808 883
Mean years of follow-up	9.5	7.3	5.5
<b>Unexposed group</b>			
Observed no of cancers	57 524	58 308	59 289
No of person years	177 191 342	179 706 249	181 869 007
Mean years of follow-up	17.3	17.3	17.1
Expected no of cancers in exposed group*	2542	1963	1196
No of excess cancers in exposed group*	608	402	209
IRR (95% CI; exposed v unexposed)	1.24 (1.20 to 1.29)	1.21 (1.16 to 1.26)	1.18 (1.11 to 1.24)
χ <sup>2</sup> (1 df) for departure of IRR from unity	129.1	74.4	33.8
P for departure of IRR from unity	P<0.001	P<0.001	P<0.001

\*Calculated from rates in unexposed group after stratification for age, sex, and year of birth.