Appendix

Supplementary method

Supplementary Table 1: The International Classification of Diseases, Ninth Revision, (ICD-9) codes for case identification.

Supplementary Table 2: The ICD-9 codes for cancer-predisposing conditions exclusion.

Supplementary Table 3: Dosimetry reference from Gao *et al.*(1) of organ-absorbed radiation dose from different computed tomographic scan types.

Supplementary Table 4: Dosimetry reference Kim *et al.*(2) of organ-absorbed radiation dose from different computed tomographic scan types.

Supplementary Table 5: Exposure status of other radiology and nuclear medicine procedures in the case and the control group.

Supplementary Table 6: Adjusted odds ratio for intracranial tumors, leukemia and lymphomas related to the total number of computed tomographic (CT) scans using different lag periods

Supplementary Table 7: The estimated effects of number of CT scans, total number of experienced high-radiation procedures, and other covariates for the conditional logistic regression models

Supplementary Table 8: Using radiation dosimetry from Kim *et al.(*2) to estimate adjusted odds ratio for intracranial tumors, leukemia, and lymphomas related to the organ-specific cumulative dose from CT scans.

Supplementary Method

In this study, we applied CT radiation dosimetry data published by Gao *et al.* in 2018 to estimate the specific organ-observed radiation dosage after CT examination in the primary analysis.(1) In the sensitivity analysis, we re-calculated the organ-observed dosage using data from Kim *et al.* published in 2012.(2) In Gao's study,(1) the authors collected the patient-specific CT parameters and body size information from 1250 CT examinations performed on 1250 pediatric patients. Due to the body stature varied greatly across children at different ages and sexes, this study also created anthropomorphic phantoms with various sizes for effective radiation dosage assessment. The authors also compared the outcome with previous literature using different method, and the results were consistent. For this reason, we used this data for our primary analysis.

Kim and colleagues published a CT radiation dosimetry study in 2012 evaluated by human phantoms with varying size from infants to adults.(2) Instead of using actual setting of performed CT examinations, this study employed CT scanning parameters from a national survey of CT technicians. As a pioneer study in the organ-effective radiation dosage from CT scans in pediatric population, little previous literature was available for comparison. We used this data to conduct the sensitivity analysis.

Supplementary table 1: The ICD-9 codes for case identification.

ICD-9 code	Description	Number of identified cases
Intracranial tumor		
191	Malignant neoplasm of brain	2013
192	Malignant neoplasm of cranial nerves	182
192.1	Malignant neoplasm of cerebral meninges	5
194.3	Malignant neoplasm of pituitary gland and craniopharyngeal duct	13
194.4	Malignant neoplasm of pineal gland	24
225.0	Benign neoplasm of brain	5
225.1	Benign neoplasm of cranial nerves	0
225.2	Benign neoplasm of cerebral meninges	<3[a]
227.3	Benign neoplasm of pituitary gland and craniopharyngeal duct	<3[a]
227.4	Benign neoplasm of pineal gland	0
237.0	Neoplasm of uncertain behavior of pituitary gland and craniopharyngeal duct	0
237.1	Neoplasm of uncertain behavior of pineal gland	0
237.5	Neoplasm of uncertain behavior of brain and spinal cord	0
237.6	Neoplasm of uncertain behavior of meninges	0
239.6	Neoplasm of unspecified nature of brain	<3[a]
Leukemia		
204.0	Lymphoid leukemia acute	2183
204.1	Lymphoid leukemia chronic	16
204.2	Lymphoid leukemia subacute	<3[a]
204.8	Other lymphoid leukemia	0
204.9	Unspecified lymphoid leukemia	9
205.0	Myeloid leukemia acute	1097
205.1	Myeloid leukemia chronic	195
205.2	Myeloid leukemia subacute	5
205.3	Myeloid sarcoma	7
205.8	Other myeloid leukemia	2
205.9	Unspecified myeloid leukemia	12
206.0	Monocytic leukemia acute	5
206.1	Monocytic leukemia chronic	<3[a]
206.2	Monocytic leukemia subacute	0
206.8	Other monocytic leukemia	<3[a]
206.9	Unspecified monocytic leukemia	<3[a]
207.0	Acute erythremia and erythroleukemia	14
207.1	Chronic erythremia	0
207.2	Megakaryocytic leukemia	<3[a]
207.8	Other specified leukemia	3
208.0	Leukemia of unspecified cell type acute	88
208.1	Leukemia of unspecified cell type chronic	3
208.2	Leukemia of unspecified cell type subacute	0

208.8	Other leukemia of unspecified cell type	<3[a]
208.9	Unspecified leukemia	21
238.72	Low grade myelodysplastic syndrome lesions	0
238.73	High grade myelodysplastic syndrome lesions	0
238.74	Myelodysplastic syndrome with 5q deletion	0
238.75	Myelodysplastic syndrome, unspecified	0
Non-Hodgkin lymphoma		
200	Lymphosarcoma and reticulosarcoma and other specified malignant tumors of lymphatic tissue	310
202.0	Nodular lymphoma	630
202.1	Mycosis fungoides	14
202.2	Sezary's disease	0
202.7	Peripheral t-cell lymphoma	0
202.8	Other malignant lymphomas	377
Hodgkin lymphoma		
201	Hodgkin's disease	564
Total		7807

[a]Due to the policy on protecting confidentiality, cells with a value of 1 or 2 were labeled as <3.

Supplementary Table 2: The ICD-9 codes for cancer-predisposing conditions exclusion.

ICD-9 code	Description	Number of excluded cases
042	Human immunodeficiency virus [HIV] disease	<3[a]
237.7	Neurofibromatosis	8
279.0	Deficiency of humoral immunity	4
279.1	Deficiency of cell-mediated immunity	<3[a]
279.2	Combined immunity deficiency	0
279.3	Unspecified immunity deficiency	<3[a]
279.5	Graft-versus-host disease	0
758	Chromosomal anomalies	47
996.8	Complications of transplanted organ	<3[a]
V42	Organ or tissue replaced by transplant	6
V84	Genetic susceptibility to disease	0
Total		72

[a]Due to the policy on protecting confidentiality, cells with a value of 1 or 2 were labeled as <3.

Supplementary Table 3. Dosimetry reference from Gao *et al.*(1) of organ-absorbed radiation dose from different computed tomographic scan types

Age (year)	Sex	Site	Dose to red bone marrow (mGy)	Dose to brain (mGy)
≤6	M	Head	9	32
≤6	F	Head	10.2	36.1
>6 ~ ≤11	M	Head	11.2	30.9
>6 ~ ≤11	F	Head	11.6	32
>11 ~ ≤16	M	Head	15.5	43
>11 ~ ≤16	F	Head	14.9	41.2
>16 ~ ≤18	M	Head	15.3	46.4
>16 ~ ≤18	F	Head	15.6	48.7
≤6	M	Chest	2.3	0.2
≤6	F	Chest	2.2	0.2
>6 ~ ≤11	M	Chest	2.7	0.2
>6 ~ ≤11	F	Chest	2.4	0.2
>11 ~ ≤16	M	Chest	2.4	0.2
>11 ~ ≤16	F	Chest	2.6	0.2
>16 ~ ≤18	M	Chest	2	0.2
>16 ~ ≤18	F	Chest	1.8	0.2
≤6	M	Abdomen	2.4	0.1
≤6	F	Abdomen	3.4	0.1
>6 ~ ≤11	M	Abdomen	3.5	0
>6 ~ ≤11	F	Abdomen	3.5	0
>11 ~ ≤16	M	Abdomen	4.5	0
>11 ~ ≤16	F	Abdomen	4.2	0
>16 ~ ≤18	M	Abdomen	4	0
>16 ~ ≤18	F	Abdomen	3.8	0

mGy: milligray

Supplementary Table 4: Dosimetry reference Kim *et al.*(2) of organ-absorbed radiation dose from different computed tomographic scan types

Age (year)	Sex	Site	Dose to brain (mGy)	Dose to red bone marrow (mGy)
0	M	Head	27.5	8.0
0	F	Head	27.5	8.0
1	M	Head	23.2	8.4
1	F	Head	23.2	8.4
2	M	Head	24.4	8.5
2	F	Head	24.4	8.5
3	M	Head	25.6	8.5
3	F	Head	25.6	8.5
4	M	Head	26.7	8.6
4	F	Head	26.7	8.6
5	M	Head	27.9	8.6
5	F	Head	27.9	8.6
6	M	Head	29.4	8.1
6	F	Head	29.4	8.1
7	M	Head	30.8	7.6
7	F	Head	30.8	7.6
8	M	Head	32.3	7.0
8	F	Head	32.3	7.0
9	M	Head	33.7	6.5
9	F	Head	33.7	6.5
10	M	Head	35.2	6.0
10	F	Head	35.2	6.0
11	M	Head	36.7	5.6
11	F	Head	37.0	5.9
12	M	Head	38.1	5.3
12	F	Head	38.8	5.8
13	M	Head	39.6	5.0
13	F	Head	40.6	5.7
14	M	Head	41.1	4.7
14	F	Head	42.4	5.6
15	M	Head	42.5	4.4
15	F	Head	44.2	5.5
16	M	Head	41.1	3.8
16	F	Head	43.7	4.8
17	M	Head	39.6	3.2
17	F	Head	43.3	4.1
18	M	Head	38.1	2.7
18	F	Head	42.8	3.4
0	M	Chest	0.4	4.2

0	F	Chest	0.4	4.2
1	M	Chest	0.3	3.9
1	F	Chest	0.3	3.9
2	M	Chest	0.3	3.6
2	F	Chest	0.3	3.6
3	M	Chest	0.3	3.2
3	F	Chest	0.3	3.2
4	M	Chest	0.3	2.9
4	F	Chest	0.3	2.9
5	M	Chest	0.3	2.5
5	F	Chest	0.3	2.5
6	M	Chest	0.3	2.7
6	F	Chest	0.3	2.7
7	M	Chest	0.3	2.8
7	F	Chest	0.3	2.8
8	M	Chest	0.3	3.0
8	F	Chest	0.3	3.0
9	M	Chest	0.3	3.1
9	F	Chest	0.3	3.1
10	M	Chest	0.3	3.3
10	F	Chest	0.3	3.3
11	M	Chest	0.3	3.4
11	F	Chest	0.3	3.5
12	M	Chest	0.3	3.5
12	F	Chest	0.3	3.6
13	M	Chest	0.3	3.7
13	F	Chest	0.3	3.8
14	M	Chest	0.2	3.8
14	F	Chest	0.3	3.9
15	M	Chest	0.2	3.9
15	F	Chest	0.3	4.1
16	M	Chest	0.2	3.9
16	F	Chest	0.3	4.1
17	M	Chest	0.2	3.9
17	F	Chest	0.3	4.1
18	M	Chest	0.2	3.9
18	F	Chest	0.3	4.1
0	M	Abdomen	0.2	2.8
0	F	Abdomen	0.2	2.8
1	M	Abdomen	0.1	2.5
1	F	Abdomen	0.1	2.5
2	M	Abdomen	0.1	2.3

2	F	Abdomen	0.1	2.3
3	M	Abdomen	0.1	2.1
3	F	Abdomen	0.1	2.1
4	M	Abdomen	0.1	1.8
4	F	Abdomen	0.1	1.8
5	M	Abdomen	0.1	1.6
5	F	Abdomen	0.1	1.6
6	M	Abdomen	0.1	1.8
6	F	Abdomen	0.1	1.8
7	M	Abdomen	0.1	2.1
7	F	Abdomen	0.1	2.1
8	M	Abdomen	0.1	2.3
8	F	Abdomen	0.1	2.3
9	M	Abdomen	0.1	2.6
9	F	Abdomen	0.1	2.6
10	M	Abdomen	0.1	2.8
10	F	Abdomen	0.1	2.8
11	M	Abdomen	0.0	2.8
11	F	Abdomen	0.0	2.9
12	M	Abdomen	0.0	2.8
12	F	Abdomen	0.0	3.0
13	M	Abdomen	0.0	2.8
13	F	Abdomen	0.0	3.1
14	M	Abdomen	0.0	2.8
14	F	Abdomen	0.0	3.1
15	M	Abdomen	0.0	2.8
15	F	Abdomen	0.0	3.2
16	M	Abdomen	0.0	2.8
16	F	Abdomen	0.0	3.3
17	M	Abdomen	0.0	2.8
17	F	Abdomen	0.0	3.4
18	M	Abdomen	0.0	2.8
18	F	Abdomen	0.0	3.5

mGy: milligray

Supplementary Table 5: Exposure status of other radiology and nuclear medicine procedures in the case and the control group.

Status	Case group (%)	Control group (%)	p value by Fisher's exact test
Cystography			
Exposed	18 (0.2)	243 (0.3)	0.26
Non-exposed	7789 (99.8)	77814 (99.7)	
Cardiac catheterization			
Exposed	8 (0.1)	63 (0.1)	0.53
Non-exposed	7799 (99.9)	77994 (99.9)	
Renal cortical scan			
Exposed	3 (0.0)	59 (0.1)	0.37
Non-exposed	7804 (100.0)	77998 (99.9)	
Dynamic renography			
Exposed	4 (0.1)	35 (0.0)	0.78
Non-exposed	7803 (99.9)	78022 (100.0)	
Other nuclear procedures[a]			
Exposed	7 (0.1)	79 (0.1)	0.99
Non-exposed	7800 (99.9)	77978 (99.9)	

[a]Including positron emission tomography, skeletal scintigraphy, lung perfusion scan, hepatobiliary scintigraphy, Meckel's scan and gastric emptying tests.

Supplementary Table 6: Adjusted odds ratio for intracranial tumors, leukemia and lymphomas related to the total number of computed tomographic (CT) scans using different lag periods

Number of CT scan(s)	Intracranial tumors			Leukemia			Non-Hodgkin lymphoma			Hodgkin lymphoma		
	Cases (*n*)	Controls (*n*)	aOR (95% CI)	Cases (n)	Controls (n)	aOR (95% CI)	Cases (n)	Controls (n)	aOR (95% CI)	Cases (n)	Controls (n)	aOR (95% CI)
Lag period: 1 year												
0			1			1			1			1
1	37	316	1.23 (0.87-1.74)	41	482	0.85 (0.62-1.18)	15	170	0.90 (0.53-1.54)	6	87	0.69 (0.30-1.59)
2 or 3	43	120	3.67 (2.57-5.24)	17	211	0.81 (0.49-1.32)	13	86	1.54 (0.86-2.78)	3	50	0.58 (0.18-1.88)
≥4	20	11	17.52 (8.37-36.69)	6	17	3.65 (1.42-9.35)	7	13	5.41 (2.16-13.57)	<3[a]	5	2.12 (0.25-18.27)
Lag period: 2 years												
0			1			1			1			1
1	24	252	0.98 (0.64-1.5)	30	390	0.77 (0.53-1.12)	11	139	0.80 (0.43-1.49)	5	79	0.62 (0.25-1.55)
2 or 3	25	100	2.53 (1.62-3.94)	13	172	0.75 (0.43-1.32)	9	75	1.21 (0.60-2.42)	<3[a]	50	0.19 (0.03-1.39)
≥4	12	8	13.89 (5.66-34.10)	6	15	4.14 (1.58-10.8)	6	7	8.66 (2.91-25.78)	<3[a]	3	3.60 (0.37-34.97)
Lag period: 3 years (the main result of present study)												
0			1			1			1			1
1	14	205	0.69 (0.40-1.20)	21	309	0.68 (0.43-1.05)	10	116	0.87 (0.45-1.68)	5	71	0.70 (0.28-1.74)
2 or 3	18	77	2.36 (1.40-3.97)	9	126	0.71 (0.36-1.40)	6	59	1.02 (0.44-2.38)	<3[a]	42	0.23 (0.03-1.68)
≥4	6	6	9.01 (2.89-28.11)	6	13	4.8 (1.79-12.84)	4	6	6.76 (1.91-23.96)	<3[a]	3	3.61 (0.37-35.08)
Lag period: 4 years												
0			1			1			1			1
1	10	155	0.64 (0.34-1.23)	14	254	0.55 (0.32-0.94)	8	97	0.83 (0.40-1.73)	4	58	0.69 (0.25-1.92)
2 or 3	9	64	1.40 (0.69-2.84)	10	98	1.02 (0.53-1.96)	5	44	1.14 (0.45-2.89)	<3[a]	34	0.56 (0.13-2.36)
≥4	5	5	8.96 (2.57-31.21)	3	10	3.01 (0.83-10.94)	<3[a]	4	5.13 (0.94-28.05)	0	3	NA

aOR, odds ratios were adjusted by the year of cohort entry, annual family income (both as linear variable) and urbanization level (as categorical variable); CI, confidence interval; NA, not applicable.

[a]Due to the policy on protecting confidentiality, cells with a value of 1 or 2 were labeled as <3.

Supplementary Table 7: The estimated effects of number of CT scans, total number of experienced high-radiation procedures, and other covariates for the conditional logistic regression models.

	Intracranial tumors aOR (95% CI)	Leukemia aOR (95% CI)	Non-Hodgkin lymphoma aOR (95% CI)	Hodgkin lymphoma aOR (95% CI)
1 CT scan versus non-exposure	0.70 (0.41~1.22)	0.68 (0.43~1.05)	0.87 (0.45~1.67)	0.70 (0.28~1.74)
2~3 CT scans versus non-exposure	2.47 (1.46~4.16)	0.71 (0.36~1.39)	1.02 (0.44~2.37)	0.23 (0.03~1.70)
≥4 CT scans versus non-exposure	12.09 (3.63~40.25)	4.52 (1.67~12.21)	6.27 (1.73~22.74)	3.79 (0.39~37.1)
Year of cohort entry	1.17 (1.02~1.34)	1.21 (1.10~1.33)	1.28 (1.01~1.63)	1.71 (0.95~3.08)
Annual family income (per 1000 NTD)	0.99 (0.99~1.00)	1.00 (1.00~1.00)	1.00 (1.00~1.00)	1.00 (1.00~1.01)
City vs metropolis	1.01 (0.92~1.12)	1.04 (0.96~1.12)	0.97 (0.85~1.10)	0.79 (0.64~0.96)
Town vs metropolis	1.00 (0.81~1.23)	1.09 (0.93~1.27)	1.15 (0.87~1.50)	0.92 (0.60~1.42)
Rural area vs metropolis	0.94 (0.73~1.22)	0.96 (0.79~1.17)	1.14 (0.82~1.60)	0.69 (0.38~1.25)
Miss vs metropolis	2.00 (1.45~2.77)	1.03 (0.74~1.44)	1.15 (0.70~1.88)	0.56 (0.20~1.54)
Total number of high-radiation procedures[a]	0.44 (0.22~0.89)	1.14 (0.87~1.49)	1.16 (0.73~1.84)	0.81 (0.36~1.82)

Lag period: 3 years.

aOR: adjusted odds ratio; 95% CI: 95% confident interval; NTD: New Taiwan Dollar.

[a]Including cardiac catheterization, cystography, renal cortical scan, dynamic renography, positron emission tomography, skeletal scintigraphy, lung perfusion scan, hepatobiliary scintigraphy, Meckel's scan and gastric emptying tests.

Supplementary Table 8: Adjusted odds ratios for intracranial tumors, leukemia, and lymphomas related to the cumulative organ-specific dose from CT scans, estimated using radiation dosimetry from Kim and colleagues.(2)

Percentile of cumulative organ dose (absolute dose in mGy)	Cases (n)	Controls (n)	aOR (95% CI)
Intracranial tumors			
No exposure			1
Brain dose 20th percentile (>0~≤24.6)	4	54	0.75 (0.27~2.08)
Brain dose 21st to 40th percentile (>24.6~≤32.3)	5	68	0.74 (0.30~1.86)
Brain dose 41st to 60th percentile (>32.3~≤36.9)	<3[a]	53	0.38 (0.09~1.56)
Brain dose 61st to 80th percentile (>36.9~≤53.4)	5	33	1.53 (0.59~3.94)
Brain dose 81st to 100th percentile (>53.4)	17	45	3.76 (2.13~6.65)
Brain dose 99th to 100th percentile (>131.2)	5	3	14.97 (3.55-63.13)
Leukemia			
No exposure			1
RBM dose 20th percentile (>0~≤5.0)	7	67	1.05 (0.48~2.30)
RBM dose 21st to 40th percentile (>5.0~≤6.6)	7	85	0.83 (0.38~1.80)
RBM dose 41st to 60th percentile (>6.6~≤8.5)	9	114	0.79 (0.40~1.57)
RBM dose 61st to 80th percentile (>8.5~≤11.2)	4	69	0.56 (0.20~1.55)
RBM dose 81st to 100th percentile (>11.2)	9	79	1.14 (0.57~2.28)
RBM dose 99th to 100th percentile (>27.0)	3	6	5.01 (1.25~20.05)
Non-Hodgkin lymphoma			
No exposure			1
RBM dose 20th percentile (>0~≤5.0)	5	42	1.21 (0.47~3.11)
RBM dose 21st to 40th percentile (>5.0~≤6.6)	3	30	1.02 (0.31~3.36)
RBM dose 41st to 60th percentile (>6.6~≤8.5)	5	41	1.22 (0.48~3.11)
RBM dose 61st to 80th percentile (>8.5~≤11.2)	<3[a]	21	0.48 (0.06~3.59)
RBM dose 81st to 100th percentile (>11.2)	5	30	1.67 (0.65~4.31)
RBM dose 99th to 100th percentile (>27.0)	<3[a]	<3[a]	4.69 (0.42~51.99)
Hodgkin lymphoma			
No exposure			1
RBM dose 20th percentile (>0~≤5.0)	4	30	1.35 (0.48-3.85)
RBM dose 21st to 40th percentile (>5.0~≤6.6)	<3[a]	27	0.36 (0.05-2.69)
RBM dose 41st to 60th percentile (>6.6~≤8.5)	0	15	NA
RBM dose 61st to 80th percentile (>8.5~≤11.2)	<3[a]	14	0.70 (0.09-5.38)
RBM 81st to 100th percentile (>11.2)	0	18	NA
RBM dose 99th to 100th percentile (>27.0)	0	<3[a]	NA

aOR, odds ratios were adjusted by the year of cohort entry, annual family income (both as linear variable) and urbanization level (as categorical variable); CI, confidence interval; mGy, milligray; RBM, red bone marrow.
[a]Due to the policy on protecting confidentiality, cells with a value of 1 or 2 were labeled as <3.

Reference:

1. Gao Y, Quinn B, Pandit-Taskar N, Behr G, Mahmood U, Long D, et al. Patient-specific organ and effective dose estimates in pediatric oncology computed tomography. Phys Med. 2018;45:146-55.

2. Kim KP, Berrington de González A, Pearce MS, Salotti JA, Parker L, McHugh K, et al. Development of a database of organ doses for paediatric and young adult CT scans in the United Kingdom. Radiat Prot Dosimetry. 2012;150(4):415-26.