

Research Letter

The Incidence of Leukemia in Children Living Near Nuclear Power Plants in Germany (2004–2019)

A Registry-Based Study

In Germany, 19 nuclear power plants (NPPs) went into operation between 1966 and 1988. For most of them, authorization expired after German reunification in 1990 or following the Fukushima disaster in 2011.

Due to concern about the health effects of radiation exposure on children, and partly motivated by the identification of a cluster of cases of childhood leukemia around the Windscale NPP in England, studies have been performed in the vicinity of NPPs in various countries.

In Germany the KiKK study investigated whether more cases of leukemia occurred between 1980 and 2003 in children under the age of 5 years who lived near operating NPPs than in other regions (1). Analysis revealed an odds ratio of 2.19 (lower 95% confidence interval [CI]: 1.51) for residence within 5 km versus further away (1).

A recently published ecological study with a quasi-experimental approach analyzed leukemia incidence among children under 15 years of age during the period 2004–2019 in the vicinity of seven NPPs at which at least one reactor was shut down in 2011. Municipalities were assigned to the study region if at least 75% of their area lay within 10 km of the NPP and to the control region if they were 10–50 km away. The difference in leukemia incidence between the study and control regions was lower after 2011 than before. Owing to the small number of cases, however, the risk estimates have large degrees of uncertainty (2).

The aim of the study reported here was to extend this study by Russo et al. to all 19 of the NPPs and to analyze the association by residential distance and plant operational status.

TABLE

Childhood leukemia by nuclear power plant (NPP), distance, and plant operational status: number of cases observed (n) and incidence rate ratios (IRR) with 95% confidence intervals (period 2004–2019)

Nuclear power plant	Number of years in operation during the period 2004–2019 ^{*3}	Age 0–14 years					
		< 5 km			< 10 km		
		n	IRR	[95% CI] ^{*1}	n	IRR	[95% CI] ^{*1}
Biblis	12	0	–	–	7	0.81	[0.27; 2.50]
Brokdorf-Brunsbüttel ^{*2}	16	0	–	–	2	0.35	[0.04; 2.87]
Emsland-Lingen ^{*2}	16	0	–	–	10	1.04	[0.41; 2.66]
Grafenrheinfeld	16	0	–	–	12	0.96	[0.41; 2.26]
Greifswald	0	2	5.53	[0.71; 43.21]	2	2.84	[0.35; 23.16]
Grohnde	16	0	–	–	9	1.14	[0.42; 3.05]
Gundremmingen	16	2	1.09	[0.14; 8.53]	4	0.82	[0.19; 3.61]
Isar	16	1	1.25	[0.68; 22.78]	2	0.55	[0.07; 4.48]
Krümmel	13	8	1.83	[0.66; 5.12]	19	2.04	[1.03; 4.03]
Mühlheim-Kärlich	0	7	1.92	[0.64; 5.76]	16	0.84	[0.40; 1.76]
Neckarwestheim	16	7	1.32	[0.44; 3.97]	24	1.49	[0.81; 2.74]
Obrigheim	6	1	0.95	[0.05; 17.43]	8	1.23	[0.43; 3.52]
Philippsburg	16	1	0.27	[0.01; 4.88]	19	0.97	[0.49; 1.92]
Rheinsberg	0	0	–	–	0	–	–
Stade	5	0	–	–	10	1.23	[0.48; 3.15]
Unterweser	12	0	–	–	6	1.03	[0.31; 3.45]
Würgassen	0	0	–	–	1	0.35	[0.02; 6.76]
Cases around NPP during operational period		17	0.85	[0.53; 1.37]	111	1.10	[0.91; 1.32]
Cases around NPP after cease of operation		12	1.77	[1.00; 3.11]	40	1.01	[0.74; 1.37]
Total		29	1.08	[0.75; 1.56]	151	1.07	[0.91; 1.26]

The incidence rate ratios (IRR) were calculated with the Poisson model and adjusted for age group at diagnosis (0–4, 5–9, and 10–14 years), using German municipalities more than 10 km from NPP as reference. Municipalities were classified according to their distance from NPP, based on where at least 50% of their area lies.

^{*1} Confidence intervals for single NPP adjusted for multiple comparisons (Sidak's method)

^{*2} NPP merged due to overlap of the 10 km zone around each

^{*3} The NPP were classified on an annual basis as "operational" (including the 5-year period after cease of operation) or "shut down"

Methods

The German Childhood Cancer Registry (GCCR) provided data on childhood leukemia by residence at the time of diagnosis for the years 2004–2019. The Federal Statistical Office supplied the corresponding population data. Municipalities with at least half of their area within 5 km or 10 km of a NPP were included in the exposed group. The NPPs were classified on an annual basis as “operational” (including the 5-year period after cease of operation) or “shut down.”

The primary endpoint was the incidence of leukemia in children under 15 years of age. The incidence rate ratios (IRRs) according to distance and plant operational status were estimated using a Poisson regression model. Municipalities more than 10 km from an NPP were used as reference region. The confidence intervals for estimates concerning individual NPPs were calculated using the Sidak method accounting for multiple comparisons (3).

Results

The incidence of leukemia in children under the age of 15 years who lived within 10 km of an operational NPP was higher than in those at greater distances. The confidence interval includes the value 1, however, and the null hypothesis cannot be rejected ($n = 111$; $IRR = 1.10$; 95% CI 0.91–1.32). An elevated IRR was observed around Krümmel NPP ($n = 19$; $IRR = 2.04$; 95% CI 1.03–4.03) (Table).

An IRR close to 1 was observed for children under 5 years who lived within 5 km of an operational NPP (data not shown in Table); however, this was based on just 10 cases. An elevated number of cases was found in children under 15 years within 5 km of a closed NPP (Table).

Discussion

In contrast to the KiKK study (covering the period 1980–2003), our research did not identify an increased occurrence of leukemia in children under 5 years of age within a radius of 5 km around the operational NPP during the period 2004–2019 (1). Over time the number of NPPs in operation has decreased, so the areas analyzed in our study are not identical to those of the KiKK study. Our analysis provides results on closed NPPs, including some which had reached the end of their operating life span and had used older technology.

More children under 15 with leukemia than expected were found around Krümmel NPP (statistically significant even after adjustment for multiple testing), confirming previous site-specific results (2).

The main limitation of our study is the large degree of statistical uncertainty, especially in subgroup analyses, due to the small number of cases observed (Table). Moreover, the distance from an NPP and the plant’s operational status are poor surrogates for actual radiation exposure (4). The categorization of cases by municipality of residence rather than birth and the classification of the municipalities may lead to non-differential classification errors and thus bias the results towards the null value (5).

The strength of the analysis is the use of complete data from the GCCR and the investigation of all NPP with a priori inclusion criteria.

We recommend that epidemiological surveillance of leukemia in the vicinity of NPPs be continued after they are shut down.

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Conflict of interest statement

The authors declare that no conflict of interest exists.

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