

## Leukaemia in Children under 5 Years in the Close Vicinity of Nuclear Power Plants<sup>1</sup>

**Białaczka u dzieci w wieku poniżej 5 lat w bliskim sąsiedztwie elektrowni atomowej**

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### Abstract

The KiKK (Kinderkrebs in der Umgebung von Kernkraftwerken) study shows that the relative risk (RR) for leukaemias in children under 5 years of age in the 5 km region around the German nuclear power plants (NPP) is significantly correlated to the distance between the living place and the NPP. The reason is unclear. There exists a discrepancy between the radiation exposure, as measured around the NPPs, and the observed risk increase. Further investigations into pathogenesis for the development of leukaemias are necessary.

**Key words:** childhood leukaemia, nuclear radiation, leukaemia risk, KiKK Germany

### Streszczenie

Studium KiKK (nowotwory u dzieci w otoczeniu elektrowni atomowych) wykazało, że względne ryzyko (RR) białaczki u dzieci w wieku poniżej 5 lat w promieniu 5 km wokół niemieckiej elektrowni atomowej (NPP) jest znacząco zależne od odległości miejsca zamieszkania od elektrowni atomowej. Przyczyna jest niewyjaśniona. Istnieje rozbieżność pomiędzy ekspozycją na promieniowanie mierzone wokół elektrowni a wzmożeniem zaobserwowanego ryzyka. Konieczne są dalsze badania przyczyn powstawania białaczki.

**Słowa kluczowe:** białaczka dzieci, promieniowanie jądrowe, ryzyko białaczki, KiKK Niemcy

<sup>1</sup> Essential parts of the Position of the Commission for Environmental Issues of the Deutsche Akademie für Kinder- und Jugendmedizin (DAKJ) regarding the KiKK Study (Kinderkrebs in der Umgebung von Kernkraftwerken, Childhood Leukaemia in the Surrounding of Nuclear Power Plants) of the Kinderkrebsregister Mainz (German Childhood Cancer Registry) and regarding the ensuing discussions. The complete document is available in German language at <http://www.dakj.de/>. The literature citations at the bottom of the last refer to the original paper.

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## Historical remarks

By the end of the eighties of the last century, British investigators reported an increased occurrence of childhood leukaemias in the vicinity of nuclear installations in England and Wales [1]. In overall contradictory findings, some studies reported an increase of leukaemias in under 5 year old children in the close proximity of nuclear reprocessing plants and power plants (NPP). The German Childhood Cancer Registry (DKKR) in Mainz performed an ecological study (comparing incidences), looking for malignant diseases in under 15 year old children in the vicinity (15 km radius) of West German NPP [2], comparing the incidence to defined regions without NPP. For the period from 1980 to 1990, there was no increase of incidences [3]. However, consecutive, detailed explorations of the data showed an increased incidence of leukaemias in the age group of 0–5 in the 5 km proximity of NPP. Some years later, a second study of the DKKR was started, using the same design, with data of the period 1991–1995. Again, no relationship between the incidence of childhood leukaemias and residence within 15 km radius of NPP was found. Also, the data for the 0–5 year old children of the first study could not be confirmed [4, 5, 6].

Discordant results came from England [7, 8] and France [9]. A later metaanalysis [10] showed an increase of leukaemias in the vicinity of NPP, but correlations were mostly weak.

A re-analysis of the Mainz data yielded again an increased relative risk (RR) for leukaemias in children under 5 years in the vicinity of German NPP [11].

## The KiKK (Kinderkrebs in der Umgebung von Kernkraftwerken) study of the Mainzer Kinderkrebsregister (DKKR)

With regard to the persisting controversies the German Ministry for Environment (Bundesumweltministerium) in 2001 invited applications for the performance of a case-control-study, and the task was given to the DKKR, also with regard to the extensive data already compiled there.

The design of the new study was, in advance, defined with the Bundesamt für Strahlenschutz (Radiation Protection Agency, BfS) and a 12 person external expert committee [12]. The KiKK study [13] investigated 16 West German NPP. Study regions were the counties where the NPP were situated, and the counties neighbouring to the east, without NPP. Since the radiation exposure by other sources (background radiation, medicine, nutrition) could not be measured, the distance of

residence to the NPP was taken as surrogate for a possible radiation exposure due to the NPP. Cases were children who, between 1980 and 2003, were diagnosed as having malignant diseases, who were not older than 5 years and who lived in the study regions. There were 1592 cases, among them 593 leukaemias (512 ALL, 75 AML), 242 tumours of the central nervous system (CNS), and 486 embryonal tumours. For each case, three controls were added, taken from the person registries, with identical sex and with birth dates as close as possible to those of the cases ( $n = 4735$ ). For cases and controls, residence was located by geo-coding (GPS); this was done for cases at the date of diagnosis, for controls at the time of attribution when they were defined as controls. Accuracy of geographical location was 25 m. There existed neither for cases, nor for controls, data on previous residences, or on changes of residency.

The KiKK study re-used data from cases that had made part of the previous DKKR studies, amounting to approximately 70%.

The median of the distance of residence to the NPP was 20.8 km in cases, and 21.1 km in controls (means: 23.4 and 24.1 km).

The relative risk (RR) for malignant diseases was 1,61 for the under 5 years old in the 5 km vicinity, and for leukaemias 2,19, reconfirming the previously stated increase of incidences.

## Interpretations of these results

### *Authors of the KiKK study*

“In Germany there is a relationship between the proximity of residence to a NPP and the frequency by which children before their fifth birthday have malignant disease, above all leukaemia. The study does not allow to say which factor is responsible for this increase in the surrounding of German NPPs. According to the present state of knowledge, radiation emitted from the NPP cannot be held to be the reason for this increase in risk. Conceivably, yet unknown factors could be implicated, or it could be accidentally.”

### *External expert group*

“The study applies the absolutely best statistical methods for probing the hypothesis which had been defined a priori. Grave weaknesses of previous studies thus were avoided. The main result gives a definite answer to the question of the study. The main result is the estimation of the regression curve, which alone answers the a priori given question of the study. The application of categories of distance has only limited power.”

*Concerning the estimation of radiation related risk by international radiation protection agencies:* “Quantitative estimations of the risk of radiation by such commissions repeatedly had to be later corrected towards higher risk values. These reports focused mainly on quantitative radiation risks caused by high doses of external gamma radiation, mainly with high dose rate and high energies. Therefore, the conclusions drawn from these reports necessarily can only conditionally be applied to NPP. .... Thus the exposition of people living close to NPP is marked by an additional radiation dose which is below the exposition from natural sources and by diagnostic X-ray, by exposition with low dose rate, a mixed exposition of direct gamma radiation, external gamma and beta radiation resulting from the decay of short lived radionuclides, and from gamma, beta, and alpha radiation resulting from the decay of incorporated radionuclides. ...

Overall, a causal effect of radioactive emissions of German NPP cannot be excluded at the moment with regard to childhood leukaemia incidences. “

### ***Strahlenschutzkommission (German Commission on Radiological Protection)*** [14, 15]

“The KiKK-Study’s new data confirm the results of earlier exploratory studies that found an increased risk of leukaemia, for children younger than five, within a 5 km radius around German nuclear power plants, relative to the risk in the outer areas around the relevant study areas [16–20].

By virtue of its design, the KiKK-Study exhibits numerous methodological weaknesses with regard to determination of exposure and surveying of influencing factors. Consequently, the study should not have been carried out in the manner in which it was carried out. In spite of such weaknesses, the study’s design is suitable for the task of analysing dependence on distance.

The study is thus not suited to the task of establishing a correlation with exposure to radiation from nuclear power plants. All of the radioecological and risk-based circumstances reviewed by the SSK indicate that exposure to ionising radiation caused by nuclear power plants cannot explain the results found by the KiKK-Study. The additional radiation exposure caused by nuclear power plants is lower, by a factor of considerably more than 1,000, than the radiation exposure that could cause the risks reported by the KiKK-Study.

The natural radiation exposure within the study area, and its fluctuations, are both greater, by several orders of magnitude, than the additional radiation exposure caused by the relevant nuclear power plants.

The reason for the increased leukaemia rate that the KiKK-Study observed in children is unclear. Since leukaemia is caused by multiple factors, numerous influencing factors could have been responsible for the observed result. If the many relevant conflicting findings in the literature, and the finding of the KiKK-Study, are to be understood, more extensive, interdisciplinary research into the causes and mechanisms of the development of leukaemias in children will have to be carried out.”

### **Commission for Environmental Issues of the German Academy of Pediatrics (DAKJ)**

#### ***Lack of transparency of DKKR data***

Deplorably the Mainz data (which all come from German pediatricians and from the families of sick children) are not open to the public, nor to pediatricians or epidemiologists, hindering further analyses and transparency. Sufficient anonymisation of data to protect privacy and conform to data protection regulations would be possible. The commission asks for a change in this practice, e.g. by offering a public use file, as has been done with the results from KiGGS (Kinder- und Jugend-Gesundheits-survey, Child and Youth Health Survey) and of the KUS (Kinderumweltsurvey, Child Environmental Survey).

Many questions remain open so far. Most historical data referring to places of residence are lacking for cases and controls. One should know where the mothers have lived before conception, and where during the pregnancy, and whether they or the fathers have worked in the NPP. The extensive and important data in the hands of the DKKR appear to be suitable to bring more differentiating and clarifying results. Further analysis of this material must go on, to be done either by the DKKR, or by another institution.

#### ***Radiation biology***

Background radiation (in Germany 2,1 mSv/a with some variations) is 100 or 1000 fold higher than the anthropogenic radiation caused by NPP. If NPP related radiations were at reason for the increase in leukaemia risk, there should be, due to the local variability of background radiation, important local differences in leukaemia frequency, which is not the case.

Taking into account the calculations of radiation damage after the atomic bomb detonations in Hiroshima and Nagasaki, and the inductions of leukaemias by X ray investigations during pregnancy, the emissions from NPP are lower by two or

three orders of magnitude than those necessary for the induction of leukaemia. However, the dose calculations derived from the above mentioned sources have a very limited applicability for the context discussed here. Also, it remains unclear whether this dosimetry is applicable for all radionuclides, or for those incorporated, e.g. for tritium. (see minority vote 3 at the end of the text)

### ***Interpretation of results (by the Commission)***

The KiKK study confirms the results of earlier explorative studies that had given partly contradictory results and shows that the relative risk for leukaemias for children up to 5 years of age within a 5 km radius around NPP is elevated (Kaatsch et al. 2008 – 13).

The reason for this increase is not clear. The maximal possible additional radiation exposure, as calculated from the data of the surveillance systems, applying a worst case scenario, is by two orders of magnitude lower than that which, according to our present state of knowledge, could explain on the basis of radiation biology the observed effect.

The distance of residences to the NPP show small differences between cases and controls (cases 20.8 km, median, controls 21.1 km). The majority of the commission is of the opinion that it is not realistic to accept distances of residency as indicator for different radiation exposures.

The investigation of confounders which has been performed in a second part of the KiKK study has shown no other significantly effective factors onto the induction of leukaemias (this second part has not made part of the KiKK study, due to methodological reasons).

The results do not permit to exclude ionising radiation as cause for the increased incidence of malignancies, as has been stated by the authors of the KiKK study (“that the radiation emitted normally by NPP principally cannot be interpreted as cause”).

Leukaemias in childhood are rare diseases, they mostly develop due to multifactorial influences, and in addition to ionising radiation, many other risk factors are defined. Within the KiKK study, the influence of such other risk factors could not be established with statistical significance. None of the known risk factors is potent enough as to explain the result, and, additionally, such factors should correlate with the distance to the NPP. The results of the second part of KiKK (case control study with questionnaires) give not any such indications.

The Commission for Environmental Issues of the DAKJ, in accordance with most experts, sees the necessity for further investigations into the causes of

leukaemia, taking into account the increase in frequency of childhood leukaemias of 0.6–1.0% per year.

### ***Attribution of risks***

According to the authors of the KiKK and also to the SSK the attribution of cases should be restricted to the 5 km distance around NPP. On this basis, around all German NPP and during the time period between 1980–2003, an additional number of 29 ALL cases have been observed.

An extrapolation for the 50 km region is mathematically possible, using a constant function, but is based on the unproven supposition that the function has an equal validity for all distances and that a supposed effect is present also in the more distant regions. This appears to be improbable if one takes into account the very small difference (300 m) between cases and controls regarding the distances between living places and NPP.

### **Minority votes**

Two members of the commission, St. Böse-O'Reilly and Th. Lob-Corzilius add the following comments:

As to the precision of monitoring in the surroundings of NPP: The model estimations were prone to remarkable uncertainties of at least one to two orders of magnitude, due to numerous biokinetic and physical assumptions and simplifications. Additionally, the measurements have been done by the NPP operators themselves. The results presented as mean values have then be controlled by supervising authorities. It would be necessary to list and control all single results of measurement in order to control and better recognize peaks of radioactivity, e.g. during nuclear fuel rod exchange, because just short lived peaks radiation could yield radiobiological explanations.

As to the special vulnerability of children: This statement takes into account only adult, male persons, the so called reference man, and not to women in reproductive age, or to embryos who have a considerably higher radiation sensitivity. Furthermore, effects of ingested or inhaled fission products are neglected by this approach.

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