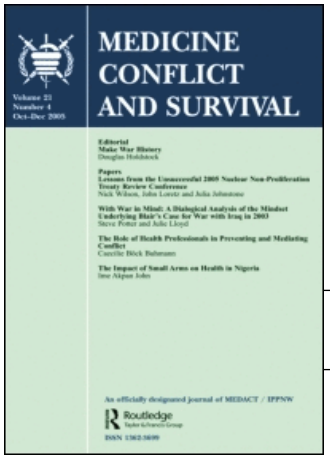

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COMMENTARY

New evidence of childhood leukaemias near nuclear power stations

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Introduction

In the late 1980s and early 1990s, a number of studies revealed increased incidences of childhood leukaemias near the nuclear facilities at Windscale (now Sellafield), Burghfield near Aldermaston and Dounreay in Scotland. Various explanations were offered for the increases; however, a series of reports from the United Kingdom government's Committee on the Medical Aspects of Radiation in the Environment (COMARE) concluded that the cause or causes remained unknown but were unlikely to involve radiation exposures[1–6]. This was because the National Radiation Protection Board had concluded that the estimated radiation doses from intakes of nuclides released by these facilities were too low, by two to three orders of magnitude, to explain the increased leukaemias.

A recent study sponsored by the German government has, rather dramatically, rekindled the childhood leukaemia debate, as it directly associates increased incidences of childhood leukaemias with proximity to German nuclear installations. The study, by the Epidemiologische Studie zu Kinderkrebs in der Umgebung von Kernkraftwerken (Childhood Cancer in the Vicinity of Nuclear Power Plants, KiKK), had been commissioned in 2003 by the Bundesampt fur Strahlenschutz (BfS, the German Federal Office for Radiation Protection, equivalent to the Health Protection Agency – Radiation Protection in the UK) following prolonged pressure by IPPNW Germany and various German citizen groups. The study was carried out by large teams from the University of Mainz which could not be accused of being opposed to nuclear power[7,8]. An advance web publication[9] resulted in

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a public outcry and media debate in Germany which has received relatively little attention in the UK.

The KiKK study is significant as it indicates that the increased risks of childhood leukaemia:

- are very large;
- are unequivocally linked to proximity to nuclear reactors;
- appear to extend as far as 70 km from the nuclear reactors;
- are accepted by the German Government.

The study is particularly significant for UK observers as it rejected the notion (often raised in the UK) that clusters can occur anywhere by chance – that is, coincidence is ruled out. The study also specifically rejected the Kinlen hypothesis (also often raised in the UK) that the cancer increases were due to population mixing.

The KiKK case–control study examined all cancers near all of the 16 nuclear reactor locations in Germany between 1980 and 2003, including 1592 under-fives with cancer and 4735 controls, with 593 under-fives with leukaemia and 1766 controls. The main findings were a 0.61-fold increase in all cancers, and a 1.19-fold increase in leukaemia among young children living within 5 km of German nuclear reactors (Table 1). These increases are statistically significant and are much larger than the cancer increases observed near nuclear facilities in other countries (see later). Indeed, the size of these increased risks is surprising.

Many previous studies (as discussed below) have indicated increased cancer risks near nuclear facilities, but the KiKK study for the first time measured *how far each cancer case was from the nuclear reactors*. This allowed the study team to examine whether distance from nuclear reactors was an important factor. The result was an unequivocal finding of a nearness – increased risk relationship which directly links increased cancer risks to living near nuclear facilities. The proximity–risk relationship is pronounced – see the final column in Table 2. Extraordinarily, small increased risks extend as far out as 70 km beyond nuclear power plants. Figure 1 below shows the estimated risk-nearness relationship, indicating

Table 1. KiKK odds ratios for all cancers in children less than 5 years old.

	All cancers	Leukaemia
Within 5 km of NPP	1.61	2.19
Within 10 km of NPP	1.18	1.33

Notes: Estimates by KiKK from its categorical regression model[7]. NPP, nuclear power plant. The odds ratio (OR) is a measure of increased risk. Here it is the ratio of the odds (that is, chance) of a cancer occurring in nearby residents to the odds of a cancer occurring in the control group. An OR of 1 would mean the odds (chances) were the same.

Table 2. KiKK odds ratios for leukaemias in children less than 5 years old.

Distance from NPP km	Mean distance km	Odds ratio
<5	3	1.76
5 to <10	8	1.26
10 to <30	18	1.10
30 to <50	37	1.05
50 to <70	57	1.03
>70	74	1.02

Notes: Estimates by KiKK from its continuous regression model[8]. NPP, nuclear power plants.

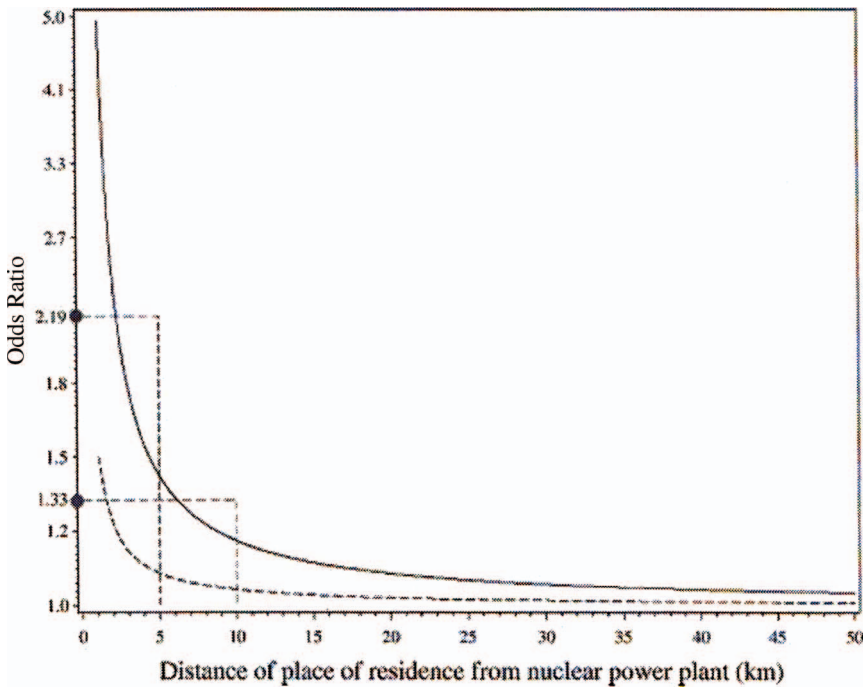

Figure 1. Increased leukaemia risks for children aged less than 5 years living near nuclear reactors.

the actual increased leukaemia risks at 5 km and 10 km from nuclear reactors.

The study tested the proximity–risk relationship by examining whether other risk factors (confounders) could have had an appreciable effect on the result. This proved not to be the case: the nearness of residence to the nuclear power plant remains the most likely explanation. It is now officially

accepted in Germany that children living near nuclear power plants develop cancer and leukaemia more frequently than those living further away[9].

The Bundesamt fur Strahlenschutz's (BfS) carefully worded conclusion stated that:

> The present study confirms that in Germany there is a correlation between the distance of the home from the nearest NPP [nuclear power plant] at the time of diagnosis and the risk of developing cancer (particularly leukaemia) before the 5th birthday. This study is not able to state which biological risk factors could explain this relationship. Exposure to ionising radiation was neither measured nor modelled. Although previous results could be reproduced by the current study, the present status of radiobiological and epidemiological knowledge does not allow the conclusion that the ionising radiation emitted by German NPPs during normal operation is the cause. This study cannot conclusively clarify whether confounders, selection or randomness play a role in the distance trend observed[10].

This could be interpreted as saying that the BfS found increased risks and a nearness-risk trend, but because of strong institutional commitments in Germany, it was unable to comment meaningfully on why these occurred. This conclusion hints at the dismay caused by the study in German radiation circles, and perhaps at embarrassment too, as the results were certainly not expected. It is noticeable that the Health Protection Agency in the UK has remained silent on these remarkable findings.

Discussion

In general terms, environmental exposure to radiation is a well-known risk factor for leukaemia[11–13]. There are many other specific epidemiological studies indicating a possible association between nuclear power plants and childhood leukaemia[14–17]. For example, 14 cases of leukaemia between 1990 and 2005 were found in children living within 5 km of the Krümmel nuclear power plant and neighbouring nuclear research facility in Geesthacht, northern Germany, significantly exceeding the four predicted cases based on national incidence rates. The increased incidence of leukaemia was found to continue in the period 1999–2005[16]. The KiKK study is arguably the most important of all these studies, partly because it is very large (covering all German nuclear power stations) and government-sponsored so that its findings are authoritative, and partly because the observed risk increases are very high in relation to the other studies. It is particularly important, however, because it unequivocally demonstrates an increased risk from proximity to nuclear rectors.

What do other studies say about such a relationship? In the UK, COMARE did not find an increased risk-nearness relationship for nuclear power plants[5,6]; nor did similar research in France reveal an increased risk of childhood leukaemia within 5 km of nuclear sites[18]. However, this lack of

evidence does not mean that there is no relationship, only that the studies were unable to find any. It is a cardinal rule in epidemiology that absence of evidence does not mean evidence of absence[19] – negative findings are less compelling evidence than positive findings.

A significant study[20] from the Medical University of South Carolina indicated that increased leukaemia risks were associated with nuclear facilities world-wide, and that there was a nuclear power plant nearness/risk relationship for leukaemia deaths. The authors carried out a sophisticated meta-analysis of 17 research papers covering 136 nuclear sites in the UK, Canada, France, United States, Germany, Japan and Spain. In children up to 9 years old, leukaemia death rates were from 5 to 24 per cent higher, and leukaemia incidence rates were 14 to 21 per cent higher. Lower increases were found in older children (Table 3). Inexplicably, this study was not mentioned in the KiKK report, although it lends support to its findings.

What is/are the cause(s) of the increased cancers?

The KiKK authors explained that population mixing was unlikely to account for the leukaemia incidence as they had specifically examined population movements and found that population had remained stable over the years studied. Another reason, coincidence – that is, that clusters can arise purely by chance – was also held improbable by the External Expert Group commissioned to supervise the drafting, the execution and evaluation of the KiKK study[10].

The obvious reason is that something connected with the nuclear stations – including their radioactive releases – results in increased cancer risks. Therefore, a key question is – are the radiation exposures to children near German nuclear power plants high enough to cause these increased risks? The KiKK authors said no – the raised levels of childhood cancer could not be explained by radioactive emissions from nuclear power plants because the estimated radiation doses/risks were too low. This will be read by UK readers familiar with the Sellafield leukaemia saga with an uncomfortable feeling of *déjà vu*.

Table 3. Leukaemia mortality and incidence risks.

Age group	Proximity to nuclear facility	Leukaemia mortality	Leukaemia incidence
0–9	All distances	1.05	1.21
	Under 16 km	1.24	1.14
0–25	All distances	1.02	1.10
	Under 16 km	1.18	1.07

Source: Ref. 20; meta-analysis using random effects model as also described in Ref. 8.

However, a crucial flaw is that KiKK reports did neither estimate these radiation doses nor carry out uncertainty analyses on them. These are glaring omissions: many studies in the past[1–4] have used emissions data from nuclear power plants to examine dose–response relationships. Indeed the omissions are so obvious that this is likely to have been a policy decision. The question remains – why?

Another crucial point is that the KiKK authors did not discuss the findings of the UK government's CERRIE Committee[21] that there could be large cumulative uncertainties in the doses estimated for internally deposited nuclides. These arise mainly from uncertainties in biokinetic and dosimetric models and in various dose qualifying factors. From the examples discussed by CERRIE, uncertainties in dose coefficients for some nuclides could well be large enough to explain the increased leukaemias.

Could the (unpublished) risk estimates from radiation to nearby German children therefore be incorrect? This requires us to look at both doses and risks. First, radiation *doses* could be underestimated, for the following reasons:

- nuclide emissions from nuclear power plants could have been incorrectly measured/estimated;
- current environmental transport models may be wrong;
- current biokinetic models for nuclide uptake and retention in local residents may be incorrect; and
- the biological effects of incorporated radionuclides may have been underestimated.

Second, the *risks* from these doses could be wrong because:

- the dose–risk coefficient (5% per Sv for fatal cancer) is incorrect; and
- perhaps local populations may contain radiosensitive people.

The net effect of these uncertainties is that the raised cancer risks found by KiKK could therefore still be explained by radioactive emissions from nuclear power plants. A straightforward explanation was therefore available but not discussed, although admittedly one that questions many official orthodoxies in radiation protection.

An interesting aspect also not discussed by KiKK is that about two thirds of the reactors in the study are pressurised water reactors (PWRs) notable for high tritium emissions. The remaining third are boiling water reactors (BWRs) which also emit relatively large amounts of tritium, but these are lower by about a factor of 10 than releases from PWRs in Germany. Tritium releases are the largest of the various nuclide releases from these reactors. Noble gases are also emitted in large quantities but these are not thought to interact with humans. These can give small external

skin doses, but such external exposures can be measured by instruments so that external doses are much more accurate than internal doses. Tritium is the radioactive isotope of hydrogen and its most common form is radioactive water. A recent report by a UK Government committee[22] examined a number of unusual aspects of tritium and discussed questions surrounding its biokinetic and dosimetric models. It concluded that the hazards of tritium (that is, its dose coefficient) should be doubled; a future paper in this journal will revisit the topic of tritium.

Finally, it may also be that there are interactions between environmental exposures that we are yet to understand. In the past[23,24,] it has been stated that there may be a synergistic effect between radiation and chemicals that could increase the risk of developing childhood leukaemia. This aspect was also not investigated by the KiKK report.

Conclusions

Taken together, these recent studies[7,8,17,20] are important in radiation protection, as they provide strong evidence of an association between increased cancer risk and children living near nuclear facilities.

The studies, especially KiKK[7,8], cast a new affirmative light on more than 40 other environmental studies throughout the world indicating a possible association between nuclear power stations and an increased risk of childhood leukaemia. In public health terms, this mass of evidence is difficult to contradict, and it should now be accepted by the radiation protection community that nuclear power station releases result in increased leukaemias among children living up to 70 km away. And the closer they live to the sites, the greater their risks.

These studies therefore raise difficult questions, including whether vulnerable people – for example, pregnant women and young children – should be advised to move away from nuclear facilities. Another question is whether local residents should be advised not to eat produce from their gardens, as the food pathway is the largest contributor to local doses.

But the largest question concerns the wisdom of the recent decisions by several governments to continue to press for the construction of nuclear reactors.

Notes on contributor

Ian Fairlie is an independent consultant on radioactivity in the environment. He has degrees in chemistry and radiation biology, and his doctoral studies at Imperial College examined the radiological impacts of reprocessing discharges at Sellafield and Cap de la Hague. He has worked for various UK government departments and regulatory agencies, and advises environmental NGOs, the European Parliament and local authorities. Between 2001 and 2004 he was Secretariat to the UK government's CERRIE committee.

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