J. Radiol. Prot. 1996 Vol. 16 No 3 213–215 Printed in the UK

Letter to the editor

Dear Sir

Leukaemia and lymphoma mortality in the vicinity of nuclear power stations in Japan 1973–1987

Recently Iwasaki, Nishizawa and Murata have published data concerning the mortality on leukaemia and lymphoma in the vicinity of nuclear power stations in Japan, 1973–1987 [1]. They concluded that leukaemia and lymphoma mortality in the Japanese municipalities containing nuclear power stations is not significantly different from control areas.

Since the authors present SMR analyses for each individual area only, their conclusion is based on a multitude of small-number comparisons. This analysis obviously results in a very low statistical power and, hence, only a very large systematic difference between the areas would be detected.

A more appropriate analysis would be to compare pooled results for all municipalities with nuclear power stations with the pooled results of the control regions. When this is done for the total period 1973–1987, 307 leukaemia deaths of all ages are observed whereas only 251 would have been expected based on Japanese national figures. The resulting overall SMR of 1.22 is significantly increased above expectation in a two-sided test based on a Poisson distribution (95% confidence interval: 1.08–1.37).

Following the method of the authors, we calculated SMRs for the nuclear power plant and control municipalities and the resulting relative risks (RR). The 95% confidence intervals (CI) of the RR were calculated according to the method suggested by Michaelis *et al* [2]. For all nuclear power plant sites combined the RR is 1.17. The increased RR is statistically significant (CI 1.03–1.33).

To further evaluate this association, in a second analysis for periods 1973–1977 and 1978–1982, we selected municipalities with respect to whether or not the reactor's first criticality occurred at least one year before the beginning of the respective period. Hence, for the period 1973–1977 site regions were restricted to Tokai, Tsuruga, Mihama, Ohkuma, and Futaba. For the period 1978–1982 additionally the sites Takahama, Kashima, Genkai, Hamaoka, and Ikata were considered whereas for the period 1983–1987 finally all sites were included in the analysis (table 1). Although the number of fatalities is considerably reduced through this approach, the RR remains significantly increased. This finding cannot be attributed to the two sites in Kyushu, where adult T-cell leukaemia/lymphoma (ATL) is endemic, as the authors suggested in their discussion. The excess mortality in Japanese municipalities with nuclear power plants remains statistically significant, even when Sendai and Genkai are excluded (table 1). Finally, the sites Onagawa, Oshika, Kashiwazaki and Kariwa were also excluded from the analysis because the start up years of these atomic power plants fell within, rather than before, the period 1983–1987 so that inclusion of these sites in the analysis would obscure any association (table 1). Again, the number of fatalities is reduced markedly compared with the pooled analysis. The excess in relative risk, however, still reaches borderline statistical significance.

Hence, the excess in SMRs of leukaemias for all ages in site regions is some 20% irrespective of the site definition. The deviation from unity reaches statistical significance or at least borderline significance in all analyses. Contrarily, with respect to malignant lymphoma mortality of all ages, site regions and control regions are very similar. According to the site definitions in table 1 the RRs are 1.06, 1.01, 0.95, 0.98, respectively. It should be noted, that disparate RRs for leukaemias and malignant lymphomas indirectly support the hypothesis. They could reflect the difference in radiosusceptibility, which is comparatively high for leukaemia and considerably lower for malignant lymphoma. When the analysis is restricted to children below age 15 RRs are consistently elevated for both leukaemias (RR 1.17, 1.26, 1.09, 1.25) and malignant lymphomas (RR 1.17, 1.28, 1.37, 1.71), respectively. Due to small numbers, however, none of these elevations is statistically significant.

An increase of the RR over the three time periods analysed by the authors would add independent evidence to the hypothesis of an impact of atomic power plant operation on local leukaemia mortality, because time since operation and absolute number of potentially exposed persons would both reflect cumulative population dose. Using site definition 4 in table 1 a RR of 1.08 (CI 0.67–1.68) for leukaemia mortality of all ages results for the period 1973–1977. For 1978–1982 the RR increases to 1.24 (CI 0.87–1.74), and becomes 1.27 (0.94–1.70) for the most recent period 1983–1987. Results for definition 4 are

0952-4746/96/030213 + 03 $19.50

Table 1. Leukaemia, all ages.

Definition of site municipalities	Site municipalities			Control municipalities				
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	RR	95%
(1) All municipalities with nuclear power plants commissioned before 1987	307	251.0	1.22	1215	1165.2	1.04	1.17	1.03–1.33
(2) 1973–1982: Municipalities with commissioning of reactor 1 year period to respective period, 1983–1987: all sites[1]	196	153.6	1.28	774	756.3	1.02	1.25	1.06–1.46
(3) 1973–1982: Municipalities with commissioning of reactor 1 year period to respective period, 1983–1987: all sites; Sendai and Genkai excluded.	161	133.0	1.21	689	697.2	0.99	1.22	1.03–1.46
(4) 1973–1982: Municipalities with commissioning of reactor 1 year period to respective period, Sendai and Genkai excluded[2]	126	104.7	1.20	570	577.8	0.99	1.22	1.00–1.48

[1]1973–1977: Tokai, Tsuruga, Mihama, Ohkuma, Futaba
1978–1982: Sites of 1973–1977 plus Takahama, Kashima, Genkai, Hamaoka, Ikata
1983–1987: Sites of 1978–1982 plus Ohi, Tomioka, Naraha, Onagawa, Oshika, Sendai, Kashiwazaki, Kariwa

[2]1973–1977: Tokai, Tsuruga, Mihama, Ohkuma, Futaba
1978–1982: Sites of 1973–1977 plus Takahama, Kashima, Hamaoka, Ikata
1983–1987: Sites of 1978–1982 plus Ohi, Tomioka, Naraha

presented here, because we consider definition 4 the most biologically plausible to study time trends. However, the other scenarios yield similar results (not shown).

For children, no trend over time was evident. However, not only are the results for children below 15 based on small numbers, but moreover we would caution against the study of mortality among children in principle. In the time period 1973–1987 leukaemia mortality in children decreased remarkably. Expected cases dropped by 40% from the first to the third period. It is safe to assume that this favourable trend is predominantly due to the significant improvements in leukaemia therapy. In the same time period the expected cases for age 15 and above increased to 1.44 times the initial value. The corresponding figures for non-Hodgkin's lymphoma are basically constant for age 0–14 and 16 for age 15+. We conclude that, at least for leukaemia in children, analyses based on leukaemia mortality are inappropriate in the first place. Incidence rather than mortality needs to be studied to evaluate the potential impact of atomic power stations. Michaelis *et al* found a significant increase in leukaemia incidence among children 0–4 years in the immediate proximity (0–5 km) of 22 West German atomic power stations [2]. Viel *et al* have recently reported an increased incidence of leukaemia among children and young adults in the vicinity of the nuclear waste reprocessing plant La Hague, France [3] which had previously been missed in a mortality study [4].

In conclusion, in an ecological analysis of Japanese municipalities with nuclear power plants compared with matched control regions without such sites, a consistent increase of leukaemia mortality of all ages was observed with various site definitions. Relative risks for children under age 15 were also elevated, but due to small numbers not significantly so. Malignant lymphoma mortality of all ages, on the other hand, was similar in site and control regions. For children, a slightly increased RR is possible, but far from statistical significance. Moreover, over three consecutive 5-year time periods, the RR in site municipalities increased steadily. These findings are compatible with the hypothesis of a leukemogenic impact of nuclear power plants in Japan.

Yours faithfully,

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References

[1] Iwasaki T, Nishizawa K and Murata M 1995 Leukaemia and lymphoma mortality in the vicinity of nuclear power stations in Japan, 1973–1987 *J. Radiol. Prot.* **15** 271–88

[2] Michaelis J, Keller B, Haaf G and Kaatsch P 1992 Incidence of childhood malignancies in the vicinity of West German nuclear power plants *Cancer Causes Control* **3** 255–63

[3] Viel J-F, Pobel D and Carré A 1995 Incidence of leukaemia in young people around the La Hague nuclear waste reprocessing plant: A sensitivity analysis *Stat. Med.* **14** 2459–72

[4] Hattchouel J M, Laplanche A and Hill C 1995 Leukaemia mortality around French nuclear sites *Br. J. Cancer* **71** 651–3