Epidemiology

CANCER NEAR POTENTIAL SITES OF NUCLEAR INSTALLATIONS

PAULA COOK-MOZAFFARI  SARAH DARBY
RICHARD DOLL
ICRF Cancer Epidemiology and Clinical Trials Unit, Gibson Laboratories, Radcliffe Infirmary, Oxford OX2 6HE

Summary
Mortality and census data for 400 districts of England and Wales were analysed with respect to existing sites of nuclear power stations and sites where the construction of such installations had been considered or had occurred at a later date (potential sites). Excess mortality due to leukaemia and Hodgkin's disease in young people who lived near potential sites was similar to that in young people who lived near existing sites. Areas near existing and potential sites might share unrecognized risk factors other than environmental radiation pollution.

INTRODUCTION
In 1969–78, mortality from leukaemia, and especially from lymphoid leukaemia, at ages 0–24 was higher in districts near nuclear installations than in matched control districts and in all other districts of England and Wales. In the latter study, we compared 78 districts that had any part of their area within 16 km of an existing nuclear installation with 330 other districts: relative risks (RRs) near the installations were increased by 15% for leukaemia of all types and by 21% for lymphoid leukaemia, after adjustment for social-class, rural status, population size, and local regional health authority of the districts. These increases corresponded to about 8 excess deaths from leukaemia annually. Mortality from Hodgkin's disease at ages 0–24 was also increased near nuclear installations (RR = 1.24), whereas mortality from lymphoid leukaemia at ages 25–64 was reduced (RR = 0.86).

Since annual radiation doses received by children living near nuclear installations are much lower than those expected to cause any detectable increase in leukaemia, and many orders of magnitude so for installations other than Sellafield, we must ask whether the observed increases are due not to the presence of the nuclear installations but to another feature of the areas in which installations have been built that was not adequately taken into account. To investigate this hypothesis we have considered the two Central Electricity Generating Board (CEGB) nuclear power stations that were established in England and Wales after the end of the period to which our mortality data referred (at Hartlepool, Cleveland in 1981 and at Heysham, Lancashire in 1983) and six other sites that, according to CEGB, were seriously considered for the construction of nuclear power stations (at Laxey, Nancekluke, and Gwythian, Cornwall; at Herbury, Dorset; at Portskewett, Monmouthshire; and at Durlidge Bay, Northumberland). These eight sites will be referred to as potential sites of nuclear installations.

METHODS
Mortality from eleven causes (or groups of causes) in 400 districts of England and Wales that approximate to the 402 County Districts established in 1974 was analysed with census and mortality data from before and after the 1974 boundary changes as previously described.

31 districts, which had some part within a 16 km radius of the potential sites, had a total population of 3.37 million at the time of the 1971 national census compared with 7.67 million in the 70 districts near to existing nuclear installations. 11 districts with a population of 1.29 million were in the vicinity of sites in both categories. The numbers of deaths from each of the causes in these three categories are shown in Table 1.

Estimates of RR were derived from log-linear regression by means of the 'GLIM' computer program; allowance for extra-Poisson variation was made with the method of Breslow, except that significance tests were done with a comparison of deviances because the original $\chi^2$ method performed poorly (Breslow, personal communication). One-sided tests in the direction of the observed difference were used to evaluate the risk in districts near the sites of interest.

For simplicity of presentation, the districts in proximity both to existing and to potential sites have been excluded from the analyses. Alternative analyses, however, in which all districts were included and adjustment was made simultaneously for the two types of site gave results very similar to those presented. RR for existing sites near potential sites.

<table>
<thead>
<tr>
<th>Ages 0–24 yr</th>
<th>Ages 25–64 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing*</td>
</tr>
<tr>
<td>Leukaemia (all types)</td>
<td>635</td>
</tr>
<tr>
<td>Lymphoid leukaemia</td>
<td>372</td>
</tr>
<tr>
<td>Other leukaemia</td>
<td>263</td>
</tr>
<tr>
<td>All lymphomas</td>
<td>222</td>
</tr>
<tr>
<td>Hodgkin's disease</td>
<td>99</td>
</tr>
<tr>
<td>Other lymphomas</td>
<td>123</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>. . . .</td>
</tr>
<tr>
<td>Cancer of the lung</td>
<td>. . .</td>
</tr>
<tr>
<td>Other malignancies</td>
<td>845</td>
</tr>
<tr>
<td>All malignancies</td>
<td>1702</td>
</tr>
<tr>
<td>All other causes</td>
<td>23708</td>
</tr>
</tbody>
</table>

*Excluding districts near potential sites.
†Excluding districts near existing sites.
‡Districts both near existing and potential sites.

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have been calculated with the inclusion of Copeland District, in which Sellafield is situated, because exclusion of this district made little difference to the overall results.⁴

RRs have been calculated both with and without adjustment for the four socioeconomic and demographic characteristics of districts that we have considered—namely, social-class structure, rural status, population size, and health authority region. As in our previous study we have based our conclusions on the adjusted values.

RESULTS

Relative risks for existing sites are strikingly similar to those of potential sites (table II), particularly for leukaemia of all types and for all malignancies at ages 0–24 years. However, the population near the potential sites is smaller and the increases in RRs, though proportionally similar, are significant only in districts near the existing sites (p = 0.08 for leukaemia; p = 0.01 for all malignancies). For Hodgkin's disease at ages 0–24, both RRs are significantly raised (p = 0.05), with a notably higher value for the potential sites than for the existing sites. The high RR for Hodgkin's disease near the potential sites contributes to a significant increase in risk also for all lymphomas (p = 0.04).

The increase in risk for leukaemia mortality in young people in districts near the existing sites is more pronounced for lymphoid leukaemia than for other types of leukaemia; this pattern is not repeated near the potential sites, although for both types of leukaemia the risks are again above unity.

At ages 25–64 years, the deficit in mortality from lymphoid leukaemia that was observed near the existing sites (p = 0.04) is repeated and is more striking in districts near the potential sites (p = 0.03). There was no material increase in risk for any of the causes of death analysed near the existing sites, but there was a significantly raised mortality from Hodgkin's disease near the potential sites at ages 25–64 years (p = 0.01), which echoes the finding at younger ages.

DISCUSSION

Our hypothesis that, with the possible exception of Sellafield, an increased risk for leukaemia is not associated with local environmental radiation pollution is strengthened by our new findings—namely, that the death rate from leukaemia in areas where there were no nuclear installations,

but where the construction of such installations was considered or actually occurred at a later date, was similar to that in areas near existing nuclear installations.

In our previous study,³ the increased death rate at young ages near nuclear installations was particularly pronounced for lymphoid leukaemia, whereas in the present study the RR is greater for other types of leukaemia. This difference may reflect sampling variation or the inaccuracy of the classification of leukaemia types on death certificates at the time of the study. However, it is noteworthy that by no means all of the leukaemias diagnosed among young people in the vicinity of Sellafield and Dounreay were recorded as the lymphoid type: in Milnol Rural District, near Sellafield, leukaemias were certified as acute lymphoid (5), chronic lymphoid (1), acute myeloid (3), chronic myeloid (1), erythroleukaemia (1), and unspecified (1),¹ⁱ whereas in Dounreay, the cases were registered as acute lymphoid (9) and acute myeloid (3).

New treatments that reduced the mortality from leukaemia in young people should be considered in the interpretation of our new findings. Between 1961–65 (just before our study) and 1976–80 (at the end of the period covered) mortality fell from 27.4 to 20.3 per 10⁵ people aged under 25 years (standardised for age and sex). That the treatment of patients near the sites of existing and, perhaps also, potential installations was possibly less effective than average has to be considered. However, we have standardised for health service region and for rural status, and this should have accounted for any major difference in the efficacy of available treatment. Definitive studies need to be based on cancer incidence but, during the period studied, standard registration data were unfortunately inadequate.

Recent data from New Towns in Scotland¹³ and from England and Wales¹⁴ are compatible with an earlier suggestion⁴ that the increased incidence of leukaemia around Sellafield and Dounreay might be attributable to a cluster of cases due to an infective agent associated with a large influx of people to these areas. However, census data for 1961 and 1971 in the districts near potential installations show that by comparison with England and Wales as a whole the population of young people increased less while the population of adults of working age decreased more. This does not obviously support a hypothesis that rests on the intermingling of populations brought about by the sudden influx of a new labour-force and their families.

Exposure to radon may also be a significant cause of leukaemia,¹⁵ particularly in Cornwall, where three of the potential sites are situated and where the average exposure indoors is more than five times higher than that in the UK as a whole.¹⁶ For adults, an effect of radon seems to be unlikely since there was no increase in the incidence of leukaemia in underground miners who were occupationally exposed to high levels of radon.¹⁷ In Sweden, radon levels in the homes of children with cancer were slightly lower than were the levels in the homes of control children.¹⁸ To investigate the issue further in our data we have subdivided the potential sites into those situated in Cornwall and those elsewhere. For districts near the three potential installations in Cornwall, the RR for leukaemia mortality at ages 0–24 was 1.18 (based on 32 deaths), whereas for districts near the remaining potential installations it was slightly lower (1.13, based on 157 deaths). Thus, although our data for Cornwall are consistent with the hypothesis that indoor radon exposure may slightly increase the risk of leukaemia among young people, clearly this factor could not, on its own, explain our findings.

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We had previously believed it to be unlikely that districts close to existing nuclear installations might differ from those elsewhere in another characteristic relevant to the development of childhood leukaemia. This was because the adjustment for geographical variation in the socioeconomic and demographic factors that influence mortality from cancer had brought close to unity the relative risks of death at ages 25–64 from most malignancies studied, including lung cancer, and also from all non-malignant diseases. By contrast, our new findings point to systematic differences between districts near existing or potential installations and other districts with respect to some important, unrecognised risk factors.19

We thank CEGB for making available to us the grid references of sites at which they have seriously considered building nuclear power stations and Paul Dolin for help with data analysis.

Correspondence should be addressed to P.C-M.

REFERENCES