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SHORT REPORT

Radon and monocytic leukaemia in England

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Abstract
The relationship between the standardised registration ratio (SRR) for monocytic leukaemia and the radon concentration by county in England was investigated. Leukaemia data were obtained from the OPCS and cover the age range 0–74 years and the period 1975–86. Radon concentrations were obtained from a recent National Radiological Protection Board report. A significant correlation was observed between the SRR for monocytic leukaemia and the radon concentration by county.

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In 1989 Lucie suggested a correlation between the radon concentration and the incidence of leukaemia in England and Wales.[1] We suggested that such a correlation might be causal, at least in part,[2] since the radon related dose to red bone marrow is by no means negligible compared with other sources of background radiation.[3] Subsequently, Alexander *et al* published significant correlations between the radon concentration and several leukaemia subtypes in England and Wales[4] and Murihead *et al* observed a significant correlation for childhood leukaemia with radon concentration by county, but not by district, for data from throughout Britain.[5] We now report a correlation between the standardised registration ratio (SRR) for monocytic leukaemia (ICD 206) and the radon concentration by county in England.

Method

Leukaemia data were obtained from the Office of Population Censuses and Surveys (OPCS) and cover the age range 0–74 years inclusive and the period 1975–86. Representative mean radon concentrations by county were obtained from the recent National Radiological Protection Board report.[6] The data are shown graphically in the figure.

Results

The correlation coefficient was highly significant ($r=0{\cdot}75$ $p<10^{-6}$) and the Spearman rank correlation coefficient (ρ) was also significant ($\rho=0{\cdot}36$ $p<0{\cdot}01$). If Devon and Cornwall, the two data points with the highest radon concentrations and incidence rates, are excluded, the correlation remains significant ($r=0{\cdot}39$ $p<0{\cdot}005$,

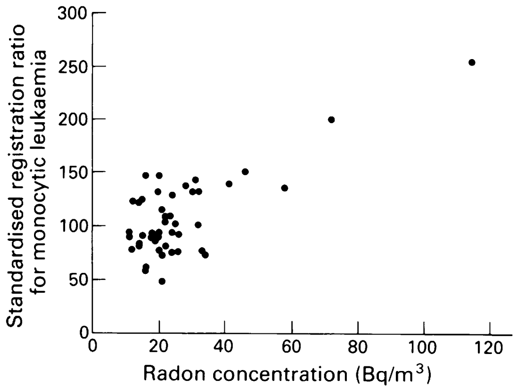

Figure Standardised registration ratio for monocytic leukaemia (ICD 206), versus *arithmetic mean radon concentration by county in England. Data are for the period 1975–86 and for the age range 0–74 years.*

$\rho=0{\cdot}27$ $p<0{\cdot}05$). Similarly, if the whole of the south west region (namely Avon, Cornwall, Devon, Dorset, Gloucestershire, Somerset, and Wiltshire) is omitted, the correlation retains borderline significance ($r=0{\cdot}37$ $p<0{\cdot}025$, $\rho=0{\cdot}22$ $p<0{\cdot}1$) and in this case the correlation within the south west is also significant ($r=0{\cdot}89$ $p<0{\cdot}005$, $\rho=0{\cdot}75$ $p<0{\cdot}05$).

A social class index was calculated for each county on the basis of the proportion of the population in each social class category.[7] No correlation was observed between the SRR for monocytic leukaemia and the social class index by county ($r=0{\cdot}12$ NS). No correlation was observed between the indoor gamma radiation exposure rate by county[8] and the SRR for monocytic leukaemia ($r=0{\cdot}16$ NS). Similar data to those for monocytic leukaemia were also obtained from the OPCS for lymphocytic leukaemia (ICD 204), myeloid leukaemia (ICD 205), and other specified leukaemia (ICD 207). Weaker correlations were observed with radon exposure for lymphocytic leukaemia ($r=0{\cdot}40$ $p<0{\cdot}005$, $\rho=0{\cdot}24$ $p<0{\cdot}1$) and myeloid leukaemia ($r=0{\cdot}43$ $p<0{\cdot}005$, $\rho=0{\cdot}22$ $p<0{\cdot}1$). No correlation was observed for other specified leukaemia ($r=0{\cdot}13$ NS).

Discussion

There are difficulties in interpreting the whole of these correlations as being the result of radon exposure. The best fit line to the data of the figure, for example, has a larger gradient than would be expected from the experience of the Japanese atomic bomb survivors. In this case, however, the exposure was to an acute dose of radiation of predominantly low linear energy transfer (LET),

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rather than the protracted high LET radiation exposure associated with radon. High LET radiation produces unique physical damage on the scale of DNA structure[9] and recent evidence suggests that this produces unique biological damage at the cellular level.[10] Accordingly, risk factors derived directly from protracted exposure to high LET radiation may prove to be more appropriate. The risk factor per Sievert derived from patients exposed to alpha particle radiation from thorotrast, used as an *x* ray contrast medium, is lower than that obtained from the atomic bomb survivors. These patients, however, received very high bone marrow doses, as evidenced by the number who died from bone marrow failure. With regard to exposure to radon gas, a statistically significant excess of leukaemia in uranium miners has not been shown, but for domestic exposures a correlation has been reported between *hprt* mutation in peripheral blood lymphocytes and the radon concentration in the homes of individuals.[11] While this is a small sample, the magnitude of the apparent doubling dose is broadly consistent with the gradients of the radon leukaemia correlations discussed above.

Conclusion

In summary, a significant correlation has been observed between the SRR for monocytic leukaemia and the radon concentration by county in England. This correlation is unlikely to have been produced by regional variations in registration efficiency, by confounding due to social class, or to gamma radiation exposure. In reporting the present correlation we add to the evidence that over several area of Britain, unusual correlations exist between the radon concentration and various leukaemia subtypes.

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