Non-Hodgkin lymphoma and occupational radiation exposure assessed using local data

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Background Our previous investigation of occupational exposure to ionizing radiation using a Finnish job-exposure matrix (JEM) showed no association with non-Hodgkin lymphoma (NHL) in a population-based case–control study in Australia.

Aims To determine whether occupational exposure to ionizing radiation assessed using an Australian JEM is associated with NHL.

Methods We analysed 694 NHL cases, first diagnosed between 1 January 2000 and 31 August 2001 and 694 controls from south-eastern Australia, matched by age, sex and region of residence. A detailed occupational history was obtained using a lifetime calendar and a telephone interview. Exposure to radiation was assessed using the ionizing radiation component of an Australian JEM. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated from logistic regression models that included the matching variables as covariates.

Results The OR for workers ever exposed to ionizing radiation was 0.86 (95% CI = 0.52–1.40). Dividing the subjects into tertiles of exposure also found ORs that were close to or below the null for each exposure group.

Conclusions The application of an Australian JEM did not provide evidence for an association between NHL and occupational exposure to ionizing radiation and is consistent with previous analyses.

Key words Ionizing radiation; non-Hodgkin lymphoma; occupational exposure.

Introduction

In Australia, between 1995 and 2004 the incidence of non-Hodgkin lymphoma (NHL) rose by an average of 1.7% per year in males and 0.8% per year in females, although there has been a flattening in the incidence rise in recent years [1]. The causes of the rise in incidence are not clear and exposure to ionizing radiation has been suggested as a possible factor [2,3]. Although ionizing radiation is ubiquitous in the environment, workplaces that use radiation sources can expose workers to levels above the natural background.

We previously reported no association between NHL and occupational exposure to ionizing radiation in an Australian case–control study [4]. However, exposure was assessed using the Finnish job-exposure matrix (FINJEM) and previous reports of the application of job-exposure matrices (JEMs) outside their country of origin have been mixed and often unfavourable [5,6]. Therefore, we have now used an Australian JEM to estimate ionizing radiation exposure in the same case–control data set. Our aim was to determine whether assessing occupational exposure to ionizing radiation with a JEM based on Australian radiation exposure data produced a different result to that obtained using FINJEM.

Methods

Details of case and control ascertainment and data collection have been published [4]. In summary, the study population was 694 NHL cases aged 20–74 years, first diagnosed between 1 January 2000 and 31 August...
2001 and 694 controls from south-eastern Australia (the State of New South Wales and the Australian Capital Territory), matched by age, sex and region of residence. A detailed occupational history was obtained using a lifetime calendar and a telephone interview.

Exposure was estimated using the ionizing radiation component of a recently developed population-based JEM specific to Australia (named ‘AUSRAD’) [7]. Information on ionizing radiation exposure in AUSRAD was collected from technical reports published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) for the years 1991, 1996 and 2004. AUSRAD lists the mean annual ionizing radiation dose above background, in milliSieverts per year (mSv/year), for each of 22 occupations in the Australian Standard Classification of Occupations.

The exposure for each subject was calculated by multiplying the duration of employment in each work history record classified as exposed by AUSRAD by the AUSRAD exposure estimate. The 1991 estimate was used for exposures before 1992; the 1996 estimate for exposures in the years 1992–96 and the 2004 estimate for exposures in the years 1997–2001. Cumulative exposure estimates were calculated by aggregating the ionizing radiation exposure across the total work history.

All analyses were performed using SPSS software (SPSS Inc., Chicago, IL, USA). Exposed subjects in tertiles of the cumulative exposure distribution were compared with unexposed subjects as the reference group. As there were small numbers exposed to ionizing radiation, a further comparison was made between those ever exposed and the unexposed. Unconditional logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs), adjusted for age, sex, region of residence and ethnic origin.

The possibility of confounding with other occupational exposures was considered by adjusting for exposure to wood dust, pesticides and all solvents other than benzene (aromatics, chlorinated hydrocarbons and aliphatics), which were found to be positively associated with NHL in other analyses of the subjects in this study [8,9].

To account for possible latency of the effect of radiation exposure on the development of NHL, ORs and 95% CIs were also calculated for exposure accumulated before 5 and 10 years prior to diagnosis. We tested for a linear trend across the exposure categories; trend $P$ values were based on the Wald test.

The study was approved by the human research ethics committee at each participating institution. Written informed consent was obtained from each participant in the research.

**Results**

The ranges of cumulative radiation doses for subjects who are occupationally exposed are shown in Table 1. The highest occupational exposure of 55.8 mSv is equivalent to an incremental increase in exposure that is comparable to the background level [10]. Also shown in Table 1 are the risk estimates for the entire work history based on AUSRAD. The ORs for ever exposed and the three tertiles of exposure were all close to or below one. Lagging the exposure (by 5 and 10 years) and adjusting for occupational exposure to pesticides, wood dust and all solvents other than benzene did not significantly alter the results (not shown in Table 1).

**Discussion**

We investigated the relationship between occupational exposure to ionizing radiation and risk of NHL in Australia by applying an Australian JEM in the assessment of exposure and compared it to previous results using FINJEM in the same subjects. Our new results do not provide support for an association between NHL and occupational exposure to ionizing radiation and are similar to those obtained when FINJEM was used to assess exposure. FINJEM produced an OR of 0.93 (95% CI = 0.69–1.26) for subjects ever exposed and when subjects were divided into tertiles of exposure, the ORs were all close to one [4].

Application of the Australian-based AUSRAD is the major strength of this study. Information on ionizing radiation exposure in AUSRAD was collected from technical reports published by ARPANSA, which annually monitors ~70% of all occupationally exposed workers in Australia [7]. In a similar population-based case-control study in the USA, where exposure was assessed by a JEM specifically designed using data from the same country to assess ionizing radiation, the results also showed no association with risk of NHL [3].

In spite of the use of a JEM based on Australian data, misclassification of exposure is possible because JEMs only provide surrogate measures of exposure. However, there is no reason to suppose that the misclassification...
of exposure would be different between cases and controls. Such non-differential misclassification generally tends to bias the risk estimates towards null [4].

Although AUSRAD classifies a similar number of occupations for ionizing radiation exposure compared to FINJEM, AUSRAD only classifies radiation workers i.e. where ionizing radiation is intrinsic to the nature of their work. FINJEM classifies specialist occupations listed in AUSRAD under one title e.g. different estimates are given in AUSRAD for aircraft pilot, flight engineer and flight attendant whereas all these have one estimate in FINJEM. FINJEM classifies other common occupations where ionizing radiation exposure is incidental to the work e.g. electricians. Consequently, FINJEM categorized 205 subjects as being exposed which included about half of the 69 subjects categorized by AUSRAD.

A recent population-based case–control study in Canada reported a 3-fold increased risk between self-reported exposure to ionizing radiation and NHL [2]. However, self-reported exposures are prone to reporting bias, which results in differential misclassification. Both the application of FINJEM and AUSRAD did not provide evidence for an association between occupational exposure to ionizing radiation and risk of NHL.

Key points
- The application of a job–exposure matrix based on exposure data from the same country as the study participants did not provide evidence for an association between occupational exposure to ionizing radiation and non-Hodgkin lymphoma.
- These findings are consistent with those using a job–exposure matrix based on Finnish exposure data.

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Conflicts of interest
None declared.

References