

An Epidemiological Study of Cancer Incidence and Mortality among Nuclear Industry Workers at Lucas Heights Science and Technology Centre in Collaboration with IARC

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ABSTRACT An epidemiological study is being undertaken at Lucas Heights Science and Technology Centre (LHSTC) where the only nuclear reactor in Australia has been in operation since 1958. The study is part of an international collaborative study (1,2) coordinated by the International Agency for Research on Cancer (IARC), and has dual objectives; first to assess whether workers at LHSTC have had different levels of mortality or cancer incidence from the New South Wales and the Australian populations, and second, as part of the IARC study, to estimate as precisely as possible, through collaboration with IARC, the risk of contracting cancer from low-level, long-term exposure to ionising radiation. The research project is a retrospective cohort study based on records of employment and exposure to radiation kept at LHSTC since 1957. Electronic linkage of all the available dosimetry and employment information with national registers of cancer incidence and mortality is being undertaken for the cohort of LHSTC workers, to allow for a passive follow-up of more than 7000 workers employed from 1957 onwards.

1. BACKGROUND

Lucas Heights Science and Technology Centre (LHSTC), previously known as Lucas Heights Research Laboratories (LHRL) (1), is the site shared by the Australian Nuclear Science and Technology Organisation (previously known as the Australian Atomic Energy Commission-AAEC) (1), two CSIRO divisions, the Division of Coal and Energy Technology and the Division of Minerals, and the Australian Institute of Nuclear Science and Engineering (AINSE). Reports have been published on the health of the workers at LHSTC, and of the residents of the surrounding area, the Sutherland Shire.

1.1. Local Studies

The Ferguson Reports

In the period 1975-1976, Professor David Ferguson conducted a detailed cross-sectional survey of current AAEC employees at Lucas Heights Research Laboratories (LHRL) at that time, on behalf of the School of Public Health and Tropical Medicine at the University of Sydney (2, 3). The survey was conducted following a request by the Labor Council of New South Wales and affiliated unions for an independent medical survey of employees at the

AAEC, at the end of 1973. The call for the health survey arose from the compensation claim for sarcoidosis in a technician exposed to uranium, and a series of claims for respiratory disease attributed to exposure to toxic substances (2, 3).

In his two reports published in 1978 and 1979, Professor Ferguson concluded that "employment in the establishment has been relatively safe by the highest standards" (3) and made a number of recommendations regarding the health and safety of workers at LHRL. However, the cross-sectional nature of the survey left diseases of long latency such as malignancies unexplored. As stated in the Second Report, "a prevalence study based on medical interview at work is not a good index of the occurrence of cancer because the person affected mostly moves out of the workforce, therefore, "no disease related to work with ionising radiation was revealed by the health interviews subject of the First Report" (3).

The Research Reactor Review Studies

In 1992, the Minister for Science and Technology commissioned a review of Australia's need for a new nuclear research reactor to replace the ageing High Flux Australian Reactor (HIFAR) which is operated

by ANSTO at Lucas Heights in the Sutherland Shire (4).

Concerns were expressed in community submissions to the Research Reactor Review about certain health outcomes among residents of Sutherland Shire. The health outcomes claimed in these submissions included leukemia in young children of pre-school age; deaths due to cancer among elderly residents; an apparent increase in thyroid cancer; and a high prevalence of asthma in Sutherland Shire especially in Lucas Heights and Menai (5).

Several submissions sought information on the health of residents of Sutherland Shire and the health of staff working at the research reactor at Lucas Heights (5).

A study was conducted by the Australian Institute of Health and Welfare National Perinatal Statistics Unit to assess the health of residents in Sutherland Shire (5). This study analysed some specific outcomes that had previously been associated with exposure of human populations to radiation. These were spontaneous abortions, fetal deaths in the later stages of pregnancy (still births), and microcephalus (a malformation with a reduced head size). The study concluded that health outcomes among residents of Sutherland Shire were similar to those in Warringah, an area in North-Eastern Sydney that was comparable to Sutherland in its socioeconomic characteristics and that there were no major differences between the two regions in fertility, most reproductive health outcomes, congenital malformations, or asthma (5).

As part of the review, Sir Richard Doll produced a report entitled "Public Health Effects of the Operation of a Research Nuclear Reactor" (6). The report described "the extent of the risk likely to be produced in the vicinity of the research reactor in New South Wales". He concluded that "the extra risk of death from cancer from living at the boundary site for the whole of one's life (taken to be 75 years) is 0.3 per cent of that attributable to natural radioactivity, which is, itself, estimated to account for about 2.6 per cent of all fatal cancer". Natural radioactivity is background level of radiation to which everyone is exposed (6).

Another study looking at leukaemia and lymphoma among residents of Sutherland Shire, as compared to Warringah Shire and New South Wales as a whole during the period 1970-1990 was undertaken by the New South Wales Cancer Registry (7). The study concluded that there was no evidence to indicate higher incidence of leukemia or lymphoma, or all-cause mortality in population groups resident near the Lucas Heights facility compared with others

more distant and the New South Wales average. However the investigators pointed out that any real adverse health effects caused by the Lucas Heights facility would be more likely to be seen in employees than in local residents (7).

Given these limitations to the studies carried out to date, the potential value became apparent of a historical cohort study of all personnel who had worked in the plant (7). Follow-up could be achieved through the national and state registries of cancer and mortality.

1.2. International Studies

Current Protection Standards of Exposure to Ionising Radiation in the Workplace

The current environmental and occupational standards for exposure to chronic low linear energy transfer (LET) ionising radiation are mainly based on estimates of radiation-induced cancer risk derived from studies of atomic bomb survivors in Hiroshima and Nagasaki, and of patients irradiated for therapeutic purposes (8, 9, 10, 11). Uncertain extrapolation methods are involved in the use of data from populations who have received comparatively high radiation doses over short periods to predict carcinogenic effects in populations receiving long-term exposures at much lower levels (8, 10, 11).

A direct assessment of the carcinogenic effect of protracted low-level radiation exposure can be made from studies of cancer among workers in the nuclear industry, many of whom have been exposed to above background levels of ionising radiation over several decades and whose exposures have been carefully monitored through the use of personal dosimeters (12).

Combined Analyses of Nuclear Workers

The International Agency for Research on Cancer (IARC) combined mortality data from seven cohort studies on 96000 nuclear industry workers monitored for external radiation in Canada, UK, and USA to directly assess the carcinogenic effects of protracted low-dose exposure to ionising radiation (11). The combined study, published in *The Lancet* in 1994, suggested that the current radiation protection recommendations based on Atomic Bomb Survivors data were not appreciably in error. However because the confidence intervals around the estimates remained wide, the investigation concluded that additional follow-up and studies of other cohorts of workers were needed to increase the precision of the estimates of radiation-related risk of cancer and to strengthen further the scientific basis for setting radiation protection standards.

In 1987, the International Agency for Research on Cancer approached ANSTO and many other nuclear agencies around the world to participate in a meeting to discuss the feasibility of carrying out an international collaborative study of cancer risk among workers in the nuclear industry (13, 14).

Following a feasibility study undertaken by IARC, ANSTO, along with most of the other agencies, agreed to participate in this project, the "International Collaborative Study of Cancer Risk Among Radiation Workers in the Nuclear Industry" (13, 14, 15).

The new combined study is the largest epidemiological investigation ever conducted of workers exposed to ionising radiation (13, 14, 15). Undertaken under the auspices of IARC, it will bring together data on over half a million nuclear industry workers from Australia, Belgium, Canada, Finland, France, Germany, Hungary, Japan, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, and the United States of America, thereby providing valuable information for determining future radiation protection standards and regulations. This international study will provide a direct test of adequacy of the current extrapolation models used for risk assessment and for the setting of radiation protection standards, and may assist in the construction of improved risk assessment models (16).

To take part in this international collaborative effort, a cohort study of workers at LHSTC is currently being undertaken.

2. STUDY OBJECTIVES

The study of workers at LHSTC has dual objectives:

1) To assess whether workers at LHSTC have different levels of cancer incidence and mortality from the New South Wales and Australian populations, and if so what factors may be involved.

2) Through collaboration with an international working group, coordinated by IARC, to estimate as precisely as possible, the risk of contracting cancer from exposure to long-term low levels of ionising radiation.

3. STUDY DESIGN AND ANALYSIS

The Australian study uses an observational retrospective cohort design based on existing records

of employment and exposure to radiation kept in hard copy format by LHSTC since its establishment.

3.1. Study Cohort

The study involves data collection on two distinct study groups:

1) All workers, males and females of working age, monitored for radiation at LHSTC. The information collected on this group will also serve the purposes of the IARC study.

2) Other LHSTC workers, males and females of working age, to provide a basis for comprehensive local analyses.

3.2. Dosimetry

Unlike many occupational epidemiological studies in which surrogate measurements are used for analyses due to the difficulty in measuring exposure of workers to chemicals or other substances, this study is characterised by detailed dosimetric information on doses of ionising radiation, collected in real time on individual workers, and recorded on historical hard copy dosimetry records kept at LHSTC. Monitoring of radiation exposure has been carried out routinely at LHSTC since 1957 even before the start of operation of the nuclear reactor in 1958. This information has been documented in dosimetry records kept by the Safety Division at the Australian Nuclear Science and Technology Organisation at LHSTC. Individual annual doses from occupational exposures to ionising radiation are abstracted from dosimetry files.

3.3. Confounding

Data on smoking habits were sought from employer medical records to adjust for tobacco consumption as a potential confounder of the association between exposure levels to ionising radiation and cancer incidence and mortality.

Data on job classification and educational level were also abstracted from personnel records to derive a measure of socio-economic status and study its confounding effect (17).

3.4. Follow-up

Data collected from historical hard copy records and brought together in one computerised database will be electronically linked with records of national cancer incidence and death registers, for a passive follow-up of more than 7000 workers employed from 1957 onwards (17).

3.5. Analyses of Data

Analyses will be conducted according to the study objectives mentioned above:

For objective 1: Mortality and cancer incidence in monitored and non-monitored workers will be compared between both groups. Also comparison to the Australian population, and the New South Wales population rates will be done taking account of age, sex, and calendar period.

For objective 2: Workers monitored for radiation will be classified by exposure level, and mortality and cancer incidence will be estimated according to exposure categories taking account of age, sex, and calendar period.

Possible confounding or effect modifying variables will be taken into account when appropriate and possible, such as job category, smoking history, socio-economic status, time since first exposure, and duration of exposure.

4. PRIVACY AND CONFIDENTIALITY

Ethical issues, mainly privacy and confidentiality, were addressed in accordance with the laws and regulations governing medical research in Australia. Ethical approval was obtained from the Committee on Experimental Procedures Involving Human Subjects (the institutional ethics committee at the University of New South), the Australian Institute of Health and Welfare Ethics Committee, the NSW Cancer Council Ethics Committee, and the Anti-Cancer Council of Victoria Institutional Ethics Committee.

Rigorous data protection is being employed including the use of randomly assigned numbers to replace identifying information in the analyses of data.

5. PROGRESS-TO-DATE

Data collection on workers at LHSTC is complete. As part of quality assurance extensive checking of the data was carried out (17).

The cohort data file has been forwarded to the Australian Institute of Health and Welfare to carry out linkage with relevant cancer and death records from the National Cancer Statistics Clearing House and the National Death Index Databases.

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