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THE LOS ALAMOS NATIONAL LABORATORY

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AN EVALUATION OF CANCER INCIDENCE AMONG EMPLOYEES AT
THE LOS ALAMOS NATIONAL LABORATORY

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ABSTRACT

As part of the National Plutonium Workers Study, we investigated cancer incidence for 1969-1978 among employees of the Los Alamos National Laboratory. Incident cancers were identified by a computer match of the Los Alamos employee roster against New Mexico Tumor Registry files. The resulting numbers of total and site-specific cancers were compared to the numbers expected based on incidence rates for the State of New Mexico, specific for age, sex, ethnicity, and calendar period. For Anglo males, we found significantly fewer cancers than expected (SIR = 0.60, 95% CI 0.44-0.79). This resulted from marked deficits of smoking-related cancers, particularly lung (2 observed, 19.4 expected) and oral (1 observed, 6.5 expected) cancer. Similarly, we did not detect any smoking-related cancers among Anglo females, though they had a slight nonsignificant excess of breast cancer (14 observed, 9.1 expected) and a suggestive excess of cancer of the uterine corpus (2 observed, 0.25 expected). The pattern of cancer incidence among Anglo employees is typical of high social class populations and not likely related to the Los Alamos working environment.

The Los Alamos National Laboratory, operated by the University of California, specializes in nuclear energy and weapons research. Workers at Los Alamos may be exposed to low levels of plutonium--an alpha-emitting radionuclide, primarily through inhalation or via wounds. Once deposited internally, plutonium has a long biological half-life and tends to accumulate in the tracheobronchial lymph nodes, lung, liver, and on the bone surface.¹ Los Alamos employees may also have low-level exposure to external penetrating radiation and other factors common to nuclear research facilities. Accordingly, our interest in this study is to evaluate cancer incidence in the Los Alamos cohort from 1969-1978, especially for anatomical sites that either accumulate plutonium or have been associated with external penetrating radiation exposure in other studies.

This effort is part of our national epidemiologic study of health effects among plutonium-exposed workers at six Department of Energy facilities. As part of this National Plutonium Workers Study, we have published a preliminary mortality analysis of workers at the Rocky Flats Plant in Golden, Colorado, and a study of

melanoma incidence at Los Alamos.^{2,3} The previous paper has described results from our more recent analyses of mortality and radiation exposure for Rocky Flats' workers.⁴ In general, these investigations have not found greater than expected mortality related to low-level plutonium or external radiation exposure.

Internally deposited alpha emitters have previously been reported to cause bone cancer among radium dial painters and lung cancer among uranium miners.^{5,6} However, these cohorts were exposed at much higher levels than Los Alamos workers and these reports may not provide a proper analogy for investigations at lower exposure levels. Studies of mortality among workers with low-level external radiation exposure have been reported from the Hanford facility and the Portsmouth Nuclear Naval Shipyard. At Hanford, Gilbert and Marks analyzed the relationship between radiation exposure and mortality from specific causes for more than 12,000 white males who were employed at least two years.⁷ They found a significant trend for radiation exposure level and mortality from cancer of the pancreas and multiple myeloma, but not for other cancer sites more commonly associated with radiation exposure. At the Portsmouth Naval Shipyard, Rinsky et al. studied 24,545 workers of whom more than 7600 had measurable radiation exposure histories.⁸ In this study, there was no increased mortality among radiation workers when compared to nonexposed workers and no association between increasing dose and mortality from any cause of death. Our own analysis of Rocky Flats' workers found significantly fewer cancers than expected based on US death rates for the total cohort.⁴ Subcohorts with plutonium exposure greater than 2 nCi day and with external radiation exposure exceeding 1.0 rem were not found to have higher cancer mortality rates than unexposed workers.

The present study is the first to consider cancer incidence among workers with low-level radiation exposure. This study of cancer incidence should be more sensitive than the previous mortality analyses, especially for nonfatal cancers which are usually underrepresented in mortality studies. Studies of disease incidence are possible only through extensive surveys of specific populations or in areas with population-based disease registries. Los Alamos is included in the statewide, population-based New Mexico Tumor Registry (NMTR), which participates in the National Cancer Institute sponsored Surveillance Epidemiology and End Results program. It is the existence of this registry that made the present study possible.

Materials and Methods

Eligible employees included all Los Alamos Anglo personnel, employed between 1969 and 1978, with at least one year's work experience. This includes employees of the University of California and the Zia Corporation, a Laboratory subcontractor. Workers employed and terminated before 1969 are not included in the present study, because their employment preceded the collection of statewide incidence data by the NMTR. The former group is particularly interesting because it contains the majority of Los Alamos workers with high plutonium exposures. This group will be considered as part of a future mortality analysis of Los Alamos workers from 1942-1979. The study roster was created by merging security office files with the Los Alamos Employee Information System and Zia personnel data bases. A quality control check of this roster against Laboratory hardcopy personnel records indicated 97% completeness (95% CI=92%-99%).

The ethnic distribution of the Los Alamos workforce is approximately 70% white non-Hispanic (called Anglo) and 30% Hispanic. Since incidence rates for most cancers are higher for Anglos in New Mexico,⁹ accurate classification of Los Alamos workers by ethnic status is essential for comparisons with statewide cancer incidence rates. To correctly classify Anglo workers, we used the self-reported designation when available on eligible employee personnel records. The remaining workers were classified by the Generally Useful Ethnic Search System computer program (called GUESS), which determines ethnicity based on combinations of letters in each individual's last name. We checked GUESS against the records that contained self-reported ethnicity and found agreement for 99.3% (95% CI=99.0-99.5%) of these records. GUESS is most likely to misclassify women who married outside their ethnic group and who use their married names at the Laboratory. However, this type of misclassification should not affect a large number of employees, according to our comparison of ethnic classifications by GUESS with self-reports.

Our primary method of analysis was to compare the observed number of incident cancer cases among Los Alamos workers with the number expected based on New Mexico incidence rates. Comparisons by radiation exposure level or job category are not possible at this time. The number of observed cases was determined by a computerized match of the Los Alamos cohort against the NMTR files for the period 1969-1978. The expected number of cases was obtained by multiplying cancer incidence rates for New Mexico specific for age (5-year age groups), sex, ethnicity (Anglo), and calendar period (1969-1973, 1974-1978) by the corresponding person years at risk in the Los Alamos population. Person years at risk included each employee's personnel time after the first year of employment until employment termination. The observed and expected numbers were then summed and tabulated for Anglo males and females.¹⁰

Standardized incidence ratios (SIR) were calculated as the ratio of observed to expected incident cancer cases. The SIR was evaluated statistically according to the associated 95% confidence interval (CI).¹¹ When the observed number of cases was less than 15, exact Fisher 95% CIs were calculated; otherwise approximate CIs were employed.

Results

An analysis of the numbers of observed and expected incident cancers among Anglo males is detailed in Table 1. For the aggregate category all cancers, there were significantly fewer than expected. This is indicated by the SIR of 0.60 and the associated 95% CI (0.44-0.79). This marked deficit results from the infrequency of smoking-related cancers among these Los Alamos workers. Particularly, the significant deficits of lung cancer (2 observed, 19.4 expected) and oral cancer (1 observed, 6.5 expected) make up a major part of the overall deficit in cancer incidence. For two other smoking-related sites, the pancreas and the bladder, incidence was less frequent than expected, but these findings were not statistically significant. Cancer incidence for the remaining sites was generally consistent with that expected, though some SIRs were slightly greater or less than 1.00. However, these SIRs are based on extremely small numbers of observed and expected events and are too variable to support firm conclusions.

TABLE 1

COMPARISON OF OBSERVED AND EXPECTED INCIDENT CANCERS AMONG
ANGLO MALE EMPLOYEES, LOS ALAMOS NATIONAL LABORATORY 1969-1978

<u>Cancer</u>	<u>(ICD8)</u>	<u>Observed</u>	<u>Expected</u>	<u>SIR</u>	<u>Exact 95% CI</u>
*All Cancers	(140-209)	49	81.71	0.60	0.44-0.79
Oral	(140-149)	1	6.47	0.15	0.00-0.86
Stomach	(151)	2	2.17	0.92	0.11-3.33
Colon	(153)	8	6.33	1.26	0.55-2.49
Rectum	(154)	1	3.35	0.30	0.01-1.66
Liver	(155,156)	1	0.71	1.41	0.04-7.85
Pancreas	(157)	2	2.29	0.87	0.10-3.15
Lung	(162,163)	2	19.37	0.10	0.01-0.37
Bone	(170)	1	0.41	2.42	0.06-12.03
Melanoma	(172)	3	4.25	0.71	0.15-2.06
Prostate	(185)	6	6.48	0.93	0.34-2.02
Testes	(186,187)	3	2.45	1.22	0.25-3.58
Bladder	(188)	2	4.13	0.48	0.06-1.75
Brain	(191,192)	2	2.43	0.82	0.10-2.97
Thyroid	(193)	1	1.33	0.75	0.02-4.19
Lymphosarcoma Reticulosarcoma	(200)	4	1.65	2.43	0.66-6.21
Hodgkins Disease	(201)	1	1.32	0.76	0.02-4.22
Leukemia and Aleukemia	(204-207)	4	2.77	1.44	0.39-3.70
Other Lymphatic Tissue	(202,203,208)	1	1.46	0.69	0.02-3.82

*Also 1 cancer of ill-defined sites (ICD 199)
 1 cancer of retroperitoneum and other digestive (ICD 158)
 1 cancer of connective and other soft tissue (ICD 171)
 1 cancer of the breast (ICD 174)

The pattern of observed to expected cancer incidence for Anglo females was quite different than that for males (Table 2). The slightly elevated all cancers SIR (1.20) contrasts with the marked deficit of observed to expected cancers among males. However, these female employees exhibit a virtual absence of smoking-related cancers similar to that seen among male employees. The slight female cancer excess results in large part from more observed than expected cancers of the female reproductive organs. Our analysis of female reproductive cancers found a slight nonsignificant excess of breast cancer (SIR 1.53, 95% CI 0.84-2.57) and a suggestive excess of cancers of the uterine corpus (SIR=8.03, 95% CI 0.97-29.02). For the remaining cancer sites there were few or no cancers. These findings were not significantly different from the expected numbers.

TABLE 2

COMPARISON OF OBSERVED AND EXPECTED INCIDENT CANCERS AMONG
ANGLO FEMALE EMPLOYEES, LOS ALAMOS NATIONAL LABORATORY 1969-1978

<u>Cancer</u>	<u>(ICD8)</u>	<u>Observed</u>	<u>Expected</u>	<u>SIR</u>	<u>Exact 95% CI</u>
*All Cancers	(140-209)	31	25.80	1.20	0.82-1.71
Melanoma	(172)	2	1.06	1.89	0.23-6.82
Breast	(174)	14	9.12	1.53	0.84-2.57
Cervix Uteri	(180)	1	1.47	0.68	0.02-3.79
Corpus Uteri	(181-182)	2	0.25	8.03	0.97-29.02
Other Genital	(183-184)	3	1.44	2.09	0.43-6.09
Eye	(190)	1	0.03	13.22	0.32-69.65
Brain	(191-192)	2	0.40	5.00	0.61-18.06
Thyroid	(193)	2	0.73	2.72	0.33-9.90
Other Lymphatic	(202,203,208)	2	0.34	5.87	0.71-21.25

*Also 1 cancer of ill-defined sites (ICD 199)
1 cancer of connective and other soft tissue (ICD 171)

Discussion

Prior to this study, the majority of our efforts have been directed toward studies of worker mortality, in general, and specifically for those with plutonium exposure. Our underlying interest is the association of plutonium and other

occupational exposures with the occurrence or incidence of disease. In this regard, studies of mortality have some well-known limitations. These include underascertainment of nonfatal cancers, inaccuracy of death certificate diagnoses, and changes in death certificate diagnoses over time and across geographic regions. However, mortality studies are useful, especially for fatal diseases, and remain common because mortality data is systematically collected and available nationally.

Occupational studies of cancer incidence detected through a population-based tumor registry have several advantages. Most important are the short time between cancer occurrence and detection, the ability to study nonfatal cancers, the specificity and uniformity of diagnoses, and the frequent availability of histologic information. The last is particularly important for evaluating associations between occupational exposures and particular cancer cell types.

One limitation of this study and others based on population-based registries is that workers who migrate out of the study area are lost to the cancer detection system. Accordingly, our estimates of comparative incidence (i.e. SIRs) pertain only to employee person years actually spent at the Laboratory between 1969-1978. In addition, we extended our surveillance for observed cancers until 6 months after employment termination for New Mexico residents to allow for the possibility that employment termination may have been precipitated by a subsequently detected cancer. This resulted in 6 additional cancers for Anglo males and 4 for Anglo females, but did not affect the major findings of the study.

The results of our analyses allow several conclusions about cancer incidence at the Los Alamos National Laboratory over the time period 1969-1978. The major conclusion is that Anglo males have significantly less cancer than expected (SIR = 0.60, 95% CI 0.44 - 0.79) based on rates from the NMTR. This finding results from the lack of smoking-related cancers, particularly the striking deficits of lung cancer (2 observed, 19.37 expected) and oral cancer (1 observed, 6.47 expected) among these workers. Similarly, Anglo female workers showed an absence of smoking-related cancers, but did exhibit a suggestive excess of cancers of the uterine body (2 observed, 0.25 expected) and a slight nonsignificant excess of breast cancer (14 observed, 9.12 expected). These findings have not previously been reported for other occupational cohorts and are likely not related to the Los Alamos working environment.

It is noteworthy that these findings involve cancer sites that have previously been reported to vary among populations with different levels of socioeconomic status (SES). Low income groups have higher rates of lung^{12,13} and oral^{14,15} cancer, while female cancers of the uterine body¹⁶ and breast^{12,17} have been associated with higher SES. A pattern of comparative cancer incidence typical for a high SES population might be expected among Anglo Laboratory employees because of the relatively high income and education level found at the Laboratory. The characteristics of high SES populations (e.g. less frequent smoking, delayed childbirth, high fat diets, etc.) would seem a likely explanation for the patterns of cancer incidence observed among Anglo Los Alamos workers.

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