Cancer Incidence and Mortality in Los Alamos County and New Mexico 1970-1996

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Introduction

This report was written in response to community concerns about occurrences of specific types of cancer in Los Alamos County (LAC). Average annual age-adjusted incidence and mortality rates per 100,000 persons for twenty-four major cancer types were calculated for LAC using data from the New Mexico Tumor Registry. The twenty-four cancer types included brain, breast, cervix uteri, colon/rectum, esophagus, gallbladder, Hodgkin's lymphoma, kidney, larynx, leukemia, liver, lung, melanoma, multiple myeloma, non-Hodgkin's lymphoma, oral/pharynx, ovary, pancreas, prostate, stomach, testis, thyroid, urinary bladder and uterine. County rates were compared to rates derived for a New Mexico state reference population, for all races, for the time period 1970 to 1996.

The cancer incidence rates that were not considered statistically significant but were elevated in comparison with the New Mexico state reference population include cancers of the brain, colon/rectum, esophagus, Hodgkin's, leukemia, and urinary bladder. The cancer mortality rates that were not considered statistically significant but were elevated in comparison with the New Mexico state reference population include cancers of the colon/rectum, kidney, liver, melanoma, non-Hodgkin's lymphoma, ovary, and pancreas.

Cancer incidence rates that were significantly elevated in LAC when compared to the state reference population rates included breast, melanoma, non-Hodgkin's lymphoma, ovary, prostate, testis (significant at the 90% confidence interval), and thyroid cancers. Cancer mortality rates that were significantly elevated in LAC when compared to the state reference population rates include breast cancer.

Significant elevations in cancers for LAC residents were determined by calculating the upper and lower confidence limits for each LAC rate at the 95% and 90% confidence intervals. If the lower confidence limit for a given LAC rate was greater than the New Mexico comparison rate, the elevation was considered significant.

Based on these findings, a second study is recommended to review the temporal and spatial trends of cancer rates by neighborhood unit. Additionally, the proximity of cancer cases to pollution sources should be evaluated. Finally, case reviews should be conducted to establish residential history, occupational history, family disease history, other behavioral risk factors, and cancer etiology.

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Study Objectives and Specific Aims

The primary objective of this study was to review incidence and mortality rates of LAC residents for twenty-four cancer types during the 27-year time period of 1970 to 1996.

Specific aims developed for this study were as follows:

- To compare LAC cancer incidence rates to incidence rates calculated for a New Mexico state reference population, for all races;
- To compare LAC cancer mortality rates to mortality rates calculated for a New Mexico state reference population, for all races;
- To determine whether any of the LAC cancer incidence and mortality rates were significantly elevated in comparison to rates observed for the New Mexico state reference population;
- To begin to assess whether any of the significantly elevated cancer rates could be attributed to ionizing radiation exposures; and
- To review existing literature on ionizing radiation exposure and health risks

Environmental Background

Nuclear-related activities have occurred in LAC since the development of Los Alamos National Laboratory (LANL) in 1943. These activities include both radioactive air emissions and waste disposal. Prior to the enactment of environmental laws in the 1970s, monitoring of radioactive emissions, waste disposal, and employee exposures was sporadic. At present, the extent to which LAC residents and LANL employees have been exposed to ionizing radiation beyond background levels remains unclear.

Sources and Health Risks of Ionizing Radiation

Radiation sources are both naturally occurring and manmade. Naturally occurring radiation sources include the sun (cosmic) and the earth's crust (terrestrial). People who live at high altitudes are more exposed to radiation from the sun, while people who reside in the west receive greater amounts of terrestrial radiation.

Manmade sources of ionizing radiation include nuclear fallout, fossil fuels, and medical and dental x-rays. Nuclear fallout consists of radioactive particles emitted into the air after a nuclear explosion. Nuclear explosions can occur as a result of a nuclear power plant accident or from nuclear weapons testing.

Manmade and natural sources of radiation are referred to as background radiation since the entire global population shares this burden. Non-background sources of radiation come from nuclear power plants, weapons plants, and uranium mines and from the waste created by these industries. Any of these nuclear activities can emit different radioactive isotopes including radioiodine, radiocesium, radiostrontium, tritium, and plutonium.

High doses of radiation occurring over a short time period (acute exposures) are thought to be more damaging to human health than low doses of radiation occurring over a short time span. However, low doses occurring over lengthy time periods (chronic exposures) can result in a high total or cumulative radiation dose and can lead to cancer and other diseases. The time period between radiation exposure and subsequent development of the disease is called the latency period. Much of the literature on radiation exposure and health effects is based on studies of the people who survived the atomic bomb blasts in Japan in 1945. Leukemia was the first latent disease to show up in survivors of the atom bomb blasts.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) concluded, "It is now known that radiation can cause cancer in almost any tissue or organ in the body, although some sites are much more prone than others." UNSCEAR elaborates further in Annex 1 (epidemiological evaluation of radiation-induced cancer), "The inability to detect increases at very low radiation doses using epidemiological methods need not imply that the underlying cancer risks are not elevated. Rather, supporting evidence from animal studies needs to be utilized in addressing risks from low-dose and low-dose-rate exposures, while recognizing that not all molecular changes result in tumors."

Methods

This is a study of cancer incidence and mortality among residents of LAC. Average annual age-adjusted rates per 100,000 persons were calculated for the 27-year time period of 1970 to 1996 for twenty-four types of cancer. The LAC incidence and mortality rates, for all races, were compared to rates calculated for New Mexico, for all races, as referenced in the document, *Cancer in New Mexico 1970 – 1996: Changing Patterns and Emerging Trends*. Following a review of all state and LAC incidence and mortality rate data, specific cancers of concern, based on ionizing radiation literature, were selected for further analysis.

Incidence Data

Data Sources: Information regarding newly diagnosed cancers among LAC residents and residents of New Mexico, for all races, was taken from the document, *Cancer in New Mexico 1970 – 1996: Changing Patterns and Emerging Trends*, and based on cancer information obtained

through the New Mexico Tumor Registry. According to the document, a case was defined as a primary malignancy diagnosed between 1/1/70 and 12/31/96 in a person who was a resident of LAC at the time of diagnosis. A similar case definition applied to the New Mexico state reference population. In referencing the document, average annual age-adjusted incidence rates, for all races, for cancer by major anatomic site among LAC residents and New Mexico residents were calculated using the direct method and standardized to the 1970 U.S. population.

Ninety-five percent and ninety percent confidence intervals were calculated for each LAC incidence rate to assess the level of statistical uncertainty. A wide confidence interval occurs as a result of low case numbers. The following equations were used to calculate 95% and 90% confidence intervals for the LAC incidence rates, respectively, LAC rate +/- (1.96*(standard error)) and LAC rate +/- (1.645*(standard error)), where the standard error is calculated as the (rate/(square root of the number of cases)). The same methodology for calculating 95% and 90% confidence intervals was used by the New Mexico Department of Health (NMDOH) in their 1993 report on cancers in LAC. Although a variety of statistical tests have been used on similar cancer data sets to determine confidence intervals, we chose to use the same method as the NMDOH to allow for a comparison of cancer incidence and mortality rate data for the time period of 1970 – 1996 with the time period of 1970 – 1990 (the time period used by the NMDOH). All negative lower confidence limits were truncated at zero. The 95% and 90% confidence interval data for incidence rates by cancer type are presented in Table 1.

Incidence rate ratios (LAC rates as the numerator and the state reference population rates as the denominator) are also presented in Table 1. These ratios illustrate the differences between the LAC rates and the state reference population rates. When the LAC rate is higher than the state reference rate, the rate ratio is greater than 1.0.

Mortality Data

Data Sources: Information regarding cancer mortality among LAC residents and residents of New Mexico, for all races, was also taken from the document, *Cancer in New Mexico 1970 – 1996: Changing Patterns and Emerging Trends*. According to the document, a cancer death is defined as a decedent who had cancer listed as the underlying cause of death on their death certificate and died between the time period of 1/1/70 and 12/31/96. Average annual age-adjusted mortality rates for all races for cancer by major anatomic site among LAC residents and New Mexico residents were calculated using the direct method and standardized to the 1970 U.S. population. The NMDOH Office of Vital Records and Health Statistics was the source used for mortality information.

Ninety-five percent and ninety percent confidence intervals were calculated for each LAC mortality rate to assess the level of statistical uncertainty. A wide confidence interval occurs as a result of low case numbers. The following equations were used to calculate 95% and 90% confidence intervals for the LAC mortality rates, respectively; LAC rate +/- (1.96*(standard error)) and LAC rate +/- (1.645*(standard error)), where the standard error is calculated as (rate/(square root of the number of cases)). Again, the calculation for the 95% and 90% confidence intervals is the same as that used by the NMDOH in their 1993 report on cancers in LAC. All negative lower confidence limits were truncated at zero. The 95% and 90% confidence interval data for mortality rates by cancer type are presented in Table 2.

Mortality rate ratios (LAC rates as the numerator and the state reference population rates as the denominator) are also presented in Table 2. These ratios illustrate the differences between the LAC rates and the state reference population rates. When the LAC rate is higher than the state reference rate, the rate ratio is greater than 1.0.

Statistical Significance

Statistical testing for elevations in the LAC rates in comparison to the state reference population rates was limited by the small number of cases (or deaths) observed for most cancers in LAC. The small case (or death) numbers resulted in wide confidence intervals for the LAC rates and a lack of statistical power to detect small to modest elevations in the LAC rates. If the lower confidence limit for a given LAC rate was greater than the state comparison rate, the elevation was considered significant and not likely due to chance alone. The same methodology for determining statistical significance was also used in a March 1993 report prepared by the NMDOH and the New Mexico Tumor Registry. Alternative statistical analysis methods could also be used such as the chi-square test (which compares the observed number of cases to that expected under an assumed Poisson distribution) and the Knox test for time-space interaction. These two types of statistical analysis methods are more typically used for descriptive epidemiologic studies.

Results

Summary: The cancer incidence rates that were not considered statistically significant, by definition above, but were elevated in comparison with the New Mexico state reference population include cancers of the brain, colon/rectum, esophagus, Hodgkin's, leukemia, and urinary bladder. The cancer mortality rates that were not considered statistically significant, by the definition above, but were elevated in comparison with the New Mexico state reference population include cancers of the colon/rectum, kidney, liver, melanoma, non-Hodgkin's lymphoma, ovary, and pancreas.

Cancer incidence rates that were significantly elevated in LAC when compared to the state reference population rates include breast, melanoma, non-Hodgkin's lymphoma, ovary, prostate, testis (significant at the 90% confidence interval), and thyroid cancers. Cancer mortality rates that were significantly elevated in LAC when compared to the state reference population rates include breast cancer.

In their March 1993 report, the NMDOH also found high incidence rates for these seven cancers for the time period, 1970 – 1990. In addition to high incidence rates for the seven cancers mentioned above, the NMDOH report also found a moderate increased incidence rate for cancer of the brain and nervous system during the mid to late-1980s. Claims compensation by the U.S. Department of Labor will be considered for all seven of the cancers mentioned above. The Energy Employees Occupational Illness Compensation Program Act of 2000 requires the U.S. Department of Labor to compensate Department of Energy employees, or their contractors, for all other cancers, with the exception of chronic lymphocytic leukemia (CLL), if on the basis of dose reconstruction modeling, the probability of causation is greater than fifty percent that the cancer was caused by occupational exposure received while working in nuclear production programs for the Department of Energy.[9] Certain workers (special exposure cohorts, e.g., workers in uranium enrichment facilities) are presumed *a priori* exposed and thus do not require a dose reconstruction to claim compensation if the individual has a qualifying illness.

Female Breast Cancer

Description and Etiology: Breast cancer is the most common form of cancer among U.S. women. Nationwide, incidence has been increasing while mortality has remained relatively constant. Epidemiologic studies have identified a number of risk factors for breast cancer. Major risk factors include family history, previous breast cancer, reproductive experience, menstrual history, socioeconomic status, and ionizing radiation.

Incidence (1970 – 1996): Breast cancer incidence in LAC women was significantly elevated when compared with the state reference population rate. LAC incidence rates were 50% higher than rates for the state reference population. However, demographic data for LAC suggests that women generally reserve childbearing for later years and exhibit higher socioeconomic status when compared with the New Mexico reference population.

Mortality (1970 – 1996): Deaths from breast cancer were significantly elevated, 41% higher, in LAC when compared with the state reference population. This elevation is cause for investigation since LAC's population is felt to have considerable access to health care facilities when compared with other areas of the state.

Melanoma

Description and Etiology: Melanoma is a cancer of the melanocytes, the skin cells that produce the dark pigment melanin. In light skinned men melanomas occur most often on the trunk. In light skinned women melanomas occur most often on the lower legs. In dark skinned people, melanomas occur most often on the palms of the hands and soles of the feet. In New Mexico, melanoma is roughly five times more common in non-Hispanic whites than Hispanic whites.

Incidence (1970 – 1996): LAC residents experienced a 125% elevation in incidence for melanoma when compared with the New Mexico state reference population. However, it should be noted that the majority of LAC's residents are non-Hispanic whites who are at a much greater risk for melanoma than Hispanic whites.

Mortality (1970 – 1996): LAC experienced more deaths (63%) due to melanoma when compared to the state reference population. However, the increased mortality rate for deaths in LAC was not statistically significant at the 95% and 90% confidence intervals.

Non-Hodgkin's Lymphoma

Description and Etiology: The non-Hodgkin's lymphomas are among the less common cancers in the U.S. Incidence generally increases with age and is higher in males than females. Etiology is not well characterized. Immunogenetic factors are important; as illustrated by the greatly increased risks that follow immunosuppression. Radiogenic origins of non-Hodgkin's lymphoma are unclear, though excess mortality has been observed in persons receiving therapeutic irradiation.

Incidence (1970 – 1996): LAC residents experienced a 48% elevation in incidence for non-Hodgkin's lymphoma when compared with the New Mexico state reference population.

Mortality (1970 – 1996): LAC experienced more deaths (26%) due to non-Hodgkin's lymphoma when compared to the state reference population. However, the increased mortality rate for deaths in LAC was not statistically significant at the 95% and 90% confidence intervals.

Ovarian Cancer

Description and Etiology: Ovarian cancer ranks second in incidence among gynecologic cancers only behind endometrial cancer. Nationally, the incidence of ovarian cancer has slightly increased since the 1940s. Childbearing is the most important known factor in reducing ovarian cancer risk, suggesting an etiologic role for hormones. The etiologic role for ionizing

radiation exposure is unclear. Ionizing radiation clearly induces ovarian cancer in experimental rodents.

Incidence (1970 – 1996): LAC residents experienced a 45% elevation in ovarian cancer when compared with the New Mexico state reference population. The elevation is considered significant based on the lower confidence limits for the 95% and 90% confidence intervals of the LAC rate when compared with the state reference rate.

Mortality (1970 – 1996): LAC experienced more deaths (27%) due to ovarian cancer when compared to the state reference population, however, the increased mortality rate for deaths in LAC was not considered statistically significant at the 95% and 90% confidence intervals.

Prostate

Description and Etiology: Prostate cancer is the most commonly diagnosed cancer in U.S. males and the second leading cause of cancer deaths in males after lung cancer. Prostate cancer usually occurs in older men. The median age at diagnosis is 72 years and the median age at death is 77 years.

Suggested risk factors for prostate cancer include diets high in fat and red meat, occupational exposure to certain chemicals, and factors related to sexual activity, including certain viruses. A family history of prostate cancer in a first-degree relative doubles the risk.

Incidence (1970 – 1996): LAC residents experienced a 49% elevation in prostate cancer when compared with the New Mexico state reference population. The elevation is considered significant based on the lower confidence limits for the 95% and 90% confidence intervals of the LAC rate when compared with the state reference rate.

Mortality (1970 – 1996): LAC experienced fewer deaths due to prostate cancer when compared to the state reference population.

Testis

Description and Etiology: Testicular cancer affects younger males and is the most common malignancy diagnosed among non-Hispanic white males aged 20 – 34 years. Still it is relatively rare, accounting for only 1% of all cancers diagnosed annually in U.S. males. The strongest risk factor is a history of undescended testicle, but this is observed in only about 10% of cases. Other potential risk factors that have been suggested, including testicular trauma and injury, antecedent inguinal hernia, low birth weight and early birth order.

Incidence (1970 – 1996): LAC residents experienced an 82% elevation in testicular cancer when compared with the New Mexico state reference population. The elevation is considered significant based on the lower confidence limit for the 90% confidence interval of the LAC rate when compared with the state reference rate.

Mortality (1970 – 1996): LAC experienced fewer deaths due to testicular cancer when compared to the state reference population.

Thyroid Cancer

Description and Etiology: Thyroid cancer is a rarely diagnosed and typically nonfatal neoplasm that occurs predominantly in women. Little is known about the etiology of thyroid cancer. The higher incidence in women suggests that hormonal factors may play a role. Exposure to relatively high doses of external and internal ionizing radiation is known to cause thyroid cancer. The highest risks appear following irradiation in early childhood.

Incidence (1970 – 1996): The incidence rate of thyroid cancer in LAC is 106% that of the state reference population for the referenced time period. This elevation is considered significant and cause for continuing investigations.

Mortality (1970 – 1996): The mortality rate for thyroid cancer was lower for LAC residents than for the state reference population. Since thyroid cancer is typically non-fatal, the lower rate of thyroid cancer mortality may suggest better access to health care for the county's population when compared with the state as a whole.

Discussion

Major Findings

The cancer incidence rates that were not considered statistically significant, by definition above, but were elevated in comparison with the New Mexico state reference population include cancers of the brain, colon/rectum, esophagus, Hodgkin's, leukemia, and urinary bladder. The cancer mortality rates that were not considered statistically significant, by the definition above, but were elevated in comparison with the New Mexico state reference population include cancers of the colon/rectum, kidney, liver, melanoma, non-Hodgkin's lymphoma, ovary, and pancreas.

Cancer incidence rates that were significantly elevated in LAC when compared to the state reference population rates included breast, melanoma, non-Hodgkin's lymphoma, ovary, prostate, testis (significant at the 90% confidence interval), and thyroid cancers. Of these

cancers, breast, melanoma, ovarian, testicular, and thyroid cancers were also elevated in LAC when compared with the U.S. Surveillance, Epidemology, and End Results Program (U.S. SEER) site data for the time period of 1991-1995. Additionally, though not considered statistically significant when compared to the New Mexico state reference population, the LAC incidence rate for leukemia was elevated when compared with the U.S. SEER site data for the time period of 1991-1995.

Cancer mortality rates that were significantly elevated in LAC when compared to the state reference population rates included breast cancer. When comparing the LAC mortality rate for breast cancer with that of the U.S. SEER sites for the time period of 1991-1995, the LAC mortality rate was also elevated. This is surprising given the greater access to health care for women residing in LAC. Although not considered significantly elevated when compared with the New Mexico state reference population, the LAC mortality rates for melanoma and ovarian cancers were also elevated when compared with the U.S. SEER data sets for 1991-1995.

The March 1993 NMDOH report entitled *Los Alamos Cancer Rate Study: Phase I, Cancer Incidence in Los Alamos County, 1970 – 1990, Final Report,* examined the spatial and temporal distribution of brain and nervous system, thyroid, melanoma of skin, breast, ovarian, leukemia, and non-Hodgkin's lymphoma cancers by using 5-year moving averages and by census tract. Table 3 shows the results of this analysis. The current study did not attempt to analyze incidence and mortality rates through space or time since rates were analyzed for a 27-year time period from 1970 – 1996 and by county and state level.

Study Limitations

Small Number of Observations: Literature suggests that low levels of radiation exposure cause so few additional cancers that a very large exposed population must be studied to detect the additional cancers. Therefore, an increase in cancers may not be detected in communities with populations the size of LAC, even if they are present.

For example, if radiation causes two additional cancers for every 10,000 people exposed, you would have to study a very large exposed population to begin to notice the additional cancers. If 100,000 people were exposed, only twenty additional cancers would occur and you may not recognize that these cancers were in excess of what you would normally expect.

When studying small populations, for example LAC, the small number of cancer cases results in unstable incidence and mortality rates, large confidence intervals, and a loss of determination in whether a rate is really statistically significant. To counteract this effect, information can be obtained on the local population demographics, the extent of the exposure of concern, and on other risk factors. Additionally, researchers have suggested looking at

cancer incidence and mortality data at a smaller level to ascertain whether cancer clusters may exist within a neighborhood unit. This type of study is called a pre-epidemiologic study. In Woburn, Massachusetts, in the early 1980s, residents reported excess cases of childhood leukemia that were confirmed by pre-epidemiologic analysis. A rigorous epidemiologic study further validated the residents' concerns and implicated chemically contaminated drinking water as the cause.

Population Mobility: An incidence study should only measure newly diagnosed cases in a population that has been stable over time. However, the LAC population is very mobile. Nearly 25% of all 1980 county residents resided in a different state in 1975. The population mobility in LAC must be accounted for when assessing LAC cancer incidence and mortality rates. A similar problem occurs when reviewing incidence and mortality rates at the census tract level. To avoid this problem, it would be important to evaluate cases in the context of residential, occupational, and environmental exposures, family disease, and behavioral risk factor histories. Additionally, it would be useful to evaluate the proximity of cases to known exposure sources.

Cause and Effect Relationships: Cause and effect is difficult to establish when examining a group of people. For example, not everyone who smokes gets lung cancer and not everyone who gets lung cancer smokes; other variables may enter into the scenario. The same can be said of radiation exposure and cancer. Some cancers, such as colon cancer, can potentially result from exposure to high doses of radiation or colon cancer may be attributed to dietary habits or a genetic predisposition. However, lack of clear information on cause and effect does not mean that there is no risk to the surrounding population from low levels of radiation. Surveillance can help clarify cause and effect relationships through obtaining case histories on behavior, occupation, residence and family. Dose reconstruction modeling based on records obtained from LANL can also help clarify the role of environmental exposures in health outcomes, such as cancer.

Socioeconomic Status and Ethnicity of LAC and New Mexico: Certain types of cancer are more common among certain ethnic groups or socioeconomic groups. This may account for the differences in cancer rates by cancer type that we see from county to county. Some counties have a higher proportion of Hispanic or non-Hispanic whites. LAC is not typical of other counties within New Mexico; it is the most affluent county in New Mexico and it is comprised mainly of non-Hispanic whites. Additionally, access to health care is also greater in LAC than in other counties throughout New Mexico. In this study, we looked at cancer incidence and mortality rates for all races and compared LAC with New Mexico. Unfortunately, LAC does not exhibit the same proportion of ethnic categories as New Mexico, nor does it exhibit the same median household income. Note that breast, prostate and melanoma cancers are

considered to be more prevalent in high-income or non-Hispanic white populations, a population that characterizes LAC.

Study Strengths

This study provides a tool that can be utilized for further analysis. Most importantly, it lists specific cancers, by anatomical site, that could be caused by ionizing radiation exposure based on information researched for cancer claims compensation. Furthermore, it illustrates the differences between LAC cancer rates and state reference population cancer rates for a large period of time, 1970 – 1996. Finally, it describes where current gaps in information exist and offers recommendations for closure of those information gaps.

Future Directions

Some of the studies referenced in this report have used descriptive epidemiology. An alternative approach might be to conduct small area analysis to determine whether cancer cases are clustered by neighborhood or in time. Although Phase I of the *Los Alamos Cancer Rate Study* did attempt to analyze both spatial and temporal trends in brain and nervous system cancer incidence rates, LAC was divided into census tracts and not into neighborhoods. By reviewing cases at a neighborhood level, one can determine the size of the population from which the cases come, the local exposure sources, and the proximity of cases to the sources of exposure. Furthermore, information can also be collected on occupation, the number of years at current residence, prior history of residence, and family disease history. Finally, without proper dose reconstruction modeling and access to LANL documents, it is virtually impossible to evaluate the environmental exposures experienced by LAC residents and whether these exposures may contribute to higher cancer incidence and mortality rates.

Recommendations

- Review cancer registry data to investigate the increases in LAC incidence rates (compared to the New Mexico state reference population) for cancers of the female breast (50%), non-Hodgkin's lymphoma (48%), melanoma (125%), prostate (49%), ovaries (45%), testis (82%) and thyroid (106%).
- Review cancer registry data to investigate the elevated LAC mortality rates (41%) for breast cancer when compared with the New Mexico state reference population.
- Review spatial and temporal trends of cancer rates by neighborhood unit and examine the proximity of cancer cases to pollution sources.
- Conduct case reviews to establish residential history, occupational history, family disease history, other behavioral risk factors, and cancer etiology.

- Conduct dose reconstruction studies by accessing LANL documents to determine potential exposures for the community of LAC.

Table 1 Cancer Incidence

Incidence	Rate	Cases	Stand. Error	95% conf. Upper limit	95% conf. Lower limit	90% conf. Upper limit	90% conf. Lower limit	Rate LAC>NM?	Difference significant at 95% CI?	Difference significant at 90% CI?
All Sites										
Los Alamos	355.90	1425.00	9.43	374.38	337.42	371.41	340.39	yes	yes	yes
New Mexico	310.30	109239.00	0.94	312.14	308.46	311.84	308.76			
Rate Ratio	1.15									
Brain										
Los Alamos	5.70	27.00	1.10	7.85	3.55	7.50	3.90	yes	no	no
New Mexico	4.80	1711.00	0.12	5.03	4.57	4.99	4.61			
Rate Ratio	1.19									
Breast										
Los Alamos	123.70	293.00	7.23	137.86	109.54	135.59	111.81	yes	yes	yes
New Mexico	82.50	15436.00	0.66	83.80	81.20	83.59	81.41			
Rate Ratio	1.50									
Cervix Uteri										
Los Alamos	5.00	11.00	1.51	7.95	2.05	7.48	2.52	no	no	no
New Mexico	11.50	2243.00	0.24	11.98	11.02	11.90	11.10			
Rate Ratio	0.43									
Colon/Rectum										
Los Alamos	37.60	144.00	3.13	43.74	31.46	42.75	32.45	yes	no	no
New Mexico	34.30	12016.00	0.31	34.91	33.69	34.81	33.79			
Rate Ratio	1.10									
Esophagus										
Los Alamos	2.50	7.00	0.94	4.35	0.65	4.05	0.95	yes	no	no
New Mexico	2.40	818.00	0.08	2.56	2.24	2.54	2.26			
Rate Ratio	1.04									
Gallbladder										
Los Alamos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	no	no	no
New Mexico	2.20	754.00	0.08	2.36	2.04	2.33	2.07			
Rate Ratio	0.00									
Hodgkin's										
Los Alamos	2.50	12.00	0.72	3.91	1.09	3.69	1.31	yes	no	no
New Mexico	2.20	838.00	0.08	2.35	2.05	2.33	2.07			
Rate Ratio	1.14									
Kidney										
Los Alamos	4.00	22.00	0.85	5.67	2.33	5.40	2.60	no	no	no
New Mexico	7.40	2554.00	0.15	7.69	7.11	7.64	7.16			
Rate Ratio	0.54									
Larynx										
Los Alamos	0.90	5.00	0.40	1.69	0.11	1.56	0.24	no	no	no
New Mexico	3.20	1086.00	0.10	3.39	3.01	3.36	3.04			
Rate Ratio	0.28									
Leukemias										
Los Alamos	11.00	45.00	1.64	14.21	7.79	13.70	8.30	yes	no	no
New Mexico	9.50	3395.00	0.16	9.82	9.18	9.77	9.23			
Rate Ratio	1.16									
Liver										
Los Alamos	2.90	9.00	0.97	4.79	1.01	4.49	1.31	no	no	no
New Mexico	2.90	1012.00	0.09	3.08	2.72	3.05	2.75			
Rate Ratio	1.00									
Lung										
Los Alamos	27.60	98.00	2.79	33.06	22.14	32.19	23.01	no	no	no
New Mexico	39.20	13521.00	0.34	39.86	38.54	39.75	38.65			
Rate Ratio	0.70									
Melanoma										
Los Alamos	21.80	99.00	2.19	26.09	17.51	25.40	18.20	yes	yes	yes
New Mexico	9.70	3578.00	0.16	10.02	9.38	9.97	9.43			
Rate Ratio	2.25									

Table 1 Cancer Incidence (continued)

M. Myeloma										
Los Alamos	2.80	10.00	0.89	4.54	1.06	4.26	1.34	no	no	no
New Mexico	3.50	1217.00	0.10	3.70	3.30	3.67	3.33			
Rate Ratio	0.80									
Non-Hodgkin's										
Los Alamos	14.20	53.00	1.95	18.02	10.38	17.41	10.99	yes	yes	yes
New Mexico	9.60	3385.00	0.17	9.92	9.28	9.87	9.33			
Rate Ratio	1.48									
Oral/Pharynx										
Los Alamos	6.40	25.00	1.28	8.91	3.89	8.51	4.29	no	no	no
New Mexico	9.30	3244.00	0.16	9.62	8.98	9.57	9.03			
Rate Ratio	0.69									
Ovary										
Los Alamos	18.30	40.00	2.89	23.97	12.63	23.06	13.54	yes	yes	yes
New Mexico	12.60	2368.00	0.26	13.11	12.09	13.03	12.17			
Rate Ratio	1.45									
Pancreas										
Los Alamos	8.80	32.00	1.56	11.85	5.75	11.36	6.24	no	no	no
New Mexico	8.90	3118.00	0.16	9.21	8.59	9.16	8.64			
Rate Ratio	0.99									
Prostate										
Los Alamos	150.00	230.00	9.89	169.39	130.61	166.27	133.73	yes	yes	yes
New Mexico	100.70	15533.00	0.81	102.28	99.12	102.03	99.37			
Rate Ratio	1.49									
Stomach										
Los Alamos	4.50	16.00	1.13	6.71	2.30	6.35	2.65	no	no	no
New Mexico	8.00	2801.00	0.15	8.30	7.70	8.25	7.75			
Rate Ratio	0.56									
Testis										
Los Alamos	6.90	15.00	1.78	10.39	3.41	9.83	3.97	yes	no	yes
New Mexico	3.80	765.00	0.14	4.07	3.53	4.03	3.57			
Rate Ratio	1.82									
Thyroid										
Los Alamos	10.10	54.00	1.37	12.79	7.41	12.36	7.84	yes	yes	yes
New Mexico	4.90	1847.00	0.11	5.12	4.68	5.09	4.71			
Rate Ratio	2.06									
U. Bladder										
Los Alamos	14.90	51.00	2.09	18.99	10.81	18.33	11.47	yes	no	no
New Mexico	12.80	4477.00	0.19	13.17	12.43	13.11	12.49			
Rate Ratio	1.16									
Uterine C.										
Los Alamos	15.00	34.00	2.57	20.04	9.96	19.23	10.77	no	no	no
New Mexico	17.30	3172.00	0.31	17.90	16.70	17.81	16.79			
Rate Ratio	0.87									

Table 2 Cancer Mortality

	Rate	Cases	Stand. Error	95% conf. Upper limit	95% conf. Lower limit	90% conf. Upper limit	90% conf. Lower limit	Rate LAC>NM?	Difference significant at 95% CI?	Difference significant at 90% CI?
All Sites										
Los Alamos	128.50	446	6.08	140.43	116.57	138.51	118.49	no	no	no
New Mexico	145.60	51176.00	0.64	146.86	144.34	146.66	144.54			
Rate Ratio	0.88									
Brain										
Los Alamos	2.70	10.00	0.85	4.37	1.03	4.10	1.30	no	no	no
New Mexico	3.60	1276.00	0.10	3.80	3.40	3.77	3.43			
Rate Ratio	0.75									
Breast										
Los Alamos	32.40	69.00	3.90	40.04	24.76	38.82	25.98	yes	yes	yes
New Mexico	22.90	4330.00	0.35	23.58	22.22	23.47	22.33			
Rate Ratio	1.41									
Cervix Uteri										
Los Alamos	1.60	3.00	0.92	3.41	-0.21	3.12	0.08	no	no	no
New Mexico	3.30	618.00	0.13	3.56	3.04	3.52	3.08			
Rate Ratio	0.48									
Colon/Rectum										
Los Alamos	16.90	55.00	2.28	21.37	12.43	20.65	13.15	yes	no	no
New Mexico	15.50	5487.00	0.21	15.91	15.09	15.84	15.16			
Rate Ratio	1.09									
Esophagus										
Los Alamos	2.30	7.00	0.87	4.00	0.60	3.73	0.87	no	no	no
New Mexico	2.30	788.00	0.08	2.46	2.14	2.43	2.17			
Rate Ratio	1.00									
Gallbladder										
Los Alamos	0.00	0.00		0.00	0.00	0.00	0.00	no	no	no
New Mexico	1.50	536.00	0.06	1.63	1.37	1.61	1.39			
Rate Ratio	0.00									
Hodgkin's										
Los Alamos	0.50	2.00	0.35	1.19	-0.19	1.08	-0.08	no	no	no
New Mexico	0.80	285.00	0.05	0.89	0.71	0.88	0.72			
Rate Ratio	0.63									
Kidney										
Los Alamos	3.20	13.00	0.89	4.94	1.46	4.66	1.74	yes	no	no
New Mexico	3.10	1066.00	0.09	3.29	2.91	3.26	2.94			
Rate Ratio	1.03									
Larynx										
Los Alamos	0.00	0.00		0.00	0.00	0.00	0.00	no	no	no
New Mexico	1.00	336.00	0.05	1.11	0.89	1.09	0.91			
Rate Ratio	0.00									
Leukemias										
Los Alamos	5.10	20.00	1.14	7.34	2.86	6.98	3.22	no	no	no
New Mexico	6.10	2194.00	0.13	6.36	5.84	6.31	5.89			
Rate Ratio	0.84									
Liver										
Los Alamos	2.80	10.00	0.89	4.54	1.06	4.26	1.34	yes	no	no
New Mexico	2.70	966.00	0.09	2.87	2.53	2.84	2.56			
Rate Ratio	1.04									
Lung										
Los Alamos	18.10	60.00	2.34	22.68	13.52	21.94	14.26	no	no	no
New Mexico	32.60	11289.00	0.31	33.20	32.00	33.10	32.10			
Rate Ratio	0.56									

Table 2 Cancer Mortality (continued)

Melanoma										
Los Alamos	3.10	12.00	0.89	4.85	1.35	4.57	1.63	yes	no	no
New Mexico	1.90	691.00	0.07	2.04	1.76	2.02	1.78			
Rate Ratio	1.63									
M. Myeloma										
Los Alamos	1.30	4.00	0.65	2.57	0.03	2.37	0.23	no	no	no
New Mexico	2.50	861.00	0.09	2.67	2.33	2.64	2.36			
Rate Ratio	0.52									
Non Hodgkin's										
Los Alamos	5.80	19.00	1.33	8.41	3.19	7.99	3.61	yes	no	no
New Mexico	4.60	1614.00	0.11	4.82	4.38	4.79	4.41			
Rate Ratio	1.26									
Oral/Pharynx										
Los Alamos	2.30	8.00	0.81	3.89	0.71	3.64	0.96	no	no	no
New Mexico	2.30	790.00	0.08	2.46	2.14	2.43	2.17			
Rate Ratio	1.00									
Ovary										
Los Alamos	9.00	18.00	2.12	13.16	4.84	12.49	5.51	yes	no	no
New Mexico	7.10	1338.00	0.19	7.48	6.72	7.42	6.78			
Rate Ratio	1.27									
Pancreas										
Los Alamos	8.30	30.00	1.52	11.27	5.33	10.79	5.81	yes	no	no
New Mexico	8.20	2886.00	0.15	8.50	7.90	8.45	7.95			
Rate Ratio	1.01									
Prostate										
Los Alamos	19.50	21.00	4.26	27.84	11.16	26.50	12.50	no	no	no
New Mexico	22.60	3385.00	0.39	23.36	21.84	23.24	21.96			
Rate Ratio	0.86									
Stomach										
Los Alamos	1.80	6.00	0.73	3.24	0.36	3.01	0.59	no	no	no
New Mexico	6.00	2094.00	0.13	6.26	5.74	6.22	5.78			
Rate Ratio	0.30									
Testis										
Los Alamos	0.00	0.00		0.00	0.00	0.00	0.00	no	no	no
New Mexico	0.30	61.00	0.04	0.38	0.22	0.36	0.24			
Rate Ratio	0.00									
Thyroid										
Los Alamos	0.20	1.00	0.20	0.59	0.00	0.53	0.00	no	no	no
New Mexico	0.40	151.00	0.03	0.46	0.34	0.45	0.35			
Rate Ratio	0.50									
U. Bladder										
Los Alamos	2.00	5.00	0.89	3.75	0.25	3.47	0.53	no	no	no
New Mexico	2.70	975.00	0.09	2.87	2.53	2.84	2.56			
Rate Ratio	0.74									
Uterine C.										
Los Alamos	2.30	4.00	1.15	4.55	0.05	4.19	0.41	no	no	no
New Mexico	3.10	588.00	0.13	3.35	2.85	3.31	2.89			
Rate Ratio	0.74									