LUNG CANCER RISKS IN THE VICINITY
OF URANIUM TAILINGS SITES

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April 1982

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ABSTRACT

Lung cancer mortality data have been assembled for many counties of interest to the Uranium Mill Tailings Remedial Action Program (UMTRAP). The counties generally either contain UMTRAP tailings sites or are adjacent to them. The lung cancer rates of nearly all counties are less than the U.S. average rate. In addition, some of the many factors associated with lung cancer are identified as are cancer risk estimators for radon daughters.

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1. INTRODUCTION

1.1 HEALTH EFFECTS FROM RADON

For over forty years it has been recognized that airborne radioactive materials might be a causal agent of lung cancer.⁽¹⁾ Literature in this field, documenting extensive studies, indicate that for uranium miners, "lung cancer rates are directly related to cumulative exposure to radon daughters."⁽²⁾ Thus; it is appropriate to ask what is the health impact of uranium mill tailings which are known emission sources of radon and are extensively found throughout the western United States. Of particular interest for the present investigation are the inactive mill tailings sites that are in the Uranium Mill Tailings Remedial Action Program (UMTRAP). Many of these tailings sites are situated in populated areas, and so it is beneficial to compile lung cancer statistics for areas near inactive uranium tailings sites. However, it is recognized that the statistical data base available is limited, and that radon gas from the inactive sites constitutes a very small fraction of the total radon in the area. Furthermore, it is recognized that lung cancer rates will be influenced by other significant factors such as cigarette smoking, environmental conditions, population age and spatial distribution in the area and even other background radiation sources. Nevertheless, a scoping study to gather and evaluate the pertinent data resources contributes to the completeness of the UMTRAP data base.

1.2 PRESENT RISK ESTIMATORS

Recent investigations have yielded values for the lung cancer risk estimator from radon daughters, which range from⁽³⁾

$$R_1 = 100 \text{ health effects}/10^6 \text{ person} \cdot \text{WLM} \quad (1)$$

to⁽⁴⁾

$$R_2 = 700 \text{ health effects}/10^6 \text{ person} \cdot \text{WLM} \quad (2)$$

The recently published BEIR-III Report⁽⁵⁾ lists the following age-dependent annual risk estimators:

<u>Age at Diagnosis (yr)</u>	<u>Excess Risk (Cancers/yr 10^6 person $\cdot$ WLM)</u>
1-34	0
35-49	9
50-65	18
60+	42

Two values of the risk estimator, obtained from the above data,⁽⁶⁾ are:

$$R_3 = 350 \text{ health effects}/10^6 \text{ person} \cdot \text{WLM} \quad (3a)$$

$$R_4 = 540 \text{ health effects}/10^6 \text{ person} \cdot \text{WLM} \quad (3b)$$

The R_3 assumes a 30 year risk plateau and R_4 is obtained assuming a lifetime risk plateau.

As noted previously,⁽⁶⁾ risk estimators R_3 and R_4 yield lung cancer rates from background radon daughter concentrations that exceed measured total lung cancer deaths for nonsmokers. A recent review and uncertainty analysis of radon daughter risk estimators⁽⁷⁾ contains the following recommended value:

$$R_5 = 150 \text{ health effects}/10^6 \text{ person} \cdot \text{WLM} \quad (4)$$

This value will be used in the present study. It is similar to the 180 health effects/ 10^6 person · WLM used in the Phase II - Title I Engineering Assessments of Inactive Uranium Mill Tailings Sites.⁽⁸⁾

Using an assumed value of 1.0 pCi/l for background indoor radon in Utah and Colorado yields a risk of about 0.2 cancers per year per ten thousand population. This value is associated with background radon.

There is value in investigating the historical lung cancer rates in areas containing UMTRAP sites and neighboring counties.

In this report, lung cancer rates are analyzed and compared for a number of counties, including ones containing tailings and others which border on counties with tailings, as well as for states and the entire U.S.

The next chapter contains a discussion of lung cancer trends in Utah and Colorado. The lung cancer rates in specific counties in these states are given in Chapter 3 and conclusions and discussion are contained in Chapter 4.

2. GENERAL LUNG CANCER TRENDS

2.1 UNITED STATES DATA

Until 1952 the National Office of Vital Statistics of the Public Health Service published only composite mortality data under the category entitled "Cancer and Malignant Tumors"⁽⁹⁾ up to 1949 and "Malignant Neoplasms Including Neoplasms of Lymphatic and Hematopoietic Tissues" from 1950 to 1951.⁽⁹⁾ In 1952, however, the National Office of Vital Statistics expanded the cancer mortality category and published data in the category (classifications: 160-164) entitled "Malignant Neoplasms of the Respiratory System" which has been separately identified up to the present time in published vital statistics.⁽⁹⁾ Thus, to estimate lung cancer death statistics before 1952 requires that one assume the fraction of cancer deaths attributable to malignant respiratory neoplasms. To avoid this estimate all statistical analyses of trends, growth, correlations, etc., are imposed upon the lung cancer death data base in the time interval 1952 to 1977 (the last year for which data is currently published) which has been separately identified by the National Office of Vital Statistics.

Figure 1 shows both the actual annual deaths due to lung cancer per 10,000 U.S. residents (actually malignant neoplasms of the entire respiratory system) indicated as solid circles and also a exponential growth curve least squares fit to the solid circle data points between 1952 and 1977. Data points for the period from 1945 to 1951 are shown for completeness and are adjusted by a fixed fraction to attempt to account for the fraction of total cancer deaths attributable to lung cancer. The exponential equation for the annual U.S. resident lung cancer deaths is given by

$$\text{LCDR (US)} = 1.59 (1.0421)^{t-1952} \quad (5)$$

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FIGURE 1. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR U.S.

where

LCDR = the lung cancer death rate for U.S.
residents per 10,000 resident population.

t = calendar year ($1952 \leq t \leq 1977$).

An excellent correlation coefficient of 0.999 is found for Equation 5 and the actual data points. A correlation coefficient exceeding 0.5 is considered to be indicative of a good fit to the data in this study. From Equation 5 it is observed that the lung cancer death rate has increased from about 1.6 deaths per 10,000 residents in 1952 to almost 4.5 deaths per 10,000 residents in 1977 and by simple extrapolation to 5.3 deaths per 10,000 residents in 1981. The annual percent growth rate as given by Equation 5 is about 4.2% per year. This implies a doubling of lung cancer deaths among U.S. residents about every 17 years. This increase in lung cancer deaths may be due to many factors but there exists considerable evidence that cigarette smoking⁽¹⁰⁻¹²⁾ is a major contributing factor. The possible linkage between human ionizing radiation exposures and lung cancer^(10,13) is much less certain although there is an elevated lung cancer incidence rate among uranium miners.⁽¹⁴⁾

The major U.S. domestic resources of uranium which have been actively worked since 1945 are in New Mexico, Colorado, Utah and Wyoming. Colorado and Utah because of their relatively large populations, proximity and similarity with each other and significant uranium tailings distributions were chosen for an initial scoping analysis and evaluation.

2.2 COLORADO STATE DATA

The main focus of data analysis was placed on Colorado and Utah for this

initial scoping study. Uranium ores and tailings are found extensively throughout much of western Colorado with specific tailings sites and distributions in Grand Junction, Durango, Gunnison, Naturita, Rifle and other locations. For a basis of comparison with Colorado counties, Figure 2 presents the actual annual lung cancer death rate per 10,000 residents of Colorado (as solid circles) and a least squares fit exponential growth curve. The equation for this exponential curve for the annual lung cancer death rate in Colorado is given by

$$\text{LCDR (Colorado)} = 1.31(1.0265)^{t-1952} \quad (6)$$

where

LCDR (Colorado) = the lung cancer death rate for Colorado residents per 10,000 resident population.

t = calendar year ($1952 \leq t \leq 1977$).

The correlation coefficient for the fit of Equation 6 to the actual data points in Figure 2 is 0.95. It is interesting to observe that both the death rate (i.e., lung cancer deaths per 10,000 residents) and the annual percent growth at about 2.7 percent are significantly lower for Colorado than the U.S. In Colorado the lung cancer death rate in 1977 was about 2.5 deaths per 10,000 residents or about 57 percent of the U.S. lung cancer death rate in 1977. However, this low incidence of lung cancer deaths is not uniform over the state as will be shown in Chapter 3 of this report. Also shown in Figure 2 is the population growth rate for Colorado.

STATE OF COLORADO

LCDR (Colorado) = 1.31(1.0265)^{t-1952}
 Correlation Coefficient = 0.95
 LCDR = Lung Cancer Death Rate (Per 10⁴ Residents)
 t = Calendar Year

POPULATION GROWTH RATE

1980

1970

1960

1950

1945

945-1002

POPULATION GROWTH RATE AND LUNG CANCER DEATH RATE (PER 10,000 RESIDENTS) - COLORADO

2.3 UTAH STATE DATA

Utah does not have the extensive distribution of uranium tailings sites that Colorado does, with the location of significant tailings at Vitro in Salt Lake County and two smaller tailings sites in less populated areas in the eastern portion of the state.

Figure 3 presents the actual lung cancer death rate per 10,000 residents of Utah (solid circles) and an least squares fit exponential growth curve for the state. The mathematical expression for the Utah lung cancer death rate curve is

$$\text{LCDR (Utah)} = 0.82 (1.0269)^{t-1952} \quad (7)$$

where

LCDR (Utah) = the lung cancer death rate for Utah
residents per 10,000 resident population.

t = calendar year (1952 ≤ t ≤ 1972)

The correlation coefficient for goodness of fit of equation 7 is 0.91. As was the case for Colorado, both the death rate and the annual percent growth for Utah at about 2.7% are significantly lower for Utah than the U.S. Interestingly, the annual percent growth values for Colorado and Utah are approximately equal at 2.7%, but the death rate coefficient (i.e., the coefficient 0.82 for Utah and 1.31 for Colorado) for Utah is only 63% of that for Colorado and 52% of that for the U.S. In Utah the lung cancer death rate was about 0.82 deaths per 10,000 residents in 1952 and about 1.6 deaths per 10,000 residents in 1977.

STATE OF UTAH

FIGURE 3. POPULATION GROWTH AND LUNG CANCER DEATHS PFP 10,000 RESIDENTS FOR UTAH

Also shown in the figure is the population growth rate for Utah.

2.4 SUMMARY OF U.S., COLORADO AND UTAH LUNG CANCER DEATH TRENDS

From Figure 1, 2 and 3 it is apparent that there is a well established trend of increasing lung cancer deaths in the U.S. and in the states of Colorado and Utah. However, significantly, both the lung cancer death rate and the annual percent of growth for Utah and Colorado are significantly lower than for the U.S.

The calculated lung cancer rate of 0.2 per ten thousand population, associated with background radon, is a small fraction of the total lung cancer rates for Utah and Colorado. It represents about 25 percent and 10 percent, respectively.

There are many credible factors and conditions which could affect lung cancer incidence. Some of the factors and conditions of particular interest here are

- (1) geographical location and natural environment
- (2) incidence of cigarette smoking
- (3) natural ionizing background radiation
- (4) man-made and technologically enhanced sources of ionizing radiation
- (5) age and sex distribution of population
- (6) atmospheric hazards from industrial employment and urban environment
- (7) mobility of the population

These factors can have a significant influence upon the lung cancer rates in the area. For example, the incidence of lung cancer is generally considered

to have a latency period of at least fifteen years. Yet, the population growth in both Utah and Colorado this past fifteen years has been 50 percent and 47 percent, respectively. Thus, lung cancers occurring recently in this segment of the population likely have a cause that is associated with another part of the country.

3. SPECIFIC COUNTY DATA

3.1 BACKGROUND

Although there are over twenty inactive uranium mill tailings sites which have been identified in the western U.S. and many additional active sites, this initial scoping study focuses on a selected group of inactive tailings sites in Colorado and Utah identified in the UMTRA program. The specific tailings sites and their respective counties are as follows

Colorado

- Grand Junction in Mesa County
- Rifle in Garfield County
- Durango in La Plata County
- Gunnison in Gunnison County
- Naturita in Montrose County

Utah

- Vitro in Salt Lake County

Figures 4 and 5 show all county boundaries, major cities and standard metropolitan statistical areas for Colorado and Utah. Also shown are the locations of the specific inactive tailings sites previously listed. The tailings volume, specific radioactivity, effective radon emanation and potential population exposure differ with each of these sites, but in general⁽⁸⁾ the radon emissions from the piles are a very small fraction of the background radon emitted from the rest of the land area.

A number of counties with topographic and population characteristics similar

FIGURE 4 LUNG CANCER STUDY COUNTIES FOR COLORADO

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FIGURE 5. LUNG CANCER STUDY COUNTIES FOR UTAH

to those counties containing tailings sites have also been studied. These counties have been subjected to the same statistical analysis as the counties and areas containing the designated tailings sites. The counties considered are as follows

Colorado

- Delta County
- Eagle County
- Las Animas County

Utah

- Utah County
- Davis County

Reference to Figures 4 and 5 shows the geographical rationale for selection of these counties. The counties of Eagle, Garfield, Mesa, Delta, Montrose and Gunnison form a contiguous and approximately rectangular area (120 miles by 160 miles) in the west central area of Colorado. Most of this area is characterized as the western slope of Colorado, although Gunnison and Eagle Counties are in high mountain valleys. La Plata County is located near the southwestern border of Colorado and the inactive tailings site in Durango is situated in this county.

Las Animas County is included for general comparison with all the other Colorado counties considered in this study. Las Animas is about 200 miles east of the tailings study areas, but it retains similar population and geographic characteristics to the study areas.

In the state of Utah, Salt Lake County, which contains Salt Lake City, and the Vitro tailings site located 6 miles south of the center of the city, will be evaluated. Although Salt Lake County is only about 750 square miles in size,

it contains about 42% of the state's population. Davis County to the north and Utah County to the south were studied for comparison. These three counties which are similar in population and geographic characteristics contain 67% of the state's population.

3.2 STATISTICAL ANALYSIS

In this section the lung cancer death statistics for the counties are analyzed. The source of the base data presented and used in this statistical analysis is the same as that reported in Chapter 2. Cancer death statistics are those published annually by the National Vital Statistics Division of the Public Health Service. Specific area population data was obtained from the official census data published by the Bureau of the Census of the U.S. Department of Commerce. Annual population changes were determined by interpolation of the official data as necessary so that annual lung cancer deaths per 10,000 residents for each county and area of interest could be determined.

3.2.1 Colorado Counties Not Containing Inactive Uranium Tailings Piles

Delta, Eagle and Las Animas Counties in Colorado do not contain inactive uranium mill tailings sites designated in UMTRAP.

Figures 6, 7 and 8 show the actual lung cancer deaths (as solid circles) per 10,000 residents for the Colorado counties of Delta, Eagle and Las Animas County, respectively. It is apparent from Figures 6 through 8 that the lung cancer death rate has varied markedly from zero deaths, reported for 11 different years in Eagle County and in 1965 in Las Animas County, to 6 deaths per 10,000 or more in Delta County in 1976, in Eagle County in 1959 and in Las Animas County

FIGURE 6. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR DELTA COUNTY, CO.

FIGURE 7. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR EAGLE COUNTY, CO.

FIGURE 8. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR LAS ANIMAS COUNTY, CO.

in 1973.

To smooth the variations in the annual data points and improve the fit of the exponential growth curve used for trend analysis, the data points from 1952 to 1977 were "smoothed" using a repeatable, three point moving, smoothing algorithm with Gaussian weighting. It can be shown that this smoothing algorithm leaves true exponential curves unchanged. The smoothed annual data points are presented as open circles and the effects of the data smoothing operation are evident in the figures. The extreme changes in the data points are adjusted to show more clearly the annual trend of lung cancer deaths for each county. Exponential growth curves were least squares fit to the smoothed point data and the resulting correlations are given in Equations 8 through 10.

$$\text{LCDR (Delta)} = 1.62(1.0435)^{t-1952} \quad (8)$$

with a correlation coefficient of 0.86 and

$$\text{LCDR (Eagle)} = 1.23(1.0062)^{t-1952} \quad (9)$$

with a correlation coefficient of 0.78 and

$$\text{LCDR (Las Animas)} = 0.99(1.0534)^{t-1952} \quad (10)$$

with a correlation coefficient of 0.83.

Delta County exhibits a greater smoothed lung cancer death rate than any of the other counties in Colorado, the Colorado State and even the U.S. over the entire period from 1952 to 1977. This county has a stable population, decreasing by ten percent between 1945 and 1970, then increasing by only 29 percent between 1970 and 1977. On the other hand, Eagle County has the lowest annual percent cancer growth rate at 0.6% of any county in this study. The Eagle County population remained steady from 1945 to 1961, then increased by 130% by 1977.

3.2.2 Garfield County

Figure 9 shows the actual and smoothed lung cancer death rate data for Garfield County which contains an inactive tailings site at Rifle. The exponential growth curve obtained from a least squares fit to the smooth data shown as open circles is

$$\text{LCDR (Garfield)} = 0.80(1.0511)^{t-1952} \quad (11)$$

with a correlation coefficient of 0.75. Garfield County has an annual percent growth rate for lung cancer at 5.1%. However, because of its lower rate coefficient (0.80), Garfield has a lower lung cancer death rate than the counties of Delta and Las Animas and exceeds the cancer death rate for Eagle County only after 1960.

Comparing the lung cancer death rate curve with the curve for Colorado gives a ratio of the coefficients of $0.80/1.31 = 0.61$ and the ratio of the annual growth rates, $0.0511/0.0265 = 1.93$. Thus, although Garfield County enjoyed a lower lung cancer death rate in 1952 (61% of the Colorado average rate of 1.31 deaths/ 10^4 people) the higher annual growth of 5.11% implied that the lung cancer death rate per 10,000 residents for Garfield County approximately equaled the state rate of 2.3 lung cancer deaths per 10^4 persons in 1974 and exceeded the state rate by about 0.3 deaths per 10^4 residents in 1977. However, these later rates are still significantly less than the U.S. average rates.

3.2.3 Gunnison County

Gunnison County contains inactive mill tailings in the city of Gunnison.

FIGURE 9. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR GARFIELD COUNTY, CO.

The lung cancer death rate data per 10,000 residents of the county is shown in Figure 10. The equation for the curve fit to the smoothed data is

$$\text{LCDR (Gunnison)} = 0.71(1.0265)^{t-1952} \quad (12)$$

with a correlation coefficient of 0.31 which is low. This poor fit arises from the rapidly changing actual data points (solid circles) from 1952 to 1977 which exhibit 16 years in which no lung cancer deaths were reported and seven years for which 2 or more deaths per 10,000 residents were reported.

3.2.4 Mesa County and Grand Junction

Figure 11 shows the actual annual lung cancer deaths per 10,000 residents for Mesa County. Grand Junction in Mesa County contains the extensively distributed mill tailings through much of the land area occupied by the town. The least-squares fit equation obtained from the smoothed data are:

$$\text{LCDR (Mesa)} = 1.01(1.0610)^{t-1952} \quad (13)$$

with a correlation coefficient of 0.97 for Mesa County. Since the correlation coefficient is particularly high for this equation (which implies a very good fit of the equation to the smoothed data) it is very significant statistically to observe that the annual percent growth rate for lung cancer is 6.1%. Since 1970, Mesa County population has increased at an annual rate of 3.7%, a 50 percent increase over the ten years. Thus, 50 percent of the population have been exposed to the mill tailings for a period of time significantly less than the latent period for lung cancer from radiation exposures.

FIGURE 10. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR GUNNISON COUNTY, CO.

FIGURE 11. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR MESA COUNTY, COLORADO

3.2.5 Montrose County

The inactive uranium tailings site at Naturita is located in Montrose County. Figure 12 shows the lung cancer death rate data for Montrose County. The exponential growth curve fit to the smooth data for this county is

$$\text{LCDR (Montrose)} = 1.23(1.0520)^{t-1952} \quad (14)$$

with a correlation coefficient of 0.86. The annual percent growth rate for Montrose County is about 5.2% and is approximately the same as that value for Garfield (5.1%) and for the county of Los Animas (5.3%). These annual growth rates are about twice that of Colorado (2.7%) and about 25% higher than the U.S. value at 4.2%.

It should be noted that the Naturita tailings pile is located in the extreme western end of the county, that less than 1000 people are in the immediate area, and that other significant mining and milling occurs in the area.

3.2.6 La Plata County

Figure 13 exhibits the lung cancer deaths per 10,000 residents for La Plata County. The city of Durango located in La Plata County is the site for an inactive uranium mill tailings pile. Again the actual annual lung cancer deaths per 10,000 county residents as given by the National Office of Vital Statistics are shown as solid black circles.

$$\text{LCDR (La Plata)} = 1.01(1.0374)^{t-1952} \quad (15)$$

with a correlation coefficient of 0.66.

FIGURE 12. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR MONTROSE COUNTY, CO

FIGURE 13. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR LA PLATA COUNTY, COLORADO

3.2.7 Utah Counties

Davis and Utah County are adjacent to Salt Lake County where the inactive Vitro uranium mill tailings site is located. Figure 14 displays the actual and smoothed data for lung cancer deaths per 10,000 Davis residents. Figure 15 displays similar data for Utah County. Using smoothed data for these counties the exponential growth curves are found to be

$$\text{LCDR (Davis)} = 0.44(1.0263)^{t-1952} \quad (16)$$

and

$$\text{LCDR (Utah)} = 0.46(1.0386)^{t-1952} \quad (17)$$

where the correlation coefficient is 0.63 for Davis County and 0.91 for Utah County. Both these counties display a lower lung cancer death rate than the state or Salt Lake County as will be shown. Davis County exhibits about the same annual percent growth rate at 2.6% as the state at 2.7% while Utah County exhibits a high growth rate at 3.9% per year.

3.2.8 Salt Lake County

Figure 18 shows the lung cancer death rate data for Salt Lake County. The exponential growth curve equation for Salt Lake County is

$$\text{LCDR (Salt Lake)} = 1.00(1.0252)^{t-1952} \quad (18)$$

with a correlation coefficient of 0.94. It is interesting to observe that although Salt Lake County has about the same annual percent growth rate at 2.5%

DAVIS COUNTY
UTAH

FIGURE 14. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR DAVIS COUNTY, UT.

UTAH COUNTY
UTAH

FIGURE 15. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR UTAH COUNTY, UT.

as Davis County at 2.6% and Utah State at 2.7% the cancer rate coefficient at a value of 1.0 exceeds the rate coefficient for the state (at 0.82) by about 22% although this coefficient is only 63% of the U.S. value at 1.59.

The population growth for Salt Lake County is also shown in Figure 16. As with the state population, the Salt Lake County population has increased by over 60 percent since 1960.

SALT LAKE COUNTY UTAH

FIGURE 16. LUNG CANCER DEATHS PER 10,000 RESIDENTS FOR SALT LAKE COUNTY, UTAH

4. DISCUSSION

4.1 DISCUSSION

Table I provides a summary of the statistical data that can be inferred regarding lung cancer death rates per 10,000 resident population in the counties. The lung cancer death rate equation ($LCDR = a(1+i)^{\Delta t}$) is given for each county or area for intercomparison of the rate coefficients (i.e., the "a" terms) and the annual percent growth values (i.e., the "i" terms). Evaluation of the two columns in the table for the ratios of the rate coefficients and percent growth terms for the study counties to the state and U.S. data indicates a broad spread of values and no apparent correlation exists between lung cancer deaths and occurrence of uranium mill tailings. A graphical compilation of the LCDR equations shown in Figures 17 and 18 also demonstrates this lack of correlation.

Figures 17 and 18 display the lung cancer death rate curves obtained from a least squares error fit of the smoothed data for all counties in Colorado and Utah, respectively, for the calendar period 1952 to 1977. The lung cancer death rate per 10,000 residents is shown along the logarithmic ordinate axis so that the exponential growth curves plot as straight lines. In Figure 17 for Colorado it is observed that the counties of Delta, Las Animas and Eagle Counties effectively contain or bracket all other curves shown except for Gunnison County. Thus, although Mesa County which contains the Grand Junction site exhibits the highest percent annual growth at 6.1%, the actual lung cancer death rate during the period 1952 to 1977 is exceeded by both the U.S. and Delta County, Colorado. In fact the cancer rates for all counties except Delta are lower than the U.S. average.

In this initial study a limited analysis of only 8 counties in Colorado

TABLE I
SUMMARY OF LUNG CANCER DEATH DATA FOR ALL STUDY COUNTIES FOR THE PERIOD 1952 TO 1977

Area or County Site	LCDR Equation ^a	Correlation Coefficient	Population Median Age	Rate Coefficient State	Ratio U.S.	% Growth State	Ratio U.S.
Colorado	1.31(1.0265) ^{Δt}	0.95	28.0	1.00	0.82	1.00	0.63
Delta	1.62(1.0435) ^{Δt}	0.86	30.0	1.24	1.02	1.64	1.03
Eagle	1.23(1.0062) ^{Δt}	0.78	24.7	0.94	0.77	0.23	0.15
Garfield	0.80(1.0511) ^{Δt}	0.75	31.3	0.61	0.50	1.93	1.21
Gunnison	0.71(1.0265) ^{Δt}	0.31	23.9	0.54	0.45	1.00	0.63
La Plata	1.01(1.0374) ^{Δt}	0.66	26.7	0.77	0.64	1.41	0.89
(Durango)	1.32(1-.0103) ^{Δt}	-.21					
Las Animas	0.99(1.0534) ^{Δt}	0.83	29.2	0.76	0.62	2.02	1.27
Mesa	1.01(1.0610) ^{Δt}	0.97	30.0	0.77	0.64	2.30	1.45
(Grand Junction)	0.41(1.0599) ^{Δt}	0.91					
Montrose	1.23(1.0520) ^{Δt}	0.86	28.0	0.94	0.77	1.96	1.24
Utah State	0.82(1.0269) ^{Δt}	0.91	22.0	1.00	0.52	1.00	0.64
Davis	0.44(1.0263) ^{Δt}	0.63	19.6	0.77	0.28	0.98	0.62
Salt Lake	1.00(1.0252) ^{Δt}	0.94	24.0	1.22	0.63	0.94	0.60
Utah County	0.46(1.0386) ^{Δt}	0.91	21.5	0.56	0.29	1.43	0.92
United States	1.59(1.0421) ^{Δt}	0.999	30.0	----	1.00	----	1.00

^a Δt = t - 1952 where t is the calendar year.

FIGURE 17. LUNG CANCER DEATHS FOR COLORADO COUNTIES

FIGURE 18. LUNG CANCER DEATHS FOR UTAH COUNTIES

and 3 in Utah has been performed. Furthermore, of the seven factors and conditions with potential influence on lung cancer death incidence given in Section 2.4 only the geographical location and natural environment factor have been examined. For example, it is known that the age distribution of a given population sample has statistical significance in lung cancer incidence. An older population has a higher cancer rate.⁽¹⁵⁾ This correlation is evident if the population median age is plotted as a function of the annual percent growth rate in lung cancer deaths. Both of these data items are given in Table I. The results of this analysis are shown in Figure 19 which exhibits the annual percent growth rate in lung cancer deaths per 10,000 resident population as a function of the median age of the resident population. It is apparent from the figure that although there is a spread in the county data points, a linear trend does exist between percent growth rate and median age. This trend is evidenced by a least squares error linear curve fit to the data. The equation for the linear curve is

$$\text{Annual Percent Growth Rate} = 0.259 (\text{Median Age in Years}) - 3.13 \quad (20)$$

with a correlation coefficient of 0.65. If the Colorado county of Eagle County could be neglected (on the basis of other influencing factors) then the correlation coefficient for a linear relationship between percent growth rate and median age is 0.80.

It is noted that the median age for the population in Mesa and Garfield Counties exceeds most of the other counties considered in Colorado, possibly accounting for the slightly higher annual percent growth rate in these counties.

A major factor influencing lung cancer rates is smoking. A previous epidemiological study⁽¹⁶⁾ of lung cancer rates versus smoking and the other factors yielded the following associations between lung cancer and smoking data

FIGURE 19. RELATIONSHIP OF LUNG CANCER DEATH GROWTH RATE WITH RESIDENT POPULATION MEDIAN AGE

for Colorado and Utah:

Colorado Lung Cancer Rate from Smoking = 0.6 cancer deaths/yr
per ten thousand population

Utah Lung Cancer Rate from Smoking = 0.3 cancer deaths/yr
per ten thousand population

The difference in these rates is attributed to the fact that the annual per capita cigarette smoking in Colorado is approximately double that in Utah. These values are larger than the calculated value of 0.2 per ten thousand associated with background radon.

Another report⁽¹⁷⁾ indicated that nationally, about 90% of lung cancer deaths in men is attributed to smoking. Therefore, a more detailed analysis of the population age distribution and smoking patterns for the study and control areas, would greatly facilitate the interpretation of the lung cancer mortality data.

4.2 SUMMARY

Lung cancer mortality data have been assembled for areas of interest to the UMTRAP. Lung cancer rates for counties in Utah and Colorado that contain tailings sites have been determined for the period 1952 to 1978 and are compared with data for nearby counties that do not contain uranium tailings piles as well as with state and U.S. average lung cancer rates. Cancer incidence risk coefficients have also been examined and a value of 150 lung cancer deaths/ 10^6 person · WLM is used in the study.

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02 / 07 / 91