LEUKEMIA MORTALITY IN SOUTHWESTERN UTAH:

1950 - 1964

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INTRODUCTION

Since its establishment in 1958, the Division of Radiological Health of the U.S. Public Health Service has been engaged in surveillance of areas in the vicinity of the Nevada Test Site with respect to potential hazards to residents and transients. Particular interest has been directed toward St. George and Cedar City, Utah, the county seats of Washington and Iron county respectively, because these towns provide the closest fair-sized population groups potentially at risk from weapons test debris moving easterly from the test site. There were about 5,000 people in each town and an equal number in the rest of each county in 1960, for a total of 21,000 residents.

Although few sophisticated or detailed environmental radioactivity measurements were made "off-site" until 1955, indeed many instruments and procedures were not designed at the time of the 1951 (Buster-Jangle), 1952 (Tumbler-Snapper) and 1953 (Upshot-Knothole) series, Dunning (1) estimated external gamma doses of 2.5-5.0 roentgens over a large part of Washington County from all tests through 1958 (Hardtack). These figures and the location of the towns mentioned are shown in Figure 1. The modification of Dunning's original map consists only of adding the outlines of Washington and Iron counties.

The estimates are explicitly given as air doses because neither the shielding nor even the presence or absence of people in many parts of the area is known. Because of changes in weapons design and test procedures, gamma activity from fallout was indistinguishable from background levels in Utah during and after the Hardtack series.

It is also necessary to make a clear distinction between these external doses and the estimates of internal thyroid dose (largely of beta energy) arising from the ingestion of milk that may have been contaminated with ^{131}I. These latter estimates, presented to the Joint Committee on Atomic Energy in June 1963 by the Committee on Nuclear Information (2) are, in some cases, orders of magnitude higher than the numbers associated with the external gamma doses.

This report is concerned with the leukemia mortality experience of the two counties over the 15 year period 1950-1964. The certificates which constitute the basic data for examination and analysis have been provided by the Division of Vital Statistics of the Utah State Health Department.

In response to local and national interest in the subject, we propose to present the basic information available to date as well as some results of investigation of the recorded events.

METHODS

All certificates specifying leukemia as a cause of death for residents of either county were collected in 1958. They included the years 1950 - 1957. Since that time the Division of Vital Statistics has provided copies of certificates concerning residents of the two counties immediately after receipt in Salt Lake City. Both sets of resident records included out of state occurrences. An apparently excessive number of deaths in the year 1959 (see Table 2) resulted in a field investigation by epidemiologists from the Division of Radiological Health and the Communicable Disease Center. In addition to searching the state files for cases missed due to improper coding or other circumstances, the team sought information on medical histories and diagnostic procedures on all reported or suspected cases of leukemia.

Hospital and attending physician records were also reviewed for the cases in order to obtain additional information such as dates of onset, type of leukemia and certainty of diagnosis. Records were also reviewed of persons certified as having died with lymphoma, various types of anemia and purpura, in addition to multiple myeloma, polycythemia vera and other conditions in which differentiation from leukemia may be uncertain.

It is difficult to establish a suitable control against which to contrast this experience. The counties in question are rural and differ in several respects from other counties in Utah as well as from the population of the United States at large. In addition, the number of people is small and thus leukemia deaths are rare. Hence sampling errors are serious. Even 3 years' experience of the whole State of Utah did not permit the establishment of firm leukemia and aleukemia death rates of white persons specific for age and sex. (3) The only dependable source of relevant data from which to construct expected numbers in each age-sex group is that covering all white persons in the United States during the period under consideration.

With respect to comparison in a finer classification scheme, that is distinguishing acute from chronic forms and for specific cell types, MacMahon's data (4) for white persons in Brooklyn, New York, are unique and therefore utilized. One need not be a public health expert to recognize the multitude of environmental and demographic differences between southwestern Utah and Brooklyn, New York. Nevertheless, as will be shown below, both the national rates and those from Brooklyn yield numbers in almost perfect agreement.

RESULTS

An abstract of selected information on each of the 28 cases reported during the 15 year period is given in Table 1. All but the onset dates and "review" diagnoses are transcribed from the death certificate. The date of onset and "review" diagnosis were determined by Public Health Service medical officers who examined the information on the death certificates and in records of physicians, clinical laboratories and hospitals. The details of these procedures have been specified in the section on methods.

For purposes of the analyses which follow, the 3 cases bearing a question mark (nos. 13, 19, & 25), have somewhat arbitrarily been classified as chronic leukemias because of the advanced age (over 60) of all of the patients and the 18 month interval from onset to death in two of them. In case 13, the death certificate diagnosis of aleukemic leukemia was simply not verifiable. Case 19 had an anemia, leukocytosis and thrombocytosis of unknown etiology. A cryptoleukemia was considered by an attending physician but the diagnosis was not established. In case 25, the diagnosis of myelogenous leukemia was made on a blood count that was recorded during a terminal acute myocarditis which is frequently associated with the blood picture noted in this case. Further available and relevant details on these cases are given in an Appendix.

Table 2 provides a general view of the pattern of leukemia mortality in each of the two counties from 1950 through 1964. The 28 deaths over the 15 year period occurred with annual frequencies of less than three in every year except 1959 when six were reported. The same 28 cases are displayed in Table 2 to show the age and sex of each person, his county of residence and whether the disease occurred in acute or chronic form. The anomalously high frequency of six cases in 1959 appears to consist of three acute cases in Washington County children and three chronic cases among elderly residents of Iron County.

If we consider that $28/15 \approx 2$ is the "true" annual expectancy, we may consult a Poisson distribution table (5) and find that the probability of observing 6 or more cases in one year is less than 2%.

Another way of summing up the 15 years of observation is shown in Table 3. Here age and sex specific leukemia death rates for the white population of the United States have been applied to the estimated average number of persons in each of 10 age groups to obtain expected annual numbers of deaths. The numbers shown in the table result from multiplying the annual expectancy by the 15 years of the period. This more refined calculation gives a total of 19 deaths which could be closely approximated simply by applying the U.S. rate for all ages of about 6 per 100,000 to the 300,000 person years of experience (20,000 people x 15 years). This second way of examining the data indicates that the difference of 9 between expected and observed numbers consists of three deaths under age 35, five between ages 45 and 64 and one among persons over 65.

In a further effort to identify the source of the difference, MacMahon's annual rates, (specific for type of leukemia as well as sex and age) were used in a manner similar to the national rates for all forms. The 1957 estimate of the population shown in Table 3 was reconstituted to conform to MacMahon's age grouping by applying the 1960 Census proportion in each age to the total shown in Table 3 for each sex.

There is no inconsistency in the common use of the term "lymphatic" but some doubt may be raised about assuming equivalence between our "granulocytic" group and MacMahon's "myelogenous" or "myeloid." Nevertheless, we have combined his "monocytic" with "type unknown" for the acute rates, and used his chronic myeloid rates for deriving expected numbers of chronic granulocytic cases.

The results of this third analytic approach are summarized in Table 4. For each of 4 age groups, the table shows the observed and expected numbers of cases within each of the six diagnostic categories. The total of 20 (19.9) expected is almost the same as the 19 (19.2) derived from the national figures. The most notable differences contributing to the difference of 8 deaths are 3 (3.48) acute lymphatic leukemias in persons under 20 and 3 (3.49) chronic lymphatic leukemias in persons over 40.

SUMMARY AND CONCLUSIONS

An examination of leukemia death records in southwestern Utah for the years 1950-1964 shows a difference between the number expected and those observed. Considered from a chronological point of view (Table 2) there seem to be 5 or 6 more deaths in the 2 years 1959 and 1960 than the 3 or 4 anticipated from the overall expectancy of 1.5-2.0 deaths per year.

In respect to deaths over the whole 15 year period by age and type of disease (Table 4), or by age and sex (Table 3) there appears to be an excess of 8 or 9, respectively. But there is poor correspondence between the individuals constituting the clusters of particular interest in 1959 and 1960 and those giving rise to the greatest differences between observed and expected numbers when the whole 15 year period is considered. For example, only one of the 3 children with acute leukemia who died in 1959 (J.T., Case #14) is among the 5 acute lymphatic leukemia cases of Table 4. It is also known that J.T. was "born sick" well before weapons testing started.

Regrouping the cases by date of onset shows little change in the annual frequency of the chronic cases. They maintain their scattered occurrence throughout the period. The largest aggregation consists of 3 cases (#6, #7, #9) with onset in 1952, the first year in which even "half-nominal" yield weapons were detonated from towers in Nevada. However, regrouping the acute cases by year of onset accentuates the clustering in 1959-1960, with 7 onsets compared to six deaths in those two years.

The problem as we see it is to select the cluster of cases of primary interest and then attempt to secure information which will support or refute current etiological hypotheses. A less likely outcome of the second step might be the establishment of a new etiological possibility.

We believe that the aggregation of seven cases with onset in 1959-1960 constitutes the cluster of primary interest. Beyond the fact of extended residence in the area, there is no evidence to associate these cases with fallout exposure, other environmental contaminants or familial disabilities.

This study of leukemia has been incorporated into an extended analysis of mortality from all causes in Utah and Nevada. As the data are collected, summarized and analyzed, they will be presented in appropriate forms of publication.

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(2) Hearings of the Joint Committee on Atomic Energy August 1963. USGPO, Washington, D. C., 1963 (Part 2, pp. 601-658)

(3) U. S. Dept. of HEW, National Office of Vital Statistics: Death rates for selected causes by age, color and sex, 1949-1951. Vital Statistics - Special Reports 49:24:335-349; March 18, 1959.

(4) MacMahon, B., and Clark, D.: Incidence of the common forms of human leukemia. Blood 11:871-881, Oct. 1956.

(5) General Electric Co.: Tables of the individual and cumulative terms of Poisson distribution. D. VanNostrand Co., Princeton 1962.

Appendix

Medical Abstracts of Questionable Cases

Prepared by S. P. Abrahams, M.D.

Case Number 13

Patient D.S. was a white male born in Cedar City, Utah, on March 17, 1892, a farmer whose usual residence was in Enterprise, Washington County, Utah. No information is available on his health status while alive. The only recorded information available is the death certificate which certifies the cause of death as aleukemic leukemia. Date of death was May 19, 1958, at age 66 years. The interval between onset and death is said to be 18 months. No autopsy was performed. The certifying physician attended the patient on the date of death only.

Case Number 19

Patient J.R. was a white male born in Kansas City, Missouri, on February 28, 1893, a retired mechanic whose usual residence during the 20 years prior to death was in Cedar City, Iron County, Utah. He had been under medical care of the certifying physician since 1946. A work exposure to cleaning solvents including kerosene and gasoline had caused chronic hand dermatitis. In February 1958 a splenectomy was performed. Peripheral blood reports recorded an anemia, a total white cell count 3,300 and platelets 180,000. The spleen weight was 960 grams with pathological findings of myeloid metaplasia and myeloblasts predominating. Postsplenectomy the patient had severe epistaxis, petechiae and ecchymosis. There was marked hepatomegaly without adenopathy. A liver biopsy showed extramedullary hematopoiesis. He was discharged alive from the hospital on January 22, 1959, with a diagnosis of anemia, leukocytosis and thrombocytosis of unknown etiology. The discharge diagnosis also states "The presence of cryptoleukemia with possible eruption at a later date is still to be considered." This diagnosis is not established. Noted were anemia, probably due to chronic blood loss, decreased survival time and questionable other factors. The patient died on February 4, 1959, with death recorded as due to "internal hemorrhage, site unknown," and to "leukemia, one year interval." No autopsy was performed.

Case Number 25

Patient M.F. was a white female born in Pennsylvania on December 18, 1891, a housewife whose usual residence was in Cedar City, Iron County, Utah. She was seen by the certifying physician on May 14, 1962, admitted to the hospital with abdominal pain, epistaxis, low grade fever and "cardiac fibrillation." One peripheral blood count was recorded as total white cell count 18,600; hemoglobin 61% (8.9 grams) and hematocrit 29. The differential white cell count was polymorphonuclear cells 87% (juveniles 20%), lymphocytes 12% and eosinophils 1%. The clinical impression was myocardial infarction and myelogeneous leukemia. She was treated with sedation and an anti-coronary regimen. Death occurred on May 25, 1962, at age 70 years. The cause of death was certified as myelogeneous leukemia and acute myocarditis of 2 weeks duration. No autopsy was performed.

TABLE 1

Leukemia Cases in Southern Utah

(1950 - 1964)

	Case	Age at Death	Sex	Date Death	Date Onset	Usual Residence City	Usual Residence County	Diagnosis Death Cert.	Diagnosis Review Dx
1.	R.T.	73	F	2/50	2/48	Enterprise	Wash.	LL	CLL
2.	H.M.	12	F	3/50	2/50	Toquerville	Wash.	AL	AL
3.	C.S.	63	M	1/51	9/50	Hurricane	Wash.	LL	CLL
4.	H.D.	49	M	7/51	7/51	Cedar City	Iron	ALL	ALL
5.	K.P.	75	F	10/53	10/51	Cedar City	Iron	LL	CLL
6.	J.R.	77	M	10/53	4/52	Parawan	Iron	CLL	CLL
7.	B.J.	64	F	8/54	8/52	Hurricane	Wash.	GL	CLL
8.	E.W.	7	F	8/55	9/54	Hurricane	Wash.	L	ALL
9.	V.H.	53	M	1/56	1/52	Hurricane	Wash.	CGL	CGL
10.	K.H.	15	F	11/56	7/56	St. George	Wash.	AGL	AGL
11.	E.S.	47	M	4/57	10/54	Cedar City	Iron	AGL	AGL
12.	M.J.	61	F	12/58	12/53	Cedar City	Iron	GL	CGL
13.	D.S.	66	M	5/58	12/56	Enterprise	Wash.	Aleuk. L.	Aleuk. L.?
14.	J.T.	9	F	3/59	2/58	Washington	Wash.	ALL	ALL
15.	L.W.	70	M	3/59	7/58	Kannaraville	Iron	LL	CLL
16.	M.S.	4	M	5/59	2/59	Enterprise	Wash.	AGL	AGL
17.	S.N.	13	M	7/59	4/59	Washington	Wash.	AGL	AGL
18.	E.T.	67	M	9/59	2/58	Cedar City	Iron	CLL	CGL
19.	J.R.	65	M	2/59	9/57	Cedar City	Iron	L	L ?
20.	P.O.	14	F	5/60	12/59	Parawan	Iron	ALL	ALL
21.	K.L.	15	M	8/60	8/60	Paragonah	Iron	ALL	ALL
22.	V.P.	38	F	12/60	3/60	St. George	Wash.	AGL	AGL
23.	L.L.	58	M	10/61	3/60	Washington	Wash.	AGL	AGL
24.	S.M.	4	F	2/62	11/60	Cedar City	Iron	AL	ALL
25.	M.F.	70	F	5/62	Unk.	Cedar City	Iron	GL	L ?
26.	P.H.	61	M	5/63	6/56	St. George	Wash.	GL	CGL
27.	D.D.	55	F	10/63	2/60	Cedar City	Iron	L	CLL
28.	A.B.	48	M	7/64	11/63	St. George	Wash.	CLL	CLL

LL = Lymphatic Leukemia
AL = Acute Leukemia
ALL = Acute Lymphatic Leukemia
CLL = Chronic Lymphatic Leukemia
GL = Granulocytic Leukemia
L = Leukemia, not otherwise specified
CGL = Chronic Granulocytic Leukemia
Aleuk. L. = Aleukemic Leukemia
AGL = Acute Granulocytic Leukemia

TABLE 2

LEUKEMIA DEATHS IN WASHINGTON AND IRON COUNTIES, UTAH;

1950 - 1964

(By age, sex & type of disease)

YEAR	TOTAL	WASHINGTON		IRON	
		ACUTE	CHRONIC	ACUTE	CHRONIC
1950	2	12F*	73F	-	-
1951	2	-	63M	49M	-
1952	0	-	-	-	-
1953	2	-	-	-	75F 77M
1954	1	-	64F	-	-
1955	1	7F	-	-	-
1956	2	15F	53M	-	-
1957	1	-	-	47M	-
1958	2	-	66M	-	61F
1959	6	9F 4M 13M	-	-	70M 67M 65M
1960	3	38F	-	14F 15M	-
1961	1	58M	-	-	-
1962	2	-	-	4F	70F
1963	2	-	61M	-	55F
1964	1	-	47M	-	-
SUM	28	8	7	5	8

*Read: 12 year old female, etc.

TABLE 3

AVERAGE POPULATION, OBSERVED AND EXPECTED NUMBER

OF LEUKEMIA DEATHS;

WASHINGTON AND IRON COUNTIES, UTAH; 1950 - 1964

AGE	POPULATION		NUMBER OF DEATHS	
	MALE	FEMALE	EXPECTED*	OBSERVED
< 5	1,425	1,350	2.30	2
5-14	2,565	2,390	2.35	5
15-24	1,700	1,625	1.06	2
25-34	1,180	1,225	.83	0
35-44	1,120	1,130	1.10	1
45-54	950	880	1.70	4
55-64	750	730	2.84	6
65-74	550	475	3.99	6
75-84	230	215	2.52	2
85 and over	40	60	.52	0
TOTAL	10,510	10,080	19.21	28

* 1950 Rates from: Vital Statistics, Special Reports
Vol 49, No. 24 (1959); PHS, NOVS

1960 Rates from: Death Rates for Malignant Neoplasms
PHS Publication No. 1113, Dec. 1963

TABLE 4

Observed and Expected* Leukemia Deaths

By Age and Type of Disease

Washington & Iron Counties, Utah - 1950-1964

Age	TYPE OF DISEASE											
	ACUTE						CHRONIC					
	GRAN.		LYMPH.		OTHER		GRAN.		LYMPH.		OTHER	
	OBS	EXP	OBS	EXP	OBS	EXP	OBS	EXP	OBS	EXP	OBS	EXP
0-19	3	2.51	5	1.52	1	1.18	-	.23	-	.02	-	.38
20-39	1	0.71	-	.12	-	.18	-	.51	-	.15	-	.12
40-59	2	1.10	1	.20	-	.36	1	1.17	2	1.00	-	.52
60+	-	1.02	-	.29	-	.53	3	1.38	6	3.51	3**	1.23
	6	5.34	6	2.13	1	2.25	4	3.29	8	4.68	3	2.25

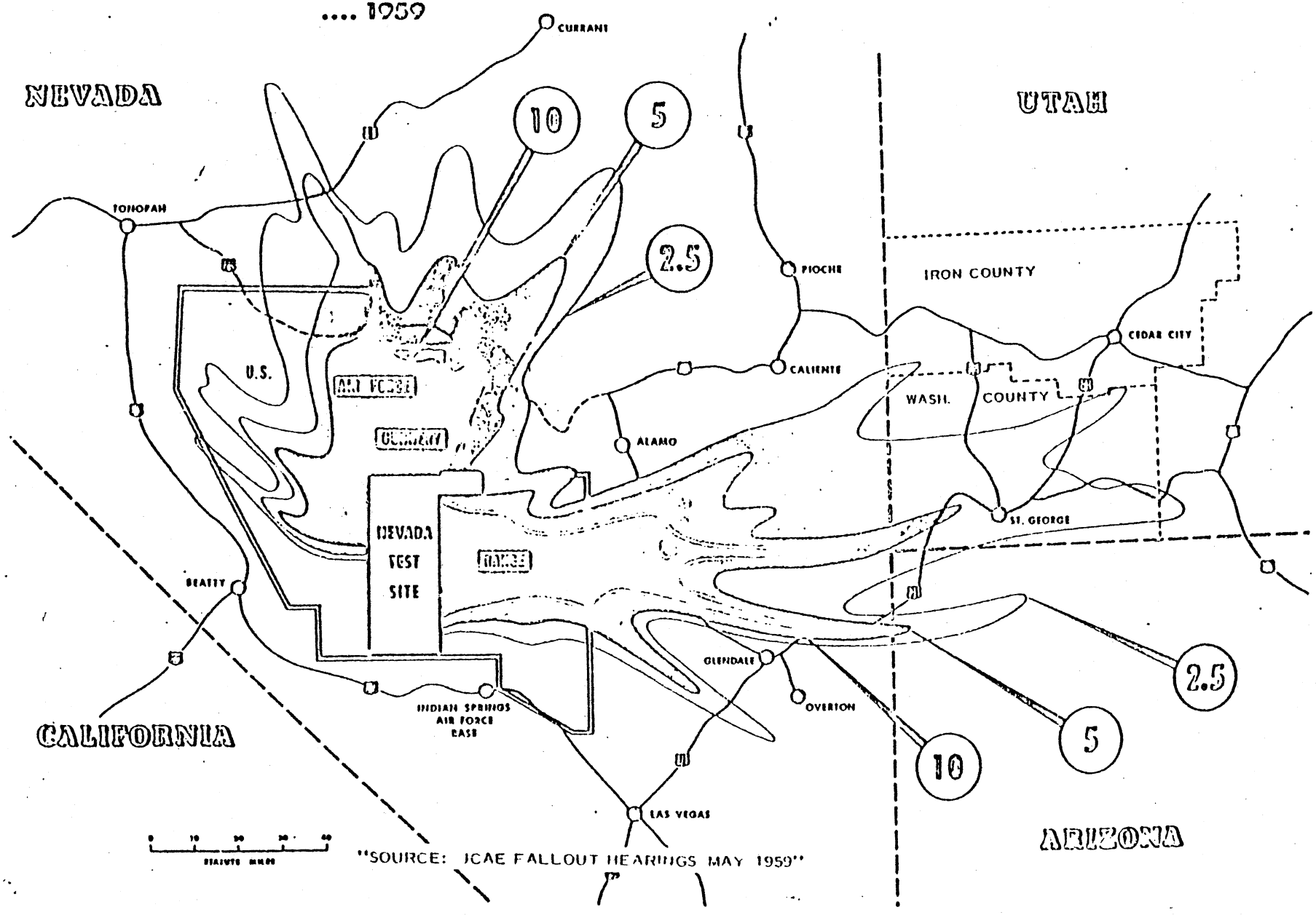
*Based on Brooklyn, N.Y. rates for white persons from 1943 to 1952 (MacMahon)

**Cases 13, 19 & 25, all questionable leukemias (see text)

ESTIMATED RADIATION DOSES (Roentgens)

FROM ALL NUCLEAR TESTS

.... 1959



"SOURCE: JCAE FALLOUT HEARINGS MAY 1959"