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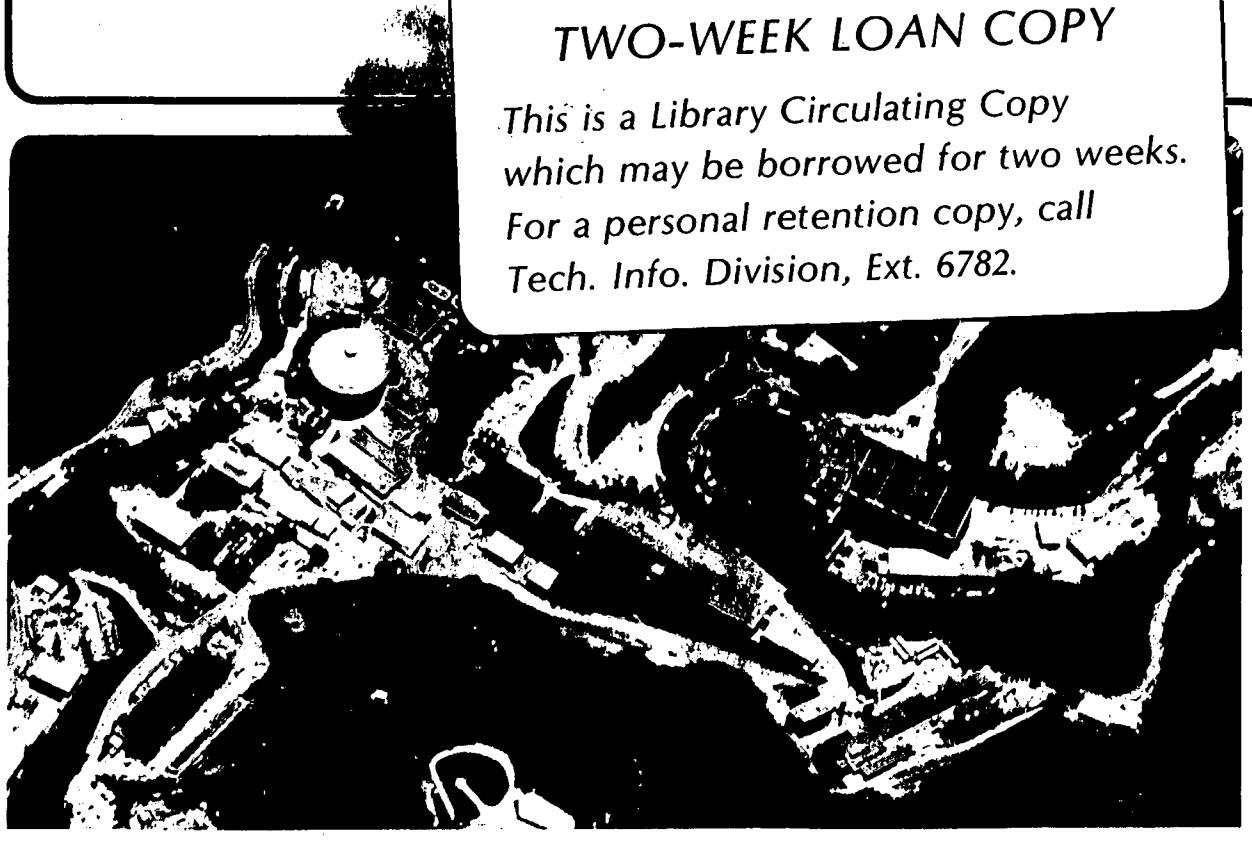

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Selected Epidemiological Observations of Cell-Specific Leukemia Mortality in the USA, 1969-1977

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The necessity for distinguishing the different histopathologic types of leukemia in epidemiologic studies has been recognized for at least 25 years (1-4). Special studies using cell specific classifications have been performed in the United Kingdom for over thirty years (2,3). Nevertheless, epidemiologic studies of leukemia which do not clearly distinguish the histopathologic types continue to appear (5). The reason for this is the failure of the International Classification of Diseases Adapted (ICDA) to differentiate cell types comprehensively prior to the 8th revision in 1968. There is now available relevant epidemiologic data for all deaths occurring in the United States during the period 1969-1977 (6). Detailed population estimates are also available by county for the nation (1970-1977). Thus, it is possible to examine the descriptive epidemiology of the specific histopathologic types of leukemia mortality for a recent time period. While it would have been preferrable to study leukemia incidence by cell type such data are not presently available for the U.S.A. as a whole.

Therefore, we have decided to analyze cell-specific leukemia mortality rates for for the U.S.A. white population with respect to certain selected characteristics. The characteristics which have been of particular interest to us include age and sex patterns, the secular trends, and the geographic distributions of the various histopathologic types.

METHODS

Death certificates assembled by the National Center for Health Statistics from 1969 through 1977 served as the principal source of data for this investigation. The numbers of age-and sex-specific leukemia deaths were obtained from the Mortality Surveillance Project conducted at Johns Hopkins University (6) and analyzed for lymphatic and myeloid cell-types for both

acute and chronic forms as coded by the Eighth Revision, International Classification of Diseases Adapted for Use in the U.S. (ICDA codes 204.0, 204.1, 205.0 and 205.1). Unspecified cell types, (ICDA codes 204.9, 205.9, 207.1, 207.2, 207.3 and 207.9) of which there were 21,400 cases, were not analyzed and monocytic (ICDA codes 206.1 and 206.2) yielded 4376 cases which were too few deaths to provide stable estimates of rates. Chronic lymphatic and chronic myeloid leukemias among children under 15 years of age were not included. These cell types are extremely rare and among those under 15 there were only 52 deaths diagnosed as chronic lymphatic leukemia and 215 deaths diagnosed as chronic myeloid leukemia during the entire nine year period 1969-1977.

The calculation of mortality rates for the years 1969 through 1977 required estimates of the person-years-at-risk. The race-, age-, and sex-specific county intercensal population estimates made by the U.S.A. Census Bureau for 1970-77 provided the denominators for the calculation of rates. The 1969 county populations were assumed equal to the 1970 populations to compute rates for that year. Certain biases and inaccuracies in these intercensal estimates are known to exist. For example, the number of Spanish surname individuals who report their race as white has sharply decreased during the past decade which, therefore, could potentially bias the estimation of white mortality rates. Data from the 1970 census and the Area Resource File (7) were used to supplement the leukemia mortality data. The smallest possible common geographic unit used for combining these three sources of data was the county of residence at time of death as recorded on the death certificate. This aggregation produced a total of 3075 county records for the United States.

The analyses were conducted using standard statistical methods. Although some statistical significance levels are presented, these values should be considered, at best, approximate since no a priori hypotheses were formalized and no corrections were made for the many ad hoc comparisons (multiple comparisons).

RESULTS

Age and Sex

The numbers of deaths and rates per 100,000 according to five year age groups, sex, and cell type are shown in Table 1. A total of 80,389 deaths among whites comprised the study cases. Of these, 45,695 were male and 34,694 were female.

The age pattern of mortality rates according to sex are shown in Figures 1 and 2. The rates shown are average annual rates and are obtained by dividing the total number of deaths by the cumulative person years at risk for each age-sex group.

With respect to acute lymphatic leukemia in males (Figure 1), childhood rates rise to a peak in the 5-9 year age group and reach a low between the ages of 35-44. The rates then show an approximately geometric rise. For acute myeloid leukemia, the peak male childhood rates occur in the age group zero to four and drop slightly to a low in the age group 5-9. Thereafter, the rates rise almost geometrically until ages 75-84 after which they appear to rise less steeply. Chronic lymphatic leukemia in males rises geometrically from very low rates in the age group 35-44 to very high rates in the oldest age group, 85 and over. Chronic myeloid leukemia in males also rises geometrically from very low rates in the age group 15-24 to high rates in the oldest ages. It should be noted that among adult males the slopes of

increasing rates for acute and chronic myeloid leukemia and acute lymphatic leukemia are essentially parallel and increase approximately by a factor of 1.75 every 5 years while chronic lymphatic leukemia rises much more steeply by a factor of about 2.5 per 5 years.

The patterns of age specific rates among females for each of the four cell specific types of leukemia are similar to those of males (Figure 2). However, the rates among females are consistently lower for each age group. Except for chronic lymphatic leukemia, female rates are the same as males with about an eight year lag among those over 15 years of age. The eight year lag was determined by fitting straight lines to the sex cell-specific age curves. The lag is then the length of the horizontal distance between any two points on the male and female curves. For chronic lymphatic leukemia, the lag was about five years. One consequence of this phenomenon is that among adults, the sex ratios are remarkably similar throughout the age span for acute and chronic myeloid and acute lymphatic leukemias. These ratios range between 1.1 and 1.9. For adult chronic lymphatic leukemia the sex ratio varies between 2.0 and 2.6. The higher sex ratios for chronic lymphatic leukemia can be viewed as a consequence of the greater lag of the age-specific mortality rates among females. Among children the sex ratios for acute myeloid leukemia are consistently lower varying between 0.9 and 1.3 while for acute lymphatic leukemia they are similar to the adult ratios varying between 1.3 and 1.9.

Secular Trends (1969-1977)

Cell specific mortality rates of leukemia showed rather different patterns of change over the nine year period under investigation. This change was summarized by fitting a straight line (least squares) to the nine

rates and calculating the percent change observed between the estimated 1969 and 1977 rates (i.e., percent change = (1969 rate-1977 rate/1969 rate)x100). The results are given in Table 2. (Note: Mortality rates by age, sex, cell type, and year of death are contained in Appendix Tables 1 and 2. They are avialable upon request from the senior author.)

Substantial declines were observed for most of the age and sex subgroups for acute lymphatic leukemia. An exception is observed for males age 10-14. For the balance of the age groups the declines ranged from -6.3 percent for males age 5-9 to -62.5 percent for females 55-64 years of age. Conversely, the rates for acute myeloid leukemia increased for most age groups with the exception of the youngest age groups for both males and females. These increases ranged from a low of 16.1 percent for males 45-54 to a high of 56.1 percent for females 10-14.

For chronic lymphatic leukemia in adults the changes over time were small and inconsistent in direction. However, for chronic myeloid leukemia in adults a different pattern was observed. For males, the significant increase of 32 percent in the 45-54 year age group declined substantially in the older age groups while among females the time trend was slightly downward among all adult age groups.

Geographic Variation

In order to examine the geographical distribution of the four cell specific leukemias, the continental United States was divided into six equal longitudinal segments and three equal latitudinal segments. When the division passed through a county its population and deaths were proportioned appropriately to the divided geographical region. This classification resulted in seventeen segments since one segment contained no land area. The age and sex specific rates for each area are shown in Appendix Tables 3A-H (see previous Note).

To evaluate the geographic variability standard deviations of the age specific rates were calculated and are shown in Table 3. For the childhood leukemias acute lymphatic appears to be more variable in both males and females than acute myeloid leukemia. Among adults the geographic variability increases with increasing age for each of the four cell types. The most variable rates are observed in acute myeloid leukemia and chronic lymphatic leukemia for males while the least variable are the acute lymphatic leukemias for both males and females.

However, when the coefficients of variation were examined, a different pattern emerged, as shown in Table 3. For the childhood leukemias, acute myeloid is clearly more variable. Among adults, the increase in variability with age essentially disappears. Now the geographical variability measured by the coefficient of variation is greatest for acute lymphatic leukemia in both males and females.

To further describe the geographic patterns in leukemia mortality each of the age-sex-cell specific groupings were then analyzed by separate rankings of the 17 longitudinal and latitudinal segments. Acute and chronic lymphatic leukemia among adults of both sexes reveal high rates in the middle regions of the country and low rates on the eastern seaboard. Additionally chronic lymphatic leukemia also shows high rates in the north-central and low rates throughout the south particularly for adults of both sexes over the age of 65. Acute myeloid leukemia has consistently high rates along the west coast for adults of both sexes. Chronic myeloid leukemia in adults showed no particular geographic pattern.

We have also examined the geographic association of leukemia mortality for childhood and adult groupings using product moment correlation coefficients. Since the correlations between the age-and cell-specific rates for childhood and adult leukemias show no relation, the coefficients for

childhood and adult leukemias have been examined separately. The correlation coefficients are presented in Appendix Tables 4 and 5 (see previous Note).

Among children, the two cell type specific acute leukemias have similar geographic distributions among both sexes with all coefficients positive and ranging from .12 for male and female acute lymphatic leukemia to .34 for male acute lymphatic and female acute myeloid leukemia. However, among adults, the lymphatic and myeloid leukemias do not show a consistent geographic correlation. Nevertheless, within cell types, there is substantial geographic association. For lymphatic leukemia, the correlation coefficients are all positive and vary between 0.21 and 0.43 while for myeloid leukemias, the coefficients, all positive, vary from 0.07 to 0.36.

Another aspect of the geographic distribution of leukemia which has received considerable attention is the relationship of urban mortality to rural mortality. The reason for this interest is the assumption that urban and rural environments are associated with substantially different potential hazards. To examine this issue, the 3056 counties of the continental United States (nineteen of the 3075 counties could not be matched with census data) have been divided into those whose proportion urban is greater than the median (34 percent) and those whose proportion urban is less than the median. One would ordinarily prefer more than two categories in order to distinguish accurately a patterned distribution. However, for these data it was found that the number of cases in the tails of the distribution were insufficient to allow for more than two categories.

Approximately the same ratios were observed for all age-specific categories. Therefore the pooled rates for children and adults were calculated. As shown in Table 4, each cell specific type reveals similar urban-rural patterns for males and females. For childhood leukemias the

urban-rural ratios are less than one for both acute lymphatic and acute myeloid leukemia. The rural excess is approximately 10 percent. Among adults, a different pattern emerges with acute lymphatic leukemia showing an urban excess of approximately 50 percent while acute myeloid shows a slight rural excess of approximately 5 percent. For chronic lymphatic leukemia there is an urban excess of approximately 15 percent while for chronic myeloid the urban excess is about 10 percent.

A final aspect of the geographic distribution which has also received some attention is the relationship of leukemia occurrence to altitude. Since ionizing radiation has been associated causally with all types of leukemia except chronic lymphatic leukemia and since exposure to cosmic sources of ionizing radiation increases at higher altitudes (8), several attempts have been made to correlate leukemia mortality with altitude (9-11). Thus, the 3056 counties of the continental United States have been divided into those which lie above the median altitude (241 M.) and those below. In Table 5, the rates and ratios for the various cell specific leukemias are shown for childhood and adult groupings by sex. The only group showing an excess at higher altitude is acute lymphatic leukemia in adults of both sexes.

DISCUSSION

It would, of course, have been desirable to have established the validity of the cell specific diagnoses and to ascertain whether there was any systematic bias between various geographic areas or over the time span of the study. Unfortunately, data for such an analysis were not available. It is hoped that the establishment of the National Death Index will facilitate such validation studies. Nevertheless the present study was based on data generated under a single revision of the ICDA. Furthermore, the data analyzed here only included deaths for which a specific cell type was designated. The fact that

as many as 18 percent of the total leukemia deaths were unspecified as to type suggest that those which were classified were based on concrete pathologic diagnoses. It seems unlikely that within the nine years encompassed by the eighth revision of the ICDA, a substantial change in diagnostic custom would have occurred. We also not have any basis for suspecting a geographic bias in cell type diagnosis.

The age distributions of mortality rates for the four cell specific leukemias investigated here differ somewhat from the patterns described by MacMahon and Clark in their classic study of leukemia incidence and mortality in Brooklyn, New York, carried out in the 1950's (4). In the earlier study, both acute lymphatic and acute myeloid leukemia showed high childhood peaks in the 0-9 year age groups and declined to a low for acute lympahtic in the 40-49 year age group and for acute myeloid in the 20-29 year age group. In the data presented here the peak for acute lymphatic leukemia occurred in the 5-9 year age group, with a low in the 25-34 year age group, a pattern similar to the Brooklyn data. However, the childhood peak for acute myeloid leukemia in these data has almost disappeared with the trough of the distribution occurring in the 5-9 year age group. Among adults, the patterns revealed by the two studies are quite similar with chronic lymphatic leukemia showing a steeper increase with age than the other cell types.

In this study all four cell specific types of leukemia have higher mortality rates among males than females in all age groups. MacMahon and Clark, on the other hand, reported higher rates in females at most ages for acute myeloid leukemia. Similar to the findings of MacMahon and Clark the highest male to female ratios occurred for chronic lymphatic leukemia. A striking feature of the data presented here is the consistent male-female ratios at all adult ages for each cell type. This phenomenon results from

the parallel patterns of the age and sex specific distributions. Such a finding can be interpreted as indicating that the determinants of the age distributions are similar in males and females with females either having a later exposure or a greater latency for the determinants. Thus, hypotheses that postulate etiologies which depend on risk factors that differ between males and females are unlikely to be sufficiently important to be reflected in mortality rates calculated on a national basis.

The secular trends revealed in this study indicate consistent reductions in mortality from acute lymphatic leukemia at all ages except among male children ages 10-14 and increases in mortality from acute myeloid leukemia particularly in the older age groups. The other cell specific types show no definite patterns. The downward trend in acute lymphatic leukemia is consistent with the generally accepted efficacy of chemotherapy (12). The failure to show a strong downward trend for this cell type in the age group 10-14 may indicate a failure of chemotherapy to produce permanent cure even though it may produce substantial increases in survival. This explanation is reinforced by the decreasing percentage change in the three childhood age groups for both males and females. These data can be also interpreted as showing that chemotherapy is simply less effective in older children.

The failure of mortality to decrease among other cell specific types is consistent with the general knowledge regarding treatment efficacy (12). The increase in mortality from acute myeloid leukemia in adults may be due to effective treatment of acute and chronic lymphatic leukemia with chemotherapeutic agents which are capable of producing neoplastic transformations of the bone marrow. If such transformation leads to the development of acute myeloid leukemia, it could explain some of the increase in mortality.

Although the basic geographic unit by which these data were organized are counties, these units were not appropriate for analysis. There are several reasons for this. First, of the 3056 counties in the continental U.S.A. only 6 percent had more than 10 deaths from any cell specific leukemia during the nine year study period. Second, the counties vary greatly in area so that mapping of county rates does not accurately reflect population size. Attempts to remedy this problem have included adjustments of county size to be proportional to population and the utilization of other geographic units such as State Economic Areas. Neither of these approaches overcome the problem discussed above. Third, for a large portion of the counties, boundaries were established by esentially political considerations and bear no consistent relationship with socio-demographic characteristics.

In order to assess the geographic variability more objectively we divided the country into 17 areas based on latitude and longitude. Within each area the population was divided into age and sex subgroups all of which contained more than 140,000 persons.

In order to assess the variation among the seventeen geographic areas designated in this study, standard deviations were first calculated for each of the age-sex-cell specific categories. These indicated substantial variability but were confounded with the effect of increasing rates with age. This was controlled by the calculation of coefficients of variation. These coefficients revealed some interesting patterns. First, the variability of acute lymphatic leukemia among adults was considerably greater on the average than for any of the other adult histopathologic type. In children acute myeloid leukemia showed substantially more variability than acute lymphatic leukemia.

Similar to previous studies (5,13), the geographic patterns revealed here are not very striking. The most important appear to be the lack of

association between specific histopathologic types in children versus adults. Of lesser importance is the association of acute and chronic forms of each cell specific leukemia in adults, the geographic correlation between acute lymphatic and acute myeloid leukemia in children, the substantial urban excess of acute lymphatic leukemia in adults and the positive association of altitude and acute lymphatic leukemia in adults.

The lack of geographic association between childhood and adult forms of leukemia, the inter-area variability, and the differences in age distribution reinforces the hypothesis originally suggested by MacMahon and Clark that childhood leukemias represent different etiologic entities. However, the geographic correlations among the childhood leukemias makes a common etiology for the two cell types a possibility. For adults, the fact that the different histopathologic types do not vary together suggest that each type has a particular constellation of risk factors.

The substantial urban excess of acute lymphatic leukemia may reflect greater exposure to medical diagnostic or industrial radiation or other urban associated leukemogenic agents. The association between altitude and childhood and adult acute lymphatic leukemia is also consistent with the known risk to this disease among those exposed to ionizing radiation.

While questions have been raised regarding the usefulness of further epidemiologic studies of leukemia (14), the availability of mortality data for histopathologically distinct types of leukemia make it possible to conduct a descriptive epidemiological study to update knowledge of the time, place and personal characteristics of these diseases. While some of the patterns were similar to those described for cell specific leukemia in the U.S.A. during the

1950's, others showed different results. Information of this type is particularly important now because of the need to interpret the reported occurrence of unusual clusters of leukemia cases in various places (15,16).

REFERENCES

1. Witts LJ. Recent work on leukemia in man. Br Med J 1957;1:1197-1202.

2. Court Brown WM, Doll R. Adult leukemia: trends in mortality in relation to aetiology. Br Med J 1959;1:1063-69.

3. Court Brown WM, Doll R. Leukemia in childhood and young adult life: trends in mortality in relation to aetiology. Br Med J 1961;1:981-988.

4. MacMahon B, Clark D. Incidence of the common forms of human leukemia. Blood 1956;11:871-81.

5. Blair A, Fraumeni JF Jr, Mason TJ. Geographic patterns of leukemia in the United States. J Chron Dis 1980;33:251-60.

6. Gittelsohn, A.M. Mortality Surveillance Project. Johns Hopkins University, Baltimore, 1982.

7. US Department of Health, Education, and Welfare. Public Health Service. Health Resources Administration. Bureau of Health Manpower. The Area Resources File. (DHEW Publication No. (HRA) 80-4), Washington DC, US GPO, 1979.

8. National Research Council. National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiations. The effects on populations of exposure to low levels of ionizing radiation. Washington, DC, USGPO, 1972.

9. Craig L, Seidman H. Leukemia and lymphoma mortality in relation to cosmic radiation. Blood 1960; 17:319-27.

10. Eckhoff ND, Shultis JK, Clack RW, et al. Correlation of leukemia mortality rates with altitude in the United States. Health Physics 1974; 27:377-80.

11. Mason TJ, Miller RW. Cosmic radiation at high altitudes and U.S. cancer mortality, 1950-1969. Radiation Res 1974; 60:302-6.

12. Krakoff IH. Cancer chemotherapeutic agents. CA 1981; 31:130-40.

13. Stark CR, Oleinick A. Urban or rural residence and histologic type distribution in 21,000 childhood leukemia deaths in the United States, 1950-1959. JNCI 1966;37:369-379.

14. Szklo M. Are further epidemiologic studies of leukemia needed? Am J Epidemiol 1980; 112:225-30.

15. Lyon JL, Klauber MR, Gardner JW, et al. Childhood leukemias associated with fallout from nuclear testing. N Eng J Med 1979; 300:397-402.

16. Land CE. The hazards of fallout or of epidemiologic research? N Eng J Med 1979; 300:431-32.

Table 1

Number of deaths and average annual age-specific leukemia mortality rates by cell type per 100,000 white males and females, U.S.A. 1969-1977.

Age Group	0-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	Total
Males												
Acute Lymphatic												
deaths	822	1643	946	1214	339	220	297	548	750	791	230	7800
rate	1.30	2.29	1.19	0.82	0.30	0.25	0.32	0.73	1.60	3.82	5.14	0.97
Chronic Lymphatic												
deaths	5	11	6	19	15	92	629	2202	3546	3776	1333	11634
rate	0.01	0.02	0.01	0.01	0.01	0.10	0.68	2.94	7.56	18.23	29.79	1.45
Acute Myeloid												
deaths	251	236	327	1028	975	1143	2042	3486	4682	3412	823	18405
rate	0.40	0.33	0.41	0.69	0.87	1.27	2.22	4.66	9.98	16.47	18.39	2.29
Chronic Myeloid												
deaths	42	33	43	219	471	629	978	1414	1875	1668	484	7856
rate	0.07	0.06	0.06	0.15	0.42	0.70	1.06	1.89	4.00	8.05	10.82	0.98
Females												
Acute Lymphatic												
deaths	610	1147	624	652	185	160	235	365	576	673	260	5487
rate	1.01	1.67	0.82	0.44	0.16	0.17	0.24	0.44	0.94	2.01	2.80	0.65
Chronic Lymphatic												
deaths	9	15	6	3	10	47	283	960	2103	2993	1341	7770
rate	0.02	0.02	0.01	0.00	0.01	0.06	0.29	1.15	3.45	8.96	14.45	0.92
Acute Myeloid												
deaths	244	183	273	813	875	1054	1695	2482	3417	3319	954	15309
rate	0.41	0.27	0.36	0.55	0.77	1.14	1.74	2.98	5.59	9.94	10.29	1.82
Chronic Myeloid												
deaths	34	29	34	127	291	442	712	1033	1384	1491	551	6128
rate	0.06	0.04	0.04	0.01	0.26	0.48	0.73	1.24	2.26	4.46	5.94	0.73

Table 2

Percent change[†‡] for age-, sex-, and cell-type specific leukemia mortality rates, U.S.A., 1969-1977.

	0-4	5-9	10-14	45-54	55-64	65+
Males						
Acute Lymphatic	-44.9*	-6.3	12.2	-49.0*	-61.1*	35.1*
Chronic Lymphatic				-10.3	-2.2	2.5
Acute Myeloid	- 7.1	31.9*	18.8	16.1	46.7*	47.3
Chronic Myeloid				31.9	14.3	6.2
Females						
Acute Lymphatic	-54.0*	-33.4*	-7.9	-56.7*	-62.5*	-46.7*
Chronic Lymphatic				-11.8	-4.0	2.5
Acute Myeloid	-4.5	47.0*	56.1*	24.3	40.3*	38.7*
Chronic Myeloid				-8.2	-10.8	-2.9

[†]indicates increase or decrease

[‡]based on a least squares fitted line

*indicates significance probability $p \leq 0.05$

Table 3

Standard deviations and coefficients of variation† for age-, sex-, and cell-type specific rates of leukemia, U.S.A, 1969-1977.

Age	0-4	5-9	10-14	45-54	55-64	65-74	75-84	85+
				Males				
Acute Lymphatic								
S	0.37	0.37	0.31	0.09	0.45	0.50	1.36	1.59
$(S/\overline{Y})\times100$	28.4	16.2	26.1	28.1	61.6	31.3	35.6	30.9
Chronic Lymphatic								
S	-	-	-	0.24	0.47	1.10	2.92	5.17
$(S/\overline{Y})\times100$	-	-	-	35.3	16.0	14.6	16.0	17.4
Acute Myeloid								
S	0.16	0.27	0.18	0.40	0.68	1.45	2.39	10.57
$(S/\overline{Y})\times100$	40.0	81.2	43.9	18.0	14.6	14.5	14.5	57.5
Chronic Myeloid								
S	-	-	-	0.24	0.39	0.56	1.74	2.98
$(S/\overline{Y})\times100$	-	-	-	22.6	20.6	14.0	21.6	27.5
				Females				
Acute Lymphatic								
S	0.39	0.46	0.25	0.12	0.13	0.29	0.70	1.63
$(S/\overline{Y})\times100$	38.6	27.5	30.5	50.0	29.5	30.9	34.8	58.2
Chronic Lymphatic								
S	-	-	-	0.14	0.22	0.39	1.17	4.27
$(S/\overline{Y})\times100$	-	-	-	48.3	19.1	11.0	13.1	29.6
Acute Myeloid								
S	0.28	0.26	0.20	0.26	0.58	0.78	1.82	2.58
$(S/\overline{Y})\times100$	68.3	96.3	55.5	14.9	19.5	14.0	18.3	25.1
Chronic Myeloid								
S	-	-	-	0.20	0.32	0.48	0.79	2.22
$(S/\overline{Y})\times100$	-	-	-	27.4	25.8	21.2	17.7	37.4

†S = standard deviation and $\overline{Y}$ the mean value for the 17 mortality rates

Table 4

Average annual mortality rates for urban and rural counties, and urban-rural ratios for specific cell types of leukemia by age and sex, U.S.A., 1969-1977.

Leukemia Type; Sex and Age	Mortality Rates/100,000 Proportion Urban Above Median	Proportion Urban Below Median	Ratios of Rates
Acute Lymphatic			
male child	1.48	1.60	0.92
adult	1.66	1.01	1.65
female child	1.13	1.16	0.98
adult	0.99	0.70	1.42
Chronic Lymphatic			
male adult	5.75	4.63	1.24
female adult	2.92	2.66	1.10
Acute Myeloid			
male child	0.34	0.39	0.88
adult	5.82	6.06	0.96
female child	0.32	0.34	0.91
adult	3.97	4.19	0.95
Chronic Myeloid			
male adult	2.89	2.65	1.09
female adult	2.05	1.77	1.15

Table 5

Average annual mortality rates for high and low altitude and high-low altitude ratios for specific cell types of leukemia by age and sex, U.S.A., 1969-1977.

Leukemia Type; Sex and Age	Mortality Rates/100,000 Proportion Urban Above Median	Proportion Urban Below Median	Ratios of Rates
Acute Lymphatic			
male child	1.56	1.60	0.98
adult	1.36	0.98	1.39
female child	1.17	1.16	1.01
adult	0.85	0.69	1.23
Chronic Lymphatic			
male adult	5.41	4.54	1.19
female adult	2.94	2.59	1.14
Acute Myeloid			
male child	0.37	0.39	0.95
adult	6.01	6.06	0.99
female child	0.31	0.35	0.89
adult	4.16	4.16	1.00
Chronic Myeloid			
male adult	2.69	2.69	1.00
female adult	1.89	1.78	1.06

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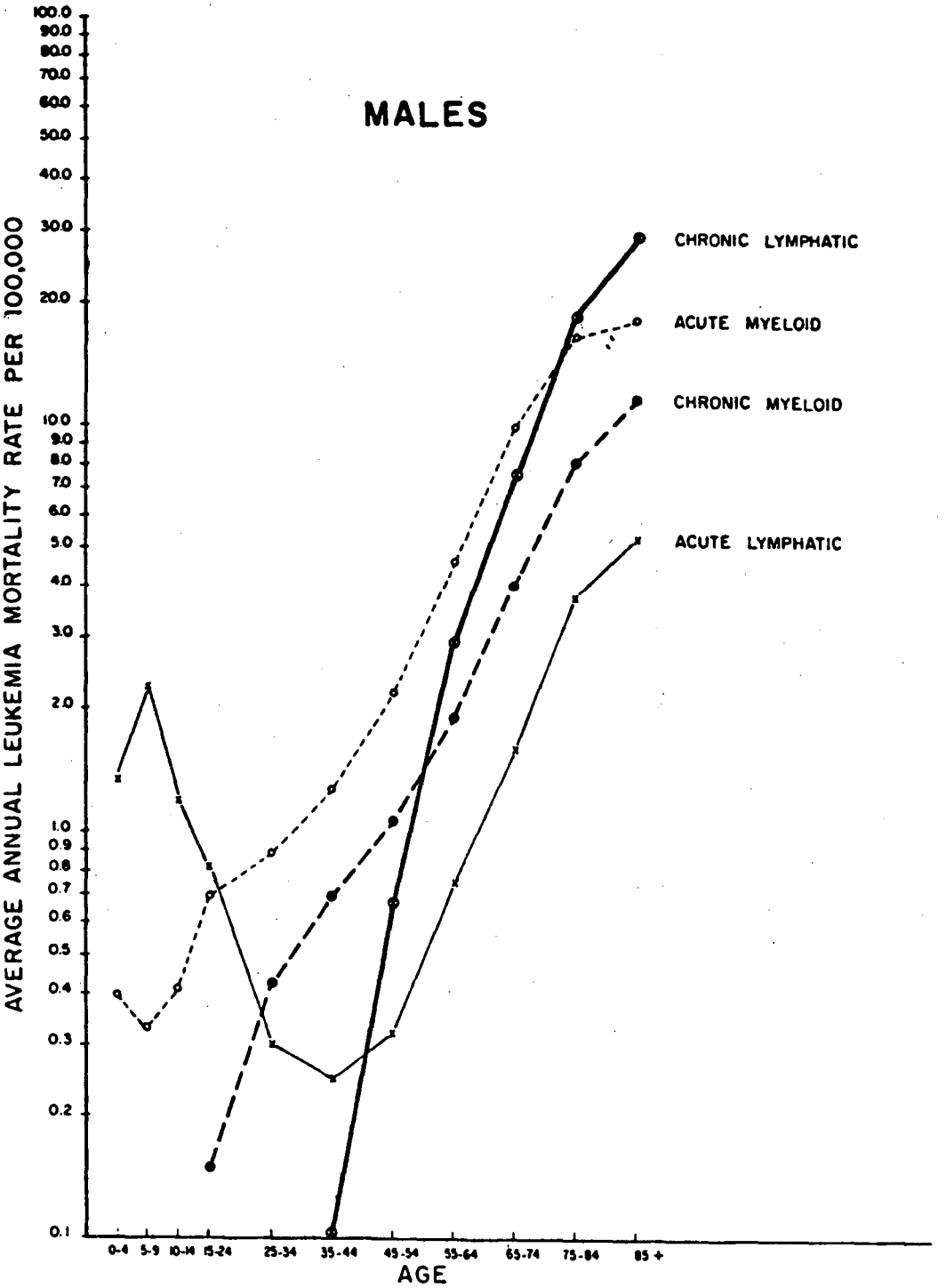
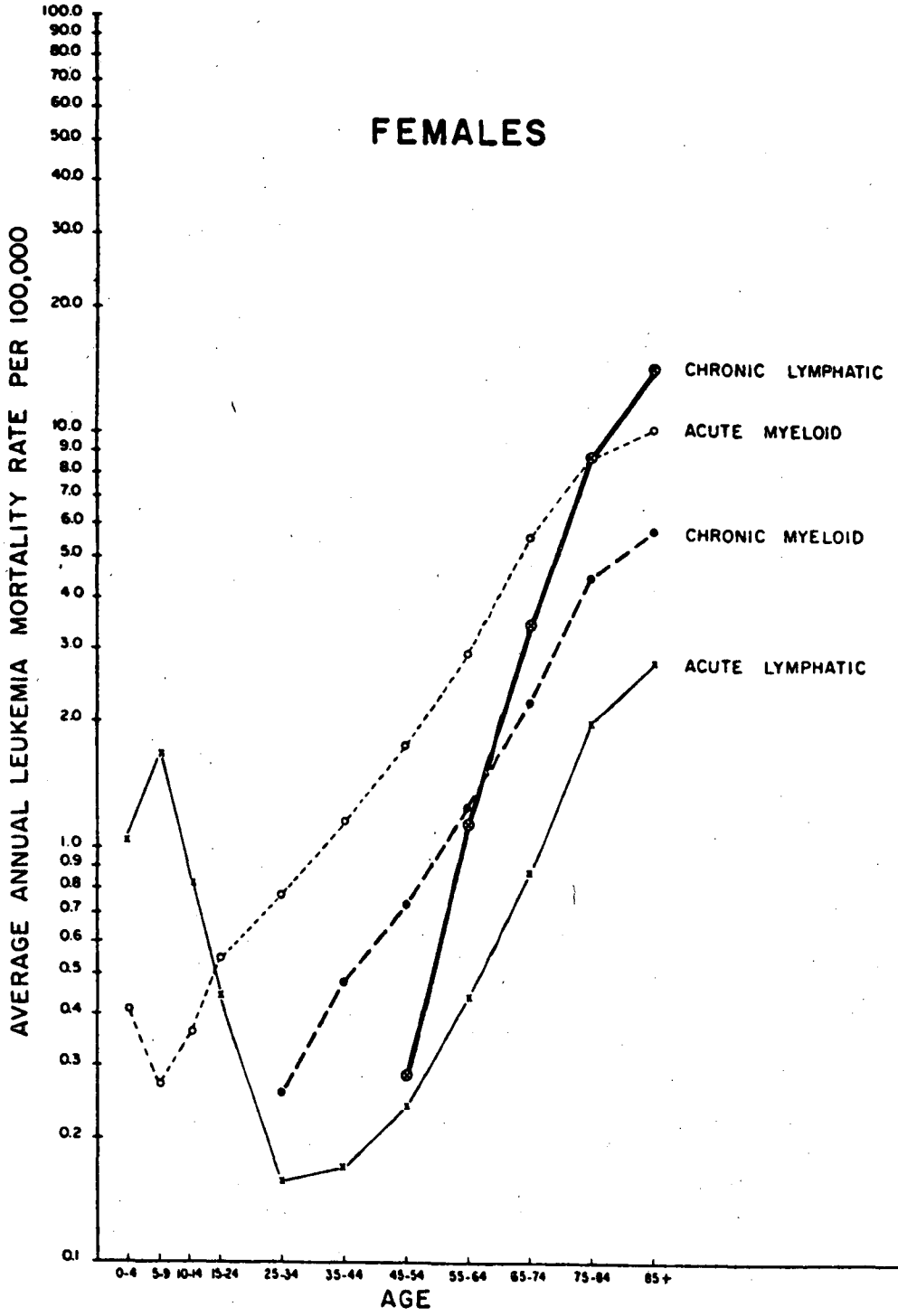

MALES
AVERAGE ANNUAL LEUKEMIA MORTALITY RATE PER 100,000
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0-4
5-9
10-14
15-24
25-34
35-44
45-54
55-64
65-74
75-84
85 +
AGE
CHRONIC LYMPHATIC
ACUTE MYELOID
CHRONIC MYELOID
ACUTE LYMPHATIC


FEMALES
AVERAGE ANNUAL LEUKEMIA MORTALITY RATE PER 100,000
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
CHRONIC LYMPHATIC
ACUTE MYELOID
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0-4
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85+
AGE

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