APPENDIX III

THIS DOCUMENT CONTAINS

POOR QUALITY PAGES

Infant Mortality and Nuclear Power Generation

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Until a few years ago no direct evidence had been available on the health effects of radiation in man at the low levels and low dose-rates encountered from nuclear weapons fallout or peace-time operation of nuclear power reactors. The present note presents data indicating that serious effects on human health such as sharp increases in infant mortality appear to have occurred from the radioactive gases released in the course of the normal operation of commercial nuclear power reactors generating electricity.

The evidence consists of an analysis of the changes in mortality rates of infants that died before reaching the age of 1 year in the area surrounding the Dresden nuclear power station located near Morris, Illinois, 50 miles south-west of Chicago.

Dresden I is a boiling water reactor (BWR) that has been operating since 1959, with a licensed power of 700 thermal megawatts and an electrical output of 210 megawatts. It uses a single coolant loop in which the steam generated by the nuclear fuel is taken directly outside the containment vessel to drive a steam-turbine. As described in a detailed study published in March 1970 by the Bureau of Radiological Health of the U.S. Department of HEW (BRH/DER 70-1),[1] the non-condensible fission product and activation gases in the coolant are released from a stack after a hold-up time of only about 20 minutes. The principal gases released are Krypton-87 and 88 and Xenon 135 and 138, with half-lives of 76 minutes, 2.8 hours, 9.1 hours, and 17 minutes respectively. Since 1961, the total annual gaseous waste discharges have ranged from 34,800 to 800,000 curies in 1966, compared with a licensed maximum release of 22,000,000 curies, or very much greater than the annual discharges of 0.001 to 0.350 curies from the submarine-type, pressurized water reactor (PWR) at Shippingport, Pennsylvania, that uses a separate secondary coolent loop to limit the escape of fission products into the environment.

As reported in the HEW publication, during the years 1967-68 when the total annual discharges were 240,000 to 250,000 curies, the radiation-dose rates directly under the plume 1-2 km from the plant ranged from 13 to 40 μR/hr, corresponding to 114 mr to 350 mr per year. When averaged over 2 weeks by means of thermoluminescent dosimeters, the dose rate was found to be between 2 and 3 μR/hr above the natural background of 9 μR/hr. On an annual basis, this is a dose between 17 and 26 mr, compared with the natural background dose of 83 mr per year in the area. The plume of radioactive gas could be identified as far away as 15 km or 9.4 miles north-east from the stack, where it resulted in a dose-rate of 22mr/year during a typical 10-minute measurement.

These dose-rates may be compared with the maximum value of 56 mr/year measured at the nearby Argonne National Laboratory by P.E. Gustafson (2) from fission products in the ground during the peak of nuclear weapons testing in 1963, and the maximum permissible dose of 170 mr per year to the average population according to the present Federal Radiation Guide levels accepted by the AEC. These local dose-rates are more than 10,000 times higher than the average dose-rate from all reactor operations to the U.S. public as a whole of about 0.001 mr per year cited by the AEC (3).

In Illinois during the mid-1960's infant mortality had reached levels about 60% in excess of expectations based on the trend prior to largescale testing (Bulletin of Atomic Scientists, December 1969).[4] Since the dose-rates from the gases emitted by the Dresden reactor are of comparable magnitude, it appears that significant increases in infant mortality might be detectable in the areas downwind from the prevailing westerly winds that should not be observed in the upwind direction. Furthermore, since about two-thirds of the population of Illinois, or some 6.6 million people, live within a radius of 50 miles from the reactor, the infant mortality rates for Illinois as a whole should show increases and decreases following the rises and declines of the short-lived annual gaseous activity released into the air.

That such a peak in infant mortality did in fact occur following the peak in the radioactive gases discharged may be seen from Figure 1, where the infant mortality rates for Illinois have been plotted together with those for a comparable large northern urban state, namely New York. Also shown in this figure is the annual amount of radioactivity discharged into the air from the Dresden reactor as reported in another recently published HEW study (BRH/DER 70-2)[5].

Examination of Figure 1 shows that in 1958, just prior to the start-up of the Dresden Reactor, the states of Illinois and New York had closely similar infant mortality rates of 24.9 and 24.5 per 1000 live births respectively. It is of interest that Illinois actually showed a lower death rate than New York in 1962 when localized fallout from the large Russian H-tests in 1961-62 occurred in the New York area. However, in 1964, a year after the rapid rise in emission from Dresden, the mortality rate for Illinois began a sharp climb while that in New York began to decline, giving rise to a period when the Illinois infant death-rates exceeded those for New York by 2.7 per 1000 births in 1968, with an absolute peak of 25.6 per 1000 births in 1965. This was a rate higher than encountered in Illinois in the eleven preceeding years, despite heavy Nevada testing during this period.

This rise of infant mortality in Illinois after the test-ban had come into effect in 1963 must be contrasted with the decline in New York and all other urban areas of the North, a situation that has now led Illinois to become the state of highest infant mortality among all the states in the entire North-East and North-Central regions of the U.S. It should be noted that although a nuclear reactor began operating in New York State 20 miles north of New York City in 1962, it was a pressurized water type (PWR) with annual gaseous emissions typically 10,000 times less than those for the Dresden reactor. (5) If this rise for Illinois as a whole relative to New York and all other states of the north is causally related to the gaseous emission from the Dresden BWR reactor, then the difference in mortality rates should be directly related to the annual amounts of short-lived radioactive gases discharged. That this does indeed appear to be the case is shown in Figure 2 where the difference in infant mortality rates between New York and Illinois has been plotted against the amount of radioactivity discharged. Least-square fits for the two periods 1963-67 and 1963-1968 have been calculated, showing a clear positive association between radiation dose and effect on infant mortality.

A similar direct correlation was found to exist for death-rates due to respiratory diseases other than pneumonia and influenza for all age groups in Illinois relative to 1959 and the amount of radioactive gas discharged. While during the decade from 1949 to 1959 these diseases, which include emphysema and bronchitis, increased less than 10% in Illinois, they rose 75% between 1959 and 1966 in direct proportion to the amount of radioactive gas discharged. Furthermore, while Illinois respiratory death-rates rose 75%, they increased by only 40% and 47% in heavily polluted Pennsylvania and New York. In Figure 3, the difference in the relative increase of respiratory disease deaths other than pneumonia and influenza has been plotted together with the annual gaseous releases from Dresden. It is evident that the death-rate increased at about the same rate as the gaseous emission, with a time-delay of one to two years.

A more stringent test may be obtained by examining the relative changes in infant mortality for the counties immediately adjacent to the one in which the reactor is located, and to compare the changes in the counties located downwind with those upwind as well as with similar counties more than 40 miles away to the north and west as controls.

Figure 4 shows a map of the counties in northern Illinois together with their total populations in 1964, the year prior to the peak emissions from the Dresden reactor located in Grundy county. The figures for infant mortality as well as the numbers of live births and infant mortality rates for the years 1964 and 1966 taken from the U.S. Vital Statistics are listed in Table I for Grundy and the five adjacent counties, as well as for six control counties located to the west and north-west that do not border on the Illinois river into which liquid effluent is discharged. The year 1964 is the year following a minimum in the gaseous activity released, just prior to the sharp rise in 1964-65. The bar-graph of of Figure 5 indicates the percent changes in infant mortality by 1966 relative to 1964 for the six adjacent and the six control counties.

Inspection reveals that among the six nearest counties, Grundy, the county in which the reactor is located, shows the greatest increase of infant mortality rates, namely 141% in excess of the 1966 rate. Next in increased rate is Livingston, to the south with a rise of 140%, followed by Kankakee to the south-east with a rise of 43%. Will to the north-east showed only a 5% rise, while LaSalle to the west actually showed a small decline of 7% and Kendal to the north registered a decline of 21%.

This tendency for upwind counties to show declines such as took place nearly everywhere else in the U.S. and all over the world since 1964 is confirmed by the bar-graph for the six upwind control counties more than 40 miles away, namely Lee, Knox, Stephens, Henry, Winnebago and Ogle, where only the last named showed an increase.

The probability of obtaining this result by chance along may be shown to be less than 1 in 200 by applying a simple statistical ranking test, and using the expectation that the downwind counties adjacent to Grundy should show increases rather than decreases in mortality rates by 1966. A similar test applied to the yearly excess mortality rates for Illinois relative to New York for the two 5 year periods before and after the sharp rise in emission which began in 1964 gives a probability of less than 1 in 250 that the observed ten year pattern of excess mortality rates in Illinois relative to New York would arise by pure chance alone. Inasmuch as these two tests are independent, the likelihood that both of these results are the result of mere chance fluctuation must be regarded as much lower than for either of these tests alone.

The likelihood that a causal relationship exists is further increased by the fact that data published in June 1970 by Dr. Alice Stewart of

Oxford University in the British medical journal "Lancet" [6] indicates that the human embryo in the first three months of its development appears to be some 500 times as sensitive for the induction of leukemia and other cancers as the mature adult, and that cancer incidence was directly proportional to the x-ray dose received.

Dr. Stewart's study involved some 19.5 million children born in England and Wales between 1943 and 1965, of which some 13,407 developed cancer before age 10. Dr. Stewart concluded that a dose of only 1 rad or 1,000 mr, given to a million infants just prior to birth in the course of pelvimetry, resulted in 300 to 800 additional leukemia and other cancer cases over a period of 10 years, compared with a spontaneous rate of about 700 per million births. When the x-rays had been given in the first three months of pregnancy, as happened in about 3% of the cases, the risk increased 15 fold, corresponding to a dose of only 80 mr needed to double the normal cancer mortality rate among the children.

Since for mature adults, a dose of 1 rad leads to only about 2 cases per year of leukemia per million individuals irradiated [7] or to 20 cases over period of 10 years corresponding to a "doubling dose" of 50 to 100 rads (500,000 to 100,000 mr), it appears that the early embryo is much more severely affected by radiation than the adult, in agreement with observations on laboratory animals. Yet it was in the basis of the low sensitivity of the adult that the present radiation standards were developed in the 1950's before Dr. Stewart's early data [8] had been confirmed in 1962 by the work of Dr. Brian MacMahon at the Harvard School of Public Health [9].

The measured radiation dose rates in the range of 10 to 300 mr per year downwind from the Dresden reactor could well have resulted in three-months doses of 2 to 75 mr to the early embryo during its most critical phase of development. Since in any five week period the present AEC regulations allow a maximum dose equal to the full annual amount of 500 mr to any individual in the general population, they imply that a six-fold increase in childhood cancer and leukemia is an acceptable risk to the population in return for the benefit of nuclear electric power generation. The measured doses do not take into account the various biological concentration mechanisms in the organs of the mother and the developing infant in utero for the radioactive cesium, strontium and yttrium daughter products among the rare gases emitted from the reactor.

It appears reasonable to expect that effects on the chromosomes of the embryonic cells which lead to underdevelopment and reduced ability to fight off respiratory and childhood infections are produced at about the same doses as chromosomal changes that lead to cancer development. On this basis, the radiation levels produced by localized weapons fallout or reactor operations measured for the case of Dresden and other reactors that emit large amounts of gaseous activity are of a magnitude sufficient to explain the observed rises in infant mortality.

The excess infant mortality in Illinois over that in New York leads to an estimated number of about 2,500 infants that died above normal expectations in Illinois over a ten year period between 1959 and 1968.

In view of the likelihood that this represents a causal effect, it would appear to be necessary to discontinue operation of the Dresden reactor, all other reactors of similar types such as those located in Humboldt, California and Charlevoix, Michigan, as well as the nuclear fuel processing facilities near Buffalo, New York, and to install devices to trap the radioactive gases now released into the air. Furthermore, all construction of large nuclear power reactors and fuel reprocessing facilities should be halted pending full studies of the evidence on health effects in the neighborhood of all existing nuclear facilities discharging large quantities of radioactive materials into the environment needed for a meaningful reexamination of present radiation standards.

Such epidemiological studies involving exposure of the general population to fission product releases have so far not been carried out either by the AEC or HEW, despite repeated requests by Congress and scientific advisory organizations and despite the grave implications that the mounting evidence for low-level radiation effects on the human embryo and infant has for the future of our children.

TABLE I

Infant Mortality Changes 1964-1966
in Illinois Counties near Dresden*

		1964 Deaths	1964 Births	1964 Rate 1000	1966 Deaths	1966 Births	1966 Rate 1000	Percent Change in Rates 1964-66
Adjacent Counties	Grundy (Reactor)	7	442	15.8	18	474	38.0	+141%
	Livingston (S)	6	728	8.2	12	608	19.7	+140%
	Kankakee (SE)	41	1976	20.7	54	1830	29.5	+43%
	Will (NE)	109	4920	22.2	100	4294	23.3	+5%
	LaSalle (W)	49	2176	22.5	39	1858	21.0	-7%
	Kendall (N)	11	460	23.9	7	422	16.6	-31%
								Av. +48%
Control Counties	Ogle (NW)	16	854	18.7	20	808	24.8	+33%
	Winnebago (NW)	122	5002	24.4	122	4788	25.5	+5%
	Henry (W)	17	930	18.3	16	862	18.6	+2%
	Stephens (NW)	25	978	25.6	20	803	24.8	-3%
	Knox (SW)	22	1130	19.5	17	946	18.0	-8%
	Lee (W)	17	658	25.8	9	594	15.2	-41%
								Av. -2%

* Source: U.S. Vital Statistics

Figure Captions

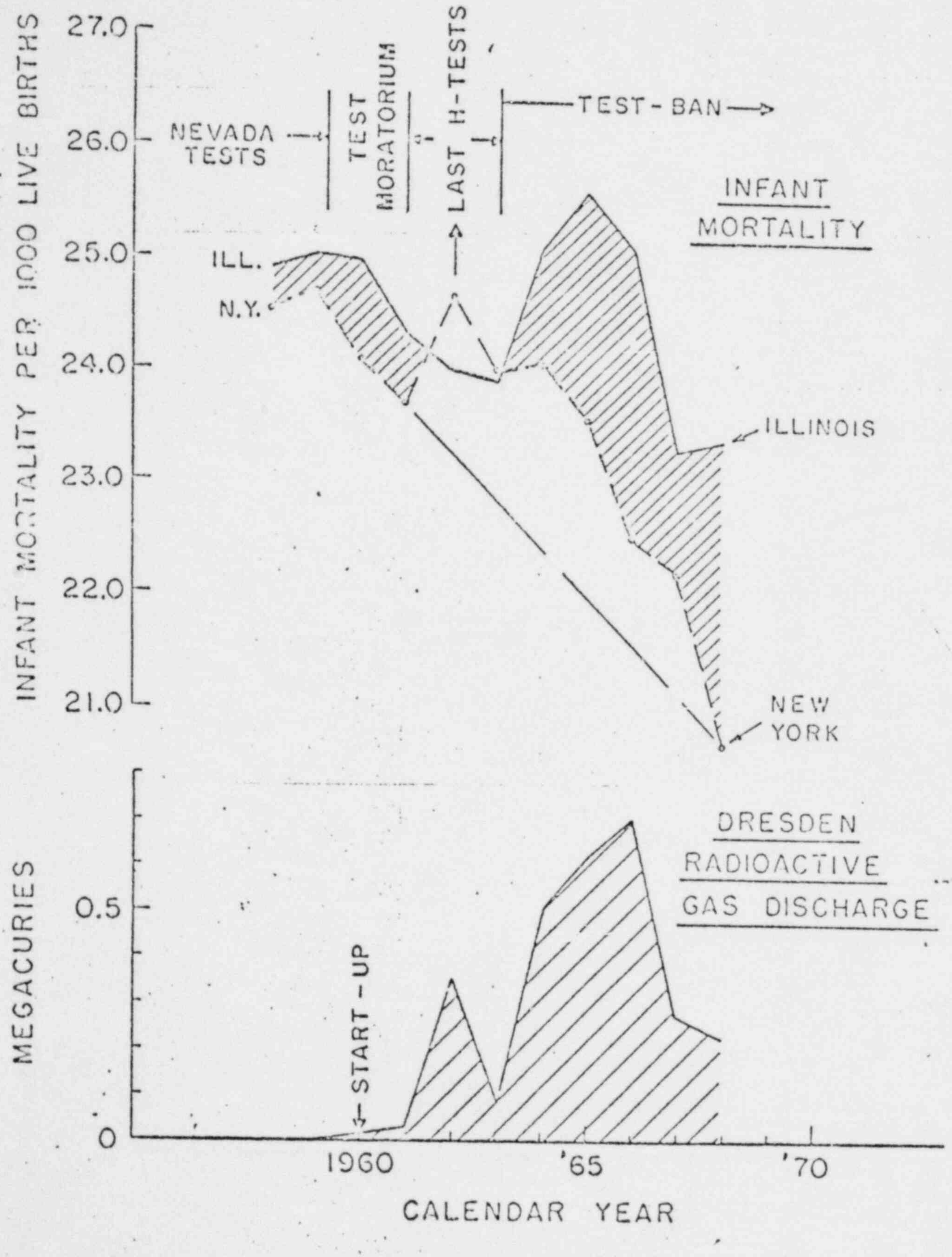
Fig. 1 Infant mortality rates per 1000 live births (0-1 year) for Illinois and New York compared with radioactive gas emission from the Dresden Nuclear Reactor (1959-1968). The excess of Illinois over New York mortality rates is indicated by shading.

Fig. 2 Difference in infant mortality rates between Illinois and New York plotted against annual gaseous releases from Dresden Reactor for the period of full power operation (1963-1968). Least square fitted lines for years 1963-1967 (N=5) and 1963-1968 (N=6). Correlation coefficients are 0.9233, t = 4.1262 for N=5 and 0.4296, t = 0.9515 for N=6.

Fig. 3 Excess respiratory disease death-rate for Illinois compared to New York vs. annual radioactive gas released from the Dresden reactor. Respiratory diseases are those other than pneumonia and influenza, and the excess rates per 100,000 are measured relative to the 1959 rate when the reactor began to operate.

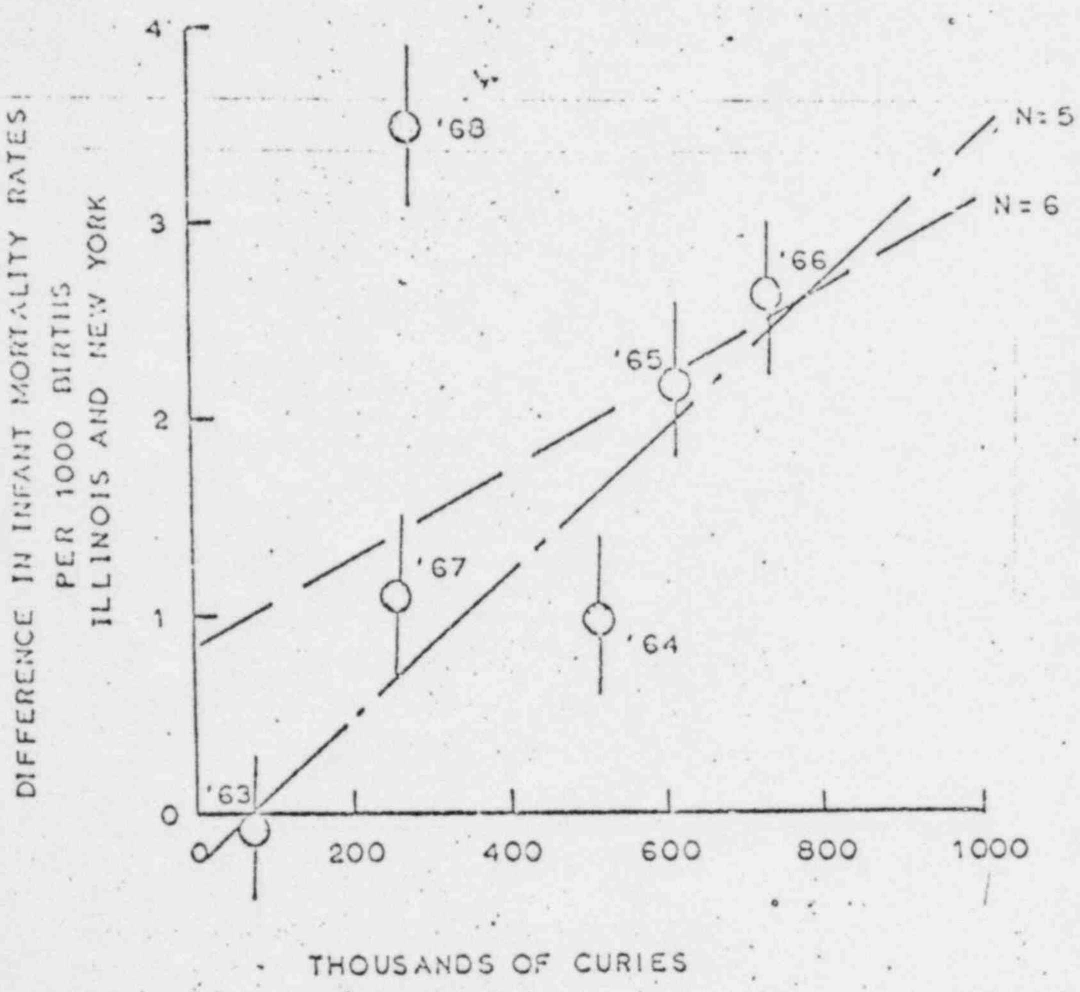
Fig. 4 Map of Illinois, showing populations in 1964 by counties. Reactor is located in Grundy county. Adjacent counties are indicated by shading, as are the control counties to the west. Cook county represents Chicago. Prevailing winds are from the north-west in winter, and from the south-west in the summer months. (See Ref. 1)

Fig. 5 Changes in the infant mortality rates per 1000 live births between 1964 and 1966 for the counties surrounding the Dresden Power Station located in Grundy County, Illinois. Also shown are the changes in a group of 6 control counties more than 40 miles to the north-west and west. The gaseous emission rate increased from 71,600 curies in 1963 to 610,000 curies in 1965.



INFANT MORTALITY PER 1000 LIVE BIRTHS
27.0
26.0
25.0
24.0
23.0
22.0
21.0
NEVADA TESTS
TEST MORATORIUM
LAST H-TESTS
TEST-BAN
INFANT MORTALITY
ILL.
N.Y.
ILLINOIS
NEW YORK
MEGACURIES
0.5
0
START-UP
DRESDEN RADIOACTIVE GAS DISCHARGE
1960
'65
'70
CALENDAR YEAR

Fig. 1



DIFFERENCE IN INFANT MORTALITY RATES
PER 1000 BIRTHS
ILLINOIS AND NEW YORK
4
3
2
1
0
'68
N: 5
N = 6
'66
'65
'67
'64
'63
0
200
400
600
800
1000
THOUSANDS OF CURIES

FIG.

Fig. 2

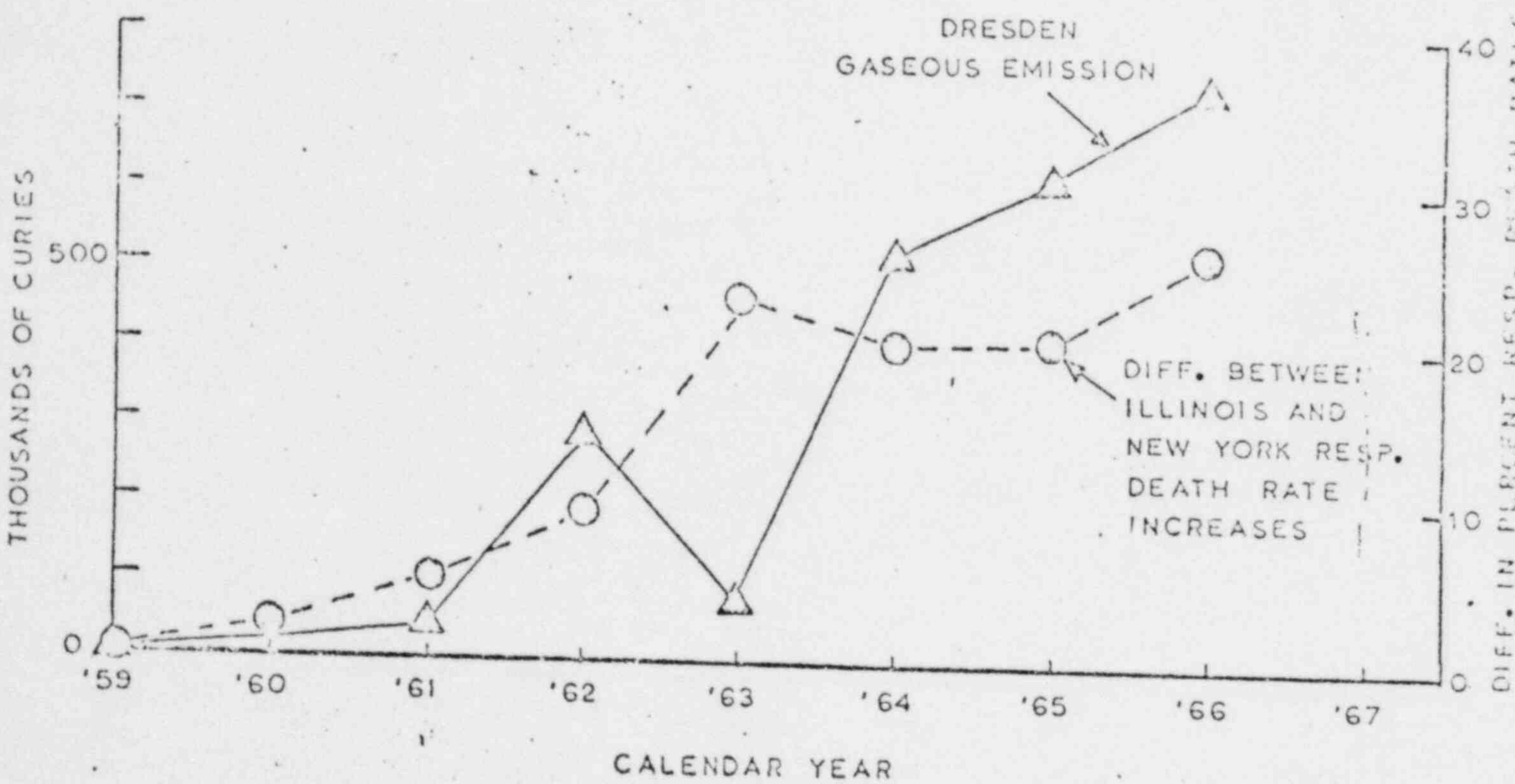
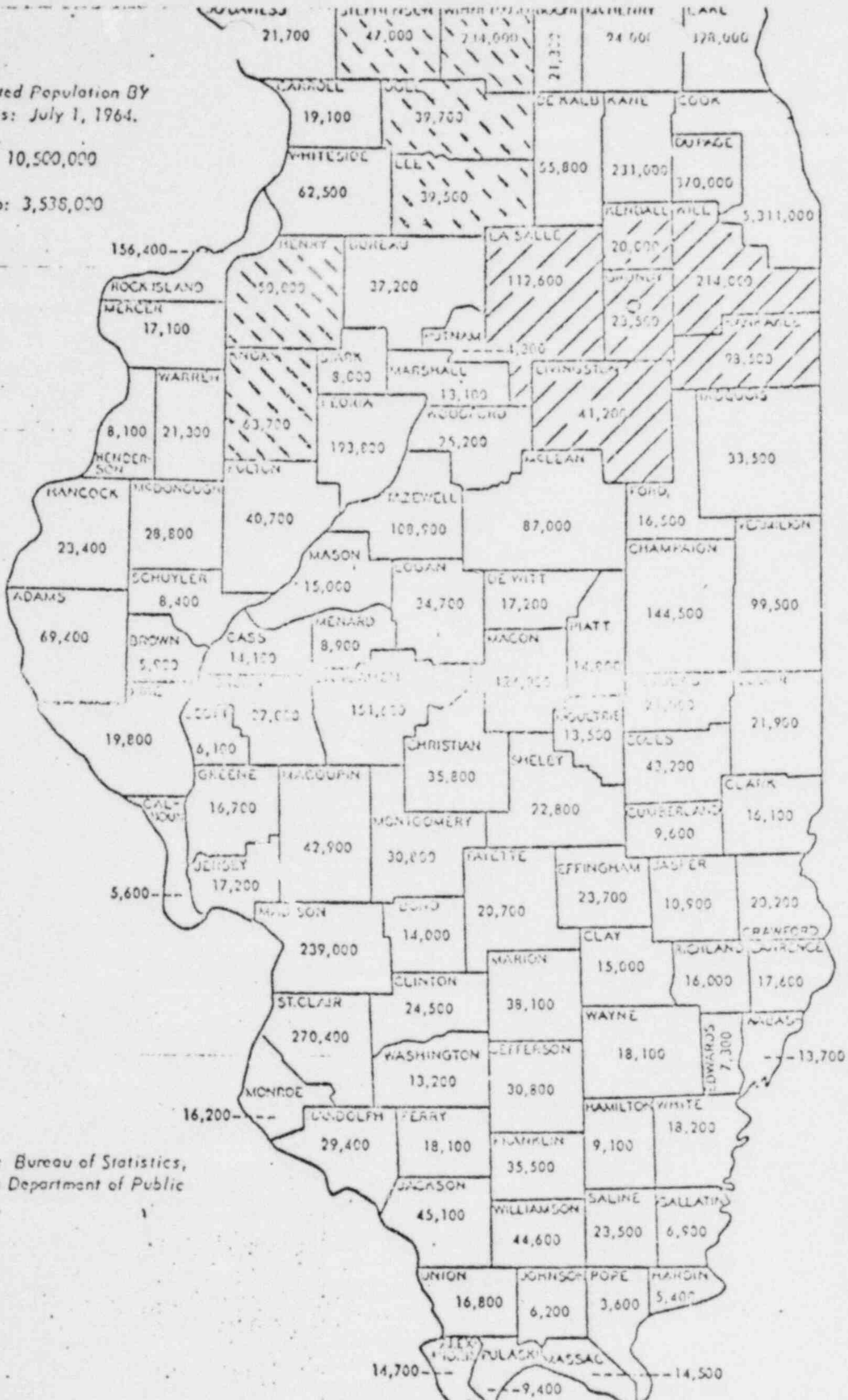

DRESDEN
GASEOUS EMISSION
THOUSANDS OF CURIES
500
0
DIFF. BETWEEN
ILLINOIS AND
NEW YORK RESP.
DEATH RATE
INCREASES
40
30
20
10
0
DIFF. IN PERCENT RESP.
'59
'60
'61
'62
'63
'64
'65
'66
'67
CALENDAR YEAR

Fig. 3

Estimated Population BY Counties: July 1, 1964.

Total: 10,500,000

Chicago: 3,538,000



Source: Bureau of Statistics, Illinois Department of Public Health.

Fig. 4

INFANT MORTALITY CHANGE 1964-66
ILLINOIS

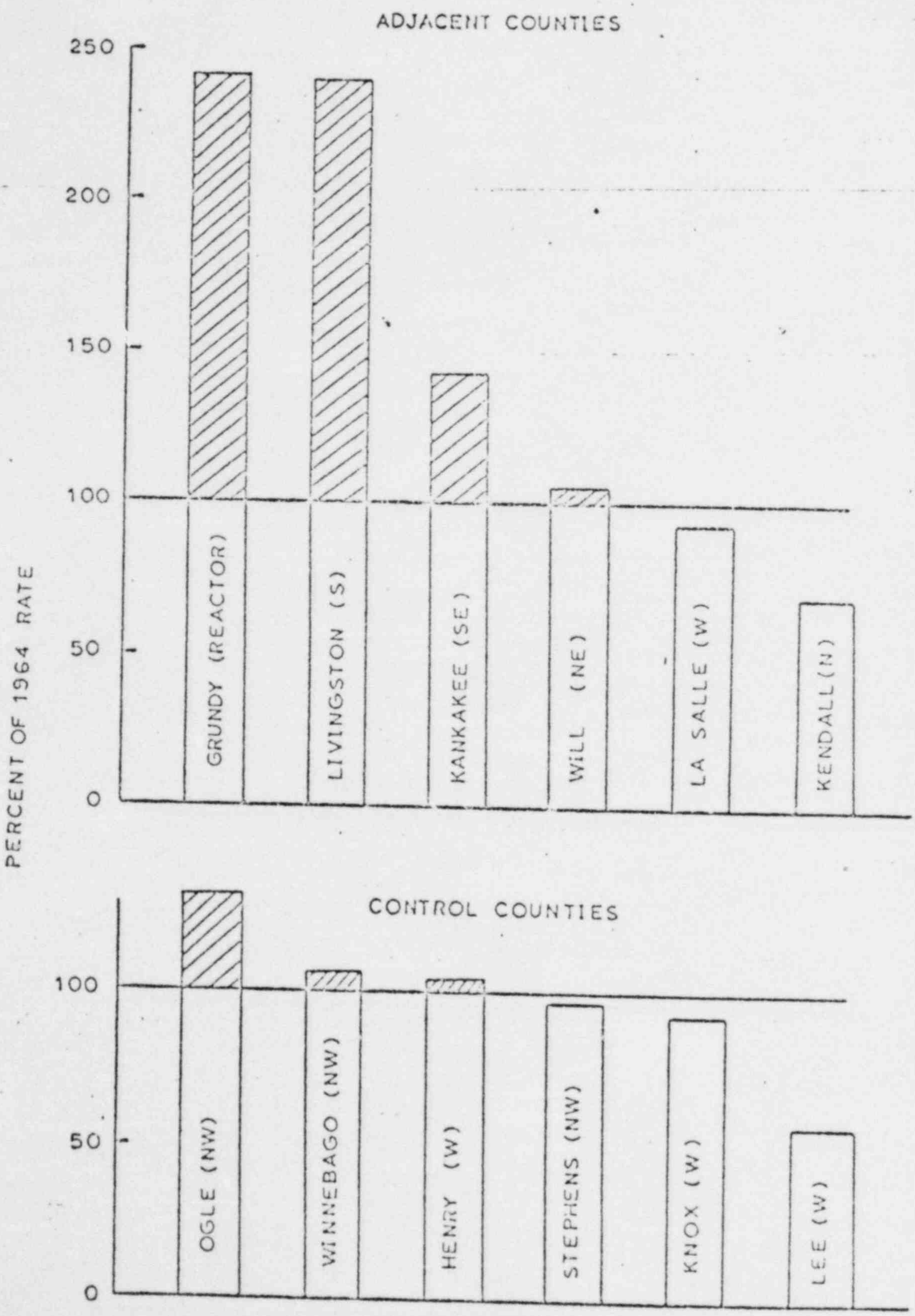


Fig. 5

References

(1) "Radiological Surveillance Studies of a Boiling Water Nuclear Power Station", BRH/DER 70-1 (March 1970), U.S. Dep. HEW, PHS, Rockville, Md.

(2) P.E. Gustafson, ANL Review 3, 67 (1966).

(3) N.Y. Times, October 18, 1970

(4) E.J. Sternglass, Bull. At. Sc. 25, 29 (Dec. 1969).

(5) "Radioactive Waste Discharges to the Environment from Nuclear Power Facilities", BRH/DER 70-2 (March 1970), U.S. Dept. HEW P.H.S., Rockville, Md.

(6) A. Stewart and G.W. Kneale, Lancet 1, 1185 (June 6, 1970).

(7) E.B. Lewis, "Science", 125, 965 (1957); also W.M. Court-Brown and R. Doll, Brit. Med. J. 2, 181 (1958).

(8) A. Stewart, J. Webb & D. Hewitt, Brit. Med. J. 1, 1495 (1958).

(9) B. MacMahon, J. Nat'l Cancer Inst. 28, 1773 (1962).

A Critical Review of "Infant Mortality and Nuclear Power Generation" by E.J. Sternglass

A. K. Davis and Bernd Kahn

In an analysis of epidemiologic data from Illinois and the counties surrounding the Dresden nuclear power reactor at Morris, Illinois, Dr. Sternglass claims that he detects serious effects on human health. (See attached draft Appendix III). His evidence consists of a comparison of infant mortality and certain respiratory deaths with the peak emission from the Dresden reactor. He calculates a dose rate of 22 mR/yr at a distance of 15 km from the plant, and implies a significant dose to metropolitan Chicago. Infant mortality in New York State and Illinois for the period of 1958-1968 is compared with the radioactivity emitted from Dresden. From 1963 to 1965 the total infant mortality in Illinois increased from 23.9 to 25.1/1,000 live births and remained at approximately this level during 1966 when the discharged radioactivity was at a maximum. A plot of the difference between Illinois and New York State for the period 1963-1968 is interpreted by Sternglass as showing a causal relation between infant mortality and the gaseous emissions. A similar type of analysis was performed for certain respiratory disease deaths in all age groups in the two states, with a similar conclusion. Sternglass extended the analysis of infant mortality to the counties bordering the reactor site by comparing 1964 and 1966, the peak emission year. The county in which the reactor is located and a "downwind" county, Livingston, show more than 200 percent increases in infant mortality.

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The review of this paper has been divided into two sections. An evaluation of exposure is presented in Appendix I, and the analysis of the epidemiologic data is presented in Appendix II. A summary of these two sections follows.

Exposure:

The original data for the exposure calculations are from a radiological surveillance study at Dresden by the Bureau of Radiological Health, DHEW. These data have been examined and it was concluded that the radiation exposure has been greatly overestimated by the calculations of Sternglass. The calculated radiation exposure in 1968, at a distance of 1-2 km from Dresden, was approximately 1/30th of the 114 to 340 mR/yr that are given in the Sternglass article. Radiation exposure from the gas plume decreased continuously with distance between 1 and 18 km. On the basis of radiation measurements, the estimated exposure was 0.4 mR/yr at a distance of 18 km from the plant. Accordingly, these measurements suggest that, of the 6.6 million people who live within 50 miles of Dresden, virtually the total population are exposed to considerably less than 0.4 mR/yr. This compares with a variation in background radiation of 46 to 110 mR/yr, depending on location and housing within the area. Furthermore, the radiation dose from radionuclides of strontium-89 and cesium-137 through inhalation, ingestion in milk, leafy vegetables and meat was calculated to be less than 1 mrem/yr to the relatively few exposed persons. Finally, the classifications of "upwind" and "downwind" used by Sternglass were not accurate. Meteorological data indicate that, contrary to the Sternglass article, Will County is more frequently downwind from Dresden than Livingston County.

Epidemiology:

Sternglass' evidence of serious health effects from the emission of the Dresden reactor consists of an analysis of changes in infant mortality and respiratory disease deaths except pneumonia and influenza for all ages. His initial evidence is that infant mortality in Illinois is greater than that in New York. However, New York is not an adequate comparison state for Illinois, as shown by the infant mortality data from 1955-1961. Furthermore, the principal population potentially exposed is metropolitan Chicago--not the State of Illinois, and when the city of Chicago is compared to St. Louis, the total infant mortality for both areas follow the same pattern. Part of the difference between Chicago and New York City is related to fewer nonwhite births in New York.

Sternglass suggests that a relationship exists between reactor effluent and the difference in infant mortality between New York State and Illinois. This interpretation is questioned because of two factors. First, the range of "excess" infant mortality (Illinois minus New York) is large (-0.7 to +3.4/1,000) with the minimum and maximum differences occurring at a single effluent level. Secondly, a year's lag would be expected since infant mortality resulting from *in utero* irradiation would be reflected the year following birth. On this basis, a comparison of the curves for emission and infant mortality shows that the 1961 emission peak is followed by a fall in infant mortality in Illinois, and the subsequent rise precedes the peak emission, whereas a fall occurs at the peak discharge.

Sternglass also analyzes the Illinois counties with the highest potential exposure. Here the number of infant deaths are few, and consequently, one must consider several years to determine the basic rate for infant mortality. Sternglass' use of a single year, 1964, is not representative of the yearly average. It is also not an unirradiated control since the reactor emissions began in 1960. The "increase" in infant mortality in Livingston County is an artifact resulting from an unusually low 1964 value. In most reactor locations the population is small, as in Grundy County, with correspondingly few births and therefore few infant deaths. Consequently, a high variability is characteristic of the data. Although the rise in infant mortality is significant in Grundy County, whether radiation exposure is the cause of this rise cannot be determined because of many other causes of infant mortality.

The death rate for all ages due to respiratory disease other than pneumonia and influenza was 10.9/100,000 in Illinois and 13.0/100,000 in New York in 1960. By 1967, both states had risen to the same rates (18.6 and 18.7/100,000). Two considerations indicate that radiation exposure is unlikely to be the sole cause of this change. First, there are many diseases with various causes included in the category, and the rise in death rates from this cause is occurring throughout the United States. More important, radiation exposure is reduced by diffusion of the gaseous emission and the dose to the lungs of the exposed population is considerably less than 0.4 mR/yr. It is highly unlikely that this dose could contribute significantly to respiratory deaths in adults.

In summary, this analysis shows that radiation exposure has been grossly overestimated. In addition, the changes in infant mortality do not correlate with the radioactive emissions from the reactor site.

Appendix I

Radiation Exposure:

An article entitled "Infant Mortality and Nuclear Power Generation" was presented at the Pennsylvania State Senate hearings on October 21, 1970, in Harrisburg, Penna., by Dr. Ernest J. Sternglass of the University of Pittsburgh. This article contained radiation exposure calculations near the Dresden I Nuclear Power Station. The original data for these calculations are from the radiological surveillance study at Dresden by the Department of Health, Education, and Welfare.(1) There are certain inconsistencies in the use of the DHEW data by Dr. Sternglass. It is the purpose of this discussion to point out these inconsistencies and to indicate the proper use of the data in making exposure estimates.

(1) According to our calculations, the radiation exposure in 1968 at a distance of 1-2 km from Dresden was approximately one-fiftieth of the values of 114 to 350 mr per year that are given in the Sternglass article. The values in the article were computed by multiplying hourly exposure rates, measured during half-hour periods near ground level beneath the centerlines of the gas plume from the Dresden stack, by the number of hours per year. To obtain values of annual radiation exposure at specific locations from short-term exposure measurements at the centerline of the gas plume, however, one must take into account the fact that the wind at Dresden blows in all directions in the course of the year, and that the plant

does not operate 365 days per year. The radiation exposure on the ground from the plume decreases rapidly as the distance from the centerline of the plume increases. We calculated that, a distance of 1-2 km from the plant, the annual exposure rate at a specific location was equal to the short-term exposure rate times the wind frequency in an 8° sector from the plant toward that location. At the three measurement locations, the wind-direction frequency for an 8° sector was approximately 3 percent in 1968, and the plant operated during 64 percent of the year; hence the exposure was approximately (115 to 350) x 0.03 x 0.64 = 2 to 7 mr per year. The exposure measurements were in directions of relatively high wind frequencies; data for wind frequency in other directions suggest that the annual average radiation exposure in those areas was approximately 30 percent lower, and the maximum value, approximately 30 percent higher.

The 2-week measurements with thermoluminescent dosimeters near Dresden that are cited on page 2 of the Sternglass article support these values of annual radiation exposure. The values of 17-26 mr per year, calculated in this article without considering the above-mentioned factors, must be multiplied by 0.5, however, as indicated in the surveillance report.[1] This factor takes into account the ratios of the annual value to the 2-week value for wind frequency in the direction of measurement (8.0/5.9), and release rate of radionuclides (8,000/11,600). Thus, the three highest 2-week measurements indicate radiation exposures of 9 to 13 mr per year. Seven other measurements show show radiation exposures below 9 mr per year.

The short-term radiation exposure at a distance of 18 km from Dresden, given on page 2 of the Sternglass article as 22 mr per year, must also be multiplied by the factors that take into account the brevity of the period of radiation exposure from the gas plume during the year. The multiplication factor used above--0.03 x 0.64--yields 0.4 mr per year as the estimated radiation exposure in 1968 at the 18 km distance.

These exposures are approximate, because the measurements on which they are based were intended only to demonstrate surveillance techniques and indicate the magnitude of the exposure, and are too few to provide definitive annual exposure data. Hence, the calculations presented in this discussion have been kept simple and within the framework of values cited in the Sternglass article. Our measurements and calculations indicate, however, that the external radiation exposure in 1968 at locations 1-2 km from Dresden, under the conditions defined in our surveillance report and the reported annual discharges was definitely not several hundred mr per year, but instead, approximately 10 mr per year at the location of maximum exposure, with the average exposure at this distance being approximately 5 mr per year.

The natural radiation background near Dresden ranged from 46 to 110 mr per year, with an average of 80 mr per year.(1) The external radiation exposure 1-2 km from Dresden due to gases discharged at Dresden was, therefore, a small fraction of the background, and smaller than differences in the background at various locations.

(2) Radiation exposure from the gas plume decreased continuously with distance between 1 and 18 km from Dresden.[1] Further decreases at greater distances are expected because of horizontal and vertical dispersion of the gas, and radioactive decay of the short-lived radionuclides. Our radiation measurements indicated an exposure of 0.4 mr per year 18 km from the plant in 1968. Accordingly, these measurements suggest that, of the 6.6 million people who live within 50 miles of Dresden, 99.5 percent are exposed to considerably less than 0.4 mr per year.

It is estimated that several hundred persons live within approximately 2 km of Dresden and therefore may be exposed to approximately 10 mr per year or less due to gases discharged at Dresden. An additional 30,000 persons are estimated to live within an 18-km radius and to receive radiation exposures between 0.4 and 10 mr per year from Dresden; most of these persons live at distances of 10 to 18 km, where the radiation exposure would be approximately 1 mr per year. Thus, few persons among those living in Illinois are exposed to measurable increments of radiation from the gases discharged at Dresden.

In view of the cited death rates due to respiratory diseases, we also considered the magnitude of the concentration of radioactive gases discharged at Dresden to which the respiratory system would be exposed. At the 1968 discharge rate of 12,400 μCi/sec during 64 percent of the time, the average radionuclide concentration in ground-level air 1-2 km from Dresden at the short-term measurement locations was computed to be 1,400 pCi/m^3, based on the observed dispersion factor of 6×10^{-6} sec/m^3[1] and the wind-direction frequency of 3 percent to an 8^o sector. The annual average concentration would be approximately 1/50 of this concentration i.e., 30 pCi/m^3 -- at a distance of 18 km due to dispersion and radioactive decay, and even lower at greater distances. The concentration of gases from Dresden at a distance of 18 km and more from the plant is lower than that of naturally occurring radioactive ^{222}Rn gas, for which 100 to 400 pCi/m^3 are typical values in this area.[2]

(3) The statement that "the measured radiation doses do not take into account the various biological concentration mechanisms in the organs of the mother and the developing infant in utero for radioactive cesium, strontium, and yttrium daughter products" should not be taken to mean that these unaccounted-for doses are significant. Radiation dose rates from ^{89}Sr and ^{137}Cs--including both measured concentrations at discharge and computed concentrations from the decay of the radioactive gases-through inhalation and through ingestion in milk, leafy vegetables, and meat, were calculated to be considerably less than 1 mrem per year to the relatively few exposed persons in the immediate environs.[3] Doses from other measured particulate radionuclides and gaseous ^{131}I and ^3H were equally low. If other radionuclides or paths appear to be significant, it would be desirable to identify them so that they could be evaluated.

(4) <u>The concepts "upwind" and "downwind" were apparently reversed in the article, in that Will County is more frequently downwind from Dresden than Livingston county.</u> In 1968, the wind at the stack height blew over Dresden from the SW, WSW, and W toward Will county during 24 percent of the year, and from N, NNE, and NE toward Livingston County during only 11 percent of the year.[4]

References:

1. Kahn, B. et al., "Radiological Surveillance Studies at a Boiling Water Nuclear Power Reactor" Public Health Service Rept BRH/DER 70-1 (1970)

2. Moses, H., H.F. Lucas, Jr., and G.A. Zerbe, J. Air Pollut. Cont. Assoc. 13, 12 (1963)

3. Blanchard, R.L. et. al., "Dose Rates Derived from Radiological Surveillance Studies at a Boiling Water Reactor Nuclear Power Station", presented at Health Physics - Midyear Topical Symposium (1970).

4. Dresden Nuclear Power Station, Meterological Data, 1968.

Appendix II. Epidemiologic Considerations

The purpose of this section is to examine in detail the epidemiologic data which Sternglass submits as evidence for a causal relationship between radioactive emissions from the Dresden reactor and an increase in infant mortality and respiratory deaths for all ages. The basic facts needed to establish association are: (1) A known exposure to ionizing radiation, and (2) changes in infant mortality must be shown to be related to this exposure. In addition, the effect of other factors which are known to influence infant mortality must be evaluated. It should be noted also that cause and effect are not proven by a positive association, nor does lack of association necessarily imply that no effect was produced.

The Dresden reactor is located in the northeast section of the State and the prevailing wind at the site is from the southwest. On the basis of radiation measurements, the estimated exposure was 0.4 mR/yr at a distance of 18 km from the plant. The average exposure at Chicago, a distance of 80 km from the plant, would be considerably less than 0.4 mR/yr. Biologically, this is considered a very small dose, as the measures of biological effects require at least 1,000 times this amount to be detectable.

Sternglass chose to compare statistics from New York State and Illinois, since two-thirds of the Illinois population resides in metropolitan Chicago. The following analysis will also more closely examine the potentially exposed population of metropolitan Chicago. Infant mortality in the rural areas of Illinois and New York are similar over a seven year period (Figure 1) nor do the changes correlate with the discharge from the Dresden reactor.

The infant mortality in the cities of New York, Chicago and St. Louis, as well as the standard statistical areas designated as the metropolitan areas were also analyzed. For brevity, only the data for the cities are presented, although similar conclusions can be drawn from the metropolitan populations. When total infant mortality is considered, the marked difference between the white and nonwhite mortality rates (Figure 2) requires that comparison areas have nearly equivalent white/nonwhite ratios. From 1960-1968, the percentage of nonwhite live births to total live births consistently rises from all three cities (Figure 3). The values for St. Louis exceed, but more closely approximate Chicago than does New York. As New York has a larger percentage of white births (with a concomittant lower rate) the total infant mortality tends to be less than Chicago (Figure 3). The ratio of white/nonwhite births in unexposed St. Louis more closely approximates the Chicago population and St. Louis closely follows the trends for Chicago (Figure 3). However, the ratio of white to nonwhite live births is not the only factor involved, as shown by a comparison of rates of infant mortality in the white and nonwhite populations of the three cities (Figure 2 An increase in total infant mortality from 1964-1966 for both St. Louis and Chicago is also related to an increased infant mortality, particularly in the nonwhite population. It is unlikely that the increase can be related to radioactive emissions from the Dresden reactors, since unexposed St. Louis shows a similar pattern to Chicago.

There are three reasons to question whether the differences in infant mortality between New York State and Illinois vary from the pattern of 1955-1964. First, the magnitude of the change is similar to the range of 23.4 to 24.7/1,000 live births characteristic of the period. (Figure 4)

Secondly, the rural portions of the state are not different. Finally, the difference in the ratio of white to nonwhite birth in the two states is becoming larger by 1964. As Sternglass indicates, the reduction in infant mortality appears to be more rapid in New York City than in Chicago, but the reasons for this difference is not known.

The "excess" infant mortality in Illinois both before and after the reactor began operation in 1960, appears to be related to prematurity although attempts to define the cause more precisely have not been fruitful. If the radiation effects postulated by Sternglass occur in utero, the effects would appear after birth and, hence, be recorded a year later than exposure. Thus, the first year of reactor operation, 1960-1961, should elicit a major portion of the increase in infant mortality in 1962. (Sternglass, Appendix III, Figure 1). No such change is observed. The 300,000 curies released in 1962 again produced no effect on 1963 infant mortality. In 1963, the release fell to 80,000 curies, but was followed by an increase in infant mortality (1964). Thus, the increase in infant mortality preceded maximum releases of radioactivity in 1964, 1965, and 1966. During two years when 500,000 and 600,000 curies were released, the difference in infant mortality between New York State and Illinois peaked. However, a reduction in infant mortality in 1966 occurred during a period when gaseous release was at a maximum of 700,000 curies per year. Thus, the time course of changes in infant mortality in Illinois is not correlated with the changes observed in gas discharge. If the in utero period is the time of significant irradiation, the rise in infant mortality precedes the peak emission and a fall occurs during maximal discharge.

Sternglass also plots the difference in infant mortality between

New York State and Illinois against the radioactive emission from the Dresden reactor. (Appendix III, Figure 2). Some fundamental objections to the plot are: (1) Two years of operation are omitted, 1961 and 1962. (2) As discussed in the preceding paragraph, the lag time of one year for infant mortality should be plotted against the activity levels. (3) The plot assumes that New York State is an adequate control for Illinois which has been questioned in a previous discussion. Nevertheless, the range of the observations is large (-0.7 to +3.4/1,000 live births) with the maximum and minimum both occurring around 300,000 curies per year, and the distribution of all the data points makes any relationship between exposure and effect doubtful.

A plot of the 1960-1967 infant mortality data from the counties around the reactor is presented in Figures 4 and 5. As the reactors are purposefully placed in sparsely populated areas, the population in the county in which a reactor is located is usually small and a high variance in infant mortality results from the small number of births and deaths being recorded. Such yearly fluctuations are evident from even a casual inspection of Figures 5 and 6. Because of the variance, it requires several years to establish a valid estimate of base line values. Sternglass' use of a single year, 1964, as a base misrepresents the trend. In Livingston County, the 1964 value is significantly lower than the preceding and following years. Consequently, the 234 percent increase for Livingston in 1966 can be also presented as a reduction of 68 percent of the 1963 value. The infant mortality in Grundy is numerically small, but the 18 deaths in 1966 is a high for the 1960-1967 period, and it is significantly different from the mean and from the 1964 value. Were these deaths caused by radiation exposure?

Are they the result of infection, disease, or accident? To answer these questions more detailed knowledge of the causes of death are required than are available to the author.

None of these data can be interpreted to mean that the large quantities of radioactivity released into the atmosphere have no effect on the infant mortality. The number of births and deaths in a county of 20,000 is so small, and the possible etiology so varied, that the analysis could only detect very large changes caused by a single agent.

Sternglass' proposed relationship between respiratory diseases and radiation exposure is based on a difference in the rate of increase between Illinois and New York. Both States had similar rates in 1967 (18.6 and 18.7/100,000), but in 1959, Illinois and New York had rates of 10.9 and 13.0/100,000, respectively. The rise in both states is not unique, but is observed in the United States as a whole and is probably related to many factors common to urban life. To resolve this problem would require an analysis of the specific disease categories in several states. Many of the etiological factors are unidentified and it appears extremely unlikely that the radiation is the single causative agent in Illinois. Perhaps the strongest evidence to substantiate this position is that the estimated exposure is considerably less than 0.4 mR/yr. This can be compared to the variation in background level of 40-110 mR/yr measured at different locations within the area of Dresden.

Although Dr. Sternglass has presented no data for the potentially exposed population, he discusses the possibility that the incidence of all malignant tumors and of leukemias might be increased in the irradiated population. Such malignancies may have a long latent period at low dose rates so it is not surprising that data for St. Louis, Chicago and New York City show no definitive trends over the 1960-1967 period. (Table 1) A comparison of death rates from all neoplasms shows that metropolitan St. Louis and New York are consistently higher than Chicago. It is evident that the rates for Chicago are not related to the gaseous discharge from Dresden over the 1961-1967 period. On the same basis the death rates from leukemia for metropolitan New York, St. Louis and Chicago are not significantly different over the 1960-1967 period. Neither the death rate from leukemia nor from all neoplasms are correlated with the gaseous discharge from Dresden.

Summary

This analysis of the epidemiologic data presented by Sternglass does not support his contention that an association exists between exposure to the radioactive emissions from Dresden and infant mortality. In contrast, the data can not be interpreted to mean that no effects were produced by the radiation exposure. However, if radiation from the Dresden reactor contributes to infant mortality or respiratory deaths in Illinois or Chicago, it has not been demonstrated by this study.

Figure 1 - Infant Mortality Rates in Illinois and New York State, Non-metropolitan
(1960-1967)

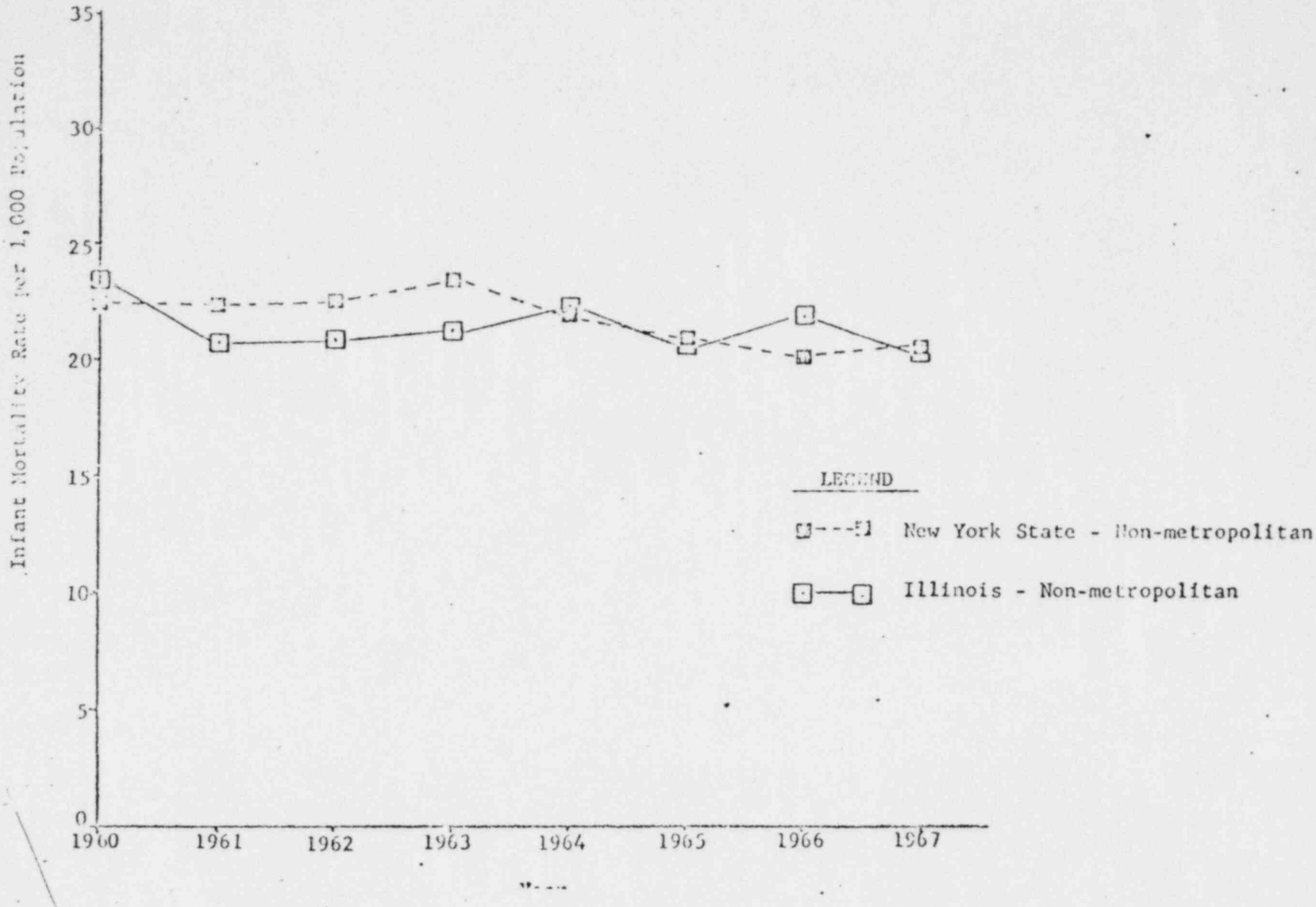

Figure 2 - Infant Mortality Rates by White and Non-White for Cities of Chicago, New York, and St. Louis - 1960-1968

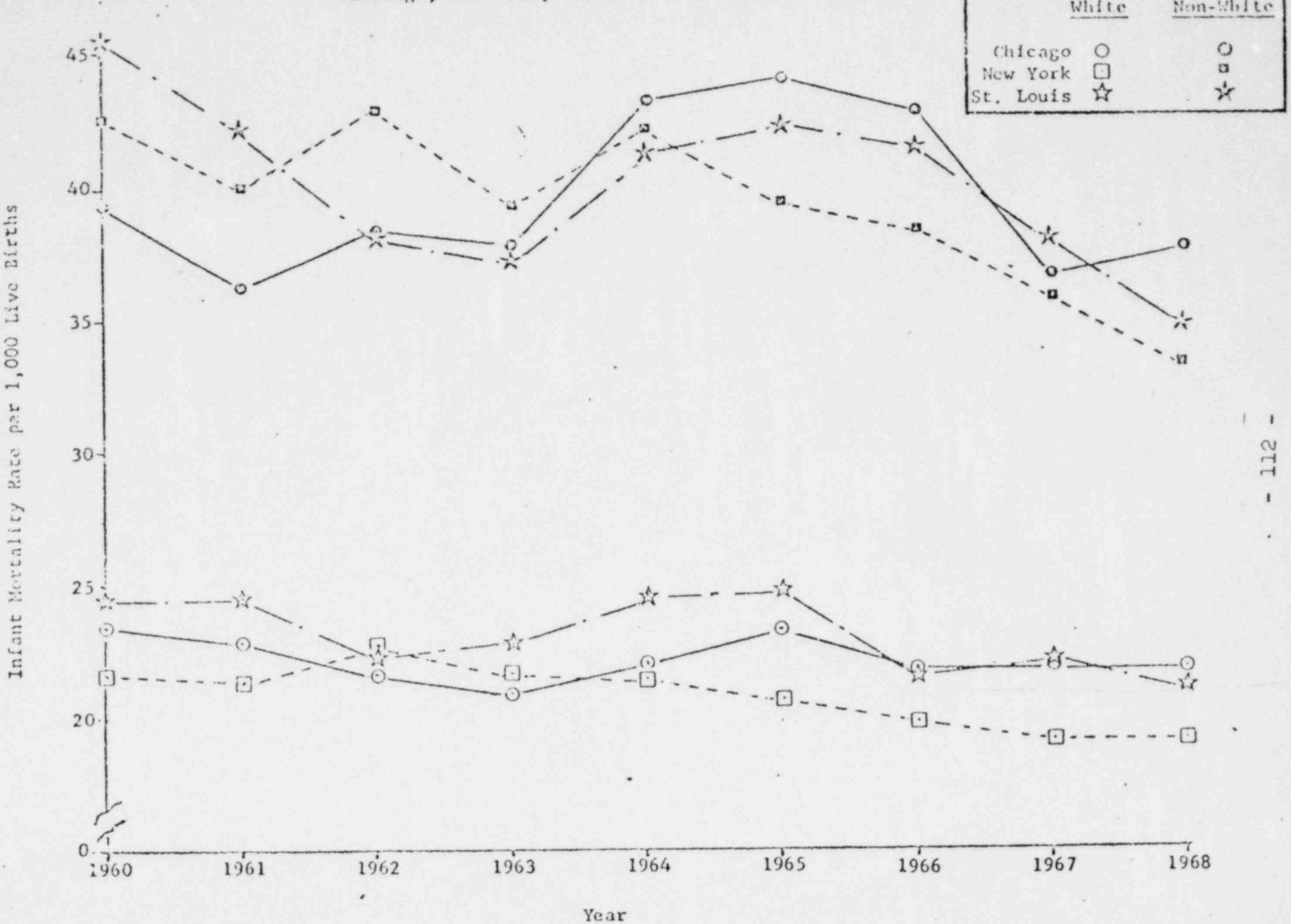

Figure 3 - Infant Mortality Rates and Percent Non-White of Total Live Births for Cities of Chicago, New York, and St. Louis - 1960-1968

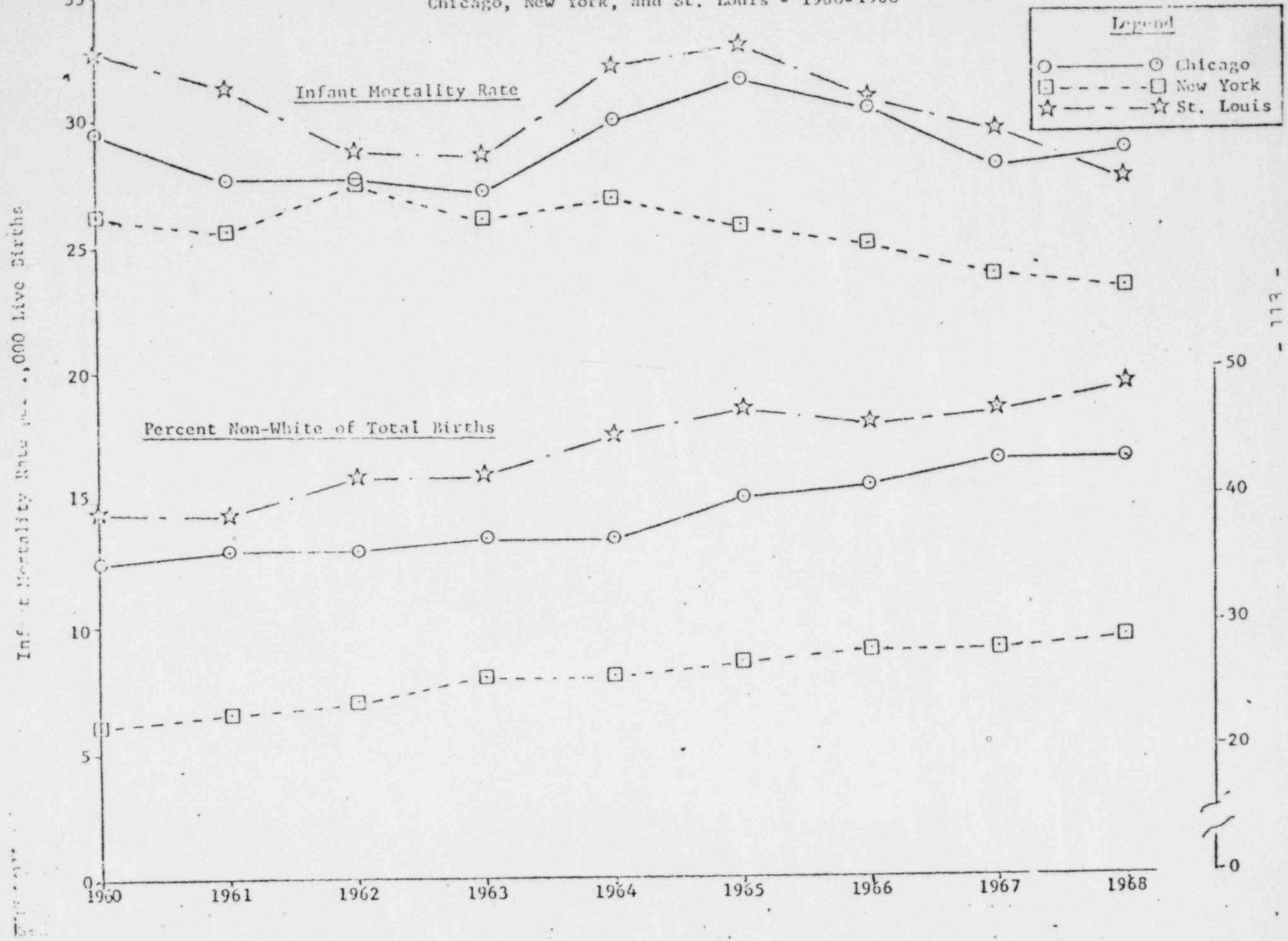

Figure 4 - Infant Mortality Rate in Illinois and New York State
(1955-1966)

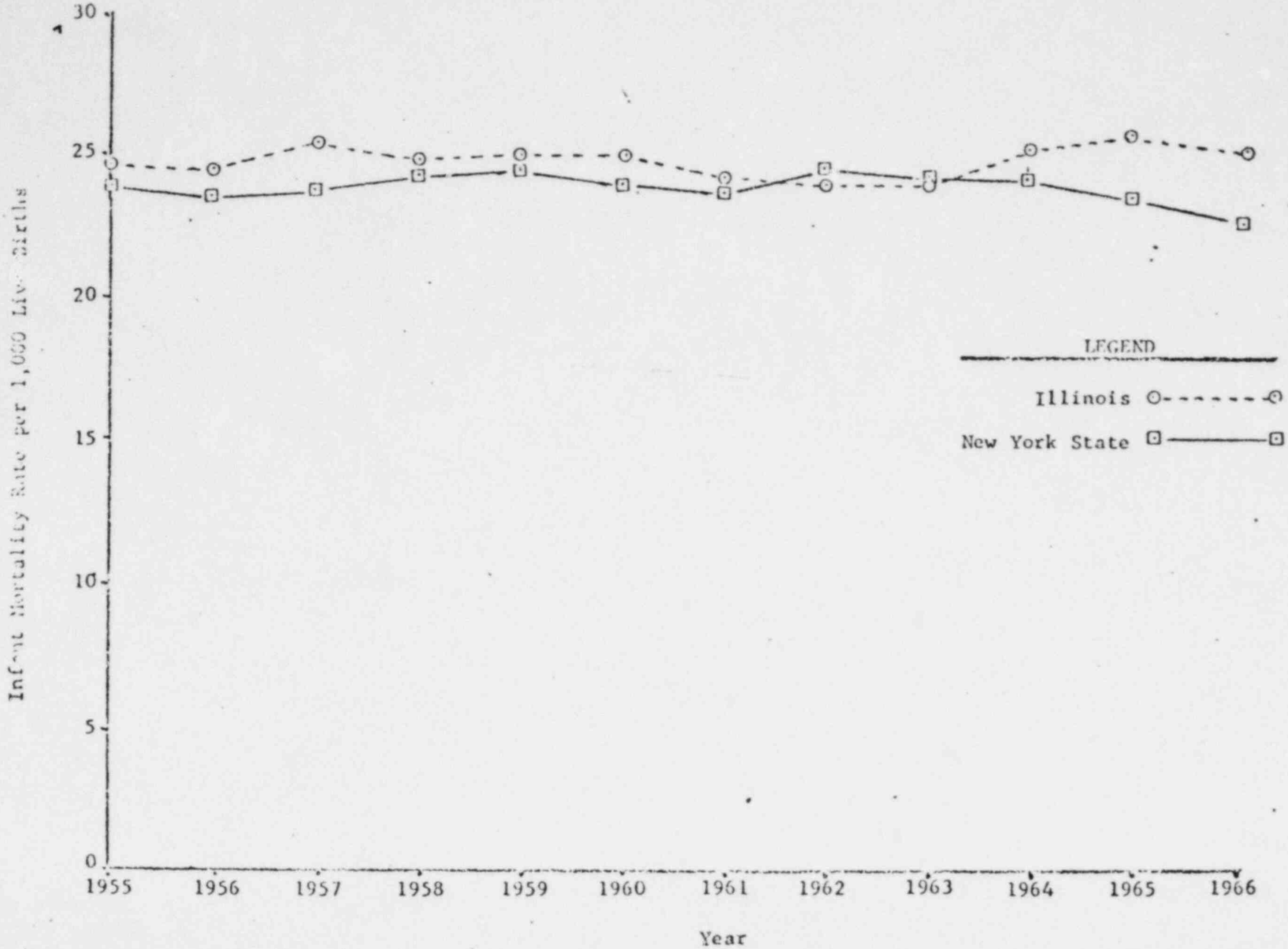

Figure 5 - Infant Mortality Rate in Counties Adjacent to the Dresden Reactor (1960-1967)

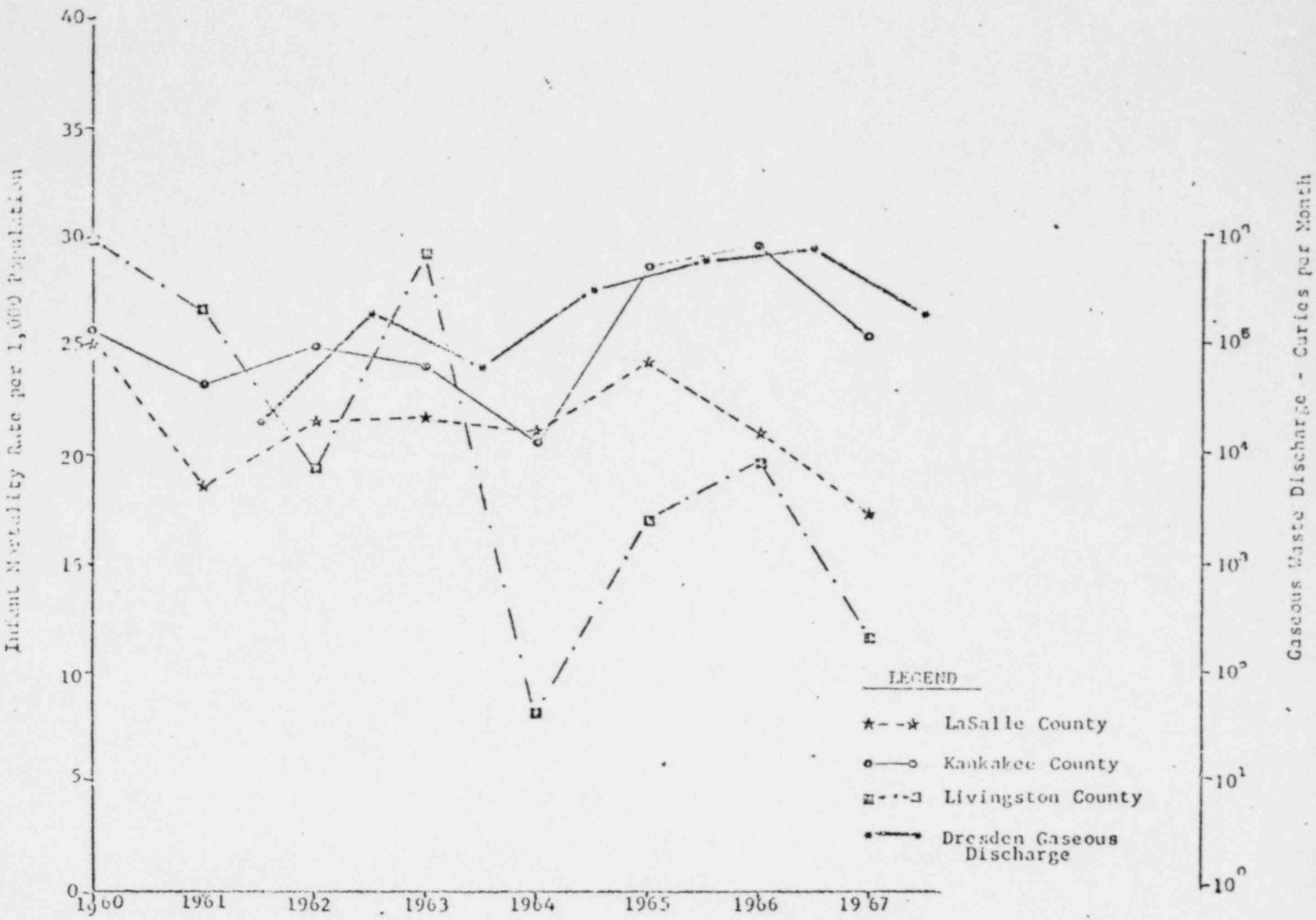

Figure 6 - Infant Mortality Rate in Counties Adjacent to the Dresden Reactor (1960-1967)

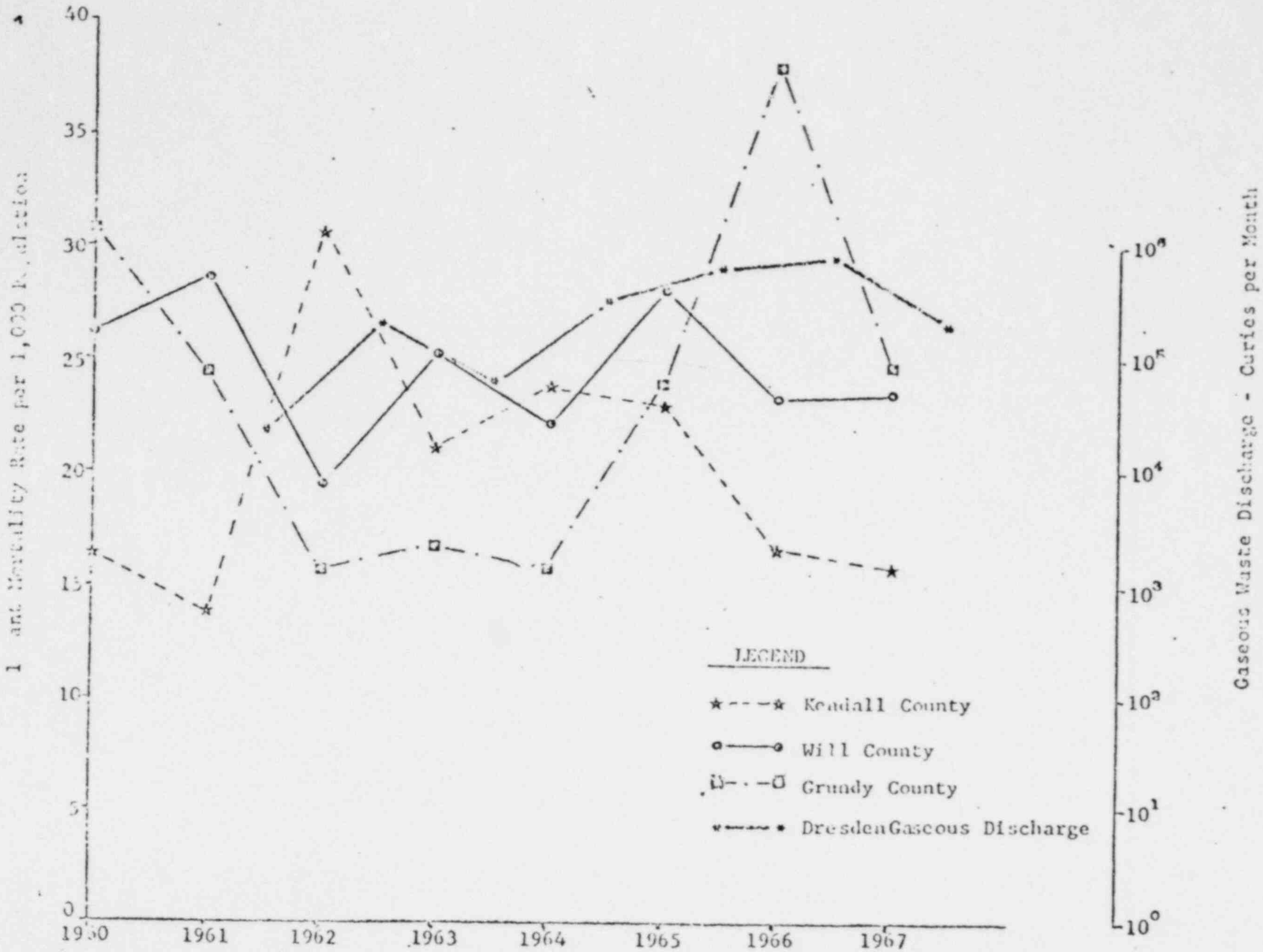

TABLE I

Deaths and Death Rates from All Neoplasms and Leukemia
Cites of Chicago, New York, St. Louis
1960 - 1967

Year	All Neop. except Leukemia	Leukemia (204)	All Neop. (140-205)	Popul.*	Rate/100,000 All Neop. exc. Leuk.	Leukemia	All Neo.
Chicago							
1960	6,887	280	7,167	3,550,404	194	8	202
1961	6,701	325	7,026	3,527,890	190	9	199
1962	6,621	259	6,880	3,505,376	189	7	196
1963	6,809	278	7,087	3,482,862	196	8	203
1964	6,684	236	6,920	3,460,348	193	7	200
1965	6,795	266	7,061	3,437,834	198	8	205
1966	6,764	260	7,024	3,415,319	198	8	206
1967	6,788	252	7,040	3,392,805	200	7	207
New York							
1960	15,935	602	16,537	7,781,984	205	8	213
1961	16,137	645	16,782	7,780,959	207	8	216
1962	16,241	583	16,824	7,779,933	209	7	216
1963	16,041	625	16,666	7,778,908	206	8	214
1964	16,450	623	17,073	7,777,882	211	8	[illegible]
1965	16,340	580	16,920	7,776,857	210	7	218
1966	16,697	666	17,363	7,775,832	215	8	223
1967	16,594	614	17,208	7,774,806	213	8	221
St. Louis							
1960	1,686	50	1,736	750,026	225	7	231
1961	1,616	63	[illegible]	[illegible]	220	[illegible]	[illegible]
1962	1,571	64	1,635	721,564	218	9	226
1963	1,580	58	1,638	707,334	223	8	232
1964	1,514	63	1,577	693,103	218	9	228
1965	1,498	63	1,561	678,872	221	9	230
1966	1,676	55	1,731	664,641	252	8	260
1967	1,564	62	1,626	650,410	240	10	250

* Population estimated from 1960 and 1970 Census figures.