December 1986

EPA / EID / LANL Solid Waste Disposal and Hazardous Waste Incineration Hearings

Starting off on a positive note, I want to thank the Democratic System that allows its citizenry the opportunity to tell our government what we think of the job they are doing for us paid for by our tax dollars.

I do not choose to be bound by the narrow minded, separatist thinking, that in my opinion has contributed to the huge environmental problems that humanity is facing today. Therefore I have not chosen to stick exclusively to the separatist guidelines of considering only the hazardous waste portion being considered at this hearing (I hope that this hearing is not merely a formality that pays only lip-service to democracy, having already arrived at the foregone conclusion promoted by the seemingly powerful religion on the hill, which continually assures the EID and the general public that technology is protecting us from harm?)

Not to have the opportunity to talk to and hear from the protagonists, namely the devotees of the religion on the hill, and to be limited to expressing my wrath to the "victims" of the hearing process, namely, Kelly Crossman and the EID, is to me, another example of the bitter, unwholesome fruit of separatist, narrow minded thinking!

These indeed are trying times that we live in. Some have said that we may not have a long time to begin to make the right choices, the truthful choices.

Is burning hazardous waste, is burning radioactive waste, is burning mixed waste the best choice? LANL seems to think that it is. They have not convinced me that it is the best choice, or even a partially correct choice. Why, in my mind, is it the wrong choice?

First of all, you can't hide from air. If toxic pollutants are added to the air, eventually, we all ingest them, either through inhalation, drinking or eating. Accidents do happen. People and the machines people create are not infallible, no matter what the proponents of the religion on the hill would like to assure us to the contrary.

Second of all, as a society, we are dis-eased from the imbalance that the process of exploding and burning have already created. We do not need more of it. Burning and exploding are part of the problem, they can not be the solution. Burning and exploding destroy oxygen. Burning hazardous, radioactive and mixed wastes destroys oxygen and simultaneously adds toxic pollutants, some that live as long as 240,000 years, to the air, the very air that sustains all aerobic life on the planet. Adding these pollutants to the atmosphere leads,eventually, to the price that must be paid, the burden of compromising the gene pool and compromising the food chain that creates and sustains life as we know it.

Thirdly, there is too much secrecy on the hill. The deck is stacked too heavily in your favor. LANL has itself too greatly influenced the rules. And you assess whether or not

you are complying with the rules. The EPA and the EID have relatively few resources at their disposal to keep a much needed, ever present watchful eye on the religion on the hill.

How many times has LANL lied to the public, hidden your mistakes, denied your problems, and hidden behind the veils of national security and top secret classification? How many times has LANL leaked radiation into the atmosphere under the cover of Chernobyl, Three Mile Island or Nevada Test Site releases?

At what price does the madness stop? How many immune systems will be compromised, damaged, or destroyed, how much ozone will be destroyed, how much of humanities gene pool will be experimented with, how many people will die as a result of the fear that drives the religion on the hill, and the fear that fuels the publics' acceptance of the actions of the religion on the hill?

What is the effect of hazardous chemical and radioactive releases into the atmosphere on ozone depletion?

Why has information on the Petkau Effect been suppressed since 1972?

Why was there an increase in radionuclides released into the environment in Santa Fe around the time of Chernobyl?

What role did Los Alamos play in determining the acceptable levels of radiation for workers and for the general public? Why should workers be allowed to receive more radiation than the general public? Are their immune systems stronger? Are their gametes more resistant to radiation? Does Los Alamos make the health data on their workers available to those workers and to the general public?

These questions that I have raised throughout this testimony are not the paranoid delusions of a communist new age thinker. I am your brother. I am concerned for our future, and the future of our children's children's children, down through the next 3,500 generations. These questions deserve your utmost careful consideration and your honest answers.

The price we pay for our nuclear gamble needs to be accurately assessed without any more lying, denying and suppressing any information concerning any part of the nuclear cycle. Generalist thinking needs equal billing along with separatist thinking. We all have two brain hemispheres. Let's begin to acknowledge the value of the more wholistic, right brain activity and use both hemispheres in decision making, as we seek to arrive at more than just partial and expedient solutions.

Thank you.

In Health, Safety and Balance,
Dr. Robert Chamberlain March, BS, MsT, ND

GUEST EDITORIAL

Jay M. Gould
Ernest J. Sternglass

THE PETKAU EFFECT

Low-level radiation and mortality

The Chernobyl accident was the largest disaster ever created by humans. Within a few days it released into the biosphere nuclear fission products equal to about a tenth of the amount released by all bomb tests since 1945.

Low-level radiation from the Chernobyl accident arrived in the United States by about May 9, 1986. An increase in mortality followed almost immediately (1). Deaths of 20,000 to 40,000 Americans appear to have been accelerated in the four summer months of 1986, according to evidence drawn from many disciplines: biochemistry, medicine, radiation physics, statistics, epidemiology, and even ornithology.

In May 1987, we attended a conference in Amsterdam on health effects of radiation. There we heard, from many parts of Europe, chilling stories of the effects of the high radiation levels from Chernobyl, accompanied by anecdotal evidence of human and animal miscarriages; but no firm statistical data on human mortality or morbidity were presented. We wondered whether sufficient radiation had reached the United States to produce detectable effects on health. We found that there was, indeed, a 5.3 % increase in mortality in the United States in May 1986 over May 1985. That increase, the highest since 1934, has a probability of less than 1 out of 1000 of being a chance event.

For earlier studies we had assembled, from official sources, comprehensive data bases on radiation and mortality. These permit the quantification of deaths associated with low-level radioactivity at specific times and specific places in ways not possible before. The data base information allows us to separate the effects of radioactivity from those of other, more slowly varying, environmental and socioeconomic factors.

As Figure 1 illustrates, the arrival of low-level radiation from Chernobyl was recorded and so identified by EPA milk-monitoring stations in each state (2). The concentration of I-131, which has a short half-life, peaked in mid-May. Other radioactive isotopes like cesium-137, strontium-90, strontium-89, and barium-140 were also identified.

Changes in infant mortality rates in the South Atlantic states in June and July of 1986 over the corresponding months of 1985 were recorded (Figure 2). There were also significant declines in the number of live births in this and other regions of the United States in this period.

In Figure 3 we display the change from May 1986 over May 1985 for the total number of deaths as well as for two selected age groups and for three selected causes of death. All of these increases are statistically significant, at less than the 0.001 level. This figure also shows the much smaller percentage changes for May 1985 over May 1984. Unusual increases in mortality were recorded for people 25–34 years old. The number of deaths on which our statistical significance tests were based come from the provisional 10% sample of all death certificates analyzed in detail by age and cause of death by the U.S. National Center for Health Statistics (NCHS).

A similar chart can be prepared for the four-month period May–August 1986. The latest NCHS estimate of the number of deaths in those months is 672,000, a 2.7% gain over 1985, which because of the large number involved is statistically significant ($P < 0.001$). Although most of the additional deaths occurred in May, there was also a statistically significant decline in the number of

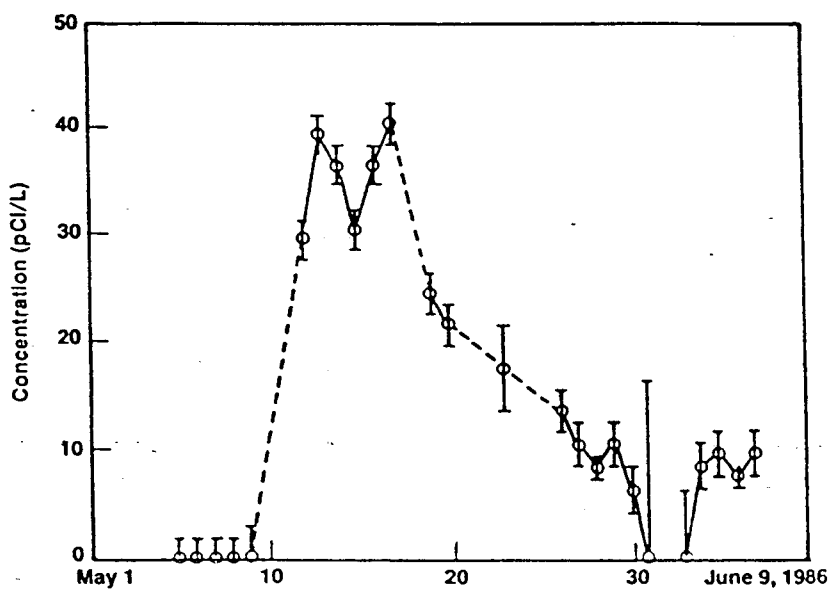

Figure 1. Concentration of I-131 in fresh farm milk, May–June 1986 in the New York metropolitan area. (Recorded by the Environmental Measurement Laboratory of the Department of Energy)

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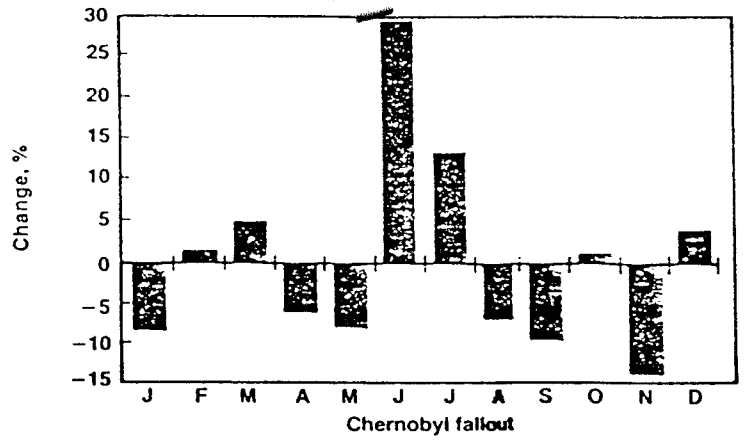


Figure [illegible]ge in infant mortality in the South Atlantic states in 1986 relative to 1985

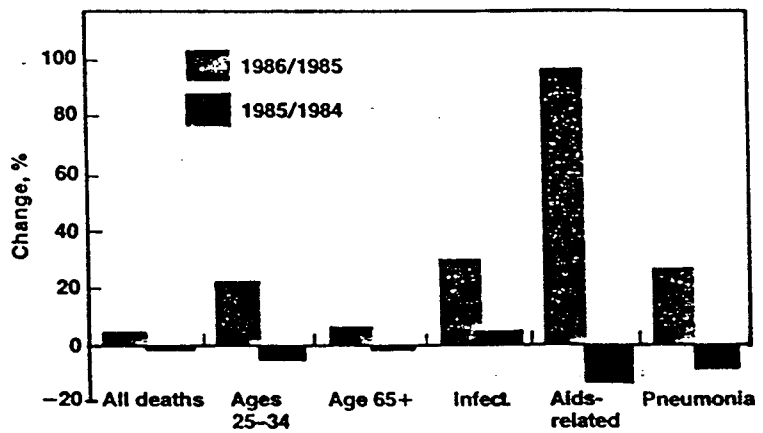


Figure 3. **Changes in mortality rates, May 1986 vs. May 1985, compared with May 1985 vs. May 1984**

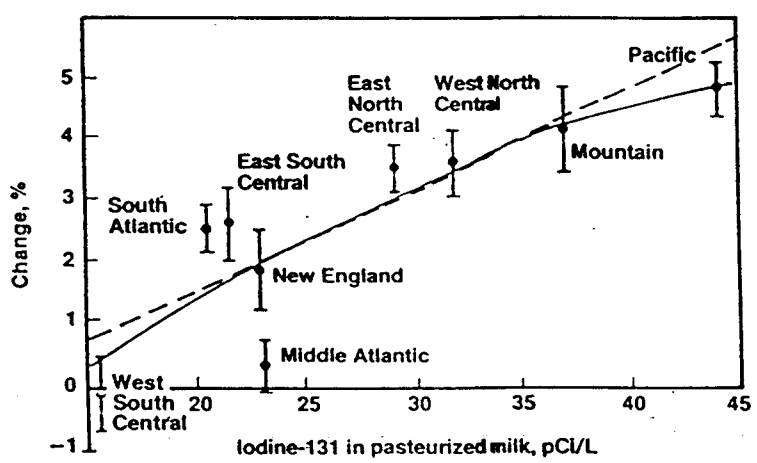


Figure 4. **Regional percent change in mortality, May–August 1986 over May–August 1985. (Source: EPA and NCHS)**

live births in June of 1986 and a sharp increase of 8% in the national infant mortality rate. By September of 1986, most of the immediate mortality effects appeared to have diminished.

In Figure 4 we show the percentage change in the total mortality of the nine U.S. census regions of the United States for May–August 1986 compared with May–August 1985, vs. the values of the I-131 levels in pasteurized milk as reported by EPA. The points shown represent the population-weighted averages of the peak concentrations of I-131 in May and June of 1986 in each state and region. The dotted line is a linear fit to the data and the solid line is the logarithmic fit that best represents the trend of the data. The error bars represent one standard deviation. The regression analysis yields a highly significant correlation coefficient of 0.87 ($P < 0.001$) for the log values, which increases to 0.94 if the Middle Atlantic division is omitted.

For the United States as a whole, the largest monthly increase in the infant mortality rate (IMR) came in June 1986, with an 8.2% increase over June 1985. In the Middle Atlantic region, which comprises New York, New

Figure 5. Dose-response c
Percent increase in mortality
function of I-131 levels (6)

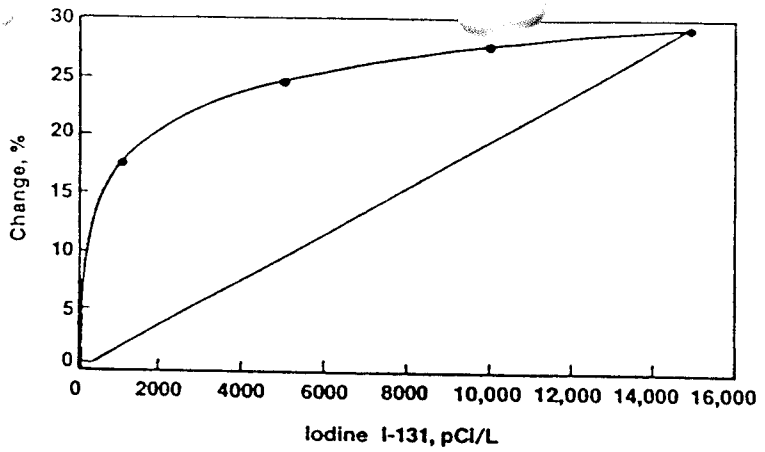
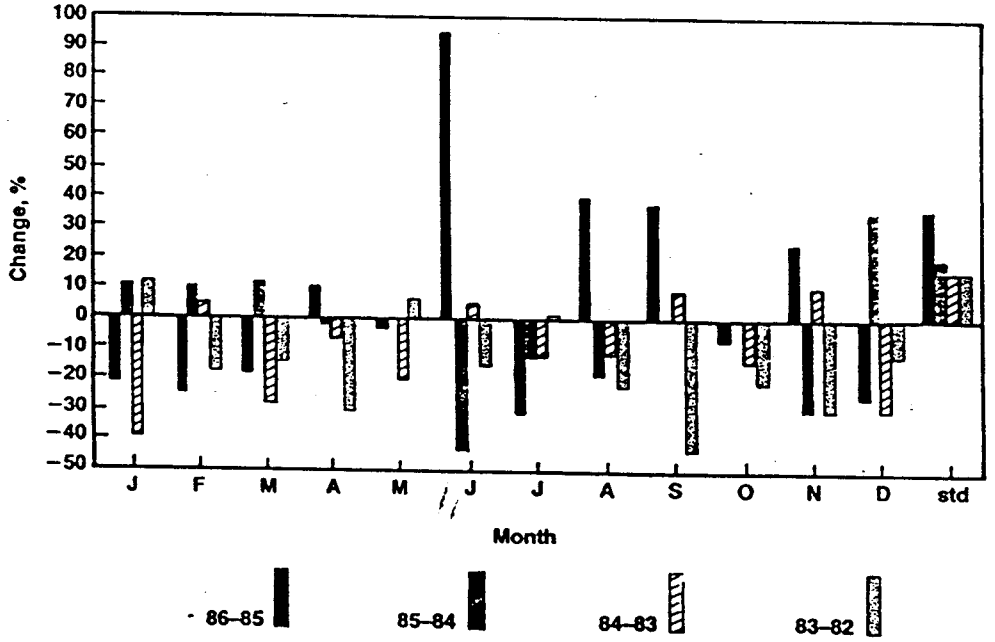


Figure 6. Infant mortality, Baden-Württemberg a year-to-year comparison



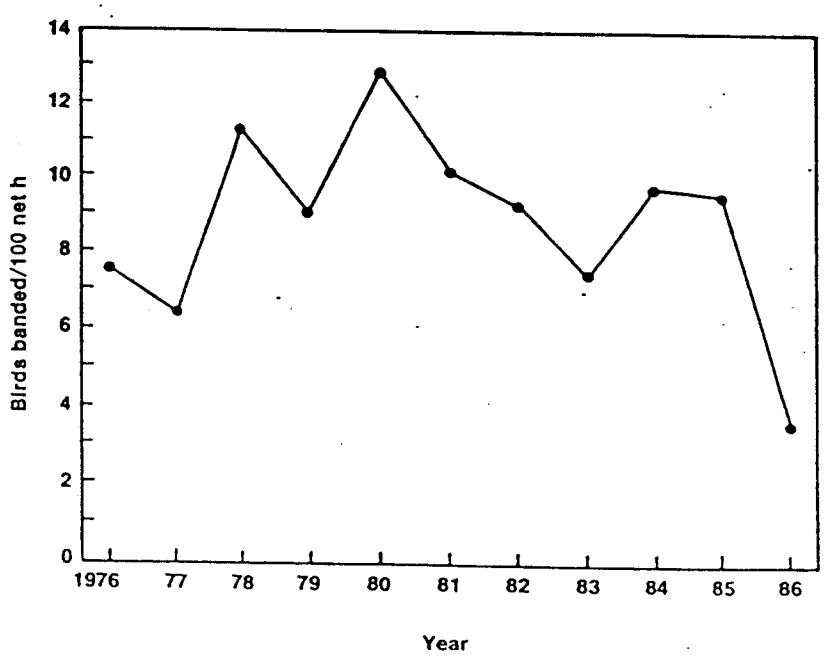


Figure 7. Number of newly hatched landbirds in the period May 10 to Aug. 17, 1976–86

Jersey, and Pennsylvania, New Y[illegible] environmental groups warned residents not to dri[illegible]esh milk, which may explain why the experience in that region lies four standard errors below the regression line. The New York state IMR *declined* by 7.9 % from June 1985, and in New York City it *declined* by an amazing 19.6%. Milk consumption declined in New York in May 1986 but not in New Jersey or Pennsylvania, further implicating the milk.

Causes?

The biochemical mechanism underlying the destructive impact of low-level radiation has been proposed by A. Petkau (3) and others (4) and can be summarized as follows: Low-level emissions from ingested radionuclides promote the formation of oxygen free radicals which, in a chain reaction, can quickly destroy the membranes of cells, such as those of the immune system. At higher intensities of radiation, the free-radical concentrations increase and radicals quench each other. As a result, per unit of radiation absorbed in tissue, the process is perversely more efficient at lower rather than at higher doses or intensities.

Figure 5 indicates the shape of the logarithmic dose–response curve, taken from Figure 4 and extended to the higher concentrations measured in Europe (5). The straight line represents the expected effect based on the assumption made by physicists that the dose–response curve obeys a linear law. This assumption is based on our experience with short bursts of very high intensities, as in the case of medical therapeutic uses, or as in the case of the brief flash from an atomic bomb. The Chernobyl data are the first direct evidence for a large human population that the shape of the dose–response curve at the very low dose rates of fallout radiation exposures is in fact logarithmic and not linear.

Further confirmation of the logarithmic nature of the dose–response curve comes from Jens Scheer of the University of Bremen, who is now assembling monthly mortality data for areas in Europe that were heavily exposed to radiation from Chernobyl in 1986 (6). Figure 6 shows that in Baden-Württemberg a peak increase in the infant mortality rate was reached in June just as in the case of the South Atlantic states (Figure 2), but with an increase of 95% over 1985, vs. 8.2% for the South Atlantic states. This was the highest increase registered by any West German state.

Radiation levels in Europe were 100 to 1000 times greater than those in the United States, but the summertime increase in European mortality was higher by only about a factor of 10. This would be further evidence for the logarithmic nature of the dose–response curve for low-level radiation. It is to be remembered, however, that warnings not to drink milk were widely heeded in Europe [illegible] oubtedly reduced exposures to fetuses.

The strong effect of low-level radiation on reproduction is supported by observations by David DeSante, who documented a massive and unprecedented reproductive failure of landbirds at the Point Reyes Bird Observatory some 25 miles north of San Francisco, in the period May 15–Aug. 15, 1986 (7). Figure 7 indicates that the number of newly hatched birds captured in the mist-netting program in this three-month period dropped 62% from the mean of the preceding 10 years (a drop of 9.4 standard errors).

The medical and scientific community has long believed, on the basis of linear extrapolations from high doses, that low-level radiation from fallout and nuclear plant releases can be dismissed as posing a negligibly small danger. This is the principal assumption that scientists must now reevaluate: It underestimates the effect of low doses for the most sensitive members of the population by a factor of about 1000.

References

(1) Gould, J. M.; Sternglass, E. J. Presented at the Symposium on Health Effects of Low Level Radiation on Humans, Institute for Radiation Biology, Munster, Feb. 26–27, 1988.
(2) Environmental Radiation Data Report No. 46; U.S. Environmental Protection Agency: Washington, DC, September 1986; EPA 520/5-87-004, Revised Edition, Table 14.
(3) Petkau, A. *Acta Physiol. Scan. Suppl.* 1980, *492*, 81–90.
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(5) *Chernobyl Radiation Data Summary;* U.S. Environmental Protection Agency: Washington, DC, May 14, 1986, and later issues.
(6) Scheer, Jens, University of Bremen, personal communication.
(7) DeSante, D.; Geupel, G. R. *The Condor* 1987, *89*, 636–53.

Jay M. Gould (Public Data Access, 30 Irving Place, New York, NY 10003), an economist and statistician, is currently the principal investigator of a Radiation and Public Health Research Project. He was founder of Economic Information Systems, a data base company absorbed by Control Data Corporation in 1981. Gould served on the EPA's Science Advisory Board from 1977 to 1980 and has since written several articles and a book on environmental problems.

Ernest J. Sternglass is Emeritus Professor of Radiological Physics in the Department of Radiology, University of Pittsburgh School of Medicine. While there he was director of the Radiological Physics and Engineering Laboratory. He has carried out extensive studies on the health effects of low-level radiation and is the author of *Secret Fallout* published by McGraw-Hill in 1981.

CEP
COUNCIL ON ECONOMIC PRIORITIES

NEWSLETTER

December, 1986 CEP Publication N86 - 12

Public Health

Nuclear Emissions Take Their Toll

By Jay M. Gould with Brian Jacobs, Celia Chen and Steven Cea

Chernobyl has raised the universal question of what is the true impact on public health of nuclear emissions. This newsletter, the fifth in a series of reports and publications by the Council on Economic Priorities on the geographic dangers of toxic waste, will review some of the evidence linking nuclear emissions in the US to increases in mortality rates.

A state is often too crude a geographic unit for the measurement of environmental dangers since these dangers are generally local and seldom impact to the same degree on all or most localities in a state. As a preliminary effort, however, statewide and county variations in total infant and cancer mortality rates can be used to appraise current regional variations in public health.

Economy Determines Mortality

The advance of any modern industrial society can be traced in terms of the systematic decline in its mortality rates over time and the consequent increase in the longevity of its population. This is true of the US over the past two hundred years or more, and certainly so in the 20th Century when the official mortality statistics became representative of the total population. The US total mortality rate stood at 17.2 deaths per 1,000 persons in 1900 and declined at an average annual rate of one percent to stand at 8.7 deaths per 1,000 persons in 1980. The annual decline in mortality rates can, of course, be expected to slow as the population ages over time. Thus the mortality rate, when adjusted for differ-

The Calculation of Excess Mortality

Insights into the probable consequences of the Chernobyl disaster can be gained through US Mortality data for areas exposed to nuclear emissions, provided the total volume of curies of radioactive materials released is known. This newsletter explores the impact on public health of the release (routine and accidental) of some 35 million curies of all noble gases and radioactive particulates emitted from all civilian nuclear power reactors in the US in the years 1974–1981, as tracked by the Brookhaven National Laboratory. Our analysis indicates that such releases (detailed in Table 4) based on mortality data for states most directly affected by such emissions, are associated with nearly 9,000 excess deaths each year.

Brookhaven emissions surveys are extremely conservative. They do not cover emissions from the plutonium producing Hanford and Savannah River military reactors. The Atomic Energy Commission has been extremely sanguine about possible nuclear contamination of communities situated downwind from military reactors.

The Portland Oregonian (on May 11 and 12, 1986) revealed, on the basis of some 19,000 pages of classified data obtained as the result of FOIA, that the Hanford military reactors in Benton County, Washington, apparently released into the air 446,700 curies of radioactive Iodine-131 in the years 1945 to 1950, and an additional 7,616 curies in the years 1951–1961. This represents staggeringly high radiation levels—only 14 curies of radioactive Iodine were reported to have been released by the Three Mile Island disaster in 1979. For example, in an experiment "related to the development of a monitoring methodology for intelligence regarding the emerging Soviet nuclear program," Hanford purposely released 5000 curies of radioactive Iodine on Dec. 2-3, 1949. One particular stretch of farmland, lying just downwind of Hanford, came to be known as "Death Mile." Nine of its ten families have been stricken with cancer since 1950. The full impact of these emissions on the area affected has never been estimated. It is time for private citizens in the US as well as the USSR and Europe to demand official evaluations of the loss of life from nuclear emissions. It is CEP's hope that the findings and methodology offered in this newsletter receive the critical attention of radiation physicists, epidemiologists, and public health officials. ■

Continued from page 1
ences due to age, declined somewhat more—from 17.8 in 1900 to 5.9 deaths per 1,000 in 1980.

The infant mortality rate (IMR)—defined as the number of deaths within the first year per 1,000 live births—does not require age adjustment and has declined much more rapidly. Over time, the IMR is very much affected by the change in relative health standards of nonwhites since the IMR for nonwhites generally has been about 50 percent higher than the IMR for all babies. In 1915, the first year in which the official infant mortality rate was considered accurate, the IMR was 99.8. The 1980 figure, at 12.6, represents an average annual decline of 3.2 percent over a 65-year period. The average annual decline in the IMR usually ranged between two and four percent in accordance with the degree to which nonwhites and poor whites enjoyed better health and nutrition in periods of economic expansion.

This fact is indicated by Table 1 which summarizes trends in infant mortality by five-year periods since 1915. Annual declines are seen to average below three percent in depression years and over four percent in the "prosperous" full employment war years. In the decade 1955–1964, the years when atmospheric bomb testing produced peak fallout levels, the average annual decline slowed to one percent, however. The signing of the test ban treaty in 1963 saw fallout levels dropping sharply, and the average rate of decline in the 1965–1979 period was again well over four percent.

Cancer Rates Steadily Increasing

As the overall US mortality rate reflects the gradual aging of Americans, so does the cancer mortality rate—it has been increasing for decades. But the cancer rate is increasing even after adjustment for age and now accounts for about 22 percent of all deaths.

These mortality rates, used to evaluate public health standards, are closely intertwined. Historically, modern industrial technology, along with advancing medical technology, has elevated nutrition and health standards. It has also contributed greatly to the systematic lowering of mortality rates. But over the past three decades, increasing cancer rates, even after age adjustment, represent the grim side of that equation. They reflect in large part the environmental deterioration accompanying modern industrial technology. CEP is committed to the exploration of these complex and often contradictory economic, environmental, and public health issues.

Infant Mortality Linked To Fallout

Of the three mortality rates, the IMR is by far the most sensitive to both economic and environmental change. It can respond to a major environmental change within months. Let us again refer to Table 1 that summarizes official US IMR data by five-year periods since 1915. The necessity of including nuclear radiation in measures of environmental degradation is indicated by the flattening out of the long secular decline in the average annual IMR that occurred in the bomb test years.

When attention was first drawn to this ominous change in the late sixties, pronuclear proponents asserted this flattening out in the annual rate of the declining IMR merely reflected the natural limits of medical technology and the possible exhaustion of the powers of antibiotics. This argument was called into question after the ban on atmospheric bomb testing by the immediate resumption of the average annual four percent decline in the US IMR. That there are such cities as Amsterdam and Yokohama today with IMR ratios of the order of four or five, as against the current US IMR of 11, indicates we are still far from reaching any "natural" limit.

A 1986 publication of the Children's Defense Fund has, however, just warned that another ominous alteration in infant mortality rates has occurred in the period 1981 to 1984—when "the annual rate of decline has slowed to approximately three percent." In this period, the black infant mortality rate was also twice that of white infants, the greatest disparity in 23 years. (Table 1 shows that nonwhite infant mortality rates have historically been most responsive to both economic and environmental changes. Average annual declines were close to six percent in prosperous periods such as 1945–49 and average annual declines less than one percent in the peak bomb test years.) The Children's Defense Fund offers much evidence that these recent changes can be attributed to cutbacks in Federal health, nutrition, and service programs. The hypothesis that emissions from nuclear reactors are also adversely affecting infant mortality rates for both white and black babies shall be explored below.

Most of the nation's civilian power reactors came on line in the seventies, particularly in 1974 and subsequent years. Routine and accidental emissions from these reactors have been tracked by the Brookhaven National Laboratory.

The following is a summary of the latest Brookhaven Report:

Emissions, All Noble Gases, Million Curies

	1974–1981	Total 1970–1981
Boiling Water Reactors	23.732	40.252
Pressurized Water Reactors	11.687	11.719
Totals	35.419	51.971

This newsletter investigates the statis-

Continued page 4

TABLE 1: INFANT MORTALITY RATES IN THE US, 1915-1979

Five Year period	Av. # Deaths per 1,000 Births All Babies	Nonwhite	Annual % Rates of Change All Babies	Nonwhite
1975–1979	14.4	22.1	-4.9	-4.6
1970–1974	18.4	27.6	-4.2	-5.7
1965–1969	22.7	36.5	-2.2	-2.7
1960–1964	25.3	41.6	-0.9	-1.0
1955–1959	26.4	43.7	-1.3	-0.5
1950–1954	28.1	44.8	-3.6	-2.2
1945–1949	33.5	49.8	-4.9	-6.2
1940–1944	42.6	67.2	-4.6	-3.9
1935–1939	53.2	81.3	-2.6	-3.9
1930–1934	60.4	98.6	-2.7	-1.4
1925–1929	69.0	105.4	-2.2	-1.8
1920–1924	76.7	115.3	-4.7	-5.3
1915–1919	95.7	149.7	—	—

Source: *Vital Statistics of the U.S., 1980, Vol. ii, Mortality, Part A, Section 2, Infant Mortality, page 1.*

TABLE 2: AVERAGE ANNUAL MORTALITY RATES, 1965-69 AND 1975-82 BY STATE AND REGION

	ANNUAL AVERAGE 1965-1969								ANNUAL AVERAGE 1975-1982								RATIOS OF CHANGE		
	BIRTHS	INFANT DEATHS	IMR	POP (TH)	DEATHS	MR	CANCER DEATHS	CMR	BIRTHS	INFANT DEATHS	IMR	POP (TH)	DEATHS	MR	CANCER DEATHS	CMR	IMR RATIO	MR RATIO	CMR RATIO
US	3571707	60399	22.5	196844	1870238	9.5	309907	157.4	3394435	45561	13.4	222093	1931224	8.7	399011	179.7	0.596	0.915	1.141
REGION																			
STATES																			
NEW ENGLAND	203572	4045	19.9	11329	117450	10.4	20753	183.2	156025	1738	11.1	12325	110743	9.0	25121	203.8	0.561	0.867	1.113
*ME	17802	339	19.0	984	10868	11.0	1819	184.9	15647	155	9.9	1112	10307	9.3	2245	201.8	0.519	0.839	1.092
NH	12152	241	19.8	692	7260	10.5	1282	185.2	12589	116	9.2	896	7356	8.2	1661	185.4	0.464	0.783	1.001
*VT	7759	154	19.8	421	4584	10.9	727	172.5	7157	70	9.8	501	4380	8.8	912	182.3	0.493	0.804	1.057
*MA	99179	1976	19.9	5408	59304	11.0	10315	190.7	71961	793	11.0	5755	53481	9.3	12001	208.5	0.553	0.847	1.093
*RI	16493	341	20.7	901	9499	10.5	1778	197.3	11986	170	14.2	953	9221	9.7	2151	225.6	0.685	0.918	1.143
*CT	50188	995	19.8	2922	25935	8.9	4832	165.3	36685	435	11.9	3107	25997	8.4	6152	198.0	0.598	0.943	1.197
MIDDLE ATLANTIC	624612	13720	22.0	36746	379695	10.3	67948	184.9	485919	6710	13.8	37008	352678	9.5	76788	207.5	0.629	0.922	1.122
*NY	316768	7048	22.3	18064	187700	10.4	34171	189.2	238206	3446	14.5	17756	167766	9.4	36670	206.5	0.650	0.909	1.092
*NJ	114861	2402	20.9	6978	65102	9.3	12405	177.8	91542	1129	12.3	7374	64995	8.8	14977	203.1	0.590	0.945	1.143
*PA	192983	4270	22.1	11704	126893	10.8	21372	182.6	156172	2134	13.7	11878	119917	10.1	25141	211.7	0.618	0.931	1.159
EAST NORTH CENTRAL	717885	15682	21.8	39166	371057	9.5	62907	160.6	632173	8464	13.4	41467	358145	8.6	74396	179.4	0.613	0.912	1.117
*OH	187946	3860	20.5	10503	99262	9.5	16931	161.2	163209	2124	13.0	10784	96324	8.9	20184	187.2	0.634	0.945	1.161
*IN	93432	2050	21.9	5018	47728	9.5	7800	155.4	84485	1066	12.6	5437	47044	8.7	9520	175.1	0.575	0.910	1.126
*IL	196649	4702	23.9	10870	108827	10.0	18354	168.9	176708	2677	15.1	11407	100418	8.8	20961	183.8	0.633	0.879	1.088
*MI	162703	3585	22.0	8581	74845	8.7	12877	150.1	137566	1878	13.7	9177	74149	8.1	15421	168.1	0.620	0.926	1.120
*WI	77154	1484	19.2	4194	40394	9.6	6947	165.6	70205	719	10.2	4662	40210	8.6	8309	178.2	0.532	0.896	1.076
WEST NORTH CENTRAL	279660	5543	19.8	16008	163935	10.2	26805	167.4	271081	3428	12.6	17063	157578	9.2	31482	184.5	0.638	0.902	1.102
*MN	66301	1235	18.6	3629	33527	9.2	5767	158.9	63172	728	11.5	4029	33010	8.2	6791	168.5	0.619	0.887	1.061
*IA	48902	943	19.3	2771	29521	10.7	4838	174.3	45090	507	11.3	2908	27040	9.3	5518	189.7	0.584	0.873	1.088
MO	80220	1757	21.9	4575	52026	11.4	8171	178.6	75737	1148	15.2	4880	49789	10.2	9809	201.0	0.692	0.897	1.125
ND	11902	227	19.1	633	5639	8.9	922	145.6	12347	162	13.1	652	5664	8.7	1088	166.8	0.688	0.975	1.146
SD	12009	261	21.7	673	6509	9.7	1072	159.3	12219	151	12.4	688	6396	9.3	1212	176.1	0.569	0.961	1.106
*NB	25176	410	16.3	1449	14898	10.3	2518	173.7	25871	323	12.5	1563	14546	9.3	2893	185.1	0.768	0.905	1.066
KS	35149	710	20.2	2278	21814	9.6	3525	154.7	36645	407	11.1	2342	21133	9.0	4170	178.0	0.550	0.942	1.151
SOUTH ATLANTIC	549057	13976	25.5	29637	276055	9.3	42176	142.3	520991	7919	15.2	36248	320918	8.9	65682	181.2	0.597	0.951	1.273
*DE	10213	223	21.8	524	4904	9.4	780	148.9	8961	118	13.1	596	5040	8.5	1118	187.5	0.603	0.903	1.259
*MD	62382	1426	22.9	3660	31342	8.6	5563	152.0	51019	687	13.5	4214	32425	7.7	7551	179.2	0.589	0.899	1.179
*DC	28530	673	23.6	804	10513	13.1	1480	184.1	18163	442	24.3	664	8715	13.1	1764	265.6	1.031	1.003	1.443
*VA	79611	1965	24.7	4547	37396	8.2	5848	128.4	72884	1036	14.2	5285	40453	7.7	8381	158.6	0.576	0.931	1.235
WV	30526	752	24.6	1819	19607	10.8	2958	162.2	29080	426	14.6	1916	19440	10.1	3621	189.0	0.594	0.941	1.165
*NC	93958	2607	27.7	5068	43458	8.6	5804	114.5	83625	1307	15.6	5775	47644	8.3	9085	157.3	0.563	0.962	1.374
*SC	50123	1398	27.9	2634	22066	8.4	2919	110.8	48484	830	17.1	3057	23853	7.8	4394	143.7	0.614	0.931	1.297
*GA	90399	2320	25.7	4510	39555	8.8	5423	120.2	87781	1294	14.7	5345	43667	8.2	7890	147.6	0.574	0.932	1.228
*FL	103316	2612	25.3	6071	67215	11.1	11415	188.0	120994	1780	14.7	9396	99682	10.6	21879	232.9	0.582	0.958	1.238
EAST SOUTH CENTRAL	245812	6768	27.5	12988	126134	9.7	17965	138.3	232995	3567	15.3	14405	132058	9.2	24997	173.5	0.556	0.944	1.255
KY	59054	1391	23.6	3205	31989	10.0	4817	150.3	58376	727	12.5	3603	32962	9.1	6448	179.0	0.529	0.917	1.191
*TN	73603	1858	25.2	3919	38466	9.8	5439	138.8	69524	1078	15.5	4482	41673	9.3	7928	176.9	0.614	0.947	1.274
*AL	65319	1839	28.2	3521	32862	9.3	4584	130.2	59996	971	16.2	3833	34588	9.0	6567	171.3	0.575	0.967	1.316
MS	47836	1680	35.1	2343	22817	9.7	3126	133.4	45099	792	17.6	2487	22834	9.2	4054	163.0	0.500	0.943	1.222
WEST SOUTH CENTRAL	363118	8633	23.8	19010	165622	8.7	26383	138.8	415029	5753	13.9	23114	190373	8.2	36606	158.4	0.583	0.945	1.141
*AR	34128	758	22.2	1973	19848	10.1	2998	151.5	34761	461	13.3	2241	21712	9.7	4226	188.6	0.596	0.963	1.245
LA	76263	2104	27.6	3663	33107	9.0	5094	139.1	76743	1234	16.1	4118	35235	8.6	6793	164.9	0.583	0.947	1.186
OK	40468	869	21.5	2514	24370	9.7	3985	158.6	47463	620	13.1	2958	27290	9.2	5297	179.1	0.608	0.952	1.129
TX	212259	4902	23.1	10861	88297	8.1	14314	131.8	256062	3438	13.4	13797	106136	7.7	20291	147.1	0.581	0.946	1.116
MOUNTAIN	155932	3447	22.1	7846	63311	8.1	9267	118.4	208613	2487	11.9	10917	77254	7.1	14425	132.1	0.539	0.877	1.116
MT	12346	269	21.8	699	6591	9.4	1004	143.6	13337	148	11.1	780	6519	8.4	1227	157.4	0.510	0.887	1.096
ID	12782	251	19.6	705	5786	8.2	893	126.7	18511	167	9.0	911	6362	7.0	1207	132.5	0.460	0.851	1.046
WY	5823	128	21.9	323	2822	8.7	395	121.7	8636	84	9.7	442	3033	6.9	530	119.8	0.443	0.786	0.984
CO	38034	838	22.0	2019	17256	8.5	2497	123.7	46947	560	11.9	2807	19034	6.8	3478	123.9	0.542	0.794	1.002
NM	21933	557	25.4	1004	7007	7.0	985	98.1	24450	299	12.2	1264	8441	6.7	1540	121.8	0.482	0.957	1.242
AZ	32610	765	23.5	1634	13204	8.1	2043	125.0	45519	614	13.5	2575	19983	7.8	4001	155.4	0.575	0.960	1.243
UT	23661	432	18.2	1020	7023	6.9	939	92.1	39592	469	11.8	1393	8217	5.9	1327	95.2	0.649	0.856	1.034
NV	8744	207	23.7	442	3623	8.2	533	120.4	11622	147	12.6	745	5666	7.6	1115	149.6	0.531	0.928	1.242
PACIFIC	432059	8585	19.9	24114	206979	8.6	35682	148.0	471609	5496	11.7	29549	231479	7.8	49515	167.6	0.586	0.913	1.132
*WA	53940	1071	19.9	3190	29404	9.2	4833	151.5	60195	731	12.1	3949	31298	7.9	6602	167.2	0.611	0.860	1.104
*OR	33100	650	19.6	1983	18923	9.5	3126	157.6	40104	494	12.3	2522	21077	8.4	4385	173.9	0.627	0.876	1.103
*CA	345019	6864	19.9	18941	158651	8.4	27724	146.4	371310	4271	11.5	23078	179104	7.8	38528	166.9	0.578	0.927	1.141

*NUCLEAR STATES

IMR = INFANT MORTALITY RATE (DEATHS/1000 BIRTHS)

MR = MORTALITY RATE (DEATHS/1,000 PERSONS)

CMR = CANCER MORTALITY RATE (DEATHS/100,000 PERSONS)

tical relationship between the 35.4 million curies emitted in the years 1974–1981 and infant and other mortality rates in the years 1975–1982 in states most directly affected.

For the purpose of this inquiry, the contiguous states (excluding Alaska and Hawaii) are divided into two groups—*nuclear states* (those with power or military reactors) and *nonnuclear states* (those without). Actually, the geographic distribution of reactors in the US is so wide that only 19 states can be regarded *nonnuclear*. Small states, like the District of Columbia or Rhode Island, lying directly downwind from reactors in adjoining states are included in the *nuclear* group.

Our definition of *nuclear* states (designated by an asterisk in Table 2) must of necessity include Washington and South Carolina, home of the Hanford and Savannah River military reactors. Emissions from these reactors are not reported by Brookhaven, and cannot be assumed to have reached peak levels in the late seventies as is the case of civilian power reactors. Again, Brookhaven does not report on emissions from the hundreds of small experimental reactors located at research institutes, universities, and large hospitals. Most of these can be found in the states designated in Table 2 as *nuclear*.

The years 1965–69 were chosen as the most suitable control time period—radiation from bomb test fallout was at very low levels. Both Nevada and Utah, which have no nuclear reactors, were included in our *nonnuclear* states. Some residents of both these states, however, might have been affected by occasional accidental emissions from underground tests in the Nevada desert. These tests continued without interruption after the atmospheric test ban in 1963. In fact, these tests are continued today with as yet unknown public health consequences.

The average annual mortality rates have been calculated in both time periods for these two groups of states. The results are summarized in Tables 3 and 4. The tables suggest that emissions from nuclear reactors in the *nuclear* states may have had a small but statistically significant adverse impact on mortality rates in the 1975–1982 period, when such emissions reached high levels.

Thus, according to Table 3, which summarizes the rate in the *nuclear* and *nonnuclear* states, the infant mortality rate in the *nuclear* states was 22.2 per thousand births in the 1965–69 period, somewhat lower than the national IMR in those years of 22.5 (not a statistically significant difference). In that same period, however, the IMR for *nonnuclear* states was much higher than the *nuclear* IMR, but ended somewhat lower in the later period. Its decline, over these years, was at the annual rate of 0.89 percent, as against 0.83 percent for the *nuclear* states.

While these differences appear small, in Table 4 they translate into disturbingly large annual estimates of *excess* deaths. This calculation yields what the observed deaths would have been in the *nuclear* states if they had had the same percentage change in mortality rates experienced by the *nonnuclear* states.

A surprisingly similar difference is arrived at between the two groups of states with respect to cancer mortality. While the cancer mortality rate in the *nuclear* states was somewhat below that of the nation in the early period, it was considerably higher in the later period.

At first glance, this appears surprising because we would expect at least a five-year lag of cancer mortality from the year of exposure, suggesting that emissions in the 1974–81 period should lead to elevated cancer mortality levels in the eighties and nineties. The elevated cancer rates in the late seventies may reflect the much higher but earlier and yet unknown emission levels from military reactors. They may also reflect the emissions from some civilian reactors in the 1970–74 years.

Indeed the impact on public health of military reactor emissions deserves separate study (See front page box) both because the time period of operation spans several decades, and because the cumulated volume of emissions may be higher than that of civilian reactors. However, so much is *not* known about the treatment and disposal of the huge stockpiles of military waste, we must

TABLE 3: SUMMARY OF CHANGES IN MORTALITY RATES, 1965–69, 1975–82, US, NUCLEAR AND NON-NUCLEAR STATES

	US	NUCLEAR STATES	NON-NUCLEAR STATES
1965–69			
Total # Infant Deaths	401995	310289	91706
Total # Live Births	17858535	13989682	3868853
Average Annual IMR (Deaths Per 1000 Live Births)	22.510	22.180	23.704
Total # of Deaths	9351192	7467466	1883726
Average Annual Population	196844	155742	41103
Average Annual Mortality Rate (Deaths Per 100,000)	950.11	958.96	916.60
Total # Cancer Deaths	1549534	1256809	292725
Average Annual Cancer Rate (Deaths Per 100,000)	157.44	161.40	142.44
1975–82			
Total # Infant Deaths	364490	270823	93667
Total # Live Births	27155479	20187695	6967784
Average Annual IMR (Deaths Per 1000 Live Births)	13.422	13.415	13.443
Total # of Deaths	15449794	12157892	3291902
Average Annual Population	222093	172840	49253
Average Annual Mortality Rate (Deaths Per 100,000)	869.56	879.27	835.45
Total # Cancer Deaths	3192087	2561141	630946
Average Annual Cancer Rate (Deaths Per 100,000)	179.66	185.22	160.13
Ratios of Change, 1975–82/1965–69			
Infant Mortality Rate	0.5963	0.6048	0.5671
Total Mortality Rate	0.9152	0.9169	0.9115
Cancer Mortality Rate	1.1411	1.1476	1.1242
Annual Percent Rates of Change			
Infant Mortality Rate	−4.04	−3.95	−4.33
Total Mortality Rate	−0.85	−0.83	−0.89
Cancer Mortality Rate	1.41	1.48	1.24

assume that the associated public health problems may be of the same order of magnitude as those of the civilian reactors.

Unlike infant and total mortality rates that are steadily declining, cancer mortality rates have been rising for several decades. The causes of this increase involve a complex mix of environmental and demographic factors for which total cancer mortality rates, unadjusted for sex, race, or age, require considerable further research.

Differences in Mortality

What do these results signify? First, the small differences between the mortality changes of the two groups of states *cannot* be attributed to chance. On the other hand, can these differences be attributed to different nuclear emissions levels? There is no clearly defined tendency evident in Table 2 among *each* of the so-called *nuclear* states to have increases in mortality that exceed those of the nation. This becomes evident by considering the ratios of change for each state for the three different mortality rates shown in Table 2. It can be said that a state does *worse* than the nation if the decline in its infant or total mortality rate was less than that of the nation or if the gain in its cancer mortality rates was greater than that of the nation. Thus, the 30 *nuclear* states have 90 opportunities to be measured against the national performance, and the 19 *nonnuclear* states have 57 such opportunities. (As examples, the *nuclear* state of Connecticut performed *worse* than the nation with respect to all three mortality rates, and the *nonnuclear* state of Wyoming performed *better* on all three counts.)

But the *nonnuclear* states can be seen to do *better* than the nation in only 54 percent of all cases, and the *nuclear* states do *better* in about 52 percent of all cases. Thus, it cannot be said that *nonnuclear* states have a tendency to perform significantly *better* than *nuclear* states. How can these apparently contradictory results be reconciled with the results of Tables 3 and 4? Can it be that the statistically significant differences between the two groups of states shown by Table 3 reflect factors other than nuclear emissions? There is a simple explanation of this paradox.

There are a total of about 90 civilian and military reactors that released emissions of varying volumes in the most recent time period. The effects of these emissions will be primarily found in residents of those relatively few counties most directly impacted by the releases. The vital statistics for these counties should then show up in these counties and not in the far more numerous remaining counties that make up the United States.

We do not have emissions data as yet for military reactors, which, in any case, were in continuous operation in both the two time periods we are considering. We can, however, attempt to de-

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TABLE 4: CALCULATION OF ANNUAL EXCESS MORTALITY IN NUCLEAR STATES 1975–82

	NUCLEAR STATES	NON-NUCLEAR STATES
1965–69		
Average Annual IMR (Deaths Per 1000 Live Births)	22.18	23.70
Average Annual Mortality Rate (Deaths Per 100,000)	958.96	916.60
Average Annual Cancer Rate (Deaths Per 100,000)	161.40	142.44
1975–82		
Average Annual IMR (Deaths Per 1000 Live Births)	12.58	13.44
Average Annual Mortality Rate (Deaths Per 100,000)	874.09	835.45
Average Annual Cancer Rate (Deaths Per 100,000)	181.45	160.10
Actual Avg. Annual Infant Deaths	33853	11708
Actual Avg. Annual Live Births	2523462	870973
Actual Avg. Annual Deaths	1519737	411488
Actual Avg. Annual Population	172840	49253
Actual Avg. Annual Cancer Deaths	320143	78868
Estimated Avg. Annual Infant Deaths	31740	—
Estimated Avg. Annual Deaths	1510780	—
Estimated Avg. Annual Cancer Deaths	313611	—
Excess Annual Infant Deaths	2113	—
Excess Annual Total Deaths	8957	—
Excess Annual Cancer Deaths	6532	—

In this table we have calculated the "excess" in mortality in the nuclear states as the difference in the number of expected deaths if these states had the same change in mortality since 1965–69 as was experienced by the nonnuclear states. These calculations are warranted by the fact that this assumption yields differences that are highly unlikely to be attributed to chance. The standard deviation (σ) of the difference between the observed mortality rate and an expected rate is given by the formula:

$$\sigma_{r_o - r_e} = \sqrt{\frac{(r_o)(1-r_o)}{N} + \frac{(r_e)(1-r_e)}{N}}$$

where r_o and r_e are the observed and expected mortality rates expressed to six decimals on a per capita basis, and N represents the number of deaths in the 1975–82 period. The results can be tabulated as follows:

	IMR	CMR	TMR
1. r_o	.01342	.001852	.008793
2. r_e	.01258	.001814	.008741
3. $r_o - r_e$	.00084	.000038	.000052
4. $\sigma_{r_o - r_e}$	.00031	.000037	.000037
5. Line 3/Line 4	2.72	1.01	1.38
6. Chance Probability	.004	.156	.084

Line 6 indicates the probabilities of securing the observed difference on line 3 purely by chance. The difference in infant mortality rates is most significant, for the probability of getting as large a difference as was observed is only four out of 1000. (A probability ratio of 50 times out of 1000 is generally taken as indicative of a highly improbable result of chance.) The observed difference in cancer mortality rates lies at the borderline of chance. The probability that both the observed differences in the infant and cancer mortality could simultaneously be the result of chance could be calculated by multiplying .004 by .156 to yield .0006, because these two mortality rates are completely independent. The p value for total mortality—.084—lies at the borderline of chance probability, but since total mortality includes both infant and cancer deaths (with a joint p of only .0006), it is hard to believe that all other deaths would not be affected by the same extra force of mortality that affected infants and cancer victims.

fine a *nuclear* county for the 50 civilian power reactors for which we do have emissions data for recent years.

Some 175 counties have been chosen as a first step to defining a *nuclear* county, one that would be more directly exposed to recent radioactive emissions from civilian reactors. These include, in addition to the county in which the reactor is located, an average of two or three counties lying within 25 or 30 miles from the reactor. Those adjacent counties lying to the north and east are favored in accordance with the prevailing wind patterns in the US. (For example, it has been suggested that such wind patterns account for the severity of acid rain in the Northeastern region of the US.)

This too is a highly simplistic definition. Windborne emissions by no means represent the most important way in which nearby residents can be affected. For example, rainfall affecting adjacent counties probably determines the ulti-

TABLE 5: NUCLEAR COUNTIES: SUMMARY OF CHANGES IN PUBLIC HEALTH MEASURES, 1965-69 AND 1975-82

	NUCLEAR COUNTIES				
	BOILING WATER REACTORS	PRESSURIZED WATER REACTORS	ALL REACTORS COUNTIES	NONNUCLEAR COUNTIES	US TOTALS
1965-69					
Number of Counties	71	114	175	2968	3143
Number of Births	1325248	1498874	2730406	15258955	17989361
Number of Infant Deaths	30524	32060	60723	348023	408746
IMR (Deaths per 1000 Births)	23.0	21.4	22.2	22.8	22.7
Number of Fetal Deaths	19185	21256	39226	239246	278472
FMR (Deaths per 1000 Births)	14.5	14.2	14.4	15.7	15.5
Population, 1970	14552937	17508052	31072244	172232619	203304863
Number of Deaths	693005	737496	1387843	8006837	9394680
MR (Deaths per 1000 Persons)	9.5	8.4	8.9	9.3	9.2
Number of Cancer Deaths	117589	126722	237103	1316843	1553946
CMR (Deaths per 100,000 Persons)	161.6	144.8	152.6	152.9	152.9
1975-82					
Th. Curies Emitted, 1974-81	2.37E+07	1.17E+07	3.54E+07		
Emission Per Capita	1.583	0.577	1.035		
Number of Births	1809882	2305116	3975794	23412534	27388328
Number of Infant Deaths	26331	29542	54210	314397	368607
IMR (Deaths per 1000 Births)	14.5	12.8	13.6	13.4	13.5
*Number of Births	1572114	1987858	3439066	20268725	23707791
*Number of Fetal Deaths	15645	18412	33071	198107	231178
*FMR (Deaths per 1000 Births)	10.0	9.3	9.6	9.8	9.8
Population, 1980	14975515	20292643	34186432	192359373	226545805
Number of Deaths	1037764	1331493	2300973	13185191	15486164
MR (Deaths per 1000 Persons)	8.7	8.2	8.4	8.6	8.5
Number of Cancer Deaths	220776	289143	495352	2707124	3202476
CMR (Deaths per 100,000 Persons)	184.3	178.1	181.1	175.9	176.7
RATIOS OF CHANGE					
IMR	0.632	0.599	0.613	0.589	0.592
FMR	0.687	0.653	0.669	0.623	0.630
MR	0.910	0.974	0.942	0.922	0.925
CMR	1.140	1.230	1.187	1.150	1.156

*Fetal Death data relates to the period 1975-81. As of this writing, 1982 data are unavailable

mate destination of most emitted radioactive particulates and effluents. Nearby residents can also be affected by the possible contamination of water, milk, and produce from counties even further removed from the point source of the emissions. Each reactor represents a unique geographic situation that deserves a careful examination of wind, precipitation and fresh food transportation patterns. This examination will offer a more complete definition of those adjacent counties vulnerable to local emissions.

Nevertheless, it turns out that even with the admittedly restricted definition of the 175 nuclear counties used here, results indicate adverse impacts on measures of infant mortality, fetal mortality, total mortality, and cancer mortality in the late seventies as compared with the earlier period. These results are summarized in Table 5 which replicates the methodology of Table 3. Now, however, the change in mortality rates of *nuclear* counties are compared with *nonnuclear* counties.

In addition, the nuclear counties are separated into two groups; those close to boiling water reactors and those close to pressurized water reactors. For all *nuclear and nonnuclear* counties, the rates for infant, fetal, and total mortality are seen to decline over the selected time period. It will be seen, however, that the declines in *nuclear* counties in each case fell short of the declines in *nonnuclear* counties. With respect to cancer mortality, which has been rising over these years, the 19 percent gain in *nuclear* counties exceeded the 15 percent gain in *nonnuclear* counties.

Could such results be the product of chance? If the answer is yes, then we would expect a 50 percent probability for each change in mortality in *nuclear* counties to be worse than the change in *nonnuclear* counties. The chance of then getting four such results at the same time would be equal to a coin tosser getting four heads in a row, i.e., $(.50)^4 = .0525$, or about one in twenty. Actually, the probability of obtaining all four observed changes in mortality rates by chance is less than 2 out of 100 as evident in the caption to Table 6.

Given the fact (demonstrated in the caption to Table 6) that the difference in the mortality experience of the two groups of counties is significant, we can speculate that there may be two ways to increase the statistical significance of our findings. The time periods studied should be extended and additional *nuclear* counties included. Extending the definition of *nuclear* counties possibly affected by radioactive rainfall might, for example, double the number of deaths involved. If the divergence between observed and expected rates remained the same, the significance of the results would be increased by 40 percent (i.e., by $\sqrt{2}$).

If the more current experience in the eighties is included, more significant divergences in the cancer rates can be expected. Based on only a few years in the early seventies, the cancer rate divergence in Table 6 is seen to be the least significant. If nuclear emissions in the seventies do result in elevated cancer rates, such effects will more likely be seen in the next twenty years.

A more detailed, properly financed study would, of course, try to account for other environmental factors and allow for adjustments for changes in age, sex, and race required by proper biostatistical procedures. These results, in CEP's opinion, would illuminate the main thrust of these findings.

It is clear that emissions in the *nuclear* counties have had an adverse impact on mortality, particularly on the very young and very old. It will be noted that the total mortality rate (TMR) registered in the *nuclear* counties had the smallest likelihood of being due to chance. This rate mainly reflects the deaths of persons over 65 years of age. But infant and fetal deaths are almost

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TABLE 6: THE STATISTICAL SIGNIFICANCE OF CHANGING MORTALITY RATES

	IMR	FMR	TMR	CMR
1. Mortality Rate, Nuclear Counties 1965-69	0.02224	0.014366	0.008933	0.001526
2. Ratio of Change in Nonnuclear Counties	0.5888	0.6234	0.9215	1.1504
3. Expected Mortality Rate, Nuclear Counties, 1975-82 (1×2)	0.013095	0.008956	0.008232	0.001756
4. Observed Mortality Rate, Nuclear Counties, 1975-82	0.013635	0.009616	0.008413	0.001811
5. Difference (4-3)	0.000540	0.000660	0.000181	0.000055
6. Standard Deviation of the Difference	0.000697	0.000745	0.000084	0.000084
7. 5/6	0.77	0.89	2.14	0.65
8. Chance Probability	0.2207	0.1867	0.0162	0.2579

In this table, we are testing the differences between a mortality rate registered in the combined group of 175 nuclear counties in 1975-82 with what would have been expected if these counties had the same change in mortality experienced by all the nonnuclear counties. We know from Table 5 that these counties had a somewhat better performance with respect to all four mortality rates.

For the sake of precision, we have expressed all rates on a per-capita basis to six decimals. For example the IMR of the nuclear counties would have been .013095 instead of .013635 if its 1965-69 rate had undergone the same ratio of change (.5888) reported for the nonnuclear counties. Is the difference between this "expected" rate and the observed actual rate (.000540) significant? The answer is given by the formula for the standard deviation (σ) of the difference between two sample rates:

$$\sigma_{r_1 - r_2} = \sqrt{\frac{(r_1)(1-r_1)}{n} + \frac{(r_2)(1-r_2)}{n}}$$

where r_2 is the expected rate, r_1 is the observed rate, and n is the number of deaths involved in the calculation of the mortality rate.

We see from rows 6, 7 and 8 above that the probability of securing by chance alone a divergence between the expected and observed IMR as great or greater than .000540 is about 22 percent. By itself, this cannot be regarded as a significant divergence. Similarly, the "chance" probabilities of securing the observed divergences in the fetal and cancer mortality rates are respectively 19 percent and 26 percent, each being high enough to be regarded as the possible product of chance. But since each of these three rates are completely independent, we can ask what is the probability that all three divergences are simultaneously the product of chance? The answer, given by multiplying the three independent probabilities is .0106, which is about one chance in one hundred.

This is in agreement with the very low chance probability (.0162) of securing the observed divergence in the total mortality rate, which of course includes infant, fetal, and cancer deaths. Thus, we have two pieces of evidence to suggest that there are less than two chances out of one hundred for the following statement to be false: In the period 1975-82 there was some extra force of mortality present in the nuclear counties not operating in the nonnuclear counties.

TABLE 7: REACTORS AND LOCATIONS

REACTOR	B/P	TOTAL EMISSIONS 1974-81	LOCATION	COUNTIES INCLUDED
Big Rock Point	B	3.34E+05	4 miles NE of Charlevoix, MI	MI: Charlevoix, Cheboygan, Emmett
Brown's Ferry	B	1.04E+06	10 miles NW of Decatur, AL	AL: Lawrence, Madison, Morgan TN: Franklin, Lincoln
Brunswick	B	1.06E+06	20 miles S of Wilmington, NC	NC: Duplin, New Hanover, Onslow, Pender
Cooper	B	1.03E+05	70 miles S of Omaha, NB	IA: Fremont, Mills NB: Cass, *Douglas, Lancaster, *Sarpy, *Washington
Dresden 1, 2 & 3	B	3.97E+06	14 miles SW of Joliet, IL	IL: Cook, DuPage, Kendall, Will IN: Lake
Duane Arnold	B	2.42E+04	8 miles NW of Cedar Rapids, IA	IA: Benton, Buchanan, Delaware, Dubuque, Linn
Edwin I. Hatch 1 & 2	B	7.47E+04	11 miles N of Baxley, GA	GA: Appling, Candler, Tatnall, Toombs
Humboldt Bay	B	9.62E+05	4 miles SW of Eureka, CA	CA: Del Norte, Humboldt, Siskiyou, Trinity
James A. Fitzpatrick	B	3.58E+05	36 miles N of Syracuse, NY	NY: Jefferson, *Oswego, St. Laurence
La Crosse	B	3.01E+05	19 miles S of La Crosse, WI	WI: Buffalo, Jackson, La Crosse, Monroe, Trempealeau
Millstone N1 & 2	B/P	5.63E+06	3.2 miles WSW New London, CT	CT: New London RI: Kent, Providence, Washington
Monticello	B	1.76E+06	23 miles SE of St. Cloud, MN	MN: Benton, Isanti, Morrison, Sherburne
Nine Mile Point	B	2.04E+06	8 miles NE of Oswego, NY	NY: Lewis, *Oswego
Oyster Creek	B	2.92E+06	9 miles S of Toms River, NJ	NJ: Middlesex, Monmouth
Peach Bottom	B	5.53E+05	17.9 miles S of Lancaster, PA	PA: Berkes, Lancaster, *Lebanon
Pilgrim	B	1.27E+06	25 miles SE of Boston, MA	MA: Norfolk, Suffolk
Quad Cities	B	1.24E+06	20 miles NE of Moline, IL	IL: Carroll, Whiteside IA: Clinton
Vermont Yankee	B	9.23E+04	5 miles S of Brattleboro, VT	NH: Cheshire, Sullivan VT: Windham
Fort St. Vrain	B	2.28E+02	35 miles N of Denver, CO	CO: Adams, Boulder, Denver
Arkansas 1 & 2	P	9.68E+04	6 miles WNW Russellville, AR	AR: Conway, Johnson, Newton, Pope, Van Buren
Beaver Valley	P	3.08E+03	Shippingport, PA	PA: Beaver, Butler, Lawrence
Calvert Cliffs	P	8.24E+04	45 miles SE of Washington, DC	MD: Calvert, Charles, Dorchester, Prince Georges, St. Marys Talbot
Crystal River	P	1.59E+05	70 miles N of Tampa, FL	FL: Alachua, Gilchrist, Marion, Putnam
Davis Besse	P	9.41E+03	21 miles E of Toledo, OH	MI: Monroe OH: Lucas, Ottowa
Donald C. Cook	P	7.34E+04	11 miles SSW of St. Joseph, MI	IN: La Porte, St. Joseph MI: Berrien, *Van Buren
Fort Calhoun	P	1.01E+04	19 miles N of Omaha, NB	IA: Harrison, Pottawattamie NB: *Douglas, *Sarpy, Saunders, *Washington
H.B. Robinson	P	8.10E+03	4.5 miles WNW of Hartsville, SC	NC: Anson SC: Chesterfield, Darlington, Marlboro
Haddam Neck	P	1.62E+04	10 miles SE of Middletown, CT	CT: Middlesex
Indian Point 1, 2 & 3	P	9.18E+04	3 miles SW of Peekskill, NY	NY: Rockland, Westchester
Joseph M. Farley	P	2.61E+04	Dothan, AL	AL: Barbour, Geneva, Henry, Houston GA: Early
Kewaunee	P	1.05E+04	27 miles ESE of Green Bay, WI	WI: *Brown, Door, *Kewaunee
Maine Yankee	P	1.96E+04	3.9 miles S of Wicassett, ME	ME: Kennebec, Knox, Lincoln, Waldo
McGuire	P	0.00E+00	17 miles N of Charlotte, NC	NC: Cabarrus, Catawaba, Gaston, Mecklenberg, Rowan, Union SC: York
North Anna	P	3.02E+04	40 miles NW of Richmond, VA	VA: Caroline, Hanover, Henrico, King William
Oconee	P	2.41E+05	30 miles W of Greenville, SC	SC: Greenville, Oconee, Pickens
Palisades	P	6.23E+03	5 miles S of South Haven, MI	MI: Allegan, Cass, Kalamazoo, *Van Buren
Point Beach	P	5.94E+04	15 miles N of Manitowoc, WI	WI: *Brown, *Kewaunee, Manitowac
Prairie Island	P	7.21E+03	26 miles SE of Minneapolis, MN	MN: Dakota, Goodhue, Hennepin, Ramsey, Scott, Washington WI: Pierce, St. Croix
R.E. Ginna	P	2.30E+04	16 miles NE of Rochester, NY	NY: Monroe, Wayne
Rancho Seco	P	2.11E+04	25 miles SE of Sacramento, CA	CA: Amador, El Dorado, Sacramento
Salem 1, 2	P	2.03E+03	20 miles S of Wilmington, DE	DE: New Castle NJ: Cumberland, Salem
San Onofre	P	7.37E+03	2.5 miles S of San Clemente, CA	CA: Orange, Riverside
Sequoyah	P	1.20E+04	Daisy, TN	TN: Hamilton, Meigs, Rhea
St. Lucie	P	1.04E+05	8 miles S of Ft. Pierce, FL	FL: Indian River, Okeechobee, St. Lucie
Surry	P	7.94E+04	19 miles NW of Newport News, VA	VA: Charles City, Surry, York
Three Mile Island 1,2	P	1.01E+07	10 miles SE of Harrisburg, PA	PA: Schuykill, Dauphin, *Lebanon, Northumberland
Trojan	P	6.52E+03	35 miles NW of Portland, OR	OR: Columbia, Multanomah WA: Clark, Cowlitz
Turkey Point	P	9.96E+04	10 miles E of Florida City, FL	FL: Broward, Dade
Yankee Rowe	P	1.29E+03	20 miles NW of Greenfield, MA	MA: Franklin NH: *Cheshire VT: *Windham
Zion	P	3.12E+05	6 miles N of Waukegan, IL	IL: Lake WI: Kenosha, Racine

*Counties close to more than one reactor.

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Council on Economic Priorities
NEWSLETTER

Editor-in-chief: Alice Tepper Marlin **Editor:** Paula Lippin

The Council on Economic Priorities is a non-profit organization established to disseminate unbiased and detailed information on the practices of U.S. corporations. These practices have a profound impact on the quality of American life. CEP was established so that the American public could become aware of this impact and work to ensure corporate social responsibility. CEP publishes 3-6 Studies and/or Reports per year, and a Monthly Newsletter. Memberships and contributions are tax-deductible. Indexed in Public Affairs Information Service Bulletin. Excerpts welcomed. Please credit the Council on Economic Priorities, 30 Irving Place, New York, New York 10003, and send us a copy.

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For Further Reading

Quality Of Life In American Neighborhoods: Levels of Affluence, Toxic Waste and Cancer Mortality In Residential Zip Code Areas, Jay M. Gould, Westview Press, 1986. See also CEP Newsletters "Toxic Waste and Cancer: The Link is Getting Stronger," Sept. 1984; "Freedom of Information Act: Breaking the Federal Barrier," June 1985; "Toxic Waste in Chesapeake Bay: Bad for People as Well as for Fish," Nov. 1985.

Maternal and Child Health Data Book, Children's Defense Fund, Washington, D.C. 1986.

Radioactive Materials Released From Nuclear Power Plants, 1981, J. Tichler and C. Benkovitz, Brookhaven National Laboratory, 1984.

Measurement of Low Levels of X-ray Mutagenesis in Relation to Human Disease, C. Waldren, L. Correll, M.A. Sognier, T.T. Puck, July, 1986, Proc. U.S. Natl Academy of Science. The data obtained by these investigators, using a new laboratory technique involving individual human chromosones implanted in animal cells, show that the effect of low dose radiation exposures is more than 200 times greater than had previously been assumed on the basis of high dose studies.

This is a part of a rapidly growing body of clinical literature on ionizing radiation effects which can be secured from the **Health and Energy Institute** in Washington, D.C. The detailed annual mortality date for the 175 counties studied here can be obtained on a personal computer diskette from Public Data Access Inc., 30 Irving Place, New York, NY 10003. (212-529-0890). PDA can assemble diskettes with mortality rates for any desired group of states or counties in great detail, and in any desired mode, such as Wordstar, Lotus, or D-Base III.

immediately responsive to the lethal effects of radioactive iodine included in the emissions. Table 5 shows that the greatest adverse change in the infant and fetal mortality rates was registered by those counties close to boiling water reactors. These counties had emission rates of 1.6 curies per capita as against 0.6 curies per capita for the pressurized water reactor counties in the 1975–82 period.

There is little point at this early stage in the investigation to attempt to quantify the extent of the adverse impact since we do not yet have a satisfactory delineation of all the *nuclear* counties affected by both civilian and military reactors. In Table 7, the 175 counties adjacent to each civilian reactor which we have chosen as *nuclear* counties for this Newsletter are listed. Almost certainly, there are several hundred more that could be included among those directly or indirectly affected by emissions from both civilian and military reactors. It is CEP's hope that environmental organizations around each reactor will, on reading this Newsletter, share with us their knowledge or even suspicions about those counties omitted from our preliminary definitions. By adding counties with a lesser impact, the average divergence in mortality rates from those in *nonnuclear* areas will be narrowed. The additional deaths, however, will make our findings more significant statistically and can lead to a more precise quantification of the number of excess deaths to be attributed to emissions. Until then, the estimate of an excess 9000 deaths per year derived from this analysis of *nuclear* states can stand as a preliminary overall estimate.

It is also clear that CEP's estimates of the public health impact of radioactivity and other environmental abuses such as toxic waste can be made far more precise by allowing for differences due to age, sex, and race. Computer tapes from the National Center for Health Statistics are now in CEP's possession. From these tapes, the mortality rates for each county, since 1968, for all white and nonwhite males and females, by age group and for several hundred detailed causes of death can be calculated. Use of this extraordinary database, a tribute to the work of statisticians and epidemiologists of the National Center, will make it possible to pinpoint those groups in our population bearing the brunt of the loss of lives from all environmental abuses. ■

TA-50

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Red LANL 6/86 & prior

December 23, 1986

Mr. Marcus Siding (6H-CP)
EPA Region VI
Interfirst Two Bldg.
1201 Elm Street
Dallas, TX 75270

Dear Mr. Siding,

At Beth Koesterer's request, I am sending to you a copy of Jacobs "Summary Report," Closure and Post-Closure Plan Review, Los Alamos National Laboratory (NMO 890010515). Keep in mind that this plan has not yet recieved PRC's QA review and is subject to revision base on PRC's comments.

If you have any questions, please feel free to contact me.

Gene Czyzewski

Gene Czyzewski
Project Manager

GC/KK

CC: Dan Chow, (letter only)
PRC

TV

February 5, 1987

Mr. Carlos Castillo
USEPA (6H-HS)
1201 Elm Street
Dallas, Texas 75270

RE: Jacobs Engineering Group Closure Plan Review

Dear Mr. Castillo:

We have read the Jacobs' December 23, 1986, review of the Los Alamos National Laboratory closure plans and find the report disappointing. It appears that Jacobs did little more than confirm the presence or absence of information required by regulation, a simple clerical function. We had expected a detailed technical review of the adequacy of LANL's proposed actions, especially the cap to be constructed over the Area P landfill and the concrete plugs in the disposal shafts at Area L.

We believe that the submittal may serve a purpose as a condensation of the plans and a summary of the proposed actions but they are entirely inadequate, without specific references to the regulations, for citing violations. Since we have no requirement for this condensation, we do not believe they have provided a useful product.

If this submittal is indicative of the results we can expect for other closure plan reviews, we strongly recommend that EPA reconsider the benefits of contractor review. We would prefer to perform our own evaluation if we had adequate staff to accomplish this in a timely manner.

Thank you for the opportunity to participate in your contract QA review process. We trust the above observations will be helpful.

Sincerely,

C. Kelley Crossman,
Environmental Scientist

cc: Mark Sides, EPA (6H-CP)
Jack Ellvinger, EID (GW/HWB)

[illegible] will [illegible] spent [illegible] will probably delay the [illegible] a period of [illegible] plans.