"HEALTH HAZARDS INVOLVED IN THE PRODUCTION, STORAGE AND USE OF NUCLEAR WEAPONS." Invited address, Japan International Congress Against A- and H-Bombs. Osaka, Japan. August 1978.

by Rosalie Bertell, Ph. D., G.N.S.H.

Thank you very much for inviting me to come and be with you on this 33rd commemoration of the tragic atomic bombing of Hiroshima and Nagasaki. Please know that I come with great sadness in my heart for what you have suffered, and with the hope of being able to make you know some of the compassion felt by most Americans for the untold grief and human pain we have caused. I join with you in praying that there will never again be war, and that nations will stop devising such instruments of torture and put more effort into meeting everyone's basic human need for food, shelter, clothing and work!

Beyond this goal, I would like to also call for a specific International Ban on RADIATION WARFARE. This would include the use of all forms of ionizing and non-ionizing radiation as weapons. The inclusion of non-ionizing radiation is a protection against the weapon spin-off which will come from technological experimentation with centralized solar power and from microwave and ultrasound developments. My reason for demanding such a ban on RADIATION WARFARE is that the production, handling, transportation and deployment of this type of weapon threatens to destroy human health and the human habitat.

The destruction in the pre-deployment stage is especially harmful. Radiation damage is poorly understood by military and political decision-makers and not easily detected by the population until the undermining of health and of the genetic pool is irreversible. The human body cannot detect the presence of low levels of radiation, but it can be seriously hurt by it. In this presentation, I will devote most of my address to the least known hazard of RADIATION WARFARE, the hazard to the nation which produces such weapons.

My observations flow from nine years of research on the environmental causes of leukemia, and five years of study on the health effects of ordinary medical X-ray. This medical X-ray involved skin doses of radiation ranging from 44 to 1000 mrad, and bone marrow doses between 1 and 600 mrad per plate. The data which I have used are from the Tri-State Leukemia Survey, a 39 million person year epidemiological study collected in the United States over a three-year period. All leukemia cases diagnosed over this period in the survey area were included in the study. A random sample of controls was taken to give information on the non-leukemic population. All reports of medical X-ray were verified at the hospital, clinic or doctor's office, and only verified reports were included in this study. The analysis which I have done on this data includes only X-ray exposures which occurred more than one year prior to the diagnosis of leukemia for cases, or interview for controls. This was done to avoid including X-ray used to giagnose the leukemia itself, and also so that there would be time allowed for the body to repair any X-ray damage which it was capable of repairing. Hence what I am showing you in the slides is the non-repaired measurable health effects of this exposure to low level ionizing radiation, radiation which is permitted under international radiation standards, to workers and even to the general public from nuclear weapon production, nuclear generators and other nuclear industries. This is the type of damage which I would expect to occur to persons who work with radioactive materials, to persons living along transportation routes or near nuclear industries, to persons exposed to residual radiation after weapon testing or actual deployment, and to persons who inhale or ingest radioactive particles in the air, water or food. The details vary according to the part of the body actually exposed to the radiation, and the immuno-strength of the person involved. They vary according to the past medical history of the person exposed, the family medical history, and the age at which the exposure takes place.

It is my purpose to establish two hypotheses:

1. exposure to radiation accelerates the aging process, i.e., the physiological breakdown of bio-regulatory systems which enable the body to cope with the environment;

2. persons with signs of natural premature breakdown are most susceptible to further breakdown when exposed to radiation.

In order to establish these two hypotheses, I will show you how I have measured the effect of exposure to X-ray against the yardstick of natural human aging, rather than in terms of the dose required to produce a particular cancer or genetic effect. This is a new concept in measurement, but it is very appropriate for a hazard like radiation which has many different kinds of effects on the body, ranging from cataracts, grey hair, heart disease, diabetes, leukemia, solid tumors, mal-formed or non-viable offspring, to hidden gene defects which require several generations before they become clinically visible.

The first slides give the intuitive information which first led me to develop this type of measurement. The leukemia which I was observing included all of the non-lymphatic types, and these show a typical increase with age.

Figure 2.

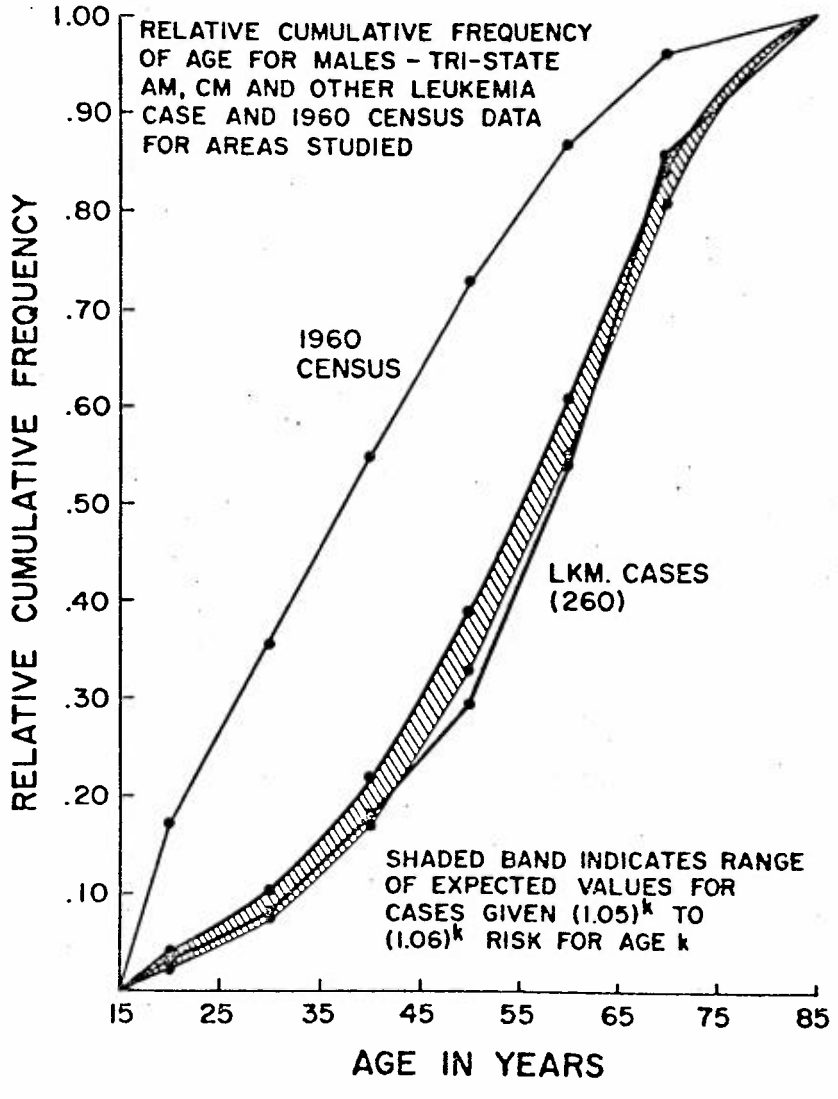
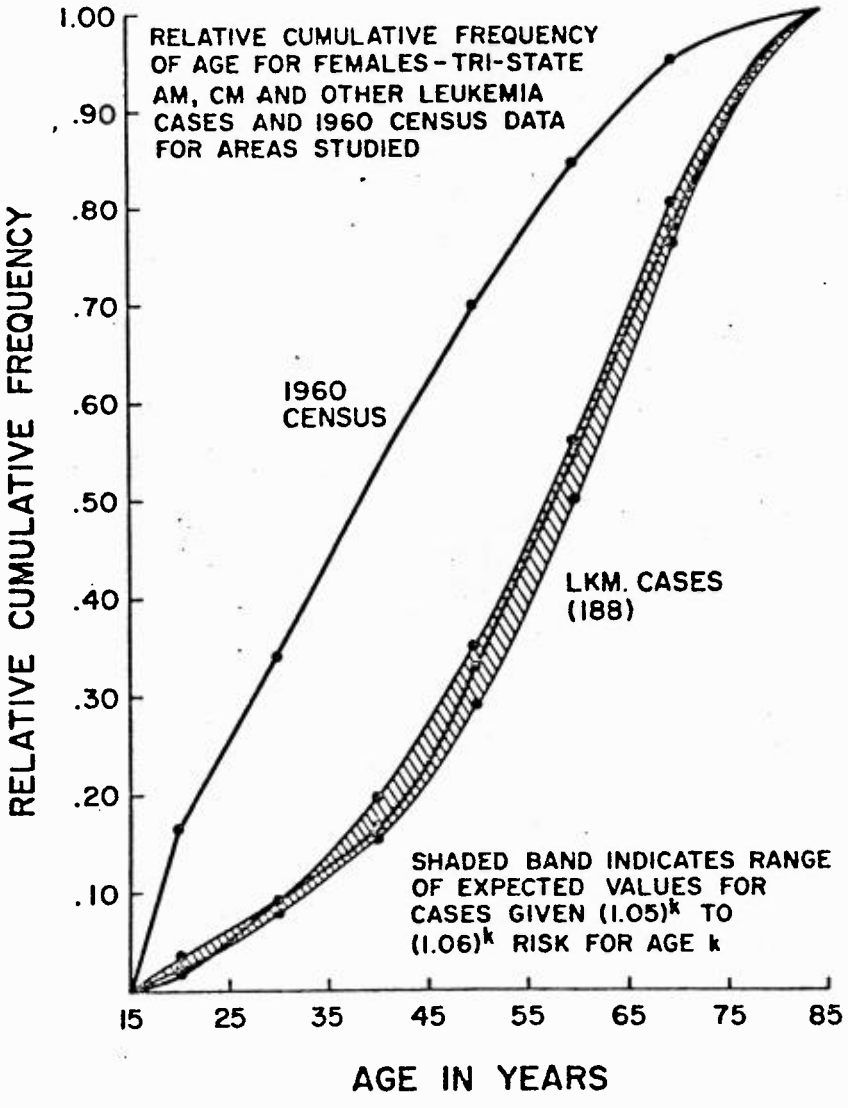


Figure 3.



Slides 1 and 2 (Figure 2, page 26 and Figure 3, page 27 of "Measurable Health Effects of Diagnostic X-ray Exposure" Testimony before the Sub-committee on Health and the Environment, U.S. House of Representatives, July 11, 1978) show the age distribution of the population which was surveyed, together with a shaded band which was constructed on the assumption that one's chances of non-lymphatic leukemia increased at a 5 to 6% rate (compounded) with each year of natural aging. The fit between this theoretical band and the actual case data was excellent. These graphs were drawn to show that the use of only a portion of the cases, namely those with verified trunk X-ray, did not spoil this fit. The next seven graphs (Figures 5 through 11, pages 30-33) were done at a different time. In trying to estimate the incidence rate increase in leukemia which was occurring with each trunk X-ray plate, I discovered that the curve which fitted the control series needed only to be adjusted by assuming a 5% increase (compounded) for each trunk X-ray, in order to give a statistically acceptable fit for the case series. The astonishing thing was that this one model fitted the observed facts for each of three different leukemia subgroups, and two age groups, separately and when combined. The mathematical process is like interest calculated on money in the bank. The interest rate is the same, although actual increase varies with the base amount in the account. Although the

Figure 5.

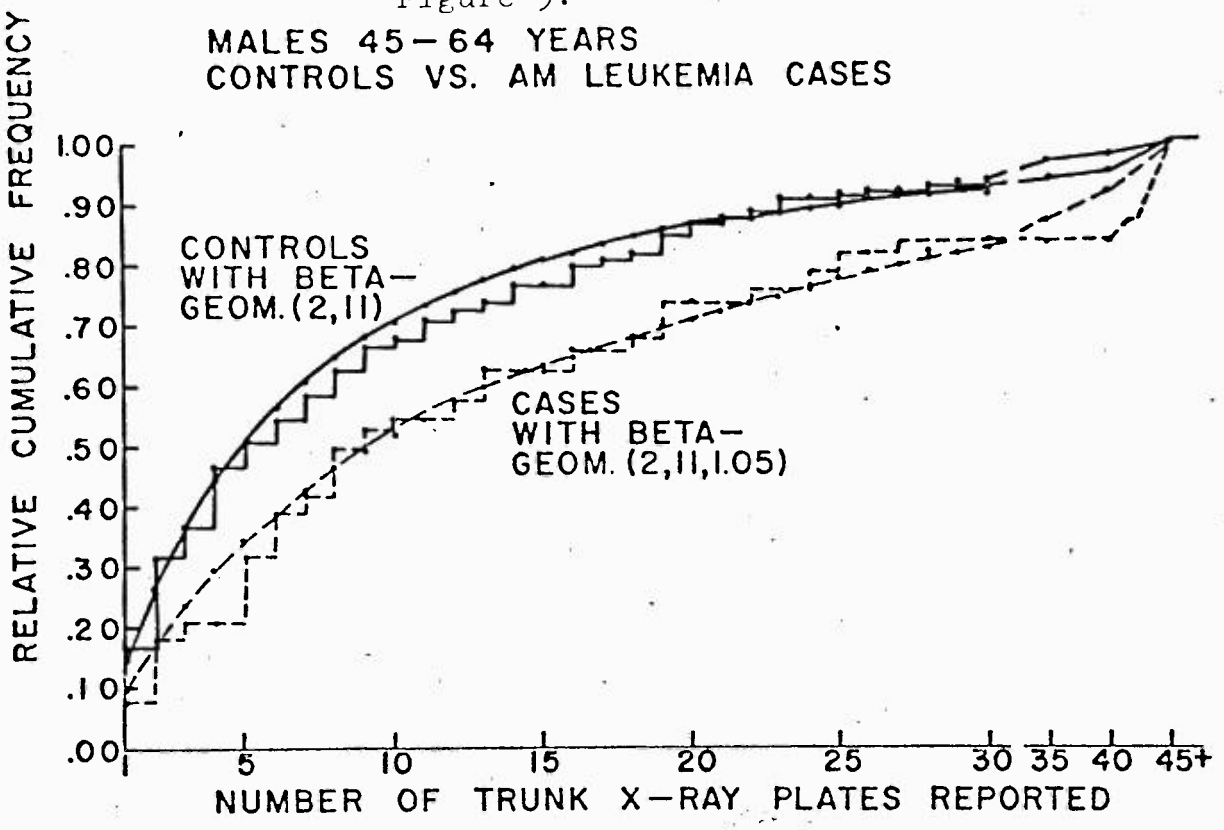


Figure 6.

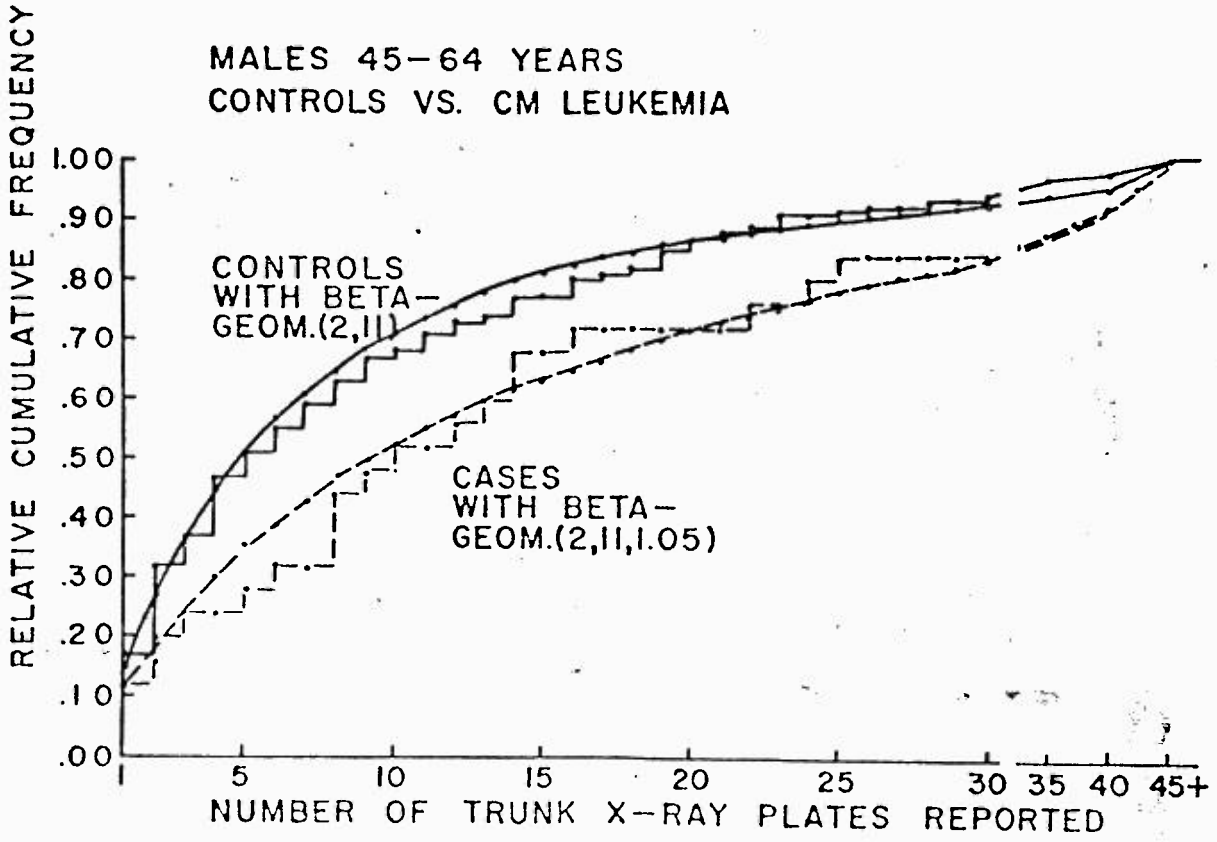


Figure 7.

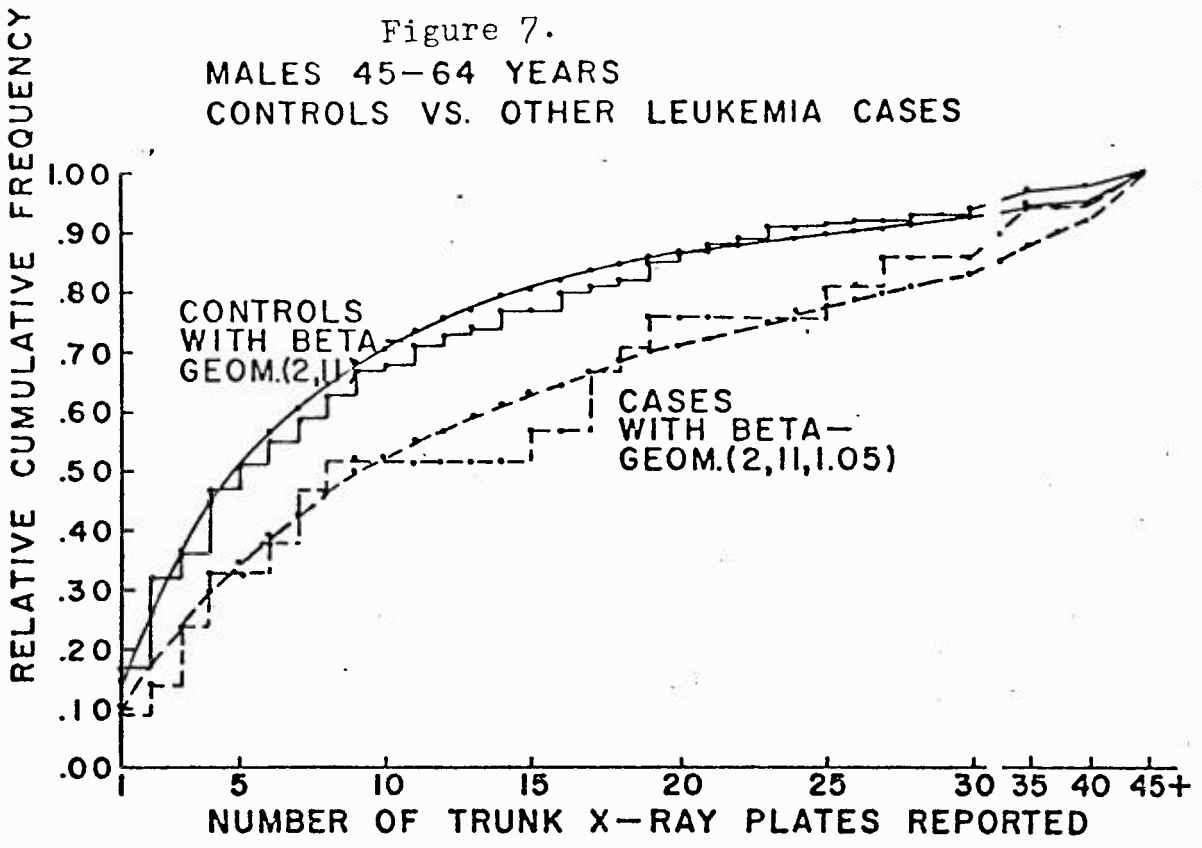


Figure 8.

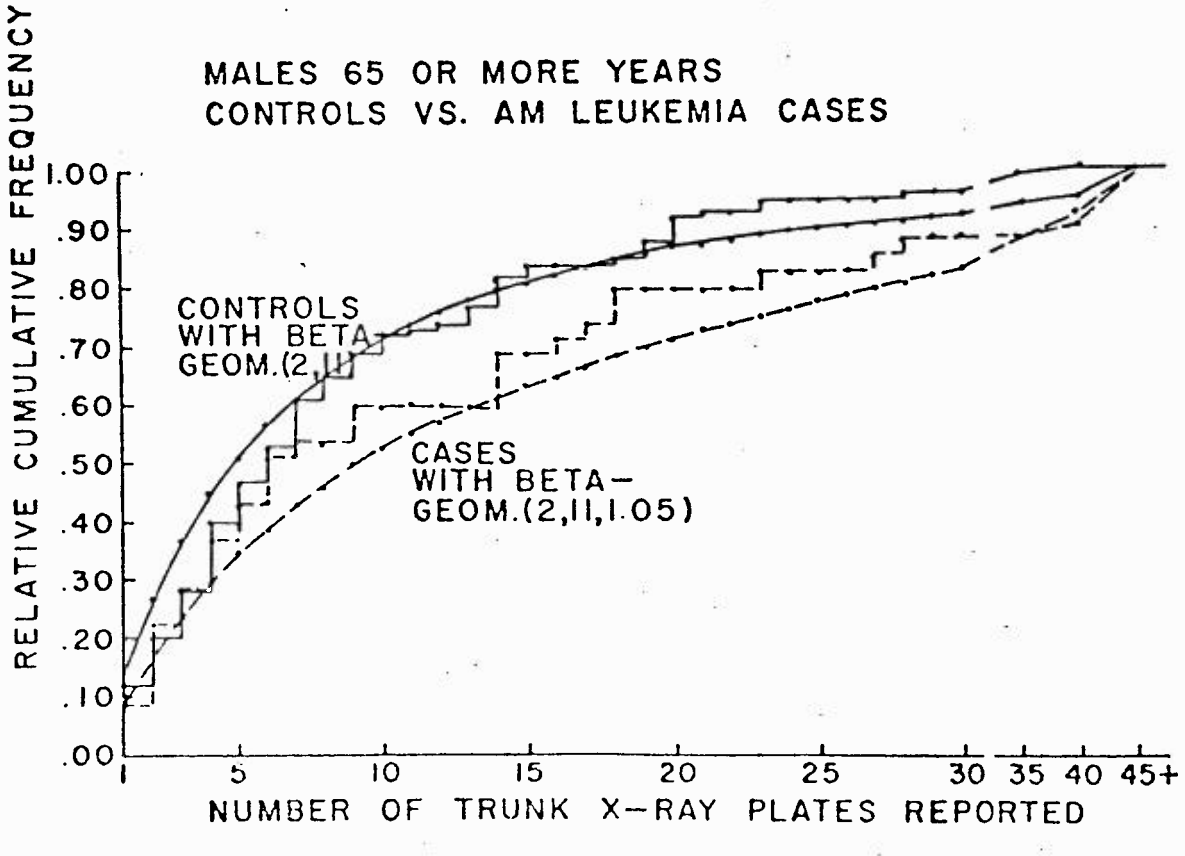


Figure 9.

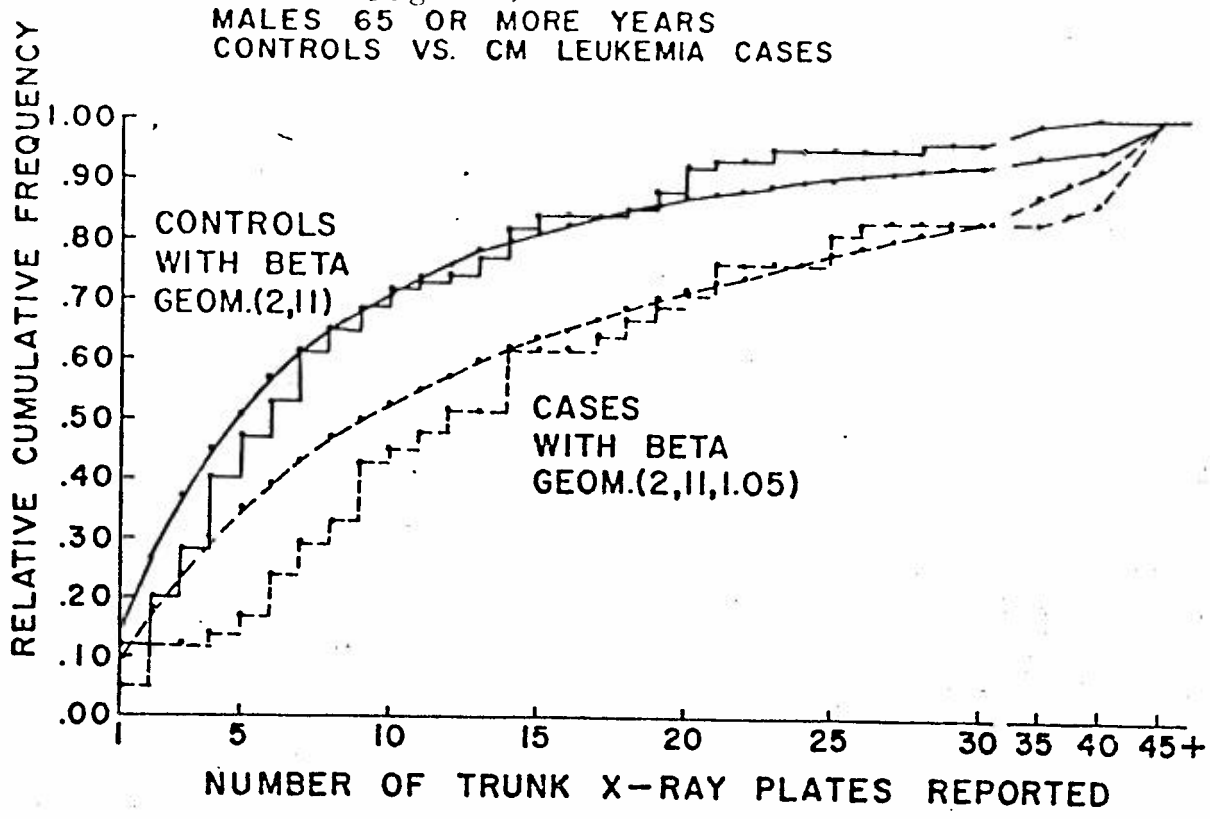


Figure 10.

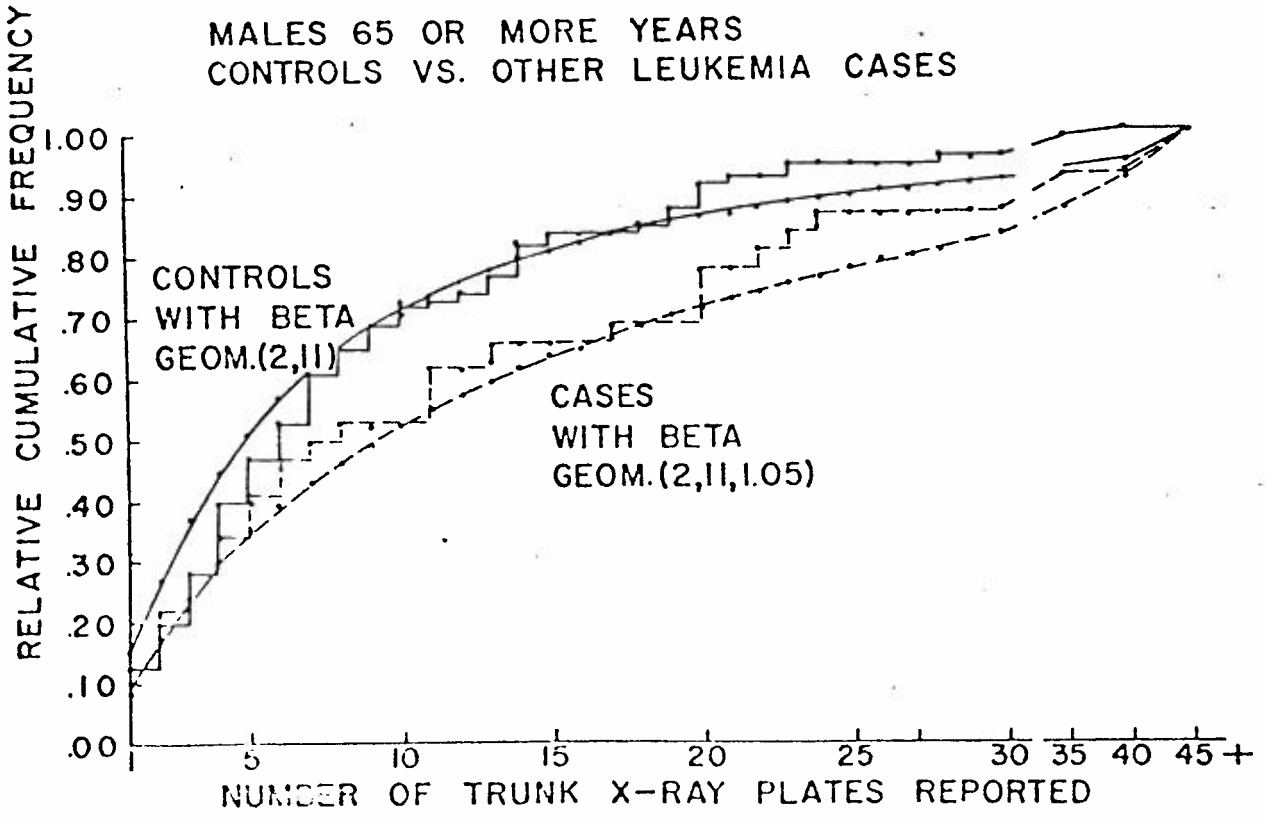
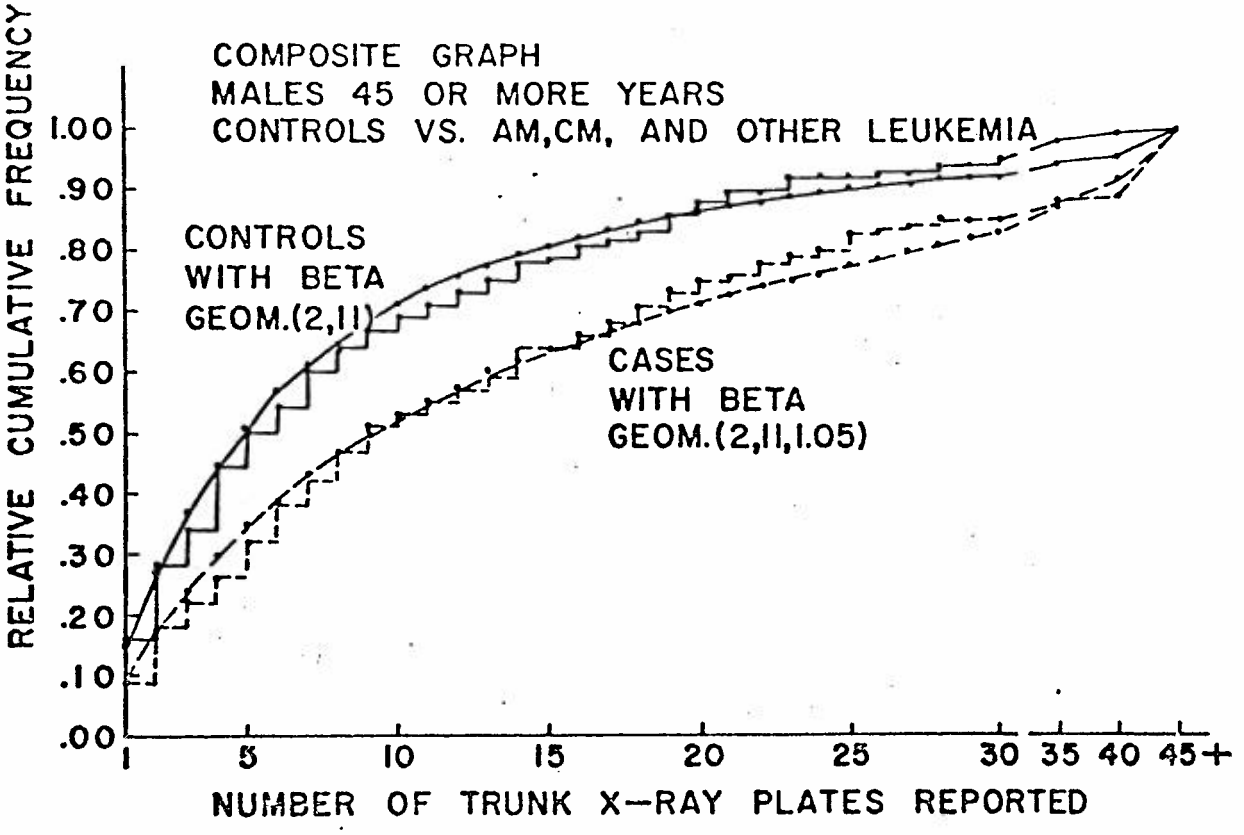


Figure 11.



leukemia base incidence rate was higher in the males over 65 years of age, the rate or percent of increase in leukemia with X-ray exposure was the same as for younger men. To see the actual incidence rates might be helpful at this point.

Table 4.

Male Non-lymphatic Leukemia
Rates per 100,000 Population

Age	# Trunk equi. Xray*	Lkm. Rate per 100,000/yr.	95% confidence interval for rate
45-64	0-10	1.97	1.80- 2.17
	10-20	2.54	1.93- 3.76
	20-30	3.64	2.45- 7.11
	30	5.33	3.45-11.59
65	0-10	6.91	6.02- 8.11
	10-20	8.51	5.99-14.68
	21-30	20.59	10.73-486.67
	30	24.55	11.54- infinity

* Trunk equivalent Xray means the number of trunk Xray plates plus one fourth the number of dental and other non-trunk Xray plates verified.

NOTE: THIS TABLE CANNOT BE USED TO ESTIMATE DOSE RESPONSE BECAUSE AVERAGE DOSE AND AVERAGE AGE IN THE SUB-CATEGORIES IS NOT GIVEN.

Slide 10 (Table 4, page 13) shows the observed leukemia rate per 100,000 persons for those having the indicated number of trunk equivalent X-rays. Trunk equivalent means the number of trunk X-rays plus one-fourth the number of non-trunk X-rays verified. You will see why I added the non-trunk X-ray later. Verification was over approximately a twenty-year period. The confidence interval indicates the reliability of the control series to estimate the size of the base population falling in the given category.

Having this in mind, I did a complete analysis of the adult sample of the Tri-State survey, involving over 1200 cases and controls, each time varying the amount of aging I assumed to be connected with one rad exposure to X-ray. Slide 11 shows the conversion factors which I used to estimate the dose from each diagnostic procedure. (Table 1, page 5)

Table 1.

Number of milliroentgens used in calculation of skin dose for cases and control, based on: Population Exposure to Xrays, U.S. 1964, U.S. Dept. of Health, Education and Welfare

Site of X-ray	mrad per film (at skin entrance)
Dental	1,138
Chest	167
Abdomen	790
Extremitics (includes head and neck)	182

The next table, Slide 12 (Table 2, page 7 of the text), shows the results of 20 separate analyses of the data. For each case and each control, using all exposures even dental, I calculated the rads exposure from diagnostic X-ray. In this analysis dental exposures predominated.

The relative risk statistic is a ratio reflecting the incidence rates of leukemia for those having more than 15 rad exposure to those having less than 15 rad exposure. It was initially signigicantly high, when no aging was assumed for exposure. As I increased the estimate of aging due to exposure, looking for the value which would give a relative risk of one, i.e., incidence rate due to radiation was the same as incidence rate due to natural aging, this remarkable pattern emerged. It reveals two very important things: 1) the underlying mathematical processes caused by both natural aging and exposure to ionizing radiation are the same, otherwise 1200 individual "experiments" could not form such a consistent composite picture coming into focus; and 2) the observed differences between male and female response to radiation exposure are most likely secondary, with the primary biological response remarkably similar.

This type of analysis was repeated more than a hundred more times, using only trunk X-ray, and adjusting the rad cut-off so as to distinguish differences in aging when different parts of the body were the target of the X-ray. Slide 13 shows the results of this series of analyses. As might have been expected, in spite of its high rad dose, the dental X-ray showed the least amount of aging--about a quarter of a year per rad exposure. Chest X-ray showed about 0.6 year aging per rad, and abdominal X-ray, targetting the major blood-forming organs, caused one year aging per rad. Based on these estimates, I devised the trunk equivalent measure which you saw on the previous slide.

Table 2.

Tri-State Leukemia Survey

Aging Estimate of Diagnostic X-ray
to all Sites including Dental

Relative Risks of Non-lymphatic Leukemia with Exposure
of 15 or more rad, adjusted for exposure age
intervals: 15-44, 45-54, 55-64, 65-74, 75+

# Years Aging per one rad expo.	Age Adj. Rel. Risks		Age and Sex adj. risk	Probability
	Male	Female		
0.00	1.35	1.32	1.34	.0021
0.05	1.27	1.27	1.27	.0136
0.10	1.21	1.16	1.19	.0724
0.15	1.10	1.11	1.11	.2893
0.20	1.05	1.07	1.06	.5333
0.25*	0.98	0.98	0.98	.8333
0.35	0.92	0.87	0.90	.2543
0.40	0.89	0.86	0.88	.1461
0.45	0.89	0.84	0.87	.1199
0.50	0.88	0.83	0.86	.0804
0.55	0.85	0.83	0.84	.0528
0.60	0.86	0.81	0.84	.0457
0.65	0.86	0.81	0.84	.0455
0.70	0.86	0.80	0.83	.0388
0.75	0.85	0.79	0.83	.0294
0.80	0.84	0.78	0.82	.0190
0.85	0.84	0.76	0.81	.0121
0.90	0.85	0.76	0.81	.0135
0.95	0.87	0.76	0.82	.0205
1.00	0.84	0.76	0.80	.0094

N.B. In this Table each of the 450 cases and 824 controls were separately evaluated for rads exposure, and age adjustment.

Table 12.

Risk of Non-lymphatic leukemia for Persons
With Heart Disease Relative to Persons Without Heart Disease

Chronological Age	Relative Risk Estimate		
	Male	Female	Combined
15-44	1.27	1.67	1.45
45-54	2.30**	0.75	1.50
55-64	2.17**	1.77	2.02**
65-74	1.26	1.06	1.17
75 or more	0.71	2.75	1.59
Summary	1.38*	1.50*	1.44**

* Significant on 5% level; ** Significant on 1% level.

Slide 17 (Table 13, page 24) shows a re-analysis of this data using a new matching variable: Exposure Age. I invented this term to express the concept of chronological age plus the number of verified trunk exposures plus one-fourth the number of non-trunk exposures a person has experienced. This Exposure Age was calculated for each case and each control, and then the analysis was repeated using matching Exposure Age groups rather than ordinary age. You can easily see that this correctly identifies the population at risk. Males and females no longer show differences, and the true susceptible group, identified by both age and radiation, has six times the normal risk. These persons are precipitated to an early death by X-ray exposure.

Table 13.

Risk of Non-lymphatic Leukemia for Persons
With Heart Disease Relative to Persons Without Heart Disease

Exposure Age	Relative Risk Estimate		
	Male	Female	Combined
15-44	0.88	1.04	0.95
45-54	6.33**	5.71**	6.01**
55-64	1.33	2.09*	1.58*
65-74	1.01	1.16	1.07
75 or more	1.79*	1.58	1.67**
Summary	1.48*	1.47*	1.47**

* Significant on the 5% level; **Significant on the 1% level.

In 1974, Dr. Enrico Viadana and Dr. Irwin D.J. Bross identified certain diseases which predisposed one to leukemia. These diseases were significant for males only, so I will show you the analysis of these diseases as indicators of increased risk for non-lymphatic leukemia for males, using Exposure Age.

The diseases include: pneumonia, heart, rheumatism, asthma, hay fever, hives, eczema, goiter, diabetes mellitus, herpes zoster, psoriasis, neurodermititis and TB. Slide 18 shows the result of this analysis (Table 11, page 21). The risks calculated with respect to chronological age were originally between 2 and 5. It is now apparent that with exposure to ionizing radiation this risk rises to 12. The critical time is Exposure Age 35-44. This means that a 25-year-old man with heart disease reaches this high-risk period if he has 10 trunk X-rays. Between 70 and 80% of the men dying before age 50 from non-lymphatic leukemia are estimated to belong to this susceptible group. Their death is hastened by exposure to radiation.

Table 11.

Relative Risk for Non-lymphatic Leukemia
for Males with Indicator Diseases, for Exposure Age

Exposure Age	No. Cases	No. Controls	Rel. Risk	Probability	Attributable Pr
15-34	15	50	1.34	0.34	14%
35-44	13	22	11.78	0.00	77%
45-54	16	53	7.27	0.00	75%
55-64	40	81	1.15	0.59	8%
65-74	50	63	1.58	0.12	28%
75-84	44	35	1.22	0.56	13%
85 or more	53	36	4.08	0.00	70%
Summary	231	340	1.91	0.00	37%

This human health damage is very subtle and not easily associated by the individual with the exposure. It has not previously been measured, but that does not mean it will not silently take its toll.

The next four slides, 19, 20, 21 and 22 (Tables 5, 6, 7 and 8, pp.14-17),, should convince you that this increase in leukemia with exposure to diagnostic X-ray, even at this low dose level, is not due to a few persons having high exposures. I considered the truncated populations, successively increasing the range of exposures to trunk X-ray. As you can see, the increase in leukemia is steady. This doese not happen in this way by chance.

Table 5.

Tri-State Leukemia Survey
Non-Lymphatic Leukemia Rates by X-ray Exposure
for Males 45-64 Years of Age

Range trunk exposures*	# Cases	Lkm. rate per 100,000/yr.
0- 2	30	1.59
0- 5	40	1.63
0- 10	58	1.99
0- 15	65	2.04
0- 20	74	2.14
0- 25	81	2.26
0- 30	82	2.24
0- 40	84	2.21
0- 50	89	2.32
0- 70	91	2.376
0- 80	92	2.378
0-120	93	2.404

* Number of X-ray plates used for chest or abdominal or other trunk X-ray.

NOTE: THIS TABLE CANNOT BE USED FOR A DOSE RESPONSE ESTIMATE BECAUSE DOSE IS GIVEN IN OVERLAPPING RANGES. AVERAGE DOSE FOR EACH RANGE, AND AVERAGE AGE FOR EACH RANGE ARE NOT GIVEN.

Table 6.

Tri-State Leukemia Survey
Non-Lymphatic Leukemia Rates by X-ray Exposure
for Males 45-64 Years of Age

Range trunk equiv. expo.*	# Cases	Lkm. Rate per 100,000/yr.
0- 2	17	1.34
0- 5	34	1.79
0- 10	53	1.97
0- 15	63	2.03
0- 20	69	2.08
0- 25	77	2.20
0- 30	80	2.21
0- 40	84	2.22
0- 50	88	2.23
0- 60	90	2.35
0- 70	91	2.376
0- 80	92	2.378
0-120	93	2.404

* Trunk equivalent exposures includes each actual trunk exposure plus one fourth the number of non-trunk exposures (dental, and extremity)

NOTE: THIS TABLE CANNOT BE USED FOR A DOSE RESPONSE ESTIMATE BECAUSE DOSE IS GIVEN IN OVERLAPPING RANGES. AVERAGE DOSE FOR EACH RANGE, AND AVERAGE AGE FOR EACH RANGE ARE NOT GIVEN.

Table 7.

Tri-State Leukemia Survey
Non-lymphatic Leukemia Rates by X-ray Exposure
for Males 65 or more years of age

Range trunk exposure*	# Case	Lkm. Rate per 100,000/yr.
0- 10	72	6.80
0- 15	87	7.23
0- 20	99	7.55
0- 25	107	8.05
0- 30	108	8.01
0- 40	110	7.85
0- 50	114	8.14
0- 60	116	8.28
0- 70	118	8.42
0- 80	119	8.49
0-100	121	8.64

* Trunk exposures include all X-ray plates verified for trunk.

NOTE: THIS TABLE CANNOT BE USED FOR A DOSE RESPONSE ESTIMATE BECAUSE DOSE IS GIVEN IN OVERLAPPING RANGES. AVERAGE DOSE FOR EACH RANGE, AND AVERAGE AGE FOR EACH RANGE AREA NOT GIVEN.

Table 8.

Tri-State Leukemia Survey
Non-lymphatic Leukemia Rates by X-ray Exposure
for Males 65 or more Years of Age

Range trunk equiv. expo.*	# Cases	Lkm. Rate per 100,000/yr.
0- 10	67	6.91
0- 15	81	6.83
0- 20	93	7.30
0- 25	102	7.78
0- 30	108	8.01
0- 40	110	7.85
0- 50	114	8.14
0- 60	116	8.28
0- 70	118	8.42
0- 80	119	8.49
0-100	120	8.57
0-110	121	8.64

* Trunk equivalent exposures includes the number of trunk X-ray plates and one foruth the number of dental and other non-trunk X-ray plates verified.

NOTE: THIS TABLE CANNOT BE USED FOR A DOSE RESPONSE ESTIMATE BECAUSE DOSE IS GIVEN IN OVERLAPPING RANGES. AVERAGE DOSE FOR EACH RANGE, AND AVERAGE AGE FOR EACH RANGE ARE NOT GIVEN.

For the more mathematically inclined, I will show you four more slides, the results of tests, using the usual Chi-square evaluation, of both the hypothesis that there was no increase in leukemia with X-ray and the alternate hypothesis that this increase was at the rate of approximately 4% with each trunk equivalent exposure. (Slides 23, 24, 25 and 26; Tables 14, 15 and 16, pp.35-37).

Table 14.

Tri-State Leukemia Data for Males 45-64 yrs.

# Verified Chest X-ray	# Cases Observed	# Cases Expected (null hypothesis)	# Cases Expected (1.04 risk/plate)
0	28	28	28
1	17	14.45	15.03
2	12	10.02	10.84
3-5	12	11.17	13.06
6-10	13	5.93	8.62
11-20	8	4.44	7.99
21 or more	3	1.22	3.26
SUM	93	75.23	86.80

Chi-square test for the expected number of cases under the null hypothesis: 14.78, with 5 DF, which is significant on 3% level.

Chi-square test for the expected number of cases under the hypothesis of a 1.04 relative risk per plate: 2.72, with 4 DF, not significant.

Note: Cases were taken over a three year period, and the expectations were for the same period of time.

Table 15.

Tri-State Leukemia Data for Males 65 yrs. or more

# Verified Chest X-ray	# Cases Observed	# Cases Expected (null hypothesis)	# Cases Expected (1.04 risk/plate)
0	29	29	29
1-2	42	38.25	40.57
3-5	21	19.52	22.32
6-10	18	10.59	14.21
11-20	9	3.91	7.04
21 or more	2	1.34	3.56
SUM	121	102.61	116.7

Chi-square test for the expected number of cases under the null hypothesis: 12.62, with 4 DF, which is significant on 3% level.

Chi-square test for the expected number of cases under the hypothesis of a 1.04 relative risk per plate: 2.37, with 3 DF, not significant.

Note: Cases were taken over a three year period, and the expectations were for the same period of time.

Table 16.

Tri-State Leukemia Survey Data
Males 45-64 Years

# Trunk Equiv. X-ray	# Cases Observed	# Cases Exp. (null hypothesis)	# Case Exp. (1.04 risk/plate)
0-10	53	53	53
10^{+} -20	16	12.42	18.36
20^{+} -30	11	5.94	13.00
30^{+}	13	4.80	15.54
Sum	93	76.16	99.90

Chi-square test for the expected number of cases under the null hypothesis: 19.35, with 2 DF, which is significant on 1% level.

Chi-square test for the expected number of cases under hypothesis of a 1.04 relative risk per trunk equivalent: 1.03, with 1 DF, NS.

Table 16. (continued)

Males 65 or more Yrs.

# Trunk Equiv. X-ray	# Cases Observed	# Cases Exp. (null hypothesis)	# Cases Exp. (1.04 risk/plate)
0 -10	67	67	67
10^{+} -20	26	21.10	31.23
20^{+} -30	15	5.03	11.03
30^{+}	13	3.68	11.93
Sum	121	96.81	121.19

Chi-square test for the expected number of cases under the null hypothesis: 44.50, with 2 DF, significant on 1% level.

Chi-square test for the expected number of cases under hypothesis of a 1.04 relative risk per trunk equivalent: 2.40, 1 DF, NS.

Note: In the above tables observed and expected numbers are for the three year period.

Other important information can be learned from the Tri-State Data, especially in terms of the genetic effects of radiation. Unfortunately, all further research on this data is now stopped because of refusal on the part of U.S. Government agencies to renew funding. The data on the Hanford nuclear workers was also showing health damage at low levels of exposure, previously thought to be harmless, and this study done by Dr. Thomas Mancuso, Dr. Alice Stewart and George Kneale also is without funding. This brings me to my last and most important point.

After the tragic bombing of Hiroshima and Nagasaki, the American people and the people of the whole world had a tremendous fear of the lethal power of this invisible energy which could destroy living tissue and break all harmony between man and the natural world, turning food, air and water into poisons. All radiation-related research and industries were relegated in the U.S. to a special government agency. This agency developed super weapons, did all research on the so-called peaceful atom, controlled all radiation health studies, had the ability to fund or not fund research relating to radiation, etc. The federal government became a partner of the nuclear industry, promoting it and ensuring its continued existence and growth.

This bureaucratic control was largely exercised by physicists, chemists and engineers involved with technology and economics. It was taken for granted that human health was able to sustain the level of radioactive pollution resulting from the increased use of fission reaction for weapons testing and generation of electricity. The supporting industries, such as uranium mining and refining have added to general background levels of radiation and in some parts of the U.S. there is not only a significant increase of lung cancer, but also increases in babies born with cleft palates and other defects, increased leukemia and general signs of deteriorating health.

There are many unanswered questions. One which very much disturbs me is the possible connection between subtle radiation effects and increases in

violence and suicide, increase in the number of hyper-kinetic children, in brain-damaged children and those with learning disabilities. I cannot prove a causal relation between the above trends in the U.S. and the increase in general radiation exposure of the public, but I can observe general trends which followed the above-ground testing era. I believe that it is time to call a halt to all further pollution of the earth with these harmful, man-made poisonous radioactive materials. We have more than enough evidence of damage.

To go back to my original call for outlawing RADIATION WARFARE, I would like to point out that this type of warfare is comparable to the use of poisonous gas, or bacteria, which destroy both those who make it and those against whom it is released. They all destroy the basic cellular life on which we depend for continued existence. It is insane to destroy the earth which sustains us. It is insane to continue down a path of destruction, when we could put our minds to the building of peace and just international relations.

On the positive side, I have two broad suggestions:

1) continue your efforts to form coalitions with persons of all races and nationalities, so that the hostility between governments can be softened by the friendships which flourish between peace-loving citizens under those governments;

2) provide within the international structure a functioning World Court in which international tensions can be resolved.

I envisage this court as recognizing suits brought by international groups of people, as well as by nations. I envisage it as calling to accountability the multinational corporations. I envisage it as a place where human values can be heard over the ever-growing clamor for profits.

Thank you again for inviting me. I will be glad to provide more data to support my claims for those who are of scientific inclination.

I have tried to let you see some of the evidence which has convinced me that an economy built on the supposition that humans could endure the equivalent of 17 chest X-rays as a legal upper limit of radiation every year, with workers receiving 10 times that much, is an economy being built at the cost of human life and the genetic integrity of future generations. Such a culture is crumbling at its very foundation.

Let us instead build a sound structure, expressive of our finest minds and our loftiest desires. Let it be mellowed with a love of fragile life, being able to both sustain the butterfly and challenge the athlete. Let it leave intact a livable habitat for future generations--one free of the fear of war and one blessed with life-giving air, food and water.

Reading List

Bertell, R. Extensions of the relative risk concept. Experientia 31:1-10 (1976).

Bertell, R. X-ray Exposure and premature aging. Journal of Surgical Oncology 9:379-391 (1977).

Bertell, R.; et. al. Proceedings of a Congressional Seminar on Low-level Ionizing Radiation. Subcommittee on energy and the environment, U.S. House of Representatives. 79-787 0. U.S. Government Printing Office, Washington, DC.

Bertell, R. Measurable Health Effects of Diagnostic X-ray Exposure. Subcommittee on health and the environment, U.S. House of Representatives, Congressman Paul Rogers. July 11, 1978.

Bross, I.D.J.; Natarajan, N. Genetic damage from diagnostic radiation. Jr. Am. Medical Assoc. 237 (22): 2399-2401 (1977).

Viadana, E.; Bross, I.D.J. Use of Medical History to predict the future occurrence of leukemia in adults. Preventive Medicine 3: 165-170 (1974).

Natural Radioactivity Contamination Problems. EPA-520/4-77-015. U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC 20460.