1

03/01/10

HIROSHIMA, NAGASAKI , YOU ARE THERE!

Seymour Abrahamson

2

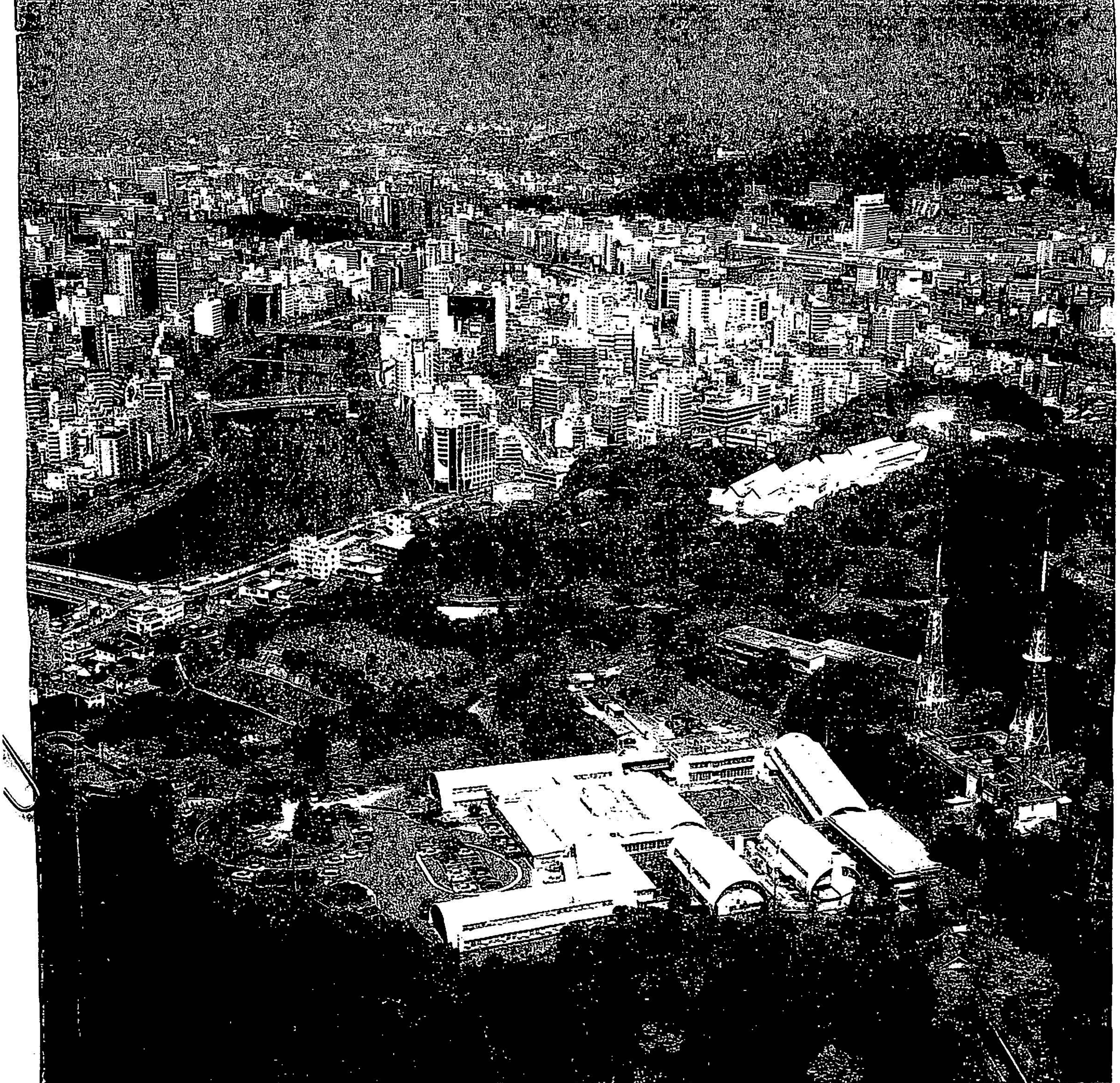
Radiation Effects Research Foundation

日米共同研究機関

A Japan-US Cooperative Research Organization

要　覧

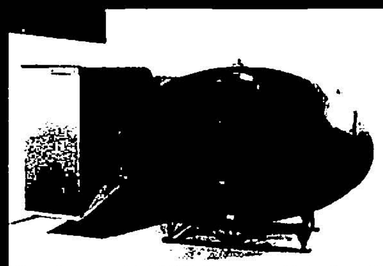
A Brief Description



Characteristics of the Atomic Bomb

gasaki (11:02 am, 9 August 1945)

Fat Man	Length :	3.5 m
	Diameter :	1.5 m
	Weight :	4.5 t
^{239}Pu		21 kt (TNT)

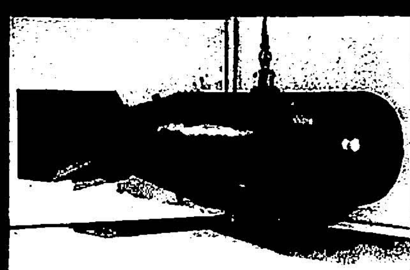


manufactured @ Oak Ridge NH Lab

Characteristics of the Atomic Bomb

oshima (8:15 am, 6 August 1945)

Little Boy	Length :	3 m
	Diameter :	0.7 m
	Weight :	4 t
^{235}U		[illegible] kt (TNT)



= ~ 150 lbs ? 16 Kt TNT

原　子

ATOMIC I

広　島
Hiroshima

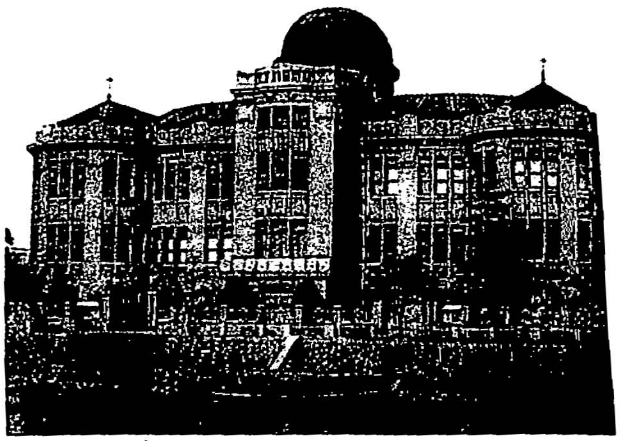
日　時：昭和20年8月6日午前
Time and Date　0815 hrs, 6 August 1945

種　類：ウラニウム ^{235}U
Type

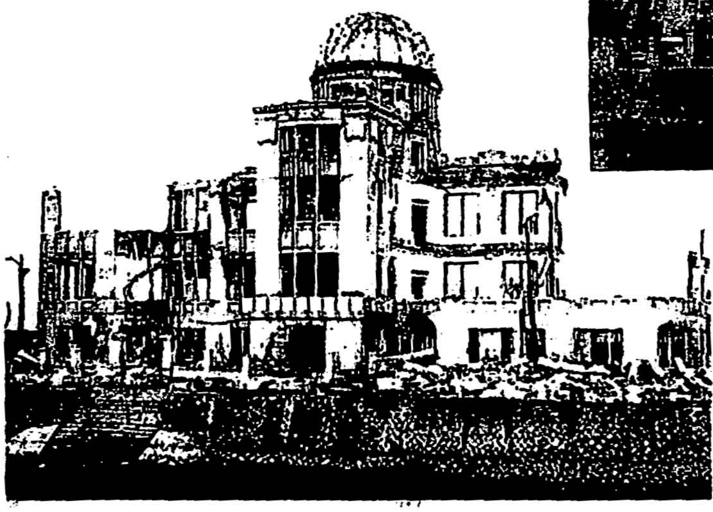
高　度：~~580~~ 600 ± 15m
Altitude　16

TNT換算：~~15~~ ±3kt
TNT equivalent

被爆前　Before



被爆後　After



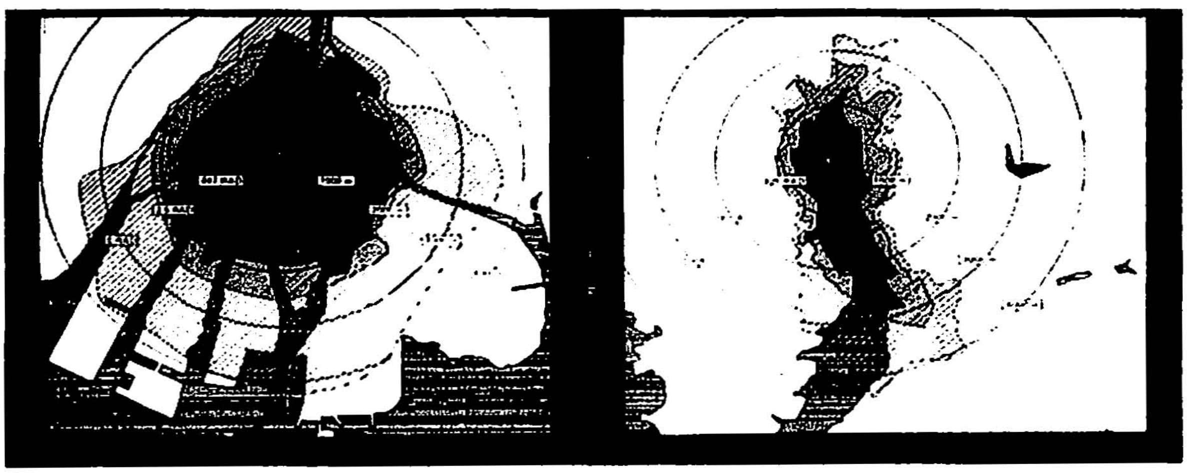
広島県産業奨励館
爆心地から約150m

Hiroshima Prefectural Industrial Promotion Hall
Approximate 150m from hypocenter

150 m from Hypocenter

被　爆　前　　　　被　爆　後

Nagasaki Church　　510 m ↑ from Hypocenter



HIROSHIMA
6 AUGUST 1945

^{235}U . ~~12.5~~ 16 kt (TNT)

ESTIMATED POPULATION 330,000

ACUTE DEATHS,
DECEMBER 1945 .... 90,000 – 120,000

NAGASAKI
9 AUGUST 1945

^{239}Pu .... 22.0 kt (TNT)

ESTIMATED POPULATION 250,000

ACUTE DEATHS,
DECEMBER 1945 .. .. 60,000 – 80,000

● ZERO POINT　　■ EXTENT OF FIRE　　MEAN LINE OF STRUCTURAL DAMAGE　　LIMIT OF STRUCTURAL DAMAGE

Atomic Bomb Dosimetry of Hiroshima (H) and Nagasaki (N)

Atomic bombs release high energy radiations of 2 major types , gamma and neutrons. "Fortunately" the gamma radiation contribution was 99 times larger than the neutron\contribution, which also was quite small . The biological effectiveness of an equivalently measured absorbed physical dose of neutrons is at least 10 times greater than that of the same dose of gamma radiation. .

Establishing a survivors dose will depend on a number of factors, the distance from the hypocenter (the point of the highest dose on the ground), in the open air or shielded with in or by a building ,the type of shielding (wood,brick, concrete , the position of the survivor relative to the blast,sitting, standing, prone, size(baby, child, adult) to name just some.

For every 200

meter distance from hypocenter the dose is reduced in half. Most exposed survivors were from 1000 meters (.62 miles) to 2500m (H) -2700m (N). Beyond those distances the exposure levels were equivalent to natural background. Dose is described in units of Gray (Gy) and in this case was instantaneously received.

Total body doses in the range of 3-4 Gy are

usually lethal in

days, weeks or a few months. About 85% of the survivors in our study have been assigned doses ranging from 0.005 Gy to 2+ Gy.

The most recent and probably the last major revision of the doses received was in 2002 and is known as DS 02, which supercedes Dose System DS 86 (cost of about 10 million dollars).

In the back of this handout I list the present level of exposure of the US population to natural background radiations and medical diagnostic radiation as compared to 30 years ago. Note that medical levels have doubled!

About the Radiation Effects Research Foundation

RERF was originally established by the U.S. National Academy of Sciences in 1947 as the Atomic Bomb Casualty Commission (ABCC) to undertake an extensive surveillance of the health of the atomic bomb survivors, The Japanese Institute of Health of the Ministry of Health and Welfare joined ABCC in its research in 1948. In April 1975, ABCC was reorganized into the nonprofit, bi-national Radiation Effects Research Foundation.

Annual funding for RERF is provided by the Japanese Government through the Ministry of Health, Labour and Welfare, and by the U.S. Government through the Department of Energy (DOE). The National Academies, through its Board on Radiation Effects Research (BRER), serves as a liaison to RERF for the DOE and provides assistance and support.

RERF collaborates on research projects with physicians and scientists from other research institutes, universities and hospitals to expand its research fields and strengthen findings on A-bomb survivors. RERF is currently involved in the tissue and tumor registries in Hiroshima and Nagasaki; site-specific cancer studies that include case review by external pathologists; and a re-evaluation of the DS86 dosimetry system that includes both Japanese and American physicists.

RERF runs several programs through the departments listed below.

The Department of Epidemiology conducts studies on 120,000 A-bomb survivors primarily with regard to cancer incidence and causes of deaths. The department endeavors to clarify the risks associated with human exposure to ionizing radiation.

The Department of Statistics analyzes interdisciplinary information collected to study radiation effects, lends statistical support and advice to radiation scientists, and assists with data management.

The Department of Clinical Studies conducts biennial health examinations on A-bomb survivors to detect diseases and any radiation-induced health effects. The survivors are informed of all examination results and referred to specialized hospitals when necessary.

The Department of Genetics conducts studies to determine whether there are increased mutations in children of A-bomb survivors. It also measures chromosome aberrations in the blood cells of the survivors and residual radiation signals in teeth.

The Department of Radiobiology studies mechanisms responsible for radiation effects including effects on the immune system and cancer induction.

The Department of Information Technology is responsible for managing and storing information for use in various studies, maintaining computers, and sending information to world computer networks.

For more information... Visit the RERF home page at www.rerf.jp or the BRER home page at www.nationalacademies.org/brer.

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

as of 1993

◆ Summary of Findings

Current evidence from ABCC/RERF studies for late health-related effects of radiation

Association with Atomic-bomb Radiation	STRONG Statistically significant results in one or more studies. Questions about potential biases are largely resolved. Risk clearly related to amount of exposure.	WEAK Borderline statistical significance or inconsistent results. More studies may be needed.	NONE No statistically significant effect observed. This may reflect a true lack of effect or result from inadequate sample size.
A-Bomb Survivors (except In-utero Survivors)			
Malignant Tumors	Leukemia (except chronic lymphoid leukemia and adult T-cell leukemia); Breast (women); Thyroid; Colon; Stomach; Lung; Ovary	Esophagus; Salivary glands; Liver; Skin; Urinary bladder; Nervous system; Multiple myeloma; Malignant lymphoma	Chronic lymphoid leukemia; Adult T-cell leukemia; Pancreas; Gallbladder; Rectum; Uterus; Bone
Noncancer Diseases and Conditions	Radiation cataract; Hyperparathyroidism; Delays in growth and development (exposed at young ages)	Cardiovascular mortality and total non-cardiovascular mortality at high doses (>1.5 Gy); Thyroid diseases; Chronic hepatitis and liver cirrhosis; Myoma uteri; Earlier onset of menopause	Infertility; Glaucoma; Autoimmune diseases; Generalized premature aging; Senile cataracts
Immune Competence	Decrease in T-cell-mediated responses; Changes in humoral immune response	Susceptibility to viral infections; Increased autoantibodies	Changes in natural immune responses
Chromosomal Aberrations	Lymphocytes		
Somatic Mutations	Erythrocytes	Lymphocytes	
In-utero Survivors			
* **Malignant Tumors**	2007 Publ. ←	Total solid tumors	Leukemia
Noncancer Diseases and Conditions	Microcephaly; Mental retardation; Delays in growth and development; Lower IQ and poorer school performance		Noncancer mortality
Chromosomal Aberrations		Lymphocytes	

Notes: For the children of A-bomb survivors (F_1), no effects with statistical significance (including borderline statistical significance) have yet been found in relation to exposure to atomic-bomb radiation. The lack of statistically significant relationships with atomic-bomb radiation has been confirmed for the following effects: solid tumors, leukemia, stillbirth, major congenital anomalies, early mortality, chromosomal abnormalities, and protein variants.

→ solid cancer rate of in utero & less than 6 yrs old exposed children significantly increased with dose


MENDOTA
LAKE MON
LAKE WINGRA
SECOND POINT
UNIVERSITY BAY
CAMP RANDALL
FOREST HILL CEMETERY
CALVARY CEMETERY
HOLY CROSS CEMETERY
GLENWAY GOLF COURSE
HENRY VILAS PARK
EDGEWOOD COLLEGE & SCHOOLS
UNIVERSITY OF WISCONSIN ARBORETUM
FRANKLIN FIELD
TURVILLE PARK
BRITTINGHAM PARK
HEIGHTS
1500 meters = 1.5 miles
1000 meters
CITY 151
CITY 12

from Rad Res - 2004 Preston et al

Table 2. Distribution of selected solid cancers identified between January 1958 and December 1998 among LSS cohort members

Site	Cases	% female	Mean age at diagnosis
TOTAL	17,448	54	67.4
Stomach	4,730	46	67.7
Lung	1,759	41	71.2
Colon	1,516	54	69.3
Liver	1,494	40	67.0
Breast	1,082	100	59.8
Cervix	859	100	60.0
Rectum	838	50	68.0
Bladder	469	33	70.6
Thyroid	471	81	60.4
Non-melanoma skin	330	63	72.4
Nervous system	281	67	62.6
Other	3,619	52	68.7

the cohort is female. As expected, stomach cancer, which has a very high incidence in Japan, was the most common cancer site. Lung cancer was the next most frequent cancer, but the number of cases was substantially smaller. Males predominated in both of these cancers. There also were over 1,000 cases of cancers of the colon, liver and breast.

Table 3 provides information on the dose distribution and cancer risks in the LSS. It can be seen that the dose distribution is highly skewed: dose estimates were less than 200 mGy for about 75% of the almost 45,000 cohort members with dose estimates above 5 mGy, whereas survivors with doses over 1 Gy account for less than 5% of survivors in this group.

The data in Table 3 also demonstrate a strong dose response and indicate that there are a considerable number of radiation-associated cancers (~160) in the 5 to 200 mGy dose range. At doses of 1 Gy or more almost half of the cancer cases identified among survivors were associated with their radiation exposure. For all solid cancers combined, we observed a linear dose response using weighted colon dose as the representative dose. There was a statistic significant dose response trend in the 0–0.15 range which was similar to that estimated for entire dose range (Figure 2).

Both the ERR per gray (ERR/Gy) and EAR 10,000 person years per Gy (EAR/10^4 PY Gy) w about 50% higher for women than men. Wl gender-specific cancers were excluded from analyses, the ERR/Gy remained significantly lar for females than males, but there was no gen difference using an EAR model. Figure 3 u gender-averaged risks to illustrate how the exc risk varies with age-at-exposure and attained a The ERR/Gy decreased with increasing age exposure and attained age. The EAR/10^4 PY Gy a decreased with increasing age at exposure, bu increased with increasing attained age. Indeed, w a 25% increase in follow-up, we estimated a 5(increase in the number of radiation-associat cancer cases indicating that the radiation-effect solid cancer incidence persists throughout life.

Statistically significant dose-responses were se for most cancer sites, including oral cavity, esopl gus, stomach, colon, liver, lung, non-melanoma sk breast, ovary, bladder, nervous system, and thyrc (Figure 4). ERR's for cancers of the pancreas, prc tate, and renal cell were non-significantly elevat but were consistent with the risk for all solid canc as a group. Our data also suggest that the radiatio related risks for cancers of the rectum, gallbladd and uterus may be lower than those for all sol cancers combined. There was evidence, however, th radiation exposure during childhood or adolescen may elevate the risk of developing cancer of the bo of the uterus.

Assessing site-specific cancer risks is importa because biologically it is almost certain that vari tion in site-specific risks exists. But, even in a stu of over 100,000 people, the number of cases for mo

Table 3. LSS solid cancers 1958–1998. Subject, person-year, and cases with fitted-excess and attributable-fraction estimates by dose category. ‡ INCIDENCE

Dose category †	Subjects	Mean distance (m)	Person years	Cases	Fitted excess	Attributable fraction (%)
Not in city	25,427	–	680,744	3,994	0	0
< 0.005	35,545	3969	918,200	5,603	3	0.0
0.005 – 0.1	27,789	2114	729,603	4,406	81	1.8
0.1 – 0.2	5,527	1608	145,925	968	75	7.6
0.2 – 0.5	5,935	1430	153,886	1,144	179	15.7
0.5 – 1	3,173	1260	81,251	688	206	29.5
1 – 2	1,647	1118	41,412	460	196	44.2
2 +	564	934	13,711	185	111	61.0
Total	105,427		2,764,732	17,448	853	10.7‡

Note: Estimates of fitted excess cases are based on an ERR model with a linear dose response effect modification by gender, age at exposure and attained age. All not-in-city subjects were used in the modeling, but the baseline risk model allows for city-specific differences in the level of the baseline risks for the not-in-city group.

† Weighted adjusted colon dose in Gy.

‡ Attributable fraction among people who were in the cities with doses greater than 0.005 Gy

‡ incidence = mortality + non mortality cases

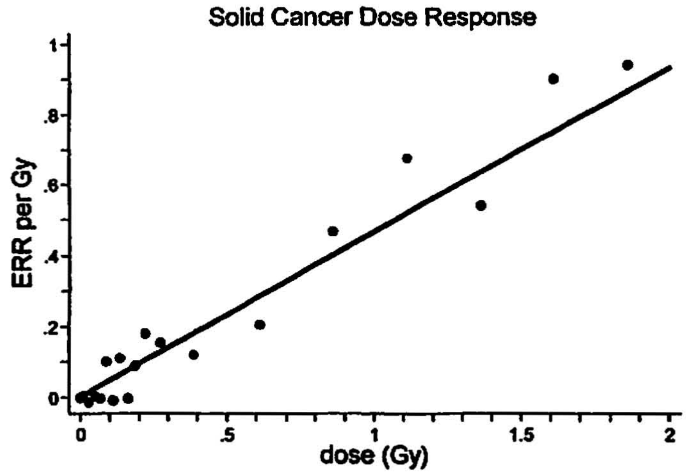
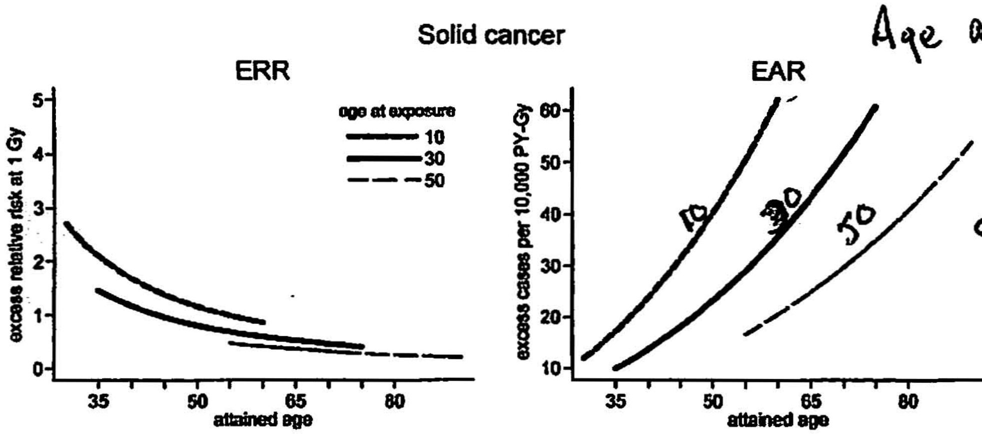


Figure 2. All solid cancer fitted linear dose response and dose category specific ERR estimates.



Age at Exposure

demonstrates youngest are at greatest risk.

Figure 3. Age-dependence for the gender-averaged solid cancer ERR (left panel) and EAR (right panel) for exposure ages of 10, 30, and 50 years.

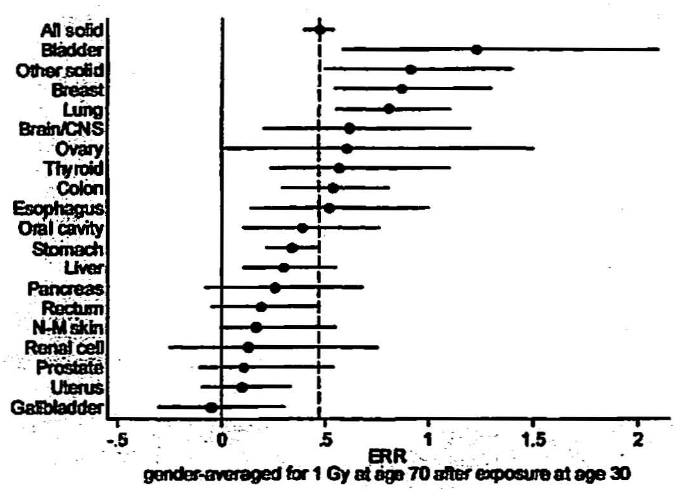


Figure 4. Site specific ERR estimates with 90% confidence intervals. The ERR's are gender-average and correspond to the fitted risk at age 70 for a person exposed to 1 Gy

Richardson et al   Published 2009 - Rad Res.

Leukemia Mortality (all types) 1950-2000

# Survivors	MARROW DOSE in Gray	Fitted cases based on backgnd	Fitted xs. cases	% Cases Radiation Induced	
35545	< .005	99		—	
27789	.005 < 0.1	65	5	11%	5/70
11262	0.1 < 0.5	28	20	46	= 20/48
3173	0.5 < 1.0	8	20	72	= 20/28
1647	1.0 < 2.0	5	27	84	= 27/32
564	2+	2	32	91	= 32/35
		207	104	Avg. 46%	
86,000					

Leukemia types: Acute & Chronic Myeloid?, Acute Lymphocytic Leukemia

In 2009; First evidence of a significant dose effect in males (H&N) for lymphoma & non Hodgkin's Lymphoma has been reported, some 35 years latency period
— Richardson et al. Am. J. of Epidem.

Non-cancer Effects of Radiation

Clinical researchers conducting the Adult Health Study (the subset of the LSS group that receives biennial clinical examinations) have analyzed the relationship between radiation exposure and a number of selected noncancer disorders. Some radiation effects have been found in the Life Span Study population, with statistically significant excess risks for cardiovascular, digestive, respiratory and non-malignant thyroid diseases. Although mechanisms for such effects are not presently understood, careful epidemiological investigation has indicated that these appear to be actual radiation effects.

Radiation studies also show a pattern of growth retardation for survivors who were exposed to the bomb's radiation in childhood. Early investigations of possible accelerated aging have largely been supplanted by study of more specific noncancer diseases, although there remains some interest in generalized aging. Of the diseases most specifically associated with aging (arteriosclerosis, senile cataract, dementia, osteoporosis, arthritis), the clearest evidence of increased risk with radiation exposure is for arteriosclerosis.

The considerable epidemiological differences among radiation-related leukemia, solid cancers and non-cancer diseases are illustrated in Figure 5.

Effects of Fetal Exposure

Fetal brains are damaged by radiation, at least at moderately high doses. RERF's examination of the in utero study population (about 3,000 people) has revealed a correlation between radiation exposure and both mental retardation and microcephaly (small head size).

Approximately 1,100 pregnant women are thought to have been exposed within 2 km of the bombsites, receiving a dose of more than 0.005 Sv. About 150 of them received doses greater than 0.5 Sv. The frequency of severe mental retardation was dose-dependent for survivors exposed before birth at either 8–15 or 16–25 weeks of their mother's pregnancy, with effects especially marked in the former group. Dose-related decreases in school performance and IQ scores have also been observed among the in utero group after excluding severely mentally retarded children.

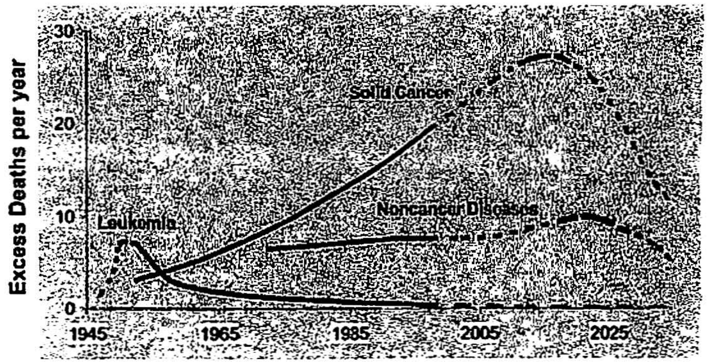


Figure 5. The epidemiological differences among radiation-associated leukemia, solid cancer and non-cancer diseases are evident in this graph showing estimated past and future radiation-associated mortality per year in the Life Span Study cohort by calendar year. There are uncertainties for both observed (solid curves) and unobserved (dashed curves).

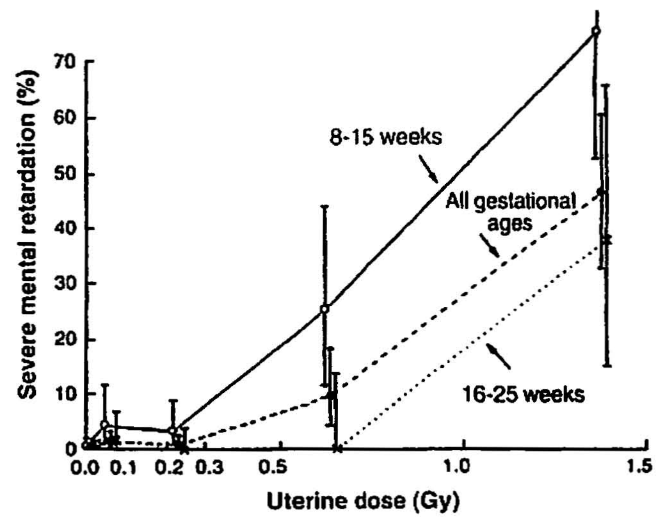


Figure 6. The figure plots the percentage risk of severe mental retardation for those exposed in the womb against the mothers' uterine dose measured in Grays. Those exposed at a gestational age of 8–15 weeks were most at risk. There were 2,800 people in this study. For gamma irradiation, 1 Gray (Gy) is approximately equal to 1 Sievert.

between 1 and 16 (arrows)
(G-band)

The Genetic Studies (A very limited synopsis)

Beginning in1947 the planning of what has been the largest human genetic studies were undertaken by Drs. James Neel and William Schull. Pregnant women registered at local government offices in order to receive additional food stamps. There were ABCC personnel at these offices to meet with these women (optional) and information was obtained on age, place at the time of the bomb ATB , what health effects they or their husbands suffered and an array of other information that would be recorded with the subsequent birth information.

By 1948 Japanese physicians, former military doctors. on the staff were instructed to screen newborns for what might be congenital defects. The majority of babies in Japan were delivered in their homes by midwives. The midwives were members of a professional organization. They were enlisted into the program and paid for informing of each birth and paid quite a larger sum if they deemed there was an observable abnormality, a stillbirth, or abortus involved.

The physicians visited these cases almost immediately. Some 65% of these were subsequently autopsied as well as those who died within 6 days of birth. (At one time there were literally hundreds of jeeps and trucks at their disposal).

From Feb. 1948 until 1954 clinical examinations were carried out on some 70,000 children within usually days after birth and over 20,000 children were reexamined 9 months later.

31, 000 children were born to exposed parents and
41,000 were born to the unexposed parents.

Extensive data analysis demonstrated that there was no statistical difference between the 2 groups for any of the endpoints studied. The doses were estimated based on distance and location and other information. These estimates were tentative until better dosimetry became available.

After 1954 clinical exams were stopped but records were continued with respect sex determination of subsequent births and mortality rates. The registry was expanded to 77,000 births and this phase was concluded in 1982.

In the 60's and 70's the children were checked, during the school year, for physical development. No difference between the groups.

In 1968 Dr Awa and his staff initiated a cyto-genetic study of 16,000 children. Blood samples were collected from them and special studies were carried out. White blood cells were grown and their chromosomes from a particular stage of development were analysed for chromosome rearrangements and numerical changes. Ten cells were examined under a microscope from each participant and the slides on which they were prepared were maintained for future studies.
These endpoints were chosen because they could have been induced by radiation but would not have been recognized as a health problem in standard clinical exams No significant differences were found.

In 1975 mutation studies were undertaken on the same group. 30 blood serum proteins from each fresh sample were examined by a new technique,electrophoresis, that could detect an alteration in the protein structure. Some hundreds of thousands of samples were analysed Also a smaller sample of 11 blood enzymes were followed for loss or diminished activity. The results were negative.

In 1985 cancer incidence studies were followed for those under 20 years. Negative results

In the late 80's blood samples were taken from 500 families from the more highly exposed groups, mother father and at least 1 child and permanently stored in frozen condition so that DNA studies could be undertaken. 500 unexposed families also provided blood. When the ability to screen a large sample of genes from each individual becomes economically feasible the immortalized cells will be available.

In 2001 -06, 12000 members of the study group visited our clinical program and were studied for late onset genetic disorders including coronary disorders, diabetes , hypertension. The results were negative

Mortality and cancer follow-up study of the entire population was completed in 2003.

A National Academy of Sciences Committee of renowned geneticists met to consider whether the program should be started. Their report published in Science(1947) stated:

"Although there is every reason to infer that genetic effects can be produced and have been produced in man by atomic radiation, nevertheless the conference wishes to make clear that it cannot guarantee significant results from this or any other study on the Japanese material. In contrast to laboratory data, this material is too much influenced by extraneous variables and are too little adapted to disclosing genetic effects. In spite of these facts, the conference feels that this unique possibility for demonstrating genetic effects caused by atomic radiation should not be lost."

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RERF Glossary

Frequently Asked Questions

Q8 How many atomic-bomb survivors are included in the group being studied by RERF and how were they chosen for this study?

A8 To establish a population framework in which to conduct long-term follow-up of mortality and cancer incidence, about 94,000 people were selected from 280,000 A-bomb survivors who were resident in Hiroshima or Nagasaki at the time of the October 1950 Japanese national census. Of these, about 54,000 were exposed to significant radiation doses (Question 11) within about 2,500 meters from the hypocenters. Another 40,000 members of the study population were exposed beyond 2,500 meters and received very low doses.

In the 1950 Japanese national census, approximately 280,000 people indicated that they had been exposed to the atomic bombs. RERF' s study population probably includes about 50% of those proximally exposed (within about 2,500 meters of the hypocenters) and 25% of those distally exposed (greater than 2,500 meters from the hypocenters). These percentages are not precise because the census did not record the location of exposure in reference to the hypocenters.

An additional 27,000 who were not in Hiroshima or Nagasaki at the time of the bombs, but whose family registries were in Hiroshima or Nagasaki and who lived in either city at the time of the 1950 census also were included as an unexposed comparison group. These groups constitute the 120,000-member Life Span Study (LSS) cohort.

In addition to studying the LSS cohort, RERF scientists are involved in studies of several other populations: the Adult Health Study (AHS), *in utero*-exposed, and F_1 cohorts. The AHS population comprises 23,000 members of the LSS, who, since 1958, have been asked to participate in biennial medical examinations carried out at RERF. The *in utero*-exposed cohort is a group of about 3,600 people who were exposed to the bomb while in the womb. The F_1 population consists of about 77,000 people born in Hiroshima or Nagasaki between 1 May 1946 and the end of 1984 to parents with and without exposure to the bombs.

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▸ JAPANESE ▸ TOP

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Frequently Asked Questions

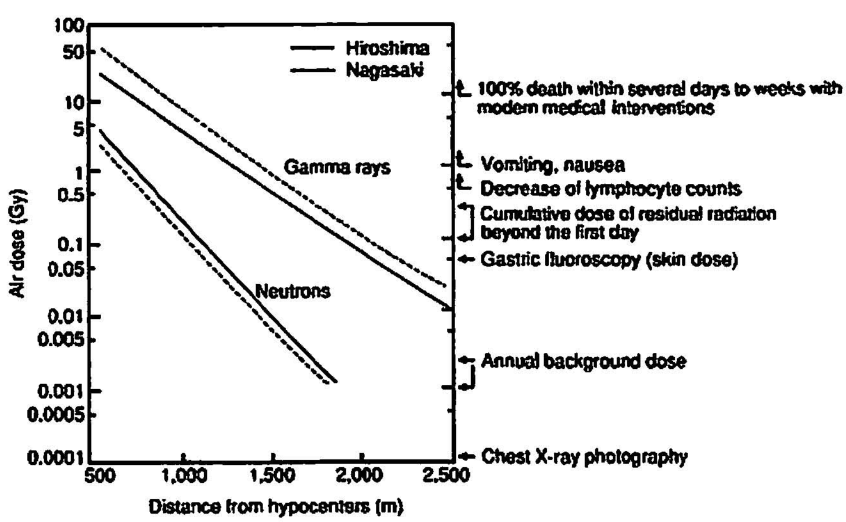
Q 11 What is "significant" radiation exposure?

A 11 In the discussion of cancer risks presented here, attention is focused on survivors with estimated exposure doses greater than 0.005 Gy (5 mGy). No excess risks of cancer or other diseases have been seen among survivors with doses below 0.005 Gy.

A dose of 0.005 Gy is somewhat greater than the typical annual background radiation level to which people are exposed in normal daily life (0.001 to 0.003 Sv per year) and about one-fourth the currently accepted maximum annual dose allowed for radiation workers (0.02 Gy).

Survivors with doses of 0.005 Gy or more were typically within about 2,500 meters of the hypocenter in Hiroshima and 2,700 meters in Nagasaki. The average dose received by such survivors is about 0.2 Gy. The radiation dose decreased by half for every 200-meter increase in distance from the hypocenters.

Figure. Relationship between distance from hypocenters and radiation dose in air.
If inside a typical house, the dose is reduced by 50% or more.
Shown at the right are general biological symptoms and
radiation doses from other sources.



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RERF Glossary

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Frequently Asked Questions

Q2 How many cancers in atomic-bomb survivors are attributable to radiation?

A2 **Table 1** summarizes the number of cancers (from 1950 to 2000 for leukemia deaths and from 1958 to 1998 for solid cancer occurrence) in the Life Span Study (LSS) A-bomb survivors in relation to radiation dose. The proportion of cancer deaths attributable to radiation exposure is considerably higher in those exposed closer to the hypocenters (as is the case with acute deaths from injuries and burns) (see also tables in "Solid cancer risks" and "Leukemia risks" in "Radiation Health Effects"). Overall, nearly half of leukemia deaths and about 10% of solid cancers are attributable to radiation exposure. If one assumes that LSS survivors represent about half of all survivors in the two cities, the total number of cancers attributable to radiation exposure through 2000 may be about 1,900 cases.

Table 1. Excess numbers of leukemia deaths and solid cancer occurrences in relation to dose

Weighted dose* (Gy)	Leukemia deaths				Solid cancer occurrences			
	No. subjects	No. leukemia	Estimated excess	Attributable fraction (%)	No. subjects	No. cancers	Estimated excess	Attributable fraction (%)
<0.005 Control	37,407	92	0	0%	60,792**	9,597	3	0%
0.005–0.1	30,387	69	4	6%	27,789	4,406	81	2%
0.1–1	16,108	71	34	48%	14,635	2,800	460	16%
≥1	2,709	64	56	88%	2,211	645	307	48%
Exposed total	49,204	204	94	46%	44,635	7,851	848	11%

* Weighted bone marrow dose (10 × neutron dose plus gamma-ray dose) for leukemia and weighted colon dose for solid cancers. For indication of the corresponding distance, please see Table 2.

** These include not-in-city (NIC) group, which is not included in the leukemia data.

Table 2 presents the rough idea regarding the distance from the hypocenters and radiation dose.

Table 2. Mean weighted colon dose of LSS subjects and the corresponding distance from the hypocenter. (Since shielding conditions differ among the survivors, this radiation dose-distance relation does not apply to everyone.)

2-4.

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Weighted colon dose	Approximate distance from hypocenters	
	Hiroshima	Nagasaki
0.005 Gy	2,500 m	2,700 m
0.05 Gy	1,900 m	2,050 m
0.1 Gy	1,700 m	1,850 m
0.5 Gy	1,250 m	1,450 m
1 Gy	1,100 m	1,250 m

Questions List

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A Cooperative Japan-US Research Organization

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Frequently Asked Questions

Q 5 What health effects other than cancer have been seen among the atomic-bomb survivors?

A 5 The Life Span Study mortality analyses have revealed a statistically significant relationship between radiation and deaths resulting from causes other than cancer (see also "Deaths due to non-cancer disease" in "Radiation Health Effects").

A total of 18,049 non-cancer deaths occurred between 1950 and 1997 among the 49,114 persons with significant radiation doses. The overall risk for non-cancer deaths is considerably smaller than that for cancer deaths, but because non-cancer causes comprise a larger fraction of human deaths overall, the total number of estimated radiation-related excess non-cancer deaths is about 50-100% of the number of estimated radiation-related cancer deaths (the reason for the wide range is that the data do not yet clarify the shape of the dose response, and different estimates of number of excess radiation-related cases result from various shapes of response that can be fit to the data).

Clinical researchers conducting the Adult Health Study of biennial clinical examinations have analyzed the relationship between radiation exposure and a number of selected non-malignant (non-cancer) disorders. Statistically significant excess risks were detected for uterine myoma, chronic hepatitis and liver cirrhosis, thyroid disease, and cardiovascular disease.

The results suggested that the thyroid gland in young persons may be more sensitive to radiation not only in the development of thyroid cancer, but also possibly in the development of non-malignant thyroid disorders.

Cataracts are another condition related to radiation. Symptoms can appear as early as one or two years following high-dose exposure and many years after exposure to lower doses.

Some non-cancer diseases may be associated with altered immune functions in A-bomb survivors. Immunological study of survivors demonstrated that the proportion of helper T cells was significantly decreased with increased radiation dose (see

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"Immunology Studies" of the Department of Radiobiology/Molecular Epidemiology).

Furthermore, the prevalence of myocardial infarction was significantly higher in individuals with a lower proportion of helper T cells. These results suggest that myocardial infarction in A-bomb survivors is partly due to defects of helper T cells. Such defects may contribute towards a reduced immune defense against microbial infections, possibly leading to atherosclerosis.

Q Questions List

Q7 What health effects have been seen among the children born to atomic-bomb survivors?

A7 One of the earliest concerns in the aftermath of the atomic bombings was how radiation might affect the children of survivors. Efforts to detect genetic effects began in the late 1940s and continue. Thus far, no evidence of increased genetic effects has been found. This does not necessarily mean that no effects exist because some past studies were limited in their ability to detect genetic damage.

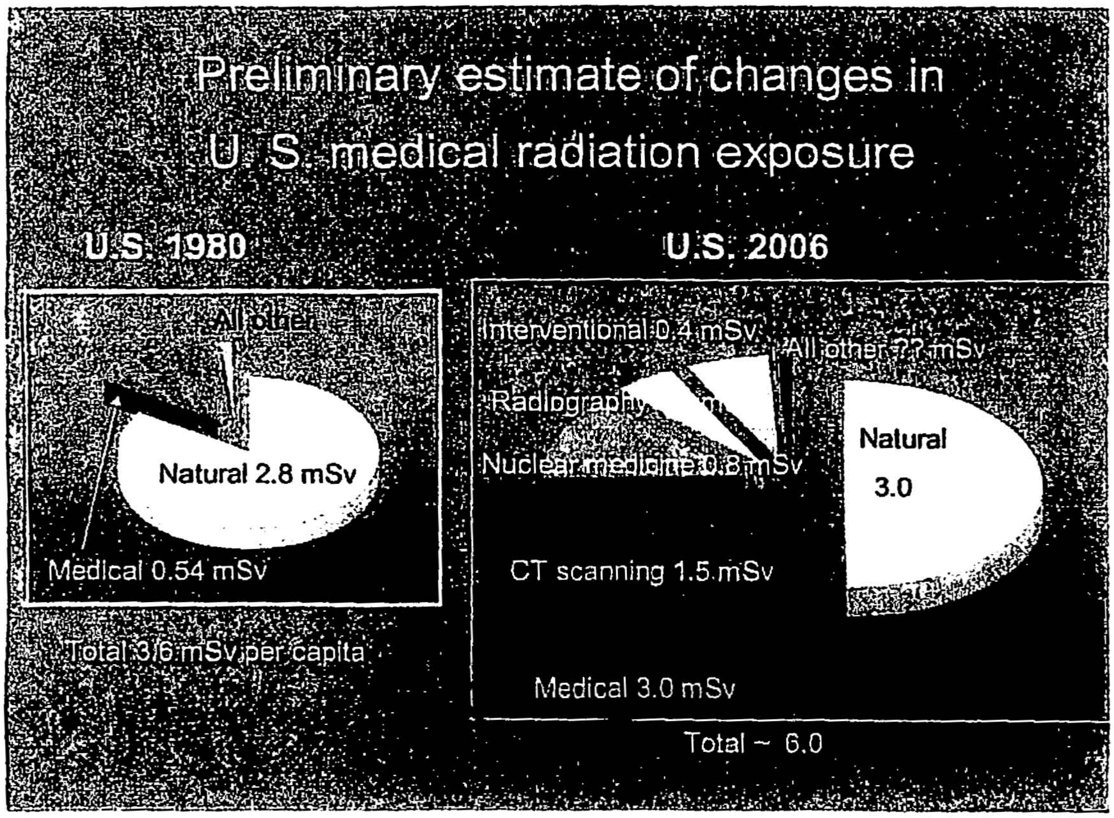
Recent advances in molecular biology make it possible to evaluate genetic effects at the gene (DNA) level. RERF scientists are preserving blood samples that can be used for such studies.

Monitoring of deaths and cancer incidence in the children of survivors continues, and a clinical health survey was undertaken for the first time during 2002 to 2006 to evaluate potential effects of parental radiation exposure on late-onset lifestyle diseases. To date, there is no radiation-related excess of disease in adulthood, but it will require several more decades to fully determine this, as this population is still relatively young.

Q Questions List

over all time from the Chernobyl accident is ' 000 person-Sv.

... of about 3.0 mSv can be compared to estimates of medical exposure from other developed countries. In Europe, the reported annual effective



almost a 6X greater medical exposure

:omparison of per capita dose to the U.S. population from various medical radiation sources in 1980 and the ary NCRP estimate for 2006.

Medical Radiation Exposure in the U.S. in 2006:
F.A. Mettler Jr. et al. Health Physics 2008

Note: about 54% of CT scans - received by those older than 50 who make up 20% of population

about 26% of CT scans - to those under 35 -- about 65% of population

mSv ≅ mGy