

Mortality of Atomic Bomb Survivors in Nagasaki¹

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ABSTRACT: In 1945, an atomic bomb was exploded on Nagasaki. The Scientific Data Center for the Atomic Bomb Disaster was founded in Nagasaki University to analyse radiation effects on atomic bomb survivors. There were about 110,000 victims registered living in Nagasaki as of 1968. Since then, data of 2,000,000 items of health examination has been stored in the computer in the Scientific Data Center. The analysed results of the mortality, the survival and the risk estimation were presented.

INTRODUCTION

In 1945, atomic bombs were dropped on Hiroshima and Nagasaki for the first time in human history. After two years, the Atomic Bomb Casualty Commission was founded by the National Academy of Sciences of the United States of America to survey atomic bomb victims and to study effects of radiation on them. This institute has been reorganized and renamed as the Radiation Effect Research Foundation in 1975 and supported by the United State and Japan equally. In 1950, the national census was performed, and the number of atomic bomb survivors, those still living in Hiroshima and Nagasaki as well as those who no longer did, was accurately known. Public interest in the effects of exposure to radiation has increased after a hydrogen bomb test on the Bikini Atoll in the Pacific Ocean was conducted by the United States in 1954. The bomb affected inhabitants in the area and killed one of the crewmen of a Japanese fishing vessel

sailing nearby. In 1972, the Scientific Data Center for Atomic Bomb Disaster was founded in Nagasaki University to analyse radiation effects on atomic bomb survivors in Nagasaki. Since then, the health examinations and the cause of death of the survivors have been surveyed.

ATOMIC BOMB DATABASE

Atomic bomb survivors are the victims who have been issued the Atomic Bomb Health Handbook from the Nagasaki city government. There were 83,050 victims registered as atomic bomb survivors living in Nagasaki as of 1968. The Health Administration Center of Nagasaki city offers free health examination to atomic bomb survivors twice a year. Since 1968, date of about two million items of health examination has been stored in a computer in the Scientific Data Center for Atomic Bomb Disaster in Nagasaki University, and a database have been established²⁾. The database is constructed from fundamental information, health examination,

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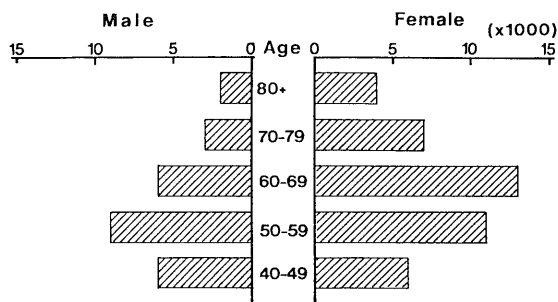


Fig. 1. Age distributions of atomic bomb survivors as of 1985.

death certificates. The fundamental information compiles name, sex, the date of birth, the distance from the hypocenter of the bomb exploded, the shielding from radiation. Data from health examinations contains results of routine examinations and any further examinations. Data from death certificates provide the date and cause of death.

Health examinations are performed in two steps. In the routine examination; anamnesis, auscultation, percussion, erythrocyte sedimentation rate, blood cell count, hemoglobin, urine, blood pressure, and liver function tests are preformed. If the routine examination shows any abnormality, further tests are preformed: hematological, visceral organ, orthopedical, ophthalmological, radiological and others.

The age distribution of atomic bomb survivors in 1985 is shown in Fig. 1. As 40 years had passed since the bombing, the minimum age was then 40 years old. The female population is larger than male. The largest fraction of the females was of the ages 60-69, while the largest fraction of the males is of the ages 50-59. This is from the fact that a large portion of the young male adults were in the military services and away from the city at the time of the bombing.

MORTALITY

We compared the mortality of survivors exposed and unexposed to radiation from the atomic bomb, to see if exposure affected life span, and we analyzed the effect of the health examinations on longevity.

The deaths of 7,782 people were examined;

Table 1. Number of deaths

Year	1970	1971	1972	1973	1974	1975	1976	Total
Male	570	562	530	607	587	575	598	4,029
Female	492	486	503	547	591	598	536	3,753
Total	1,062	1,048	1,033	1,154	1,178	1,173	1,134	7,782

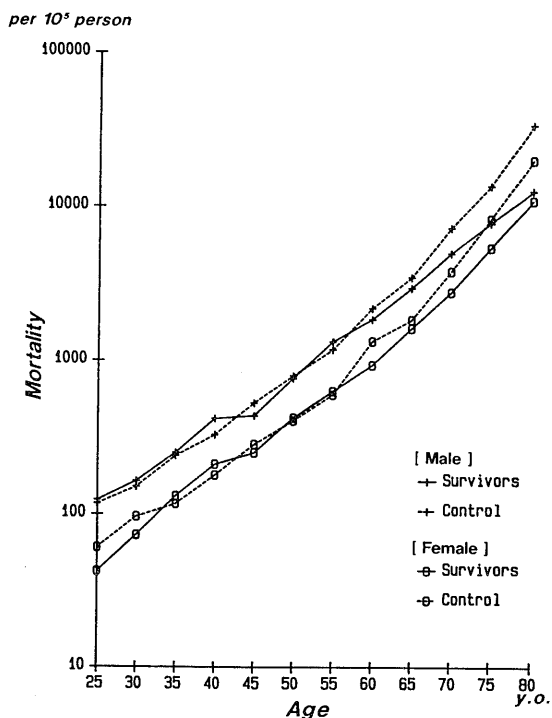


Fig. 2. The mortality due to all causes.

4,029 males and 3,753 females from 1970 to 1976, as shown in Table 1. About one thousand deaths occurred every year. Although the population of the males was smaller than that of the females, the number of deaths for each year was comparably the same for both sexes, meaning the mortality rate of males was higher than that of females.

The mortality due to all causes is shown in Fig. 2. The solid lines are for atomic bomb survivors, the dotted lines are for the control group. Control group were persons residing in Nagasaki, but not having an Atomic Bomb Health Handbook. The plus symbols are for males, the open circles are for females. The mortality increases with age for both sexes. Overall, the mortality of the males was higher

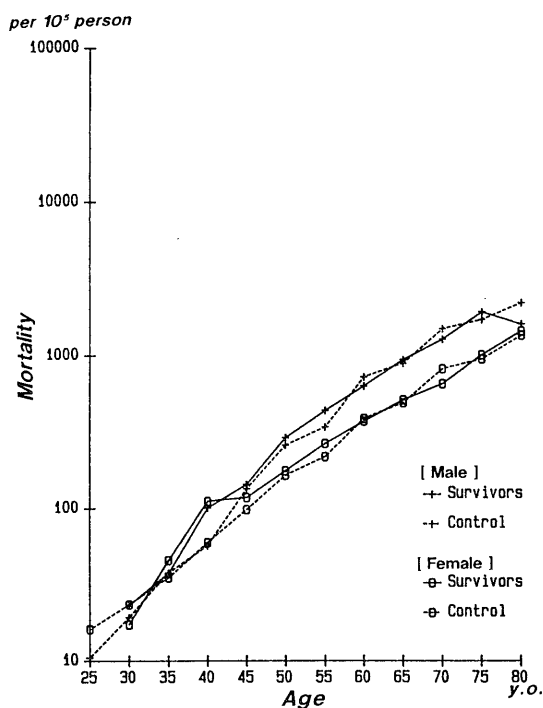


Fig. 3. The mortality due to cancer.

than that of the females.

There was virtually no difference in mortality between the survivors and the control group for the ages under 55, above 60 years old, the mortality of the survivors is actually lower than that of the control group³⁾. It is a wonder that the mortality of the atomic bomb survivors is lower than that of the control, for many of the survivors must have received some harmful effects.

The mortality due to cancer is shown in Fig. 3. The cancer mortality of the males was higher than that of the females above 40 years of age. The cancer mortality was not statistically different between the survivors and the control group. It is well known that radiation is one of carcinogens, and the incidence of cancer is significantly higher for the people exposed to radiation¹⁾. The radiation dose received by the atomic bomb survivors ranged from more than 6 Gy to negligible zero. In this kind of situation, where the level of radiation diminishes exponentially as moving away from the hypocenter, the doses of exposure will range widely. The

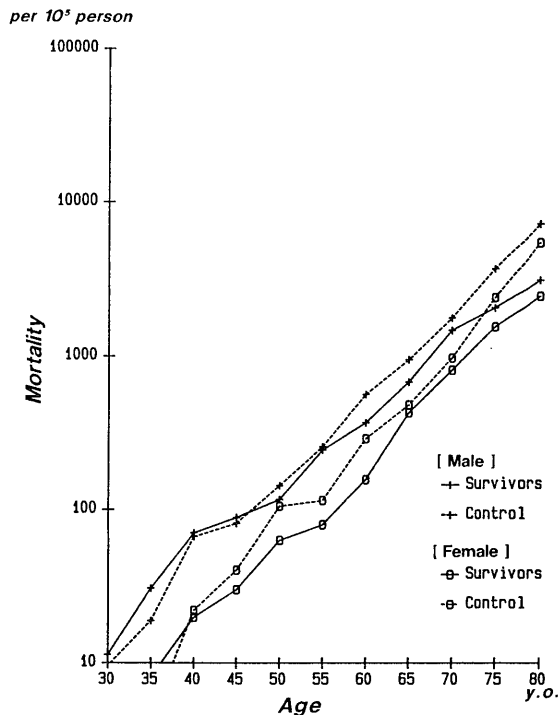


Fig. 4. The mortality due to cerebrovascular disease.

number of survivors who received small doses will be greater than the number who received the larger doses. Any kind of average will be greatly skewed. The overall effect of radiation on the cancer mortality was not observed.

The mortality due to cerebrovascular disease is shown in Fig. 4. The tendency of mortality to increase and the difference between the survivors and the control is the same as the mortality due to all causes. Cerebrovascular disease was less dangerous for the survivors than for the control group. This might be due to early detection, the control of blood pressure and the advice of health care officials in the periodical health examinations.

SURVIVAL

The survival of the atomic bomb survivors was analyzed by grouping the received radiation dose. Fifty-three hundred and thirty-one survivors who received between 1 and 599 cGy of radiation dose were followed up for 11 years from 1970 to 1981. As a control group, those

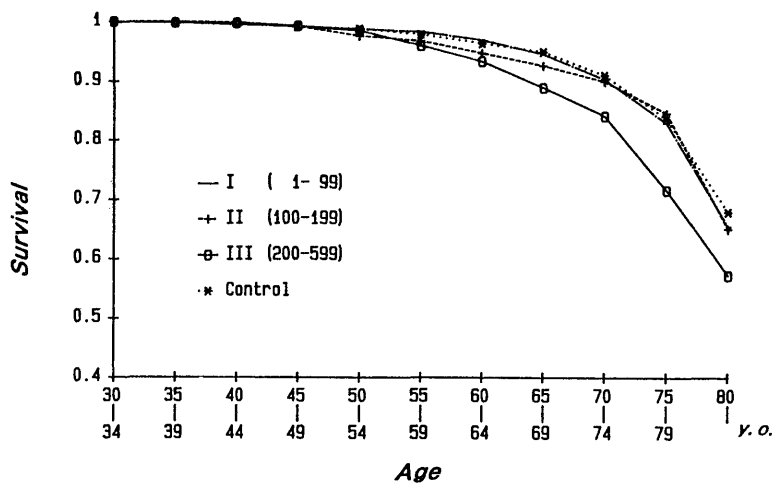


Fig. 5. The survival for groups of different radiation dose ranges.

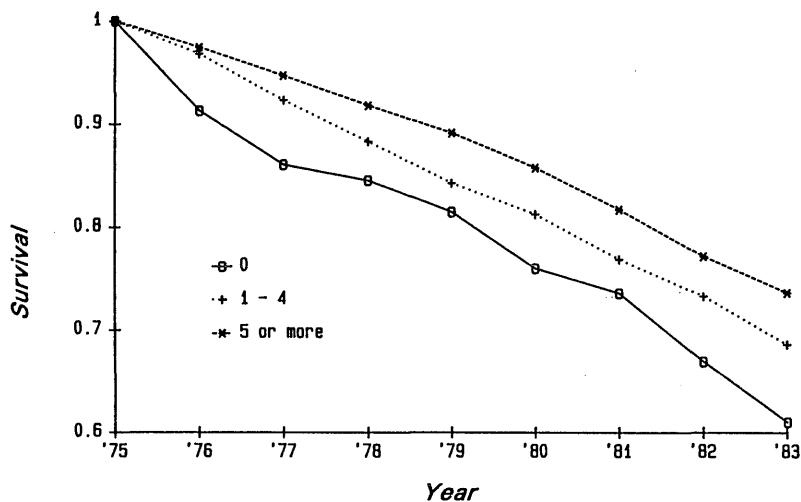


Fig. 6. The survival for groups of different times of health examination received

persons were taken who were exposed to the atomic bomb at distances of more than 2000 m from the hypocenter where the radiation dose was less than 1 cGy. In this period, 672 persons died. The survivors were grouped by dose ranges: group I, 1 to 99 cGy; group II, 100 to 199 cGy; and group III, 200 to 599 cGy. The survival curves for groups I and II, and for the control showed no difference (Fig. 5). But the survival for group III, 200 to 599 cGy, was significantly lower than the other groups. This suggests that the radiation dose of more than 200 cGy from the atomic bombing affected longevity⁴⁾.

We analyzed the survival according to the number of health examinations undergone, in order to examine if health examination given to the survivors is effective or not. The survivors were put into 3 groups. Group I was those who received no health examinations, group II was those who received 1 to 4 examinations, and group III was those who received 5 or more during the surveyed five years. The analyzed survival for each group is shown in Fig. 6. The lowest curve is for the group who never had a health examination. The middle curve is for the group who had 1 to 4, or less than once a

year. The highest curve is for the group who underwent the health examinations more than five times in five years, or at least once a year. This suggests that the health examination taken periodically at least once a year contributed to the prolongation of life⁸⁾.

RISK ESTIMATION

We have analyzed the risk of atomic bomb survivors of 3,456 who lived in 1970, and who were followed up until 1988. The subjects and the observed deaths are tabled according to

Table 2. Subjects followed-up and observed deaths (1970-88)

Dose (cGy)	Subjects		Deaths	
	Male	Female	Male	Female
1- 49	562	938	162	202
50- 99	182	168	56	39
100-149	108	158	36	39
150-199	196	267	59	48
200-599	440	437	172	79
Total	1,488	1,968	485	407
	3,456		892	

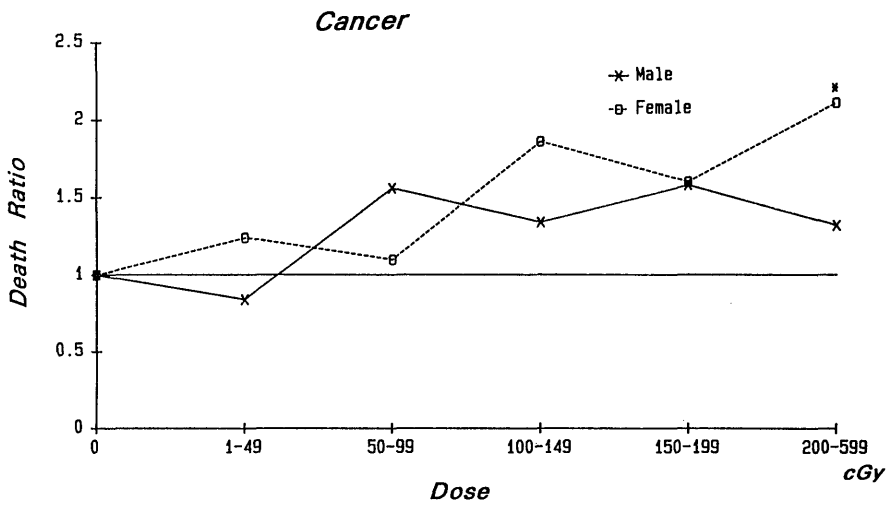


Fig. 7. The death ratio of cancer.

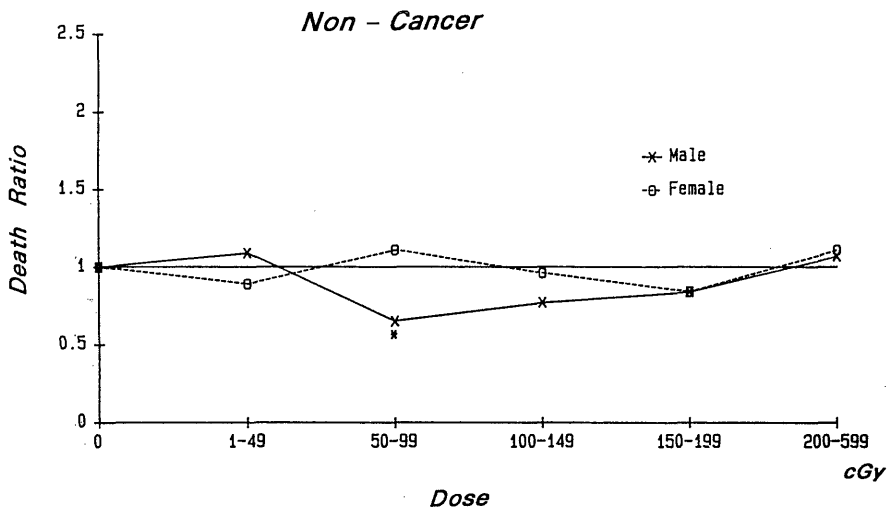


Fig. 8. The death ratio of non-cancer.

radiation dose for males and females (Table 2). The total number for the males was 1,488, and 1,968 for the females. The total deaths for the males was 485, and 407 for the females. As a control, three times the above number, or 10,368, were followed up who were age-matched to the subjects.

The risk of cancer is shown in Fig. 7. A unity of the risk means that the exposed and unexposed people had the same mortality. The risk of cancer increased for both sexes with dose. The asterisk indicates that the risk for females exposed to 200-599 cGy was significantly higher than the control.

The risk of non-cancerous diseases is shown in Fig. 8. The risk of non-cancerous diseases are lower than the control for a wide dose range. The asterisk indicates that males exposed to 50-99 cGy had significantly lower risk than the control. This result may suggest a beneficial effect. It is possible that a small amount of radiation might stimulate some human functions, probably immunological functions, and resulted in negating risk. This phenomenon could be called "Radiation Hormesis". We think that the present study of human data suggests that low doses of radiation are not necessarily harmful, and may be beneficial under certain conditions⁵⁾.

HEALTH CONTROL

The database has facilitated not only the study of the late effects of the atomic bombing, but also the study of improvement of the health conditions of atomic bomb survivors. Computer terminals are placed in the Health Administration Center in Nagasaki city for doctors' use, this center is situated in the center of the city about 3 km away from the Scientific Data Center for Atomic Bomb Disaster. The computer terminals are connected with the computer in the Scientific Data Center. The doctors in the Health Administration Center can easily use the data in the database of the Scientific Data Center. When the doctor inputs ID number into the computer terminal, results of the health examinations are displayed on the CRT as shown in Fig. 9. An example of figure shows that a survivor has received examinations 27 times from 1973 to 1990. The first column is the items examined, such as erythrocyte, leukocytes, hemoglobin, and others. The top row is the date of the examination.

An example of a graphical display of the data of blood examination is shown in Fig. 10. The data of four items are displayed. The abscissa is the year of examination performed. The

XXXXXX - X Hanako Nagasaki		F S.08.03.23 Age 57.5			
Exam. Date	H01.05.26	H01.12.05	H02.01.09	H02.07.09	C: 25-28/28
Age	56.1	56.7	56.8	57.2	R: 1-16/57
Diag.	Normal	Further	Abn.	unnec.	
ICD Code			285.9		
Disease			Hem.		
RBC	443	364	378	430	10 ⁴ /mm ³
WBC	3200	4400	3600	4100	/mm ³
HB	12.9	10.7	10.6	13.2	g/dl
C. I.	0.90	0.91	0.88	0.95	
ESR	10	14		7	mm
Uro.	+-	+-		+-	
Uri. Pro.	-	-		-	
Uri. Sug.	-	-		-	
Uri. Blo.	-	-		+-	
B. P. Max	130	120		142	mm/Hg
B. P. Min	82	80		88	mm/Hg
GOT	17	20		16	K. U
GPT	9	14		14	K. U
ALP	6.6	5.3		6.2	K. AU

Fig. 9. The example of displayed data of the health examination on the CRT.

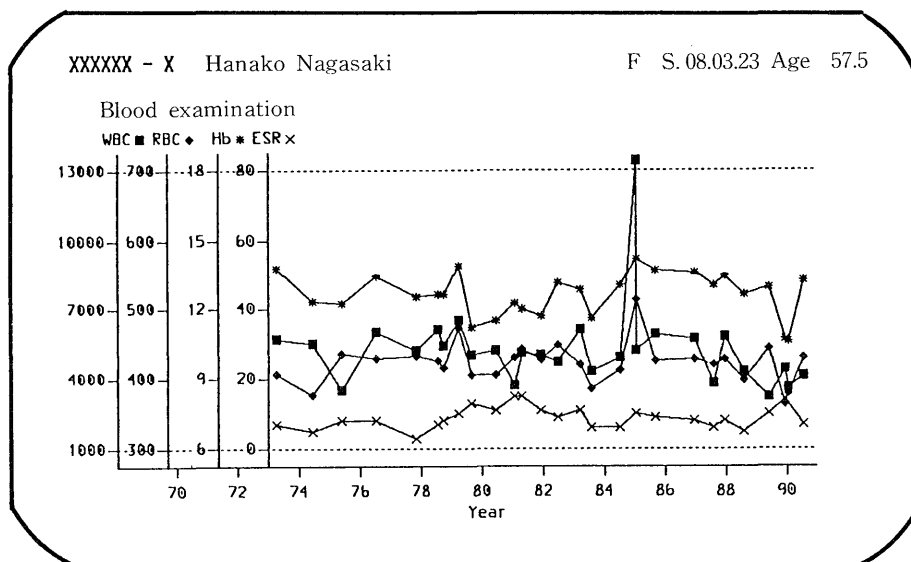


Fig. 10. The example of a graphical display of the data of blood examination

square shows the number of leukocytes, the diamond is of the erythrocyte count, the asterisk is of the amount of hemoglobin, and the cross is of the erythrocyte sedimentation rate. The chronological changes in each item can be found easily on the display.

This system is useful in the health care of atomic bomb survivors. The doctors can find every changes in the results of examinations so easily and rapidly, and can advise suitably to the survivors by showing the past examination results. Participants in the health examination also can understand their own health condition easily^{2, 6)}.

Forty-five years have passed since the atomic bomb was dropped on Nagasaki. By now many survivors have died of radiation hazards. Still now, survivors are living with the fear of radiation effects appearing late. The analysis which we have done in the Scientific Data Center should reveal the effects of radiation on human beings as the result of atomic bombings, which we should not repeat again. We hope our analysis might contribute to the welfare of survivors still living today.

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