Nuclear Disaster Response Basic Training Session

Basic Knowledge about Radiation Protection for Disaster Relief Activities

(English translation)

(Translated by the Red Cross Nuclear Disaster Resource Center)

日本赤十字社
Japanese Red Cross Society

1. Basic knowledge about radiation

2. Atomic bombings (1945): High-dose radiation exposure.

3. Chernobyl (1986): Low- to high-dose radiation exposure;
internal exposure (thyroid gland).

4. Fukushima (2011): Low-dose radiation exposure.

1. Basic knowledge about radiation

2. Atomic bombings (1945): High-dose radiation exposure.

3. Chernobyl (1986): Low- to high-dose radiation exposure;
internal exposure (thyroid gland).

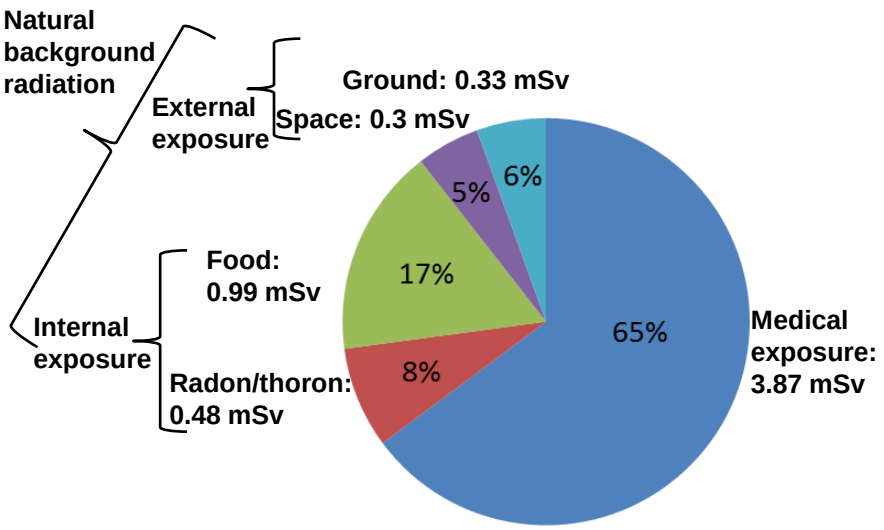
4. Fukushima (2011): Low-dose radiation exposure.

Types of natural background radiation

日本赤十字社
Japanese Red Cross Society

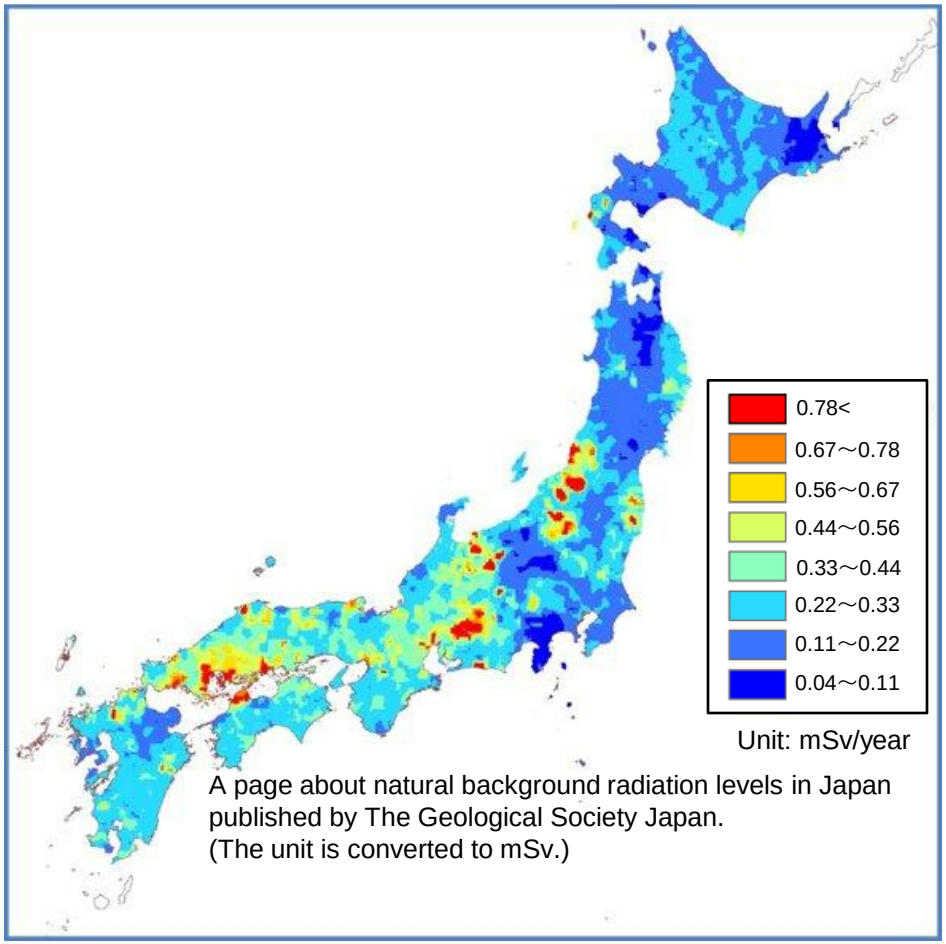
Exposure dose in daily life

In Japan: 5.97 mSv per year on average.



The chart was compiled from data about radiation exposure from the living environment, which is published by Nuclear Safety Research Association.

Radiation from the ground



A page about natural background radiation levels in Japan published by The Geological Society Japan.
(The unit is converted to mSv.)

Source: Chapter 2 (exposure to radiation) of a comprehensive document published by the Ministry of the Environment about basic knowledge and data regarding health effects, etc. from radiation.
http://www.env.go.jp/chemi/rhm/kisoshiryo/h27shiryo2a.html (in Japanese)
(The above two charts were translated and modified by the Red Cross Nuclear Disaster Resource Center.)

Environmental radiation around the world

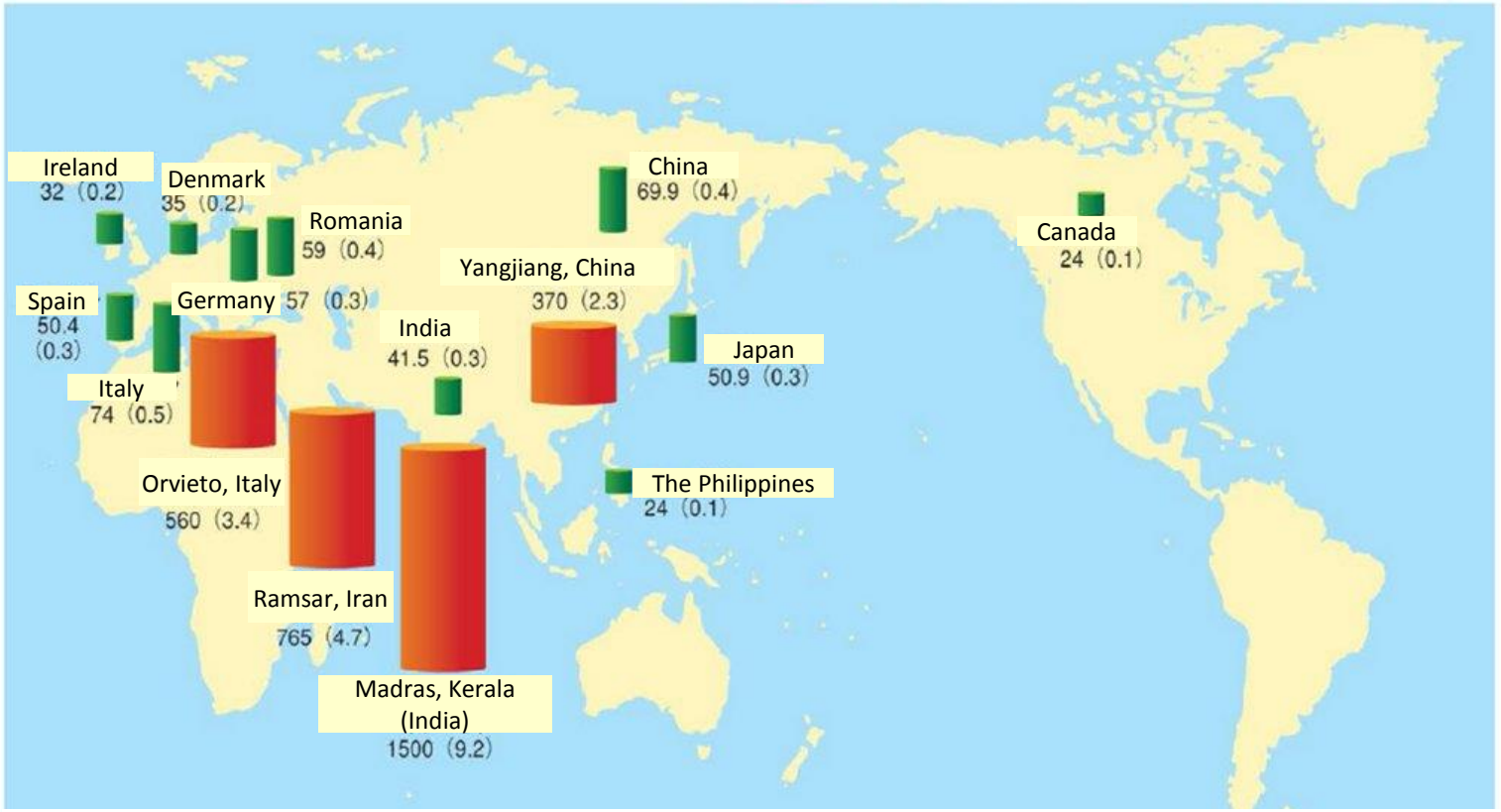
日本赤十字社
Japanese Red Cross Society

Radiation in daily life

Radiation from the ground (worldwide)

nGy/h (mSv/year)

Converted to effective dose using 0.7 Sv/Gy.



Source: 2008 UNSCEAR report;
Data on radiation from the living environment published by Nuclear Safety Research Association (2011).

Source: Source: Chapter 2 (exposure to radiation) of a comprehensive document published by the Ministry of the Environment about basic knowledge and data regarding health effects, etc. from radiation. http://www.env.go.jp/chemi/rhm/kisoshiryo/h27shiryo2a.html (in Japanese)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Environmental radiation

There are some areas of high environmental radiation dosages in some part of Iran, Brazil, India and China.

In these areas, millions of people are exposed to radiation throughout their entire lives.

Their life-time personal radiation dosages may range from hundreds of mSv to over 1 Sv.

Currently, there has not been a significant increase in the number of cancer incidences from the residents in these areas that were exposed to radiation.

Global nuclear contamination from the fallout caused by nuclear tests in the atmosphere

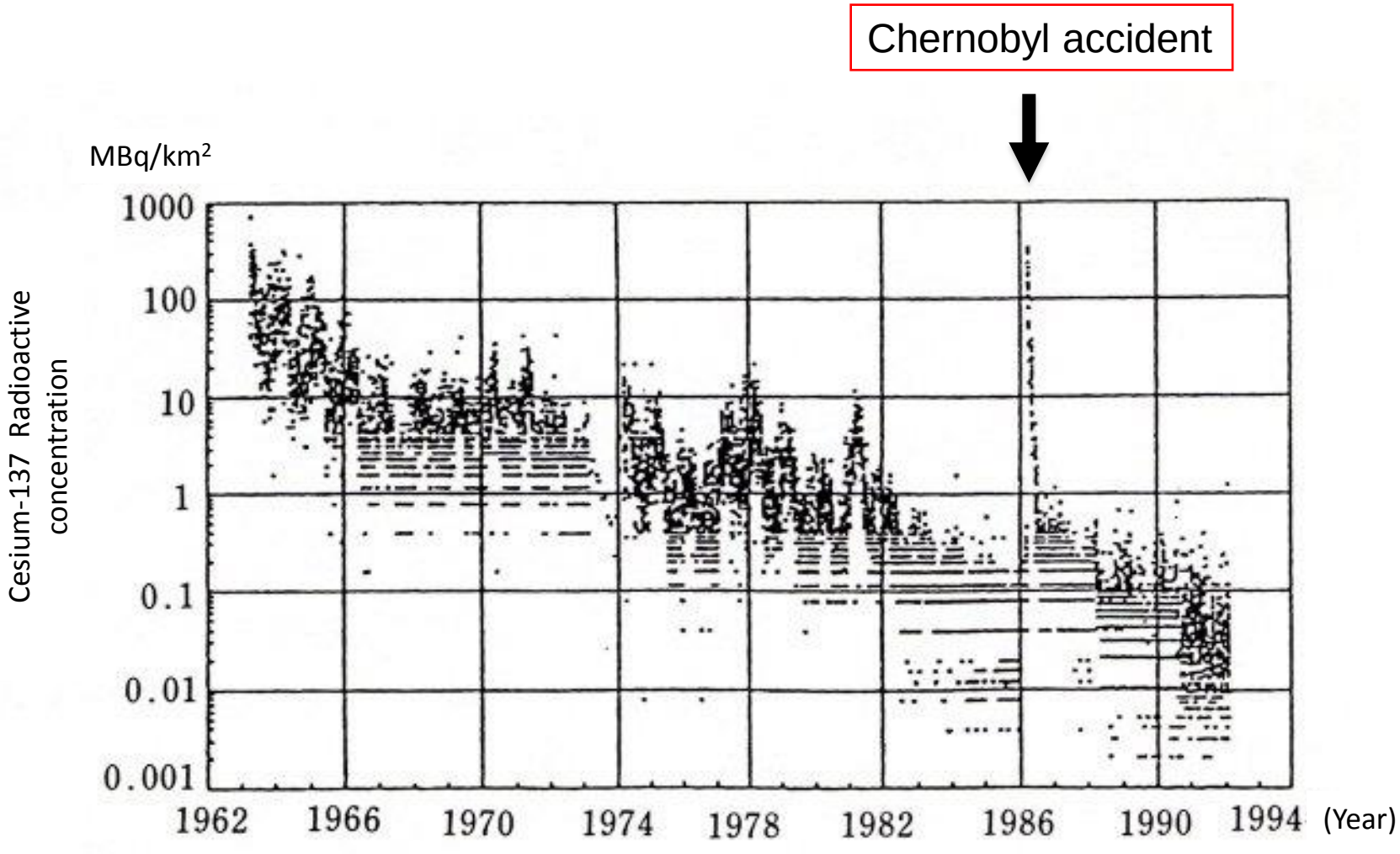


Figure 11: Changes in radioactive concentration of Cecium-137 in “fallout”
(Source: Data of Japan Chemical Analysis Center)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Daily foods contain radioactive material.

Rice
30

Loaves of bread
30

Fish
100

Beef
100

Spinach
200

Dried *shiitake* mushroom
700

Dried kelp
2000

Potato chips
400

Milk
50

Sake
1

Beer
10

Wine
30

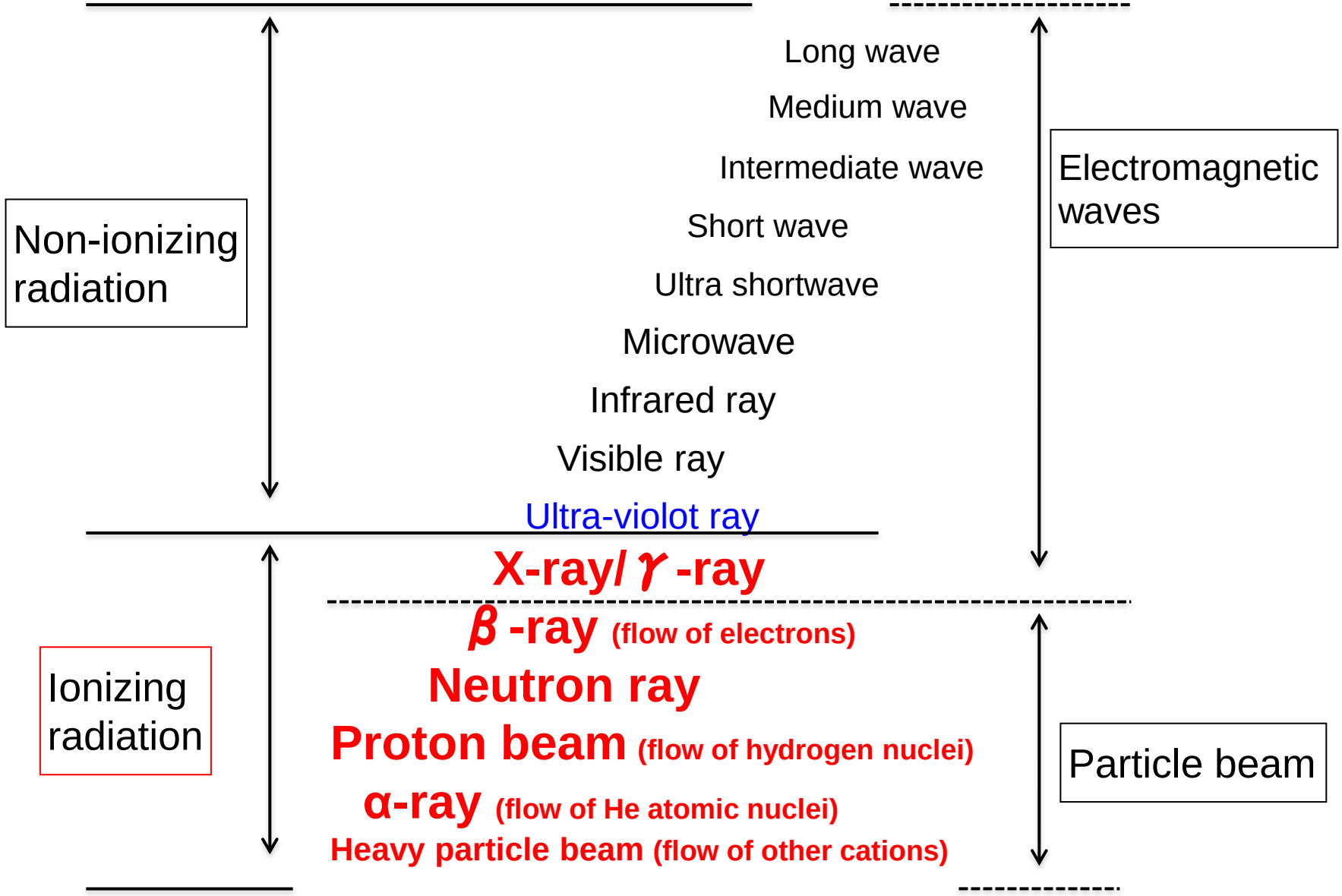
Milk powder
200

40K (Potassium-40) contained in 1kg of food in Japan
(Unit: Bq/kg)

Source: A leaflet about the relation between nuclear energy and the environment published by Environmental Technical Laboratory, Ltd. in 2008. http://www.ies.or.jp/publicity_j/mini/2007-09.pdf (in Japanese)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

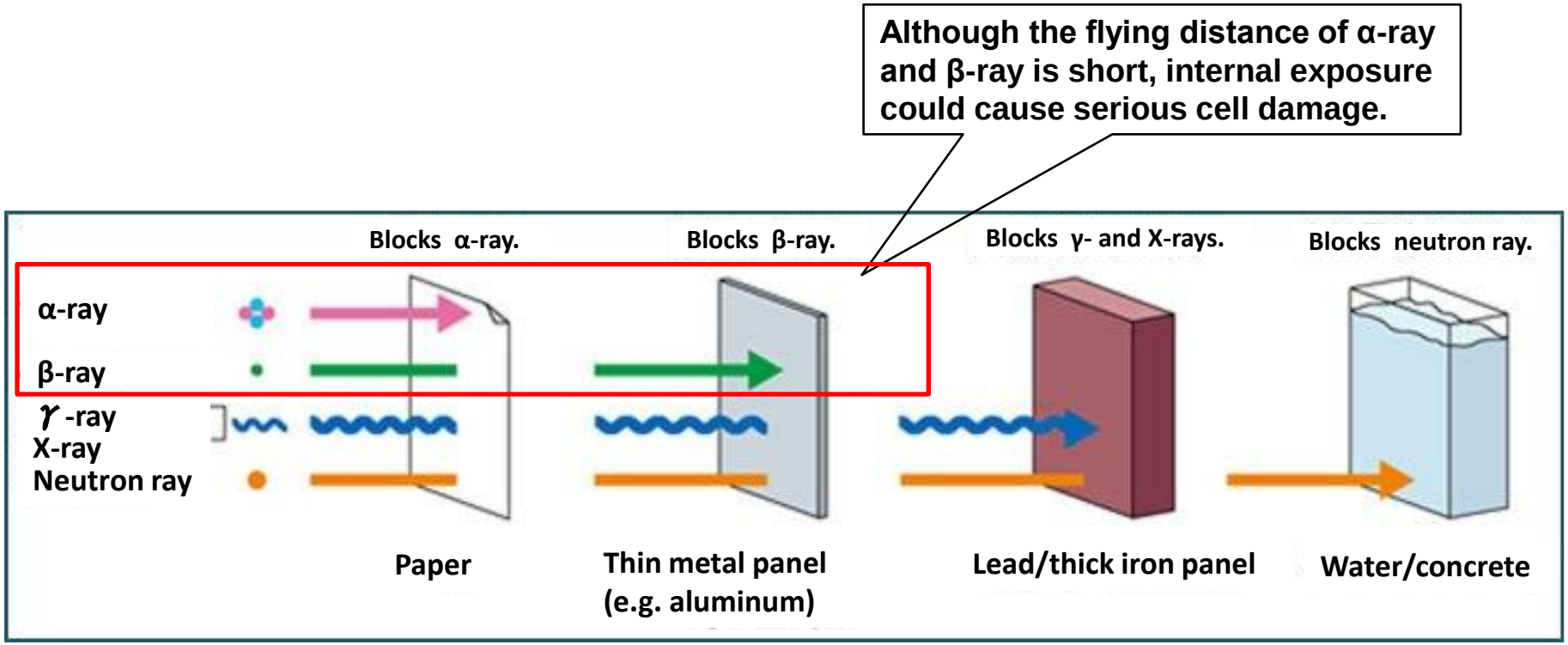
Groups of radiation

日本赤十字社 Japanese Red Cross Society



Ionization: Causes hazardous ion in the body which leads to DNA impairments.

Types of radiation



Source: A side reader about radiation published by the Ministry of Education, Culture, Sports, Science and Technology
http://www.mext.go.jp/b_menu/shuppan/sonota/attach/1314159.htm (in Japanese)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Units for radiation

Becquerel (Bq): Activity of releasing radiation (radioactivity).

Gray (Gy): Quantity of radiation absorbed in substance.

Sievert (Sv): Radiation energy which impacts the body, i.e. radiation dose (Gy x Coefficient).

Coefficient:

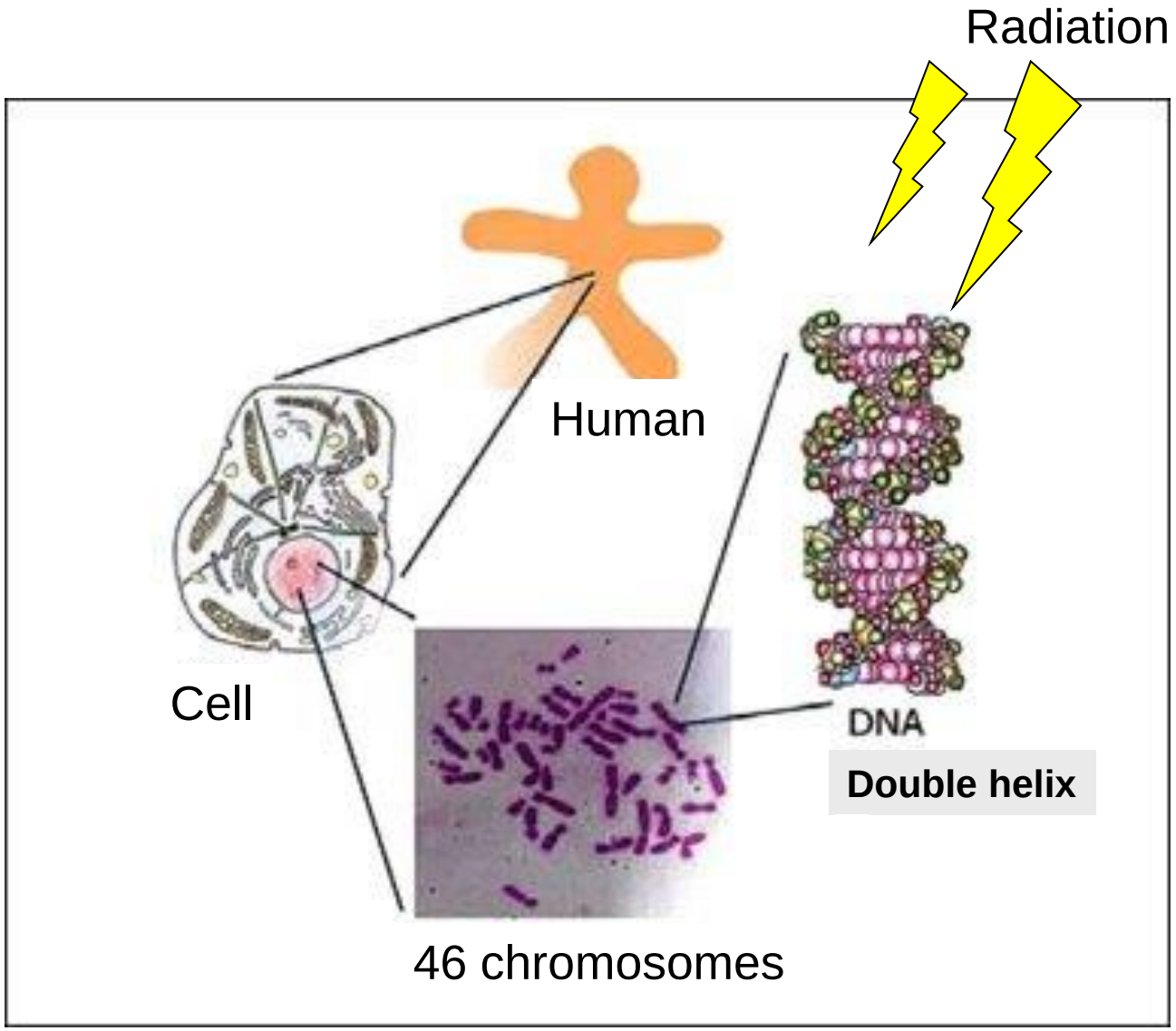
X-ray/β-ray/γ-ray：1

Proton beam： 2

α-ray/heavy particle: 20

Neutron ray: 5 - 20

DNA damage induced by radiation and enzymatic repair



Source: A website on radioactivity Q&A published by Atomic Bomb Disease Institute, Nagasaki University. (Part of the chart above is edited by the Red Cross Nuclear Disaster Resource Center.) http://www-sdc.med.nagasaki-u.ac.jp/abdi/publicity/radioactivity_qa.html (in Japanese)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Biological effects from radiation begins with DNA break.

日本赤十字社
Japanese Red Cross Society

- Single-strand break -> Complete repair
- Double-strand break -> Complete repair
  (Recombination repair)

- Irreparable double-strand break -> Death of cells
  (Deterministic effects)

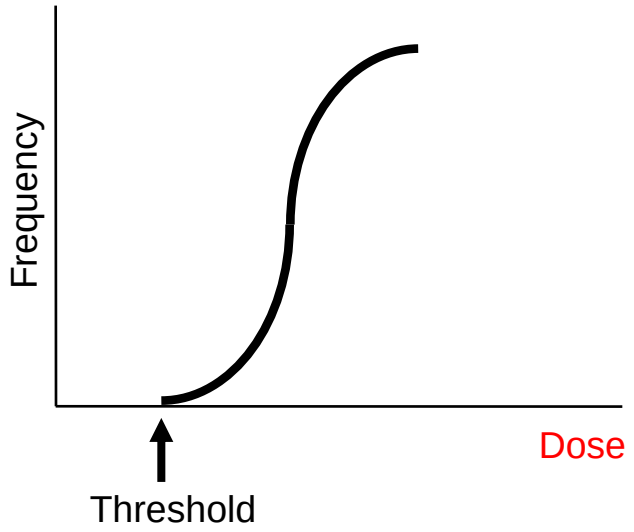
- Erroneous repair -> Mutation -> Cancer
  (Stochastic effects)

Acute radiation exposure and threshold

日本赤十字社
Japanese Red Cross Society

- ~0.25 Sv: No clinical symptom.
- 0.5 Sv: Temporary decline in the number of white blood cells (general body).
- 1 Sv: Nausea, fatigue (general body).
- 3 Sv: Loss of hair (skin).
- 5 Sv: Erythema (skin), infertility (reproductive organ).
- 7 Sv: Danger of death (general body).
- 8.5 Sv: Blister, erosion (skin).
- 10 Sv: Ulcer (skin).

Summary: Radiation and its effects on the body



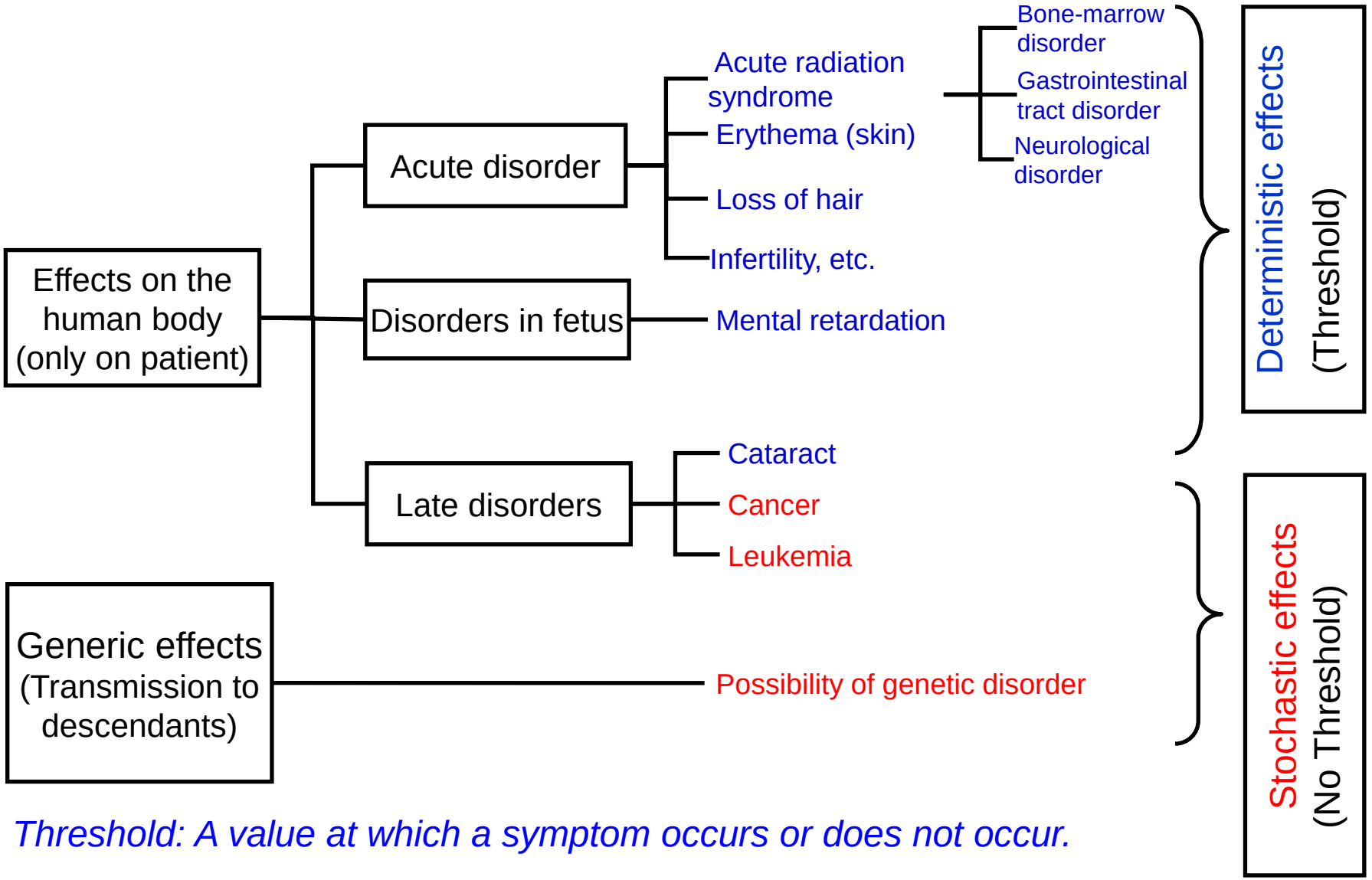
・Deterministic effects

No incidence of disorder if the dose does not exceed the threshold. (DNAs are reparable.)
Incidence and severity depends on the dose exposed to.
e.g. Organ disorder (in acute/chronic periods)

・Stochastic effects

No threshold.
Incidence depends on the dose exposed to but some events have been seen with some frequency even with a zero dose.
e.g. Development of cancer

Radiation effects on the human body



Threshold: A value at which a symptom occurs or does not occur.

1. Basic knowledge about radiation

2. Atomic bombings (1945): High-dose radiation exposure.

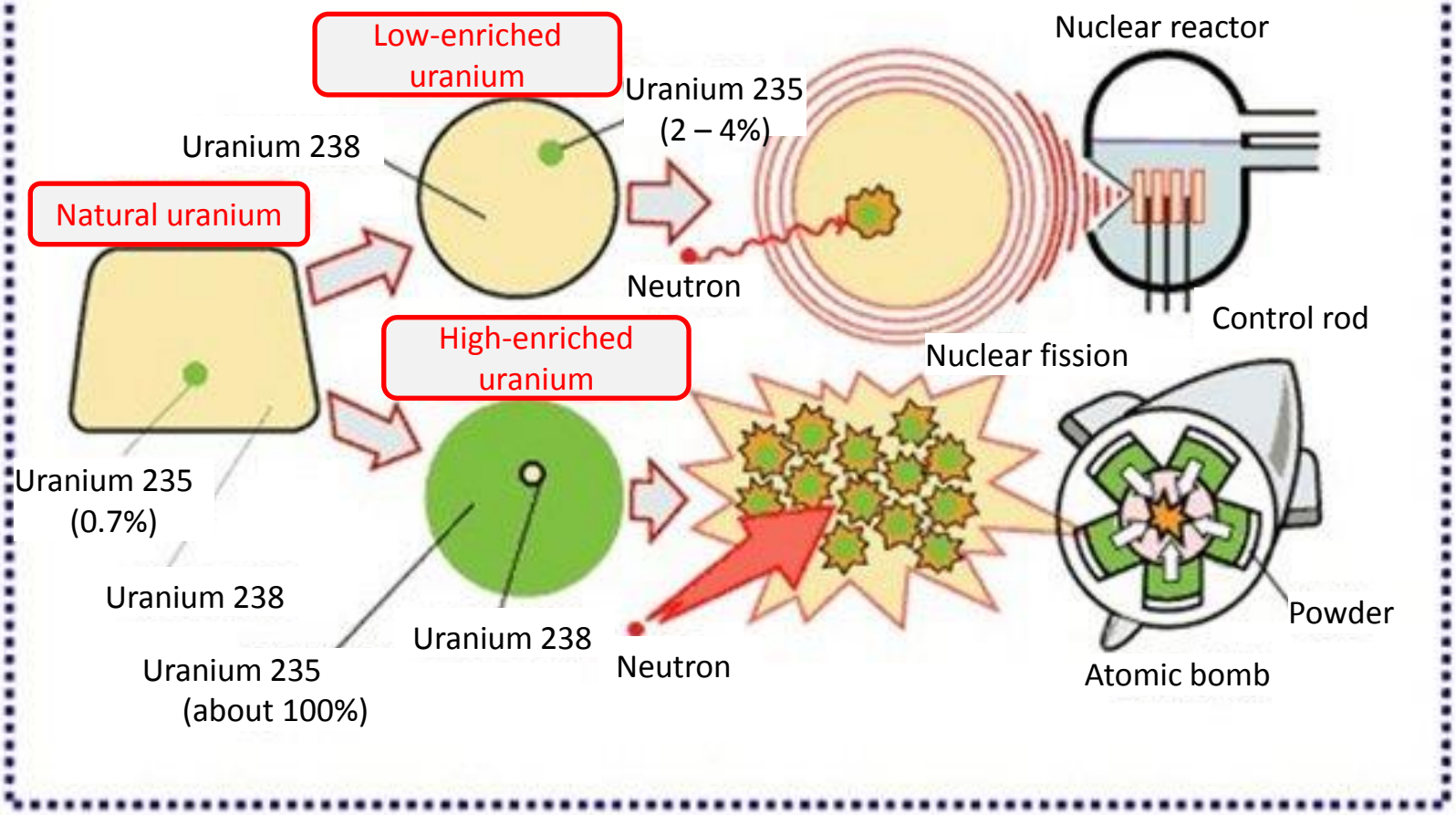
3. Chernobyl (1986): Low- to high-dose radiation exposure;
internal exposure (thyroid gland).

4. Fukushima (2011): Low-dose radiation exposure.

Nuclear fission: Atomic bomb and nuclear power generation

日本赤十字社 Japanese Red Cross Society

Differences between a nuclear reactor and an atomic bomb



Source: A website about nuclear power generation Q&A published by Fukui Atomic Information Center Foundation
http://www.athome.tsuruga.fukui.jp/nuclear/information/faq_02/safty/tigai.html (in Japanese)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

日本赤十字社
Japanese Red Cross Society

Dose per irradiation and its effects on the human body:

(Unit: mSv = millisievert)

7000 mSv (7 Sv): 100% death (within 1km).

4000 mSv (4 Sv): 50% death in 30 days.

2000 mSv (2 Sv): 5% death.

1000 mSv (1 Sv): Nausea, vomiting (about 1.5km).

500 mSv: Temporary decline in the number white blood cells.

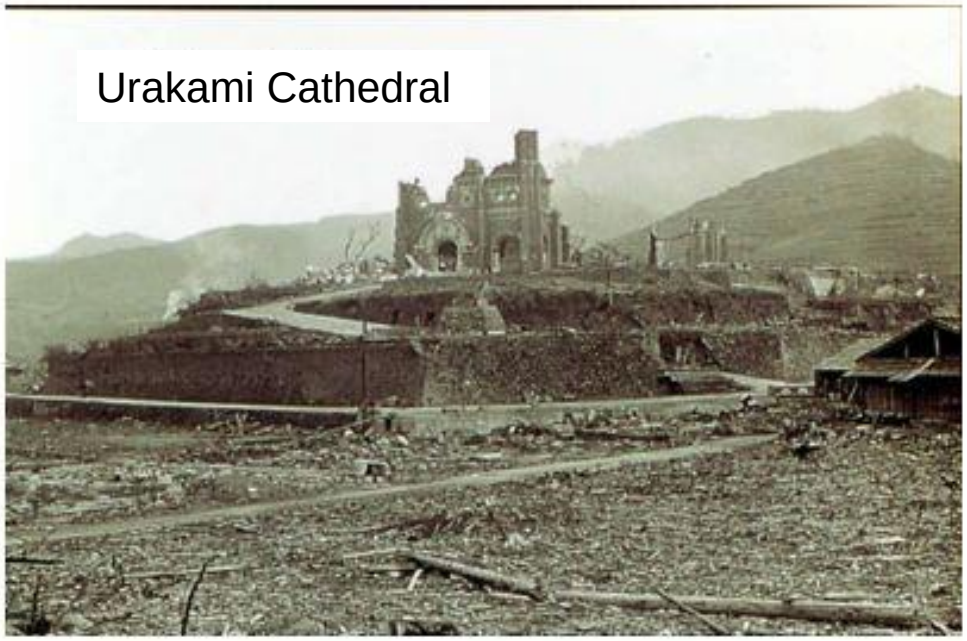
250 mSv or less: No physical symptom (more than about 1.8km).

( ) = Distance of the hypocenter of the atomic-bomb blast

Nagasaki immediately after the atomic-bomb blast

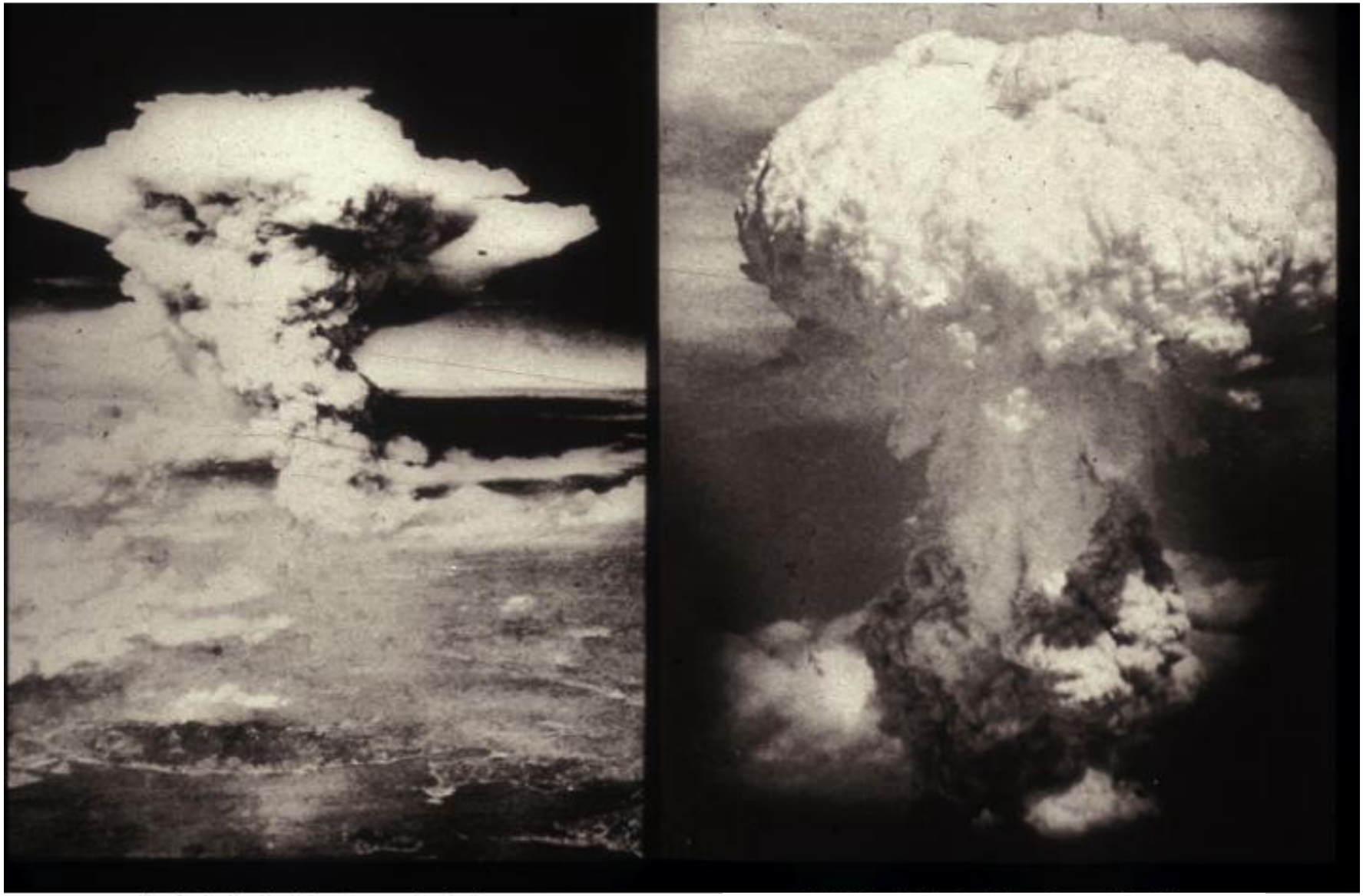
日本赤十字社
Japanese Red Cross Society

Urakami Area photographed from the back side of the former Nagasaki Medical University.
About 900 lives of faculty members, medical students, nurses, patients and others were lost instantly.



Urakami Cathedral

Mushroom-shaped cloud (Atomic cloud)



Hiroshima (Uranium)

Nagasaki (Plutonium)

Atomic bomb

Hiroshima: Uranium.

Equivalent to 15 kton of ordinary powder (trinitrotoluene: TNT).

About 120,000 people were killed.

Nagasaki: Plutonium.

Equivalent to 21 kton of TNT.

About 75,000 people were killed.

Energy distribution of atomic energy by nuclear fission:

- ✓ Blast wind: 50%; radiation heat of heat ray: 35%; radiation: 15%.
- ✓ Blast wind and heat ray reached the radius of 4 – 5 km from the hypocenter.
- ✓ Radiation reached 2.5 km of the hypocenter in Hiroshima; 3 km in Nagasaki.

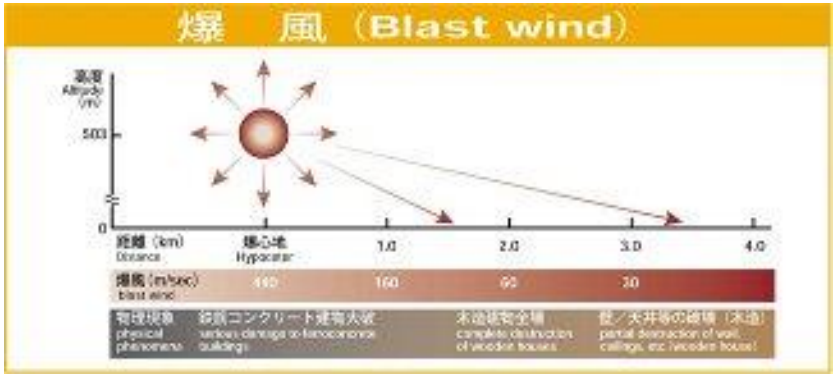
Furthermore, as many people as the numbers of deaths had to go through hardships as *hibakusha* (survivors of the atomic bombings).

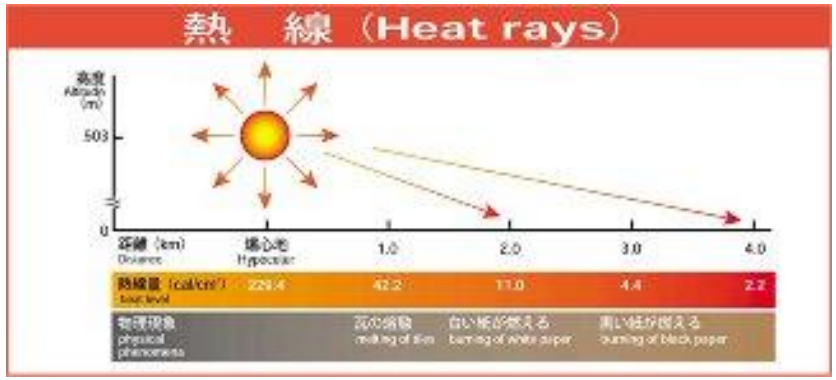
Physical damage/effects by the Nagasaki atomic bombing

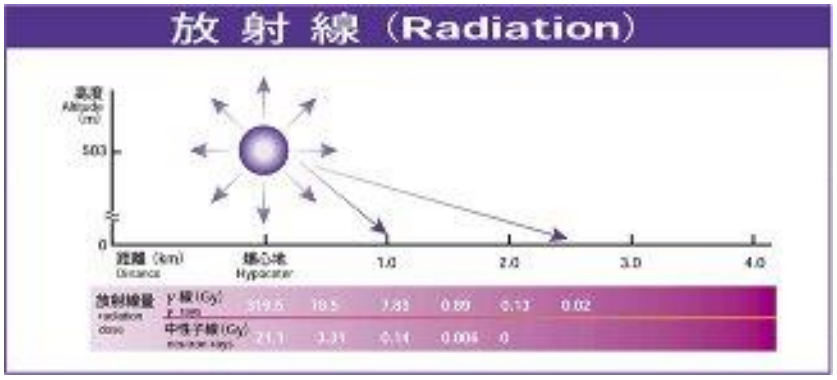
日本赤十字社 Japanese Red Cross Society

Physical damage by the atomic bomb

Physical effects of the atomic bomb







Source: “Physical Effects Caused by the Nagasaki Atomic Bombing” of a leaflet published by Atomic Bomb Disease Institute, Nagasaki University on its website. http://abomb.med.nagasaki-u.ac.jp/abomb/data/panf.pdf

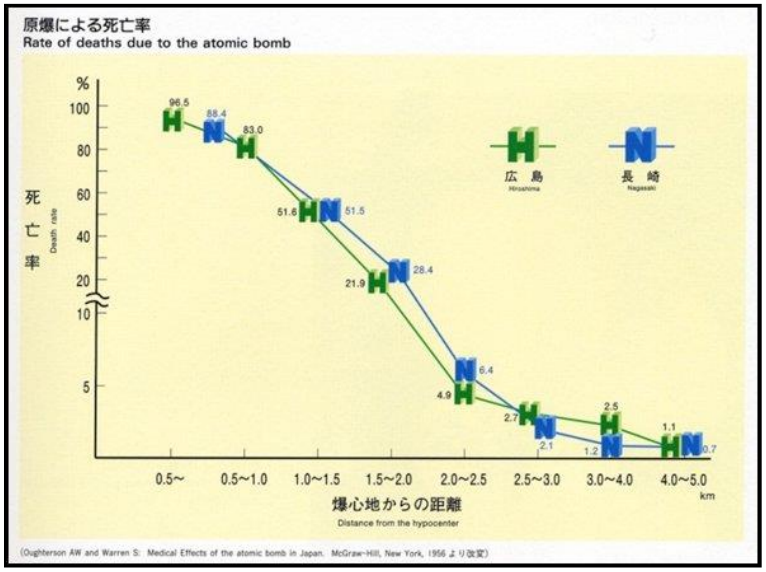
Effects from the heat ray of the atomic bombing

日本赤十字社
Japanese Red Cross Society

Source: Atomic Bomb Disease Institute, Nagasaki University

日本赤十字社 Japanese Red Cross Society

Acute Radiation Syndrome (ARS)



Source: "The Medical Effects of the Nagasaki Atomic Bombing" published by Atomic Bomb Disease Institute, Nagasaki University on its website.
http://abomb.med.nagasaki-u.ac.jp/abomb/data/panf.pdf

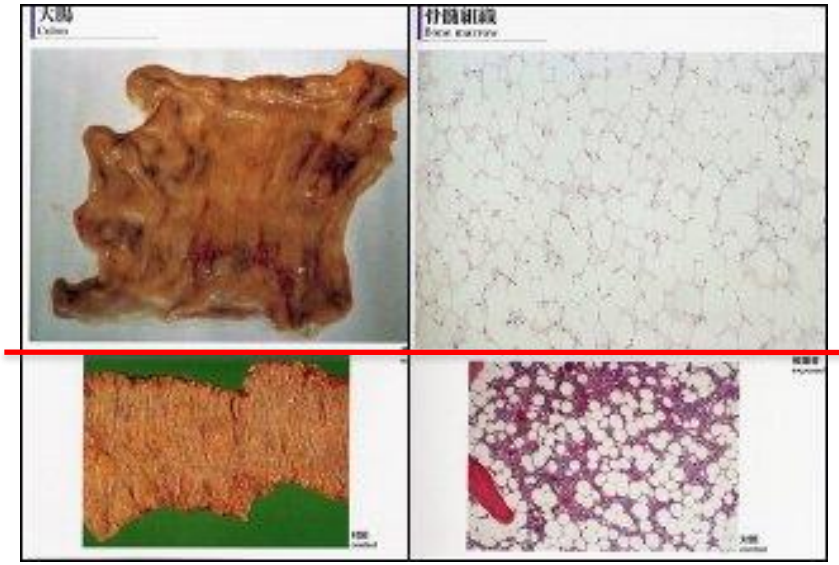
No difference in the rate of deaths between Nagasaki and Hiroshima.

	ARS	Atomic-bomb victims
Nagasaki	70,000	80,000
Hiroshima	120,000	140,000

Two major pathologies of ARS:

1. **Intestinal disorder;**
2. **Bone marrow disorder.**

Intestinal mucosa **Bone marrow tissue**



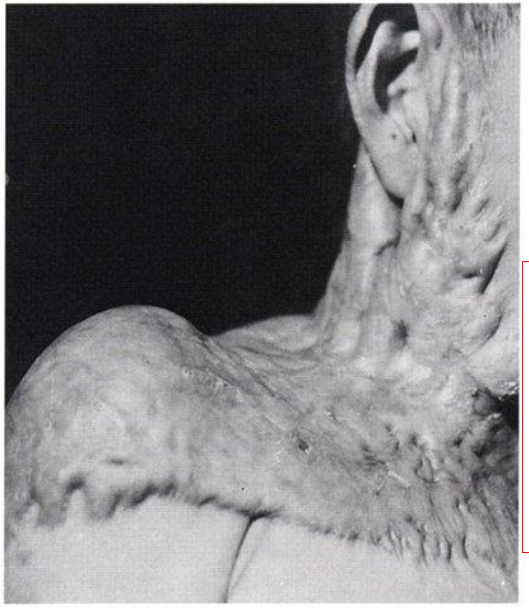
Source: "The Medical Effects of the Nagasaki Atomic Bombing" published by Atomic Bomb Disease Institute, Nagasaki University on its website. http://abomb.med.nagasaki-u.ac.jp/abomb/data/panf.pdf

Early phase of late effects

日本赤十字社
Japanese Red Cross Society

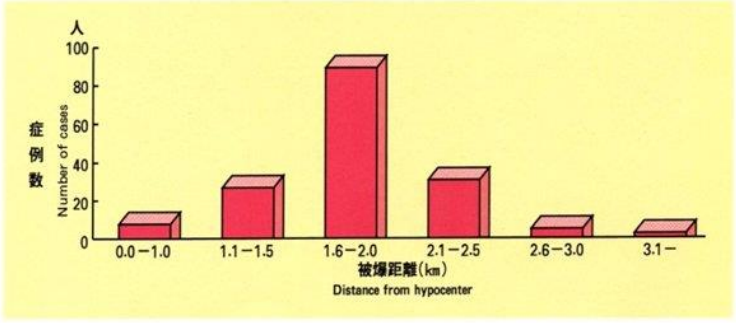
2 後障害初期
Early phase of late effects

ケロイド
Keloid

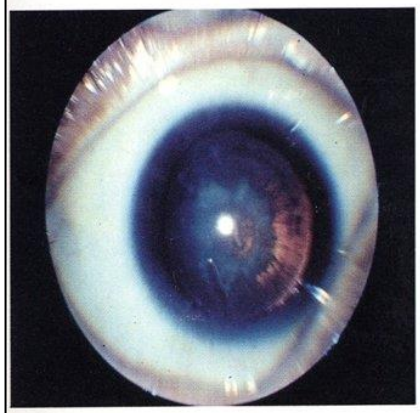


Developed during a healing process of a burn injury.

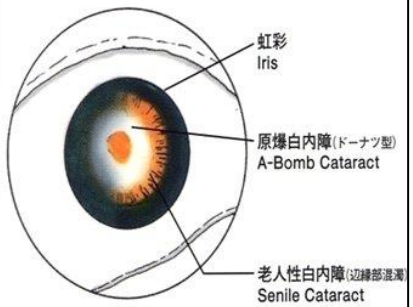
ケロイドの症例数（被爆距離別）
Number of keloid cases by distance from the hypocenter

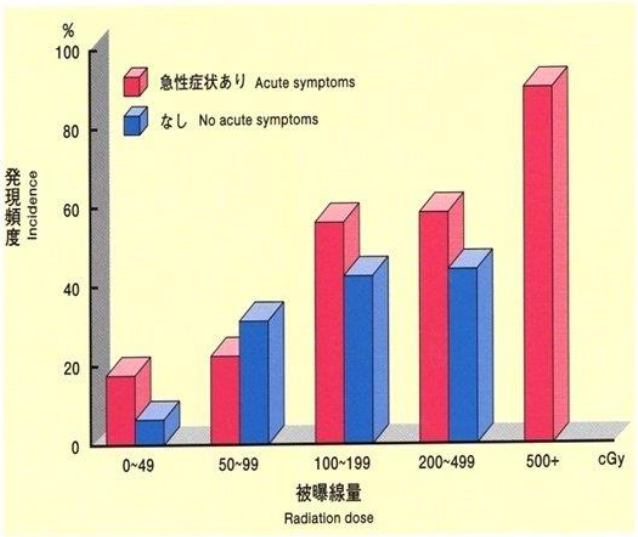


原爆白内障
Atomic bomb cataract



白内障模式図
Scheme of Cataract





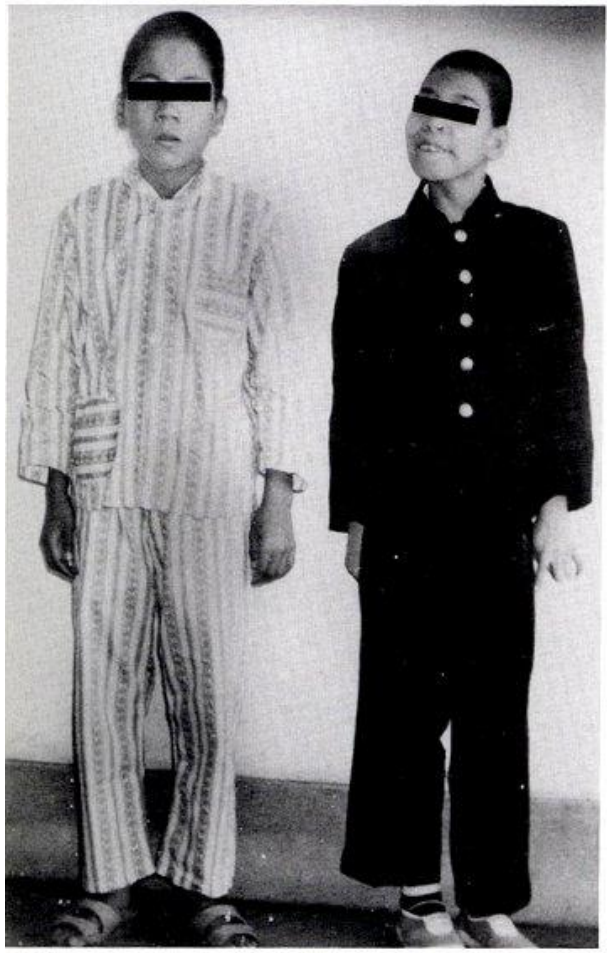
Dose of about 100 mSv could cause the disorder.

Source: “The Medical Effects of the Nagasaki Atomic Bombing” published by Atomic Bomb Disease Institute, Nagasaki University on its website.
http://abomb.med.nagasaki-u.ac.jp/abomb/data/panf.pdf

Early phase of late effects

日本赤十字社
Japanese Red Cross Society

小頭症
Microcephaly



The atomic bombing irradiation to the fetus during the early stage of pregnancy caused developmental disorder of the central nervous system. Due to this, the number of cases of microcephaly increased.

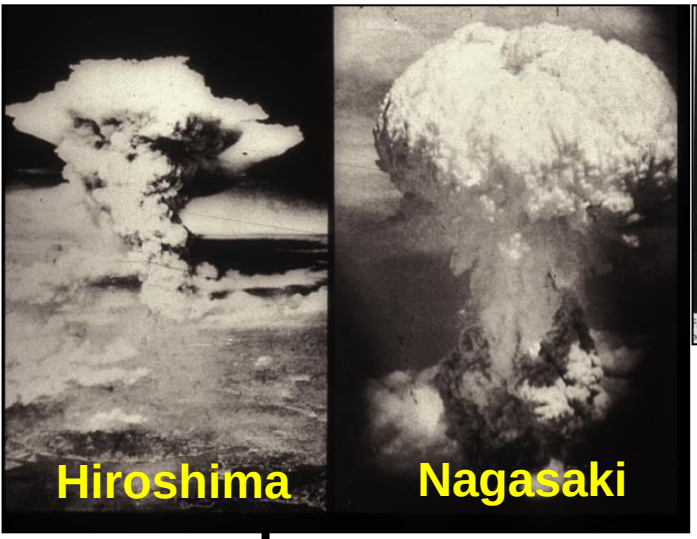
被曝線量(cGy) Exposure dose	胎齢18週未満 Gestational age 0~17 Weeks	胎齢18週以上 Gestational age 18+ Weeks
0 ~ 9	0 / 1	0 / 9
10 ~ 19	0 / 7	0 / 6
20 ~ 29	0 / 5	2 / 7
30 ~ 39	2 / 4	0 / 6
40 ~ 49	0 / 6	0 / 3
50 ~ 99	0 / 9	0 /11
100 ~149	0 / 2	1 / 5
150 ~	8(3) / 9	2(1) / 9
胎内被爆合計 Total	10(3)/43	5(1)/56
対 照 Control	10/246	

( ) は知能発育障害の例数

Of all the microcephaly, the number in parentheses means the number of mental retardation.
(Miller & Blot, 1972年より改変)

Source: “The Medical Effects of the Nagasaki Atomic Bombing” published by Atomic Bomb Disease Institute, Nagasaki University on its website. http://abomb.med.nagasaki-u.ac.jp/abomb/data/panf.pdf

Number of years after the atomic bombings and increase trend in deaths from leukemia and cancers



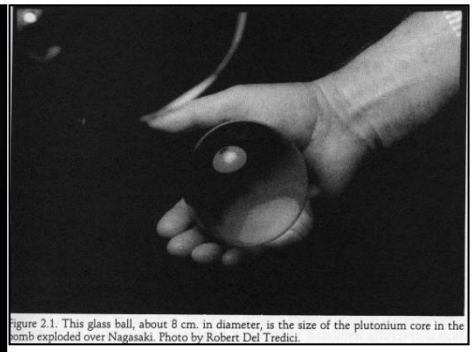


Figure 2.1. This glass ball, about 8 cm. in diameter, is the size of the plutonium core in the bomb exploded over Nagasaki. Photo by Robert Del Tredici.

Number of years after the atomic bombings; and increase tendency in deaths from leukemia and cancers.

Lifetime persistence among young atomic-bomb survivors.

Solid tumor/multiple primary cancers (thyroid gland/breast/lung/colon/stomach, etc.)

First decade

Leukemia

Present

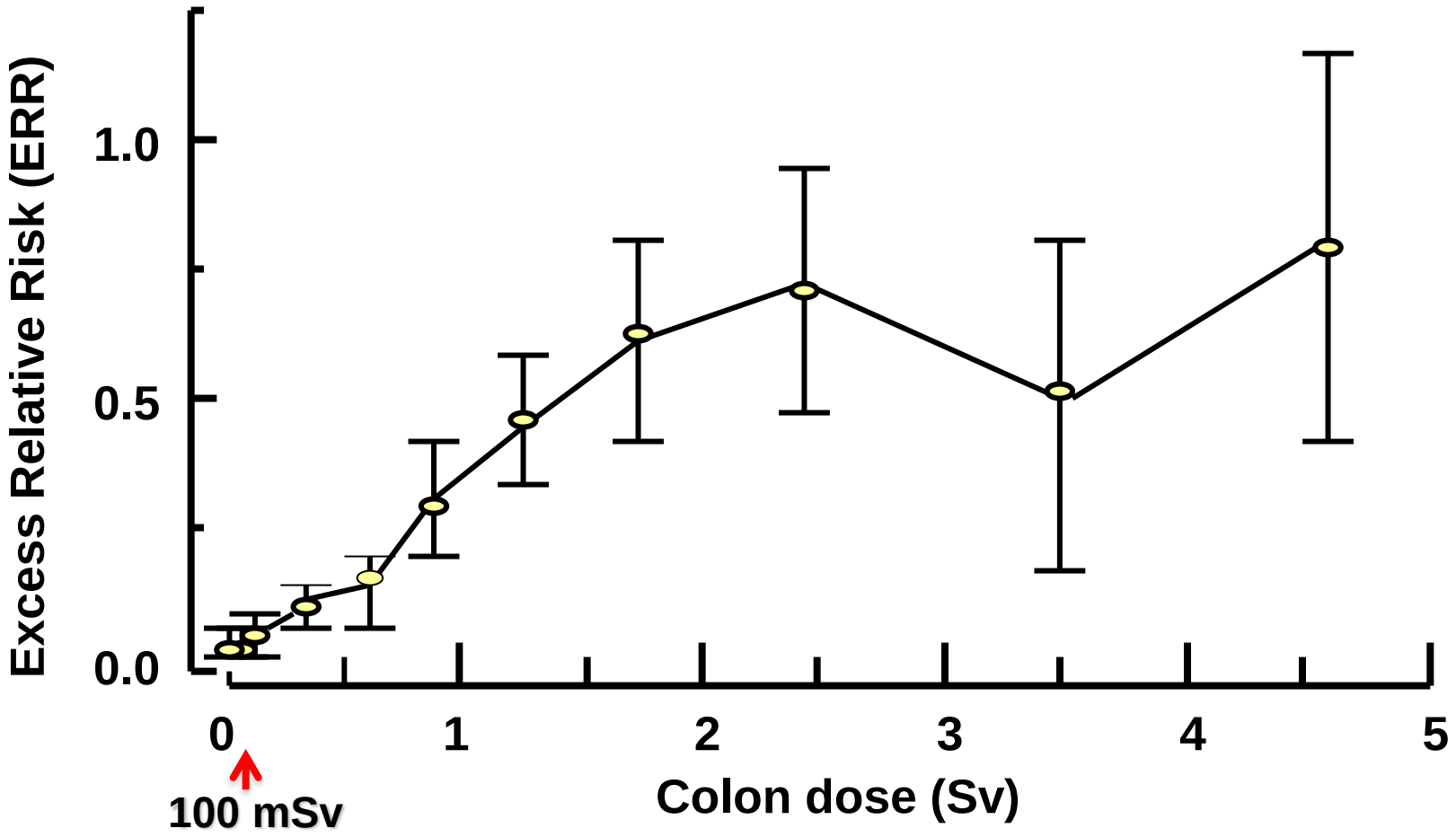
Myelodysplastsic syndrome (Leukemia)

Leukemia

0 **10** **20** **30** **40** **50** **60** **(year)**

Number of years after the atomic bombings

Linear model on dose response on all tumor cancers



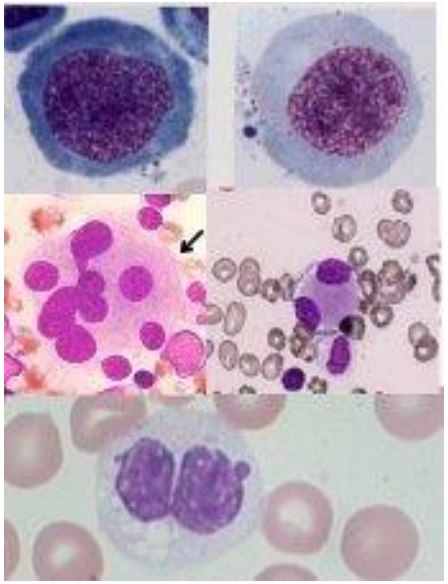
Pierce AD, Shimizu Y, Preston DL, Vaeth M, Mabuchi K: Studies of the Mortality of atomic bomb survivors. Report 12, Part 1. Cancer: 1950-1990. Radiation Research, 146, 1-27, 1996

Excess Pelative Risk (EPR): Ratio of death rate (or rate of incidence) for the exposed population and the death rate (or rate of incidence) in the control group. An ERR = 0.5 means an increase of 50%.

日本赤十字社
Japanese Red Cross Society

(Myelodysplastic syndrome, MDS)

A clonal blood disease which is caused by a number of gene expression disruptions in hematopoietic stem cells.



Clinical characteristics:

1. **Despite having enough hematopoietic cells in one's bone marrow, pancytopenia is caused in peripheral blood (ineffective hematopoiesis).**
   Broken in the process due to impaired expression of genes.

2. **Deformation of blood cells (dysplasia).**
   Deformation due to impaired gene expression.

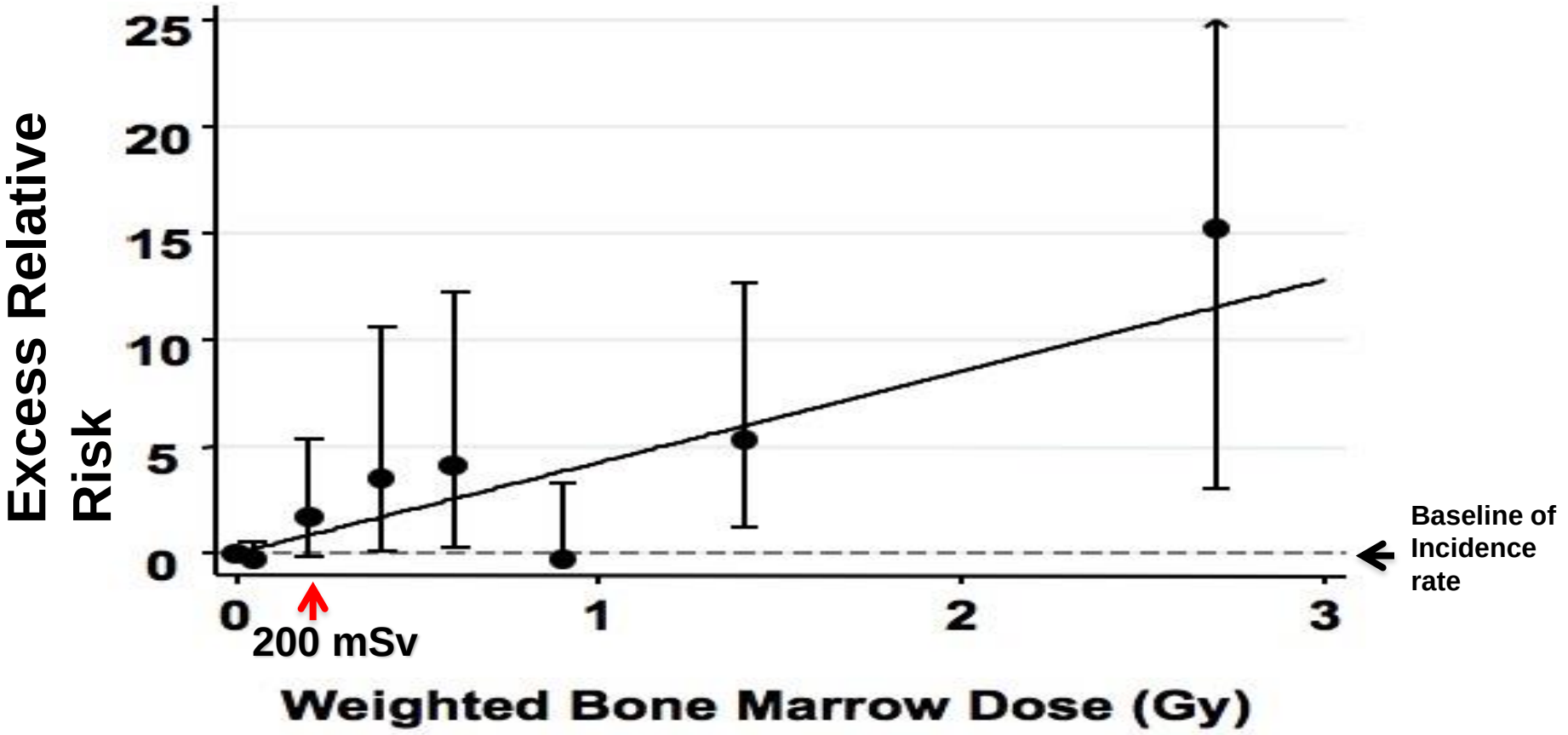
3. **Treatment is difficult.**
   A variety of impaired gene expressions make it difficult for anti-cancer drugs to work.

4. **Many cases have been found in the elderly. The number of cases may increase further in the elderly.**

5. **Many cases have also been found in the atomic-bomb survivors.**

日本赤十字社
Japanese Red Cross Society

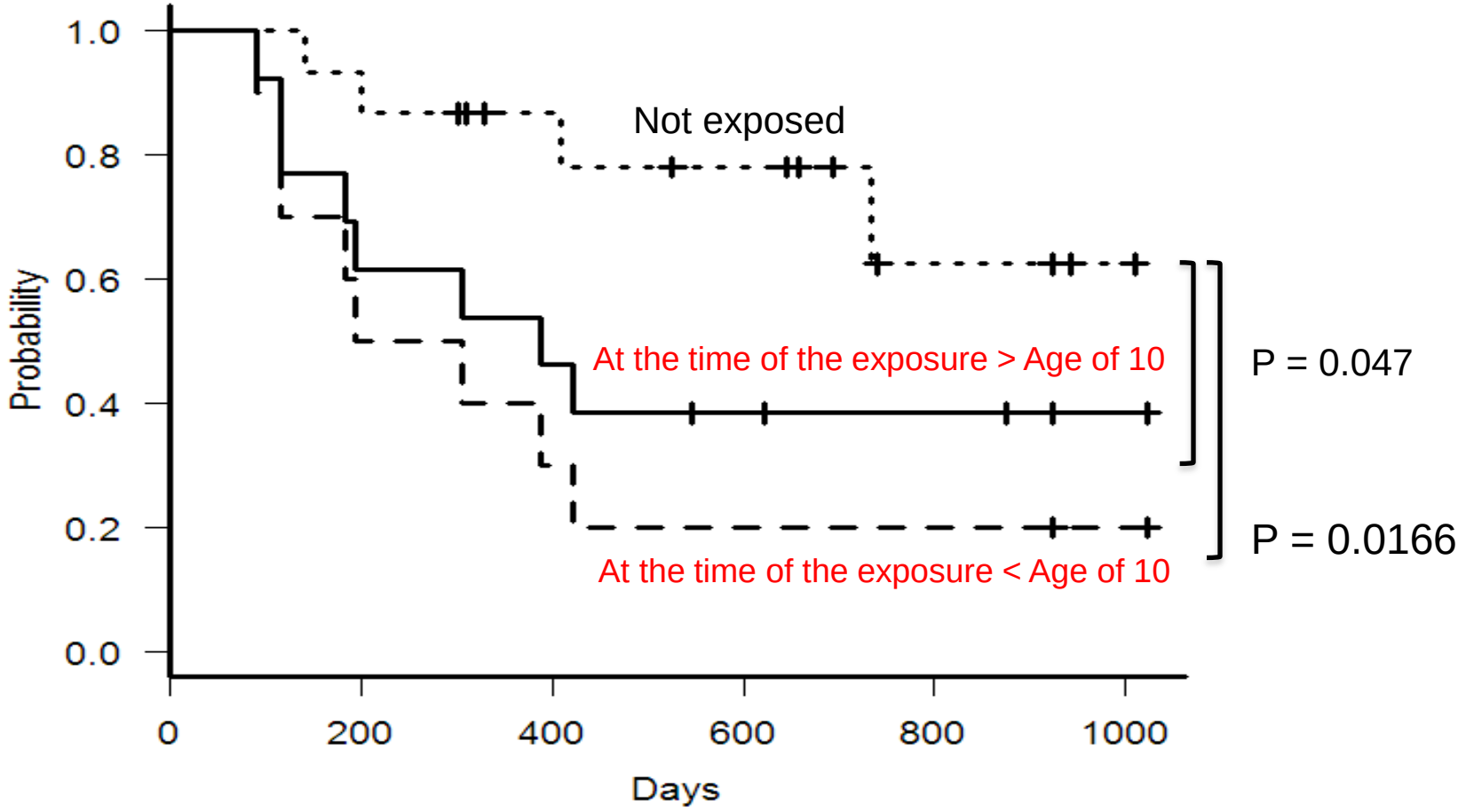
Dose-response relationship



A significant linear dose response relationship was observed. ($P<0.001$)

Overall survival probability

Survival period of myelodysplatic syndrome patients who were treated using Azacitidine was looked at.



Tatsuro Jo, *et al.* Impact of Nagasaki Atomic Bomb Exposure on Myelodysplastic syndrome patients who are treated with Azacitidine. *Anticancer Res.* 2015 May 35(5):2929-2933

1. Basic knowledge about radiation

2. Atomic bombings (1945): High-dose radiation exposure

3. Chernobyl (1986): Low- to high-dose radiation exposure; internal exposure (thyroid gland)

4. Fukushima (2011): Low-dose radiation exposure

Atomic bombing/nuclear test/nuclear disaster

日本赤十字社
Japanese Red Cross Society

1944 -	Nuclear test in Nevada by the U.S.
1945/08/06	Atomic bombing in Hiroshima
1945/08/09	Atomic bombing in Nagasaki
1949 - 1911	Nuclear test by the former Soviet Union (in Semipalatinsk, etc.)
1952 -	Nuclear test by the U.K.
1954 -	Nuclear test at Bikini Atoll (in the Marshall Islands) by the U.S.
1957	Nuclear waste processing plant accident in Kyshtym in the former Soviet Union (Level 6)
1960 -	Nuclear test by France
1964 -	Nuclear test by China
1974 -	Nuclear test by India
1979/03	Three Mile Island Nuclear Power Plant accident in the U.S. (Level 5)
1986/04	Chernobyl Nuclear Power Plant accident (Level 7)
1998 -	Nuclear test by Pakistan
2006 -	Nuclear test by North Korea
2011/03/11	Fukushima Daiichi Nuclear Power Plant accident (Level 7)

日本赤十字社
Japanese Red Cross Society

Nuclear reactor accident:

An event which releases a large amount of radioactive materials from a nuclear reactor, which causes radiation damage to humans and contaminates the environment with radiation and radioactive materials.

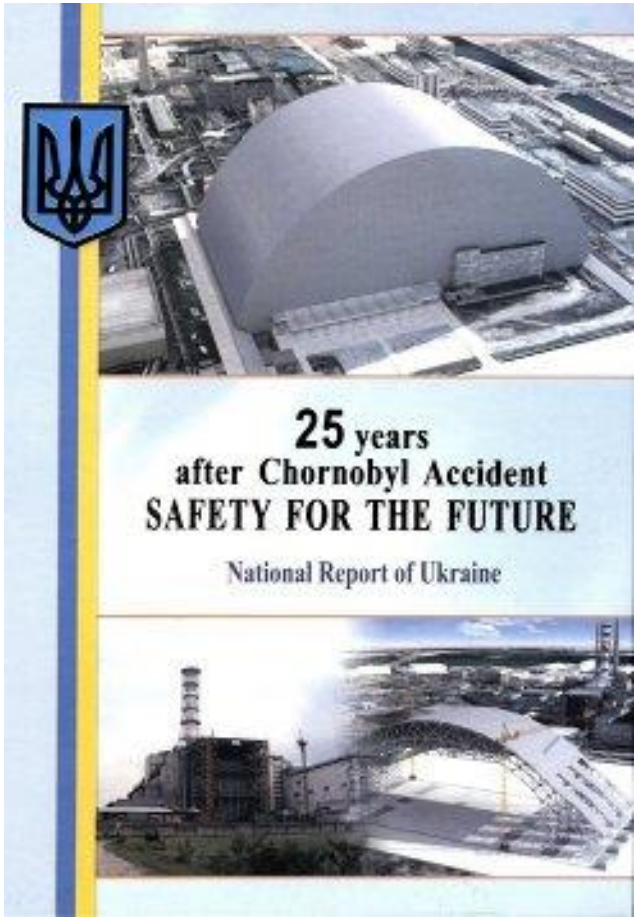
Nuclear fuel for a light-water reactor contains only about 3 – 5% of fissile Uranium 235, meaning that it is different qualitatively from almost 100%-enriched fuel used for an atomic bomb.

Therefore, there will be no nuclear explosion at a reactor.

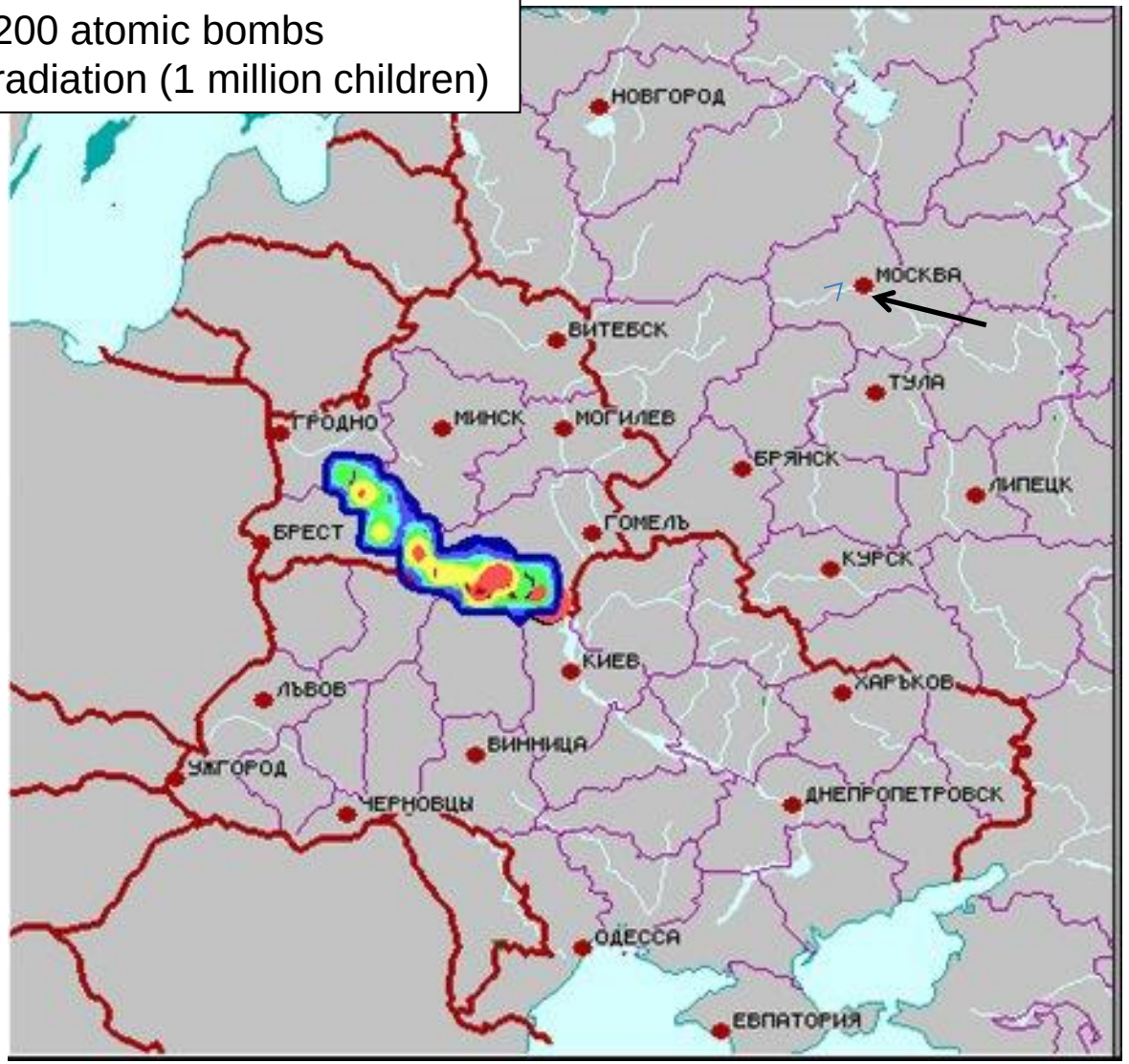
Chernobyl Nuclear Power Plant accident (former Soviet Union)
1986/04/26

日本赤十字社
Japanese Red Cross Society

About 7 million TBq: Equivalent to 200 atomic bombs
About 5 million people exposed to radiation (1 million children)

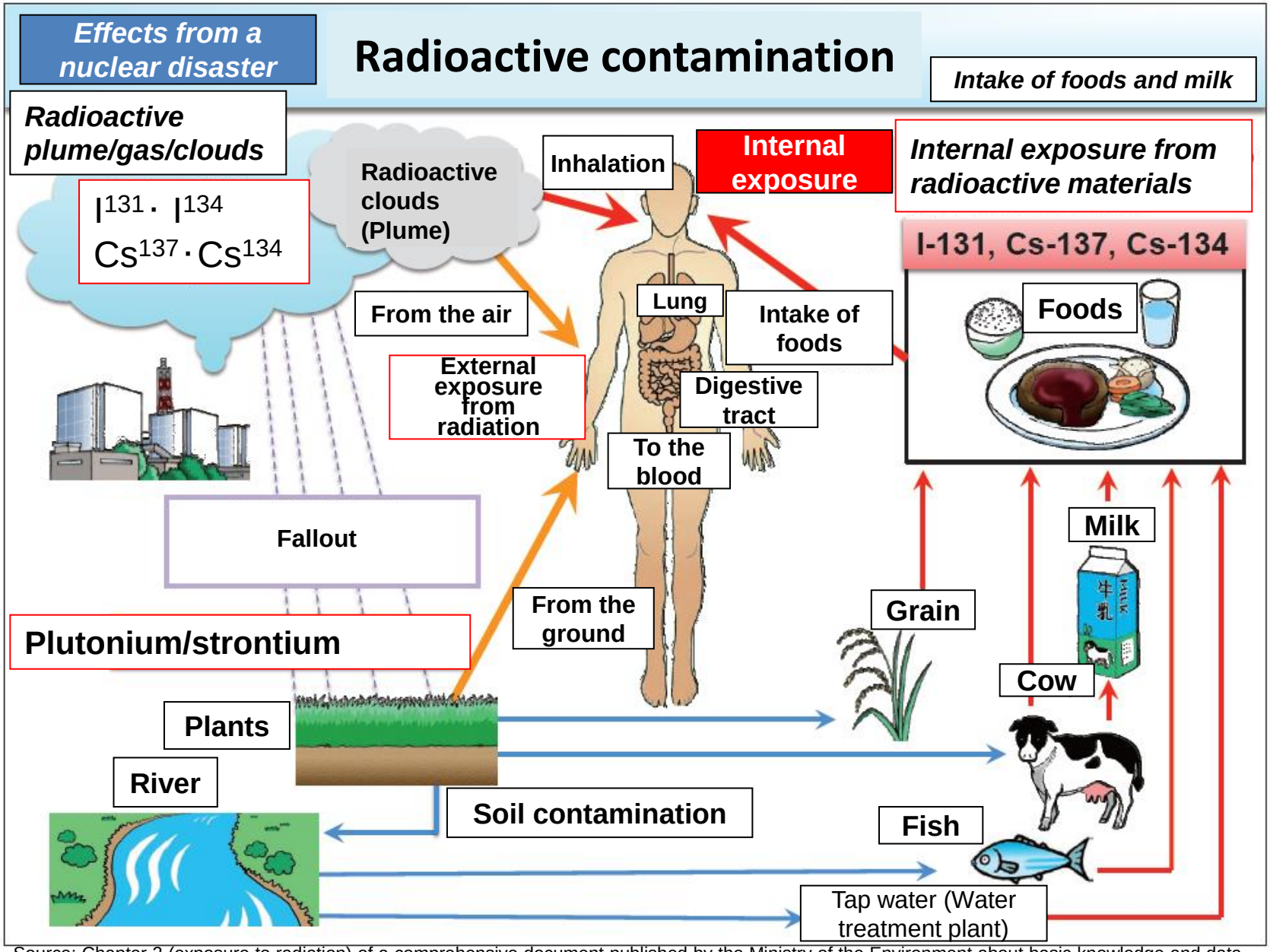


Simulation of I^{131} spread



Internal exposure and external exposure

日本赤十字社 Japanese Red Cross Society

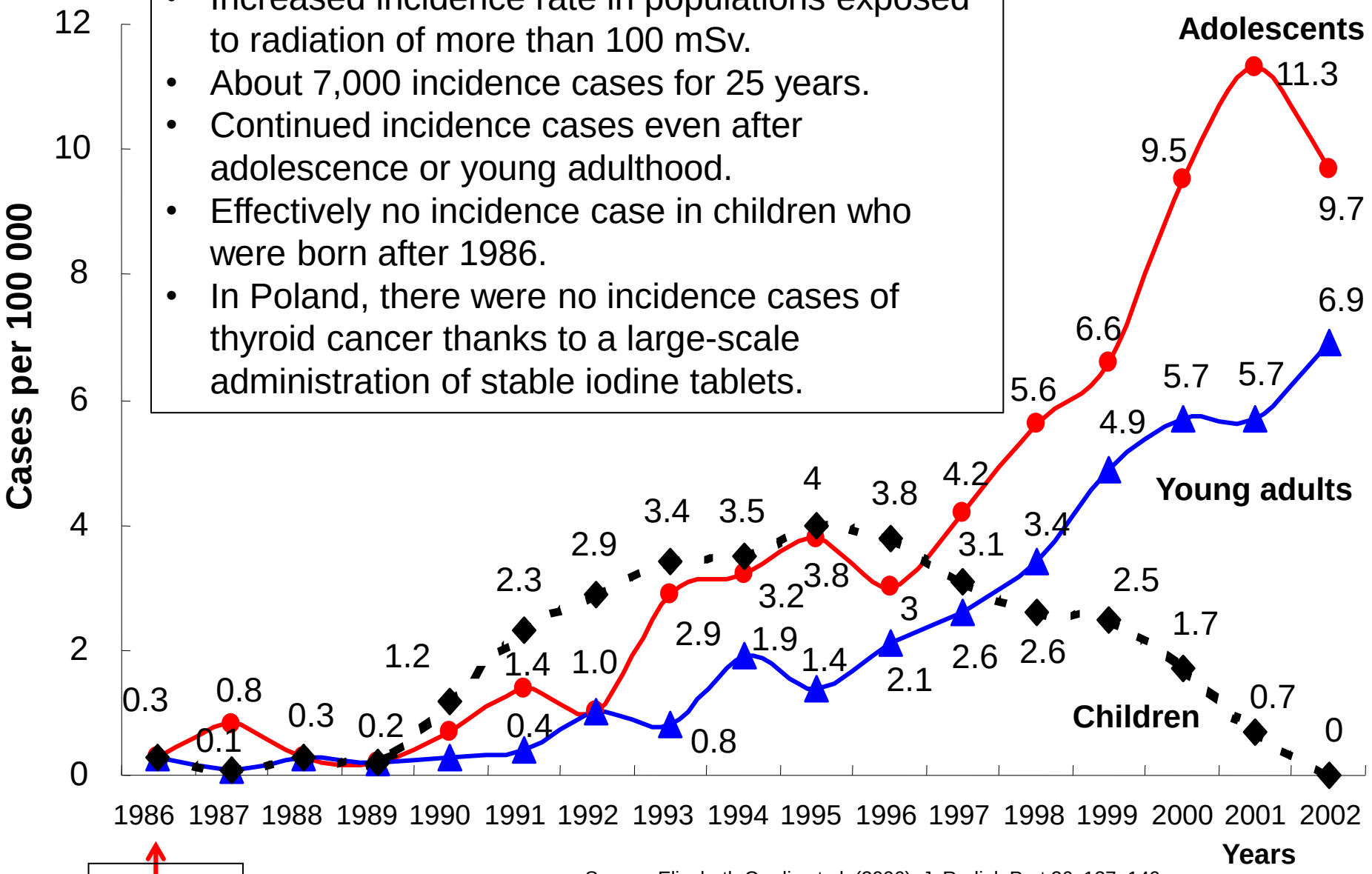


Source: Chapter 2 (exposure to radiation) of a comprehensive document published by the Ministry of the Environment about basic knowledge and data regarding health effects, etc. from radiation. http://www.env.go.jp/chemi/rhm/kisoshiryo/h27shiryo2a.html (in Japanese)
(The chart above was translated and modified by the Red Cross Nuclear Disaster Resource Center.)

Many incidence cases of thyroid cancer in Belarus after the Chernobyl accident

日本赤十字社
Japanese Red Cross Society

- Increased incidence rate in populations exposed to radiation of more than 100 mSv.
- About 7,000 incidence cases for 25 years.
- Continued incidence cases even after adolescence or young adulthood.
- Effectively no incidence case in children who were born after 1986.
- In Poland, there were no incidence cases of thyroid cancer thanks to a large-scale administration of stable iodine tablets.



Source: Elisabeth Cardis et al. (2006). J. Radiol. Prot.26, 127–140.

1. Basic knowledge about radiation

2. Atomic bombings (1945): High-dose radiation exposure.

3. Chernobyl (1986): Low- to high-dose radiation exposure; internal exposure (thyroid gland).

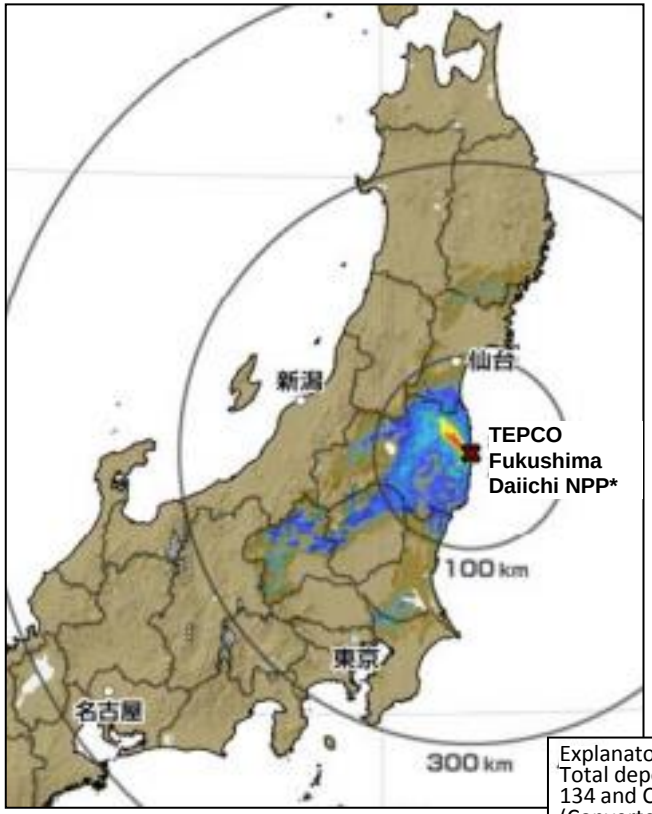
4. Fukushima (2011): Low-dose radiation exposure.


Fukushima Disaster
March 11, 2011
北原
福島第二
原子力発電所

Spread of radioactive materials from Fukushima Daiichi NPP*

日本赤十字社 Japanese Red Cross Society

* nuclear power plant



Explanatory note:
Total deposition of Cs-134 and Cs-137 (Bq/m²)
(Converted to values as of 2012/05/31.)

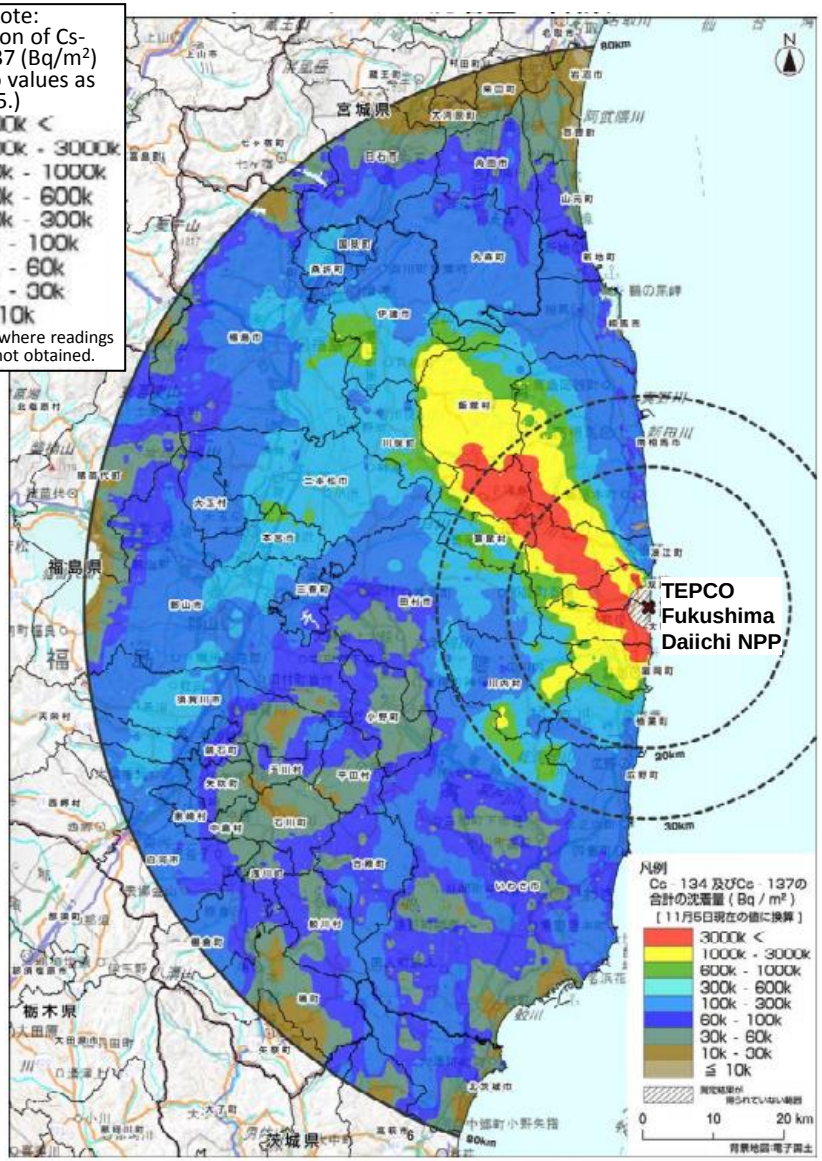
- 3000k <
- 1000k - 3000k
- 600k - 1000k
- 300k - 600k
- 100k - 300k
- 60k - 100k
- 30k - 60k
- 10k - 30k
- ≦ 10k
- Areas where readings were not obtained.

Part of the results of the aircraft monitoring by MEXT**
(Total surface deposition of Cs-134 and Cs-137 across Japan published on July 27, 2012)
** Ministry of Education, Culture, Sports, Science and Technology

http://radioactivity.nsr.go.jp/ja/contents/6000/5847/24/203_0727.pdf

Explanatory note:
Total deposition of Cs-134 and Cs-137 (Bq/m²)
(Converted to values as of 2011/11/05.)

- 3000k <
- 1000k - 3000k
- 600k - 1000k
- 300k - 600k
- 100k - 300k
- 60k - 100k
- 30k - 60k
- 10k - 30k
- ≦ 10k
- Areas where readings were not obtained.



Results of the fourth aircraft monitoring by MEXT
(Total surface deposition of Cs-134 and Cs-137 inside 80 km zone of TEPCO Fukushima Daiichi NPP) (Converted to values as of November 5, 2011) http://radioactivity.nsr.go.jp/ja/contents/5000/4901/24/1910_1216.pdf

Fukushima Daiichi NPP accident

1. Workers at the NPP
   Direct exposure to radiation.
   Treatment and enough follow-ups are needed.

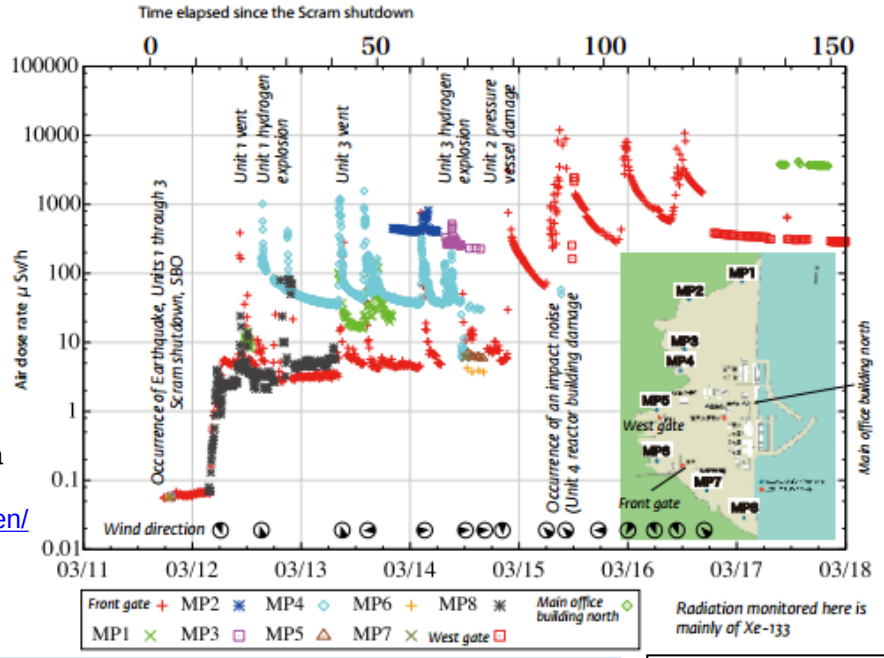
2. Fukushima citizens
   The dose they were exposed to was quite low.
   Therefore, they will unlikely suffer from health problems.

   Due to the spread of radioactive materials, the highly-contaminated areas are designated as areas in which the residents are not permitted to reside.

Air dose rate near Fukushima Daiichi NPP/in Fukushima City

3.11 Earthquake and Tsunami
3.14 Hydrogen explosion

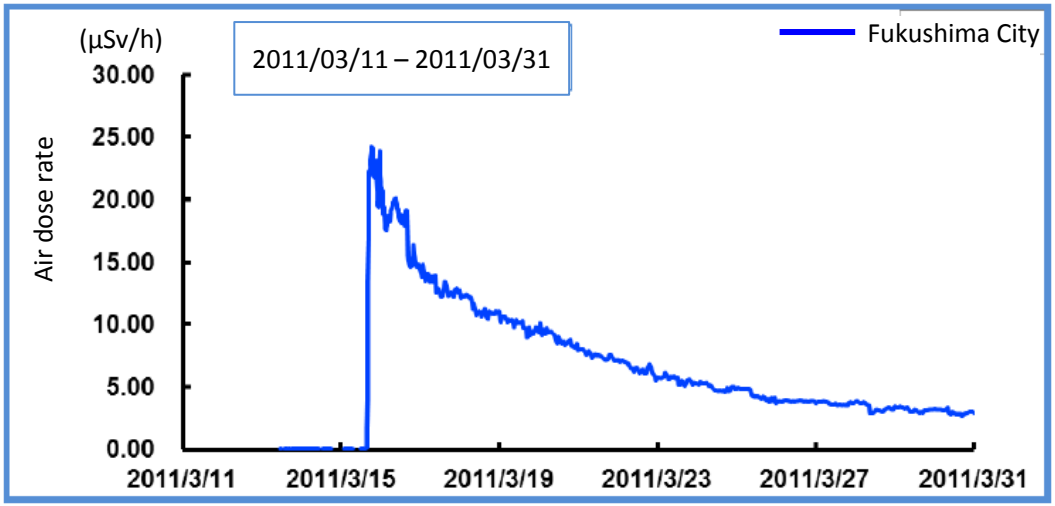
Figure 2.1.4-1: Radiation dosage measured by a monitoring car in the Fukushima Daiichi plant



Near the NPP

Unit: μSv/h

Source: Reports of The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission.
http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/

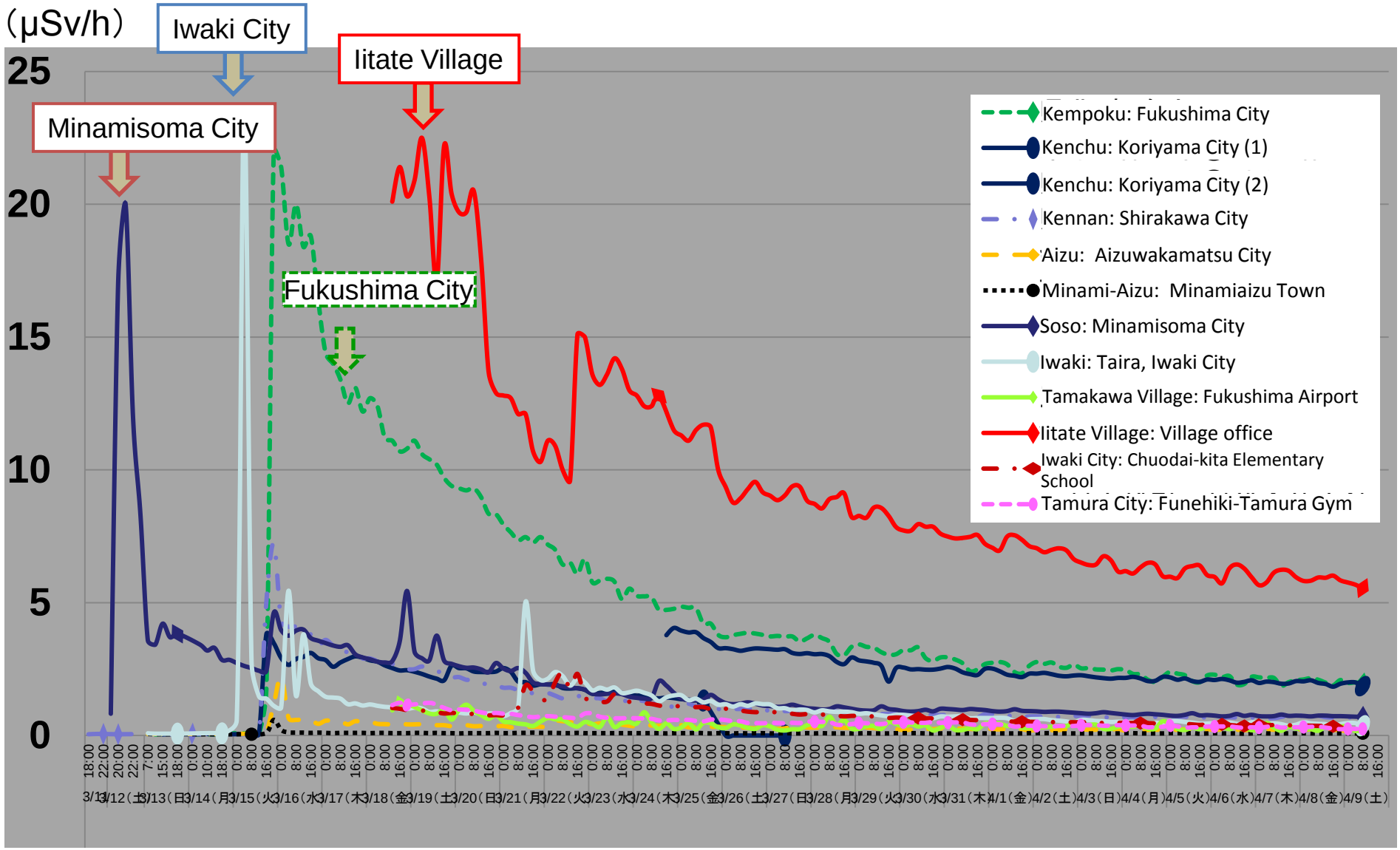


Fukushima City, about 60 km from the NPP

Source: Data published by the Ministry of the Environment about the air dose rate changes over time in Fukushima Prefecture which was compiled from the information on the nuclear disaster published by Fukushima Prefectural Government.
https://www.env.go.jp/chemi/rhm/kisoshiryo/attach/20140707mat2-03-1.pdf
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Air dose rate in Fukushima Pref. over time after the accident

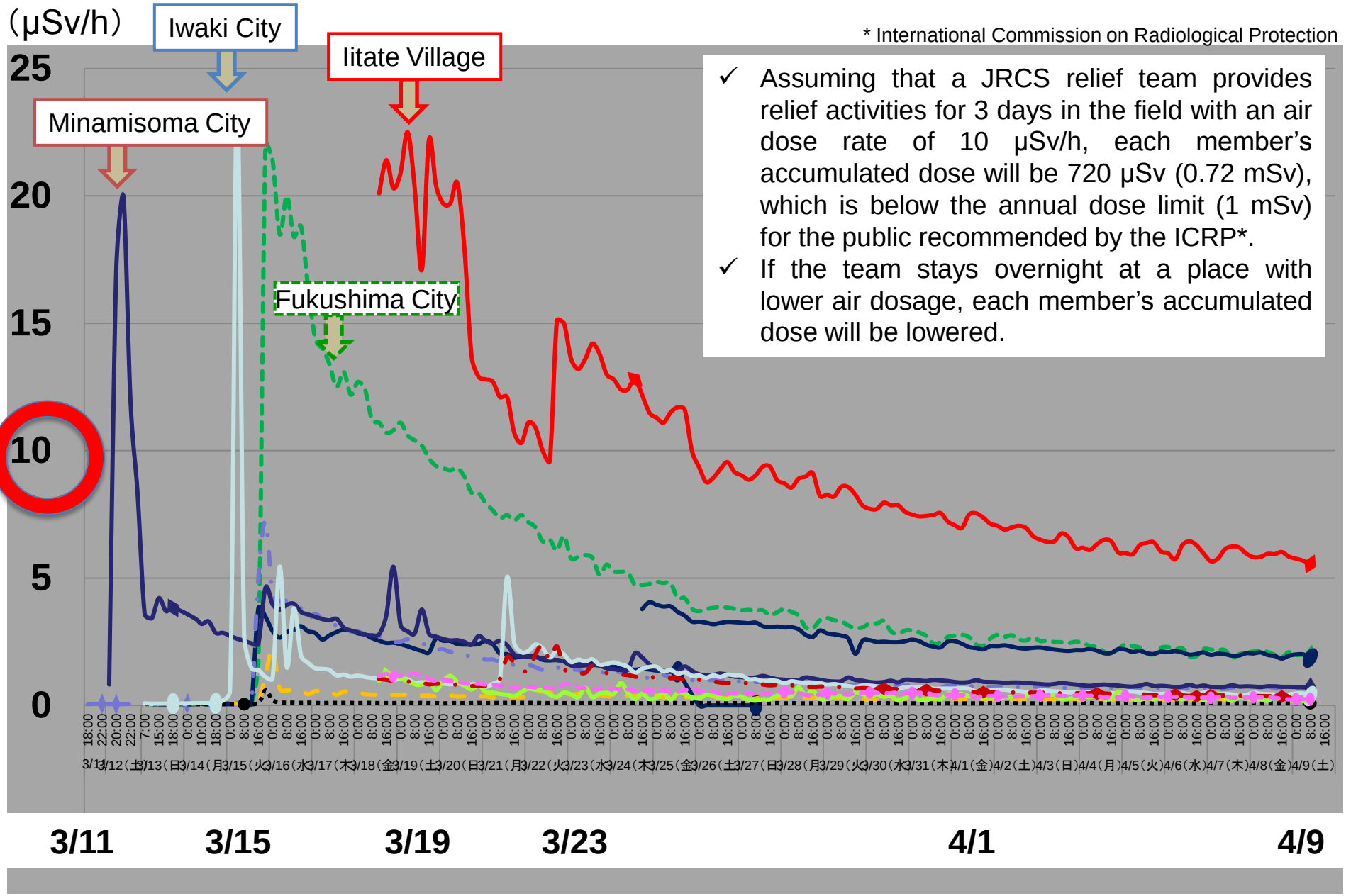
日本赤十字社
Japanese Red Cross Society



Source: The Journal of Japan Hospital Association, 58：1112-1116, 2011.
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Air dose rate in Fukushima Pref. over time after the accident

日本赤十字社 Japanese Red Cross Society



* International Commission on Radiological Protection

- ✓ Assuming that a JRCS relief team provides relief activities for 3 days in the field with an air dose rate of 10 μSv/h, each member's accumulated dose will be 720 μSv (0.72 mSv), which is below the annual dose limit (1 mSv) for the public recommended by the ICRP*.
- ✓ If the team stays overnight at a place with lower air dosage, each member's accumulated dose will be lowered.

Source: The Journal of Japan Hospital Association, 58：1112-1116, 2011.
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Radiation dose of evacuees?

日本赤十字社
Japanese Red Cross Society

Radiation dose on clothes/body surface of evacuees?

Secondary radiation dose which relief team members may be exposed to?

Body surface screening for evacuees from the nuclear disaster

日本赤十字社 Japanese Red Cross Society

(Unit: person)

Number of screened evacuees:	Number of evacuees with detected dose of more than 100,000cpm:
266,042	102

Source: Results of screenings conducted until June 30, 2013, published on the website of Fukushima Prefecture
https://www.pref.fukushima.lg.jp/sec/21045c/iryou-screeningkatsudou.html
(The table above was translated by the Red Cross Nuclear Disaster Resource Center.)

How dangerous is the level of 100,000cpm?

日本赤十字社
Japanese Red Cross Society

Assumption: To provide medical practice to a patient with body surface contamination of 100,000 cpm (1 μSv/h at 10 cm)

At 10cm from the patient and 1-hour treatment: 1 μSv

At 40cm from the patient and 1-hour treatment: 0.0625 μSv

At 100cm from the patient and 1-hour treatment: 0.01 μSv

Medical personnel will be secondarily exposed to approximately the doses above, while depending on nuclides or levels of contamination.

Radiation dose on clothes/body surface of the evacuees?

日本赤十字社 Japanese Red Cross Society

-> No problematic level.

Treatment for an evacuee with 100,000 cpm at 10 cm for one hour -> 1 μSv

Reference:

- Dose limit for the public: 1 mSv/year (Dose limit recommended by the International Commission on Radiological Protection)
- Dose limit for each JRCS relief team member:
  1 mSv as accumulated dose for an activity period (3 days)

日本赤十字社 Japanese Red Cross Society

Dose per irradiation and its effects on the human body:

(mSv = millisievert) ( ) = Distance of the hypocenter of the atomic-bomb blast

7000 mSv (7 Sv):	100% death (within 1km)
4000 mSv (4 Sv):	50% death in 30 days
2000 mSv (2 Sv):	5% death
1000 mSv (1 Sv):	Nausea, vomiting (about 1.5km)
500 mSv:	Temporary decline in the number of white blood cells
250 mSv or less:	**No physical symptom (more than about1.8km)**

Treatment for an evacuee with 100,000 cpm at 10 cm for one hour:
1 μSv

Equivalent dose limit on skin (Ordinance on Prevention of Ionizing Radiation Hazards)

日本赤十字社 Japanese Red Cross Society

Radiation worker: 500 mSv/year
General public: 50 mSv/year

Skin disorder begins to develop at around 3 Gy.

Treatment for an evacuee with 100,000 cpm at 10 cm for one hour:
1 μSv

Skin dose in tests

Scan region	Skin exposure dose on the entrance face
Chest	0.2 mSv/scan
Abdomen	1 mSv/scan
Thoracic vertebra (Front)	4 mSv/scan
Fluoroscopy of the upper digestive tract	10 mSv/scan

Treatment for an evacuee with 100,000 cpm at 10 cm for one hour:
1 μSv

Radiation effects on fetus

Radiation effects on fetus	Skin exposure dose on the entrance face	Threshold
Death of embryo/fetus	Pre-implantation phase (fertilization – 9 days)	100 mSv
Deformity	Organogenesis period (2 – 8 weeks)	100 mSv
Mental deficiency	Fetal period (8 – 15 weeks)	120 mSv

Treatment for an evacuee with 100,000 cpm at 10 cm for one hour:
1 μSv

Late effects

1. Cataract from radiation

Equivalent dose limit for the crystalline lens
Radiation worker: 150 mSv/year
General public: 15 mSv/year
Clouding of the lens with more than 2 Gy per irradiation

2. Death risk of leukemia from radiation

The risk to be increased by exposure of 1 mSv: 0.0005%
Probability of death from spontaneous leukemia: 0.66%
Probability of death from leukemia due to exposure of 200 mSv: 0.76%

Treatment for an evacuee with 100,000 cpm at 10 cm for one hour:
1 μSv

JRCS's relief activities

日本赤十字社
Japanese Red Cross Society

Relief activities for people evacuated from the 20km-radius area from the NPP.

Lecture for basic knowledge about radiation right before starting relief activities.

Photos: JRCS

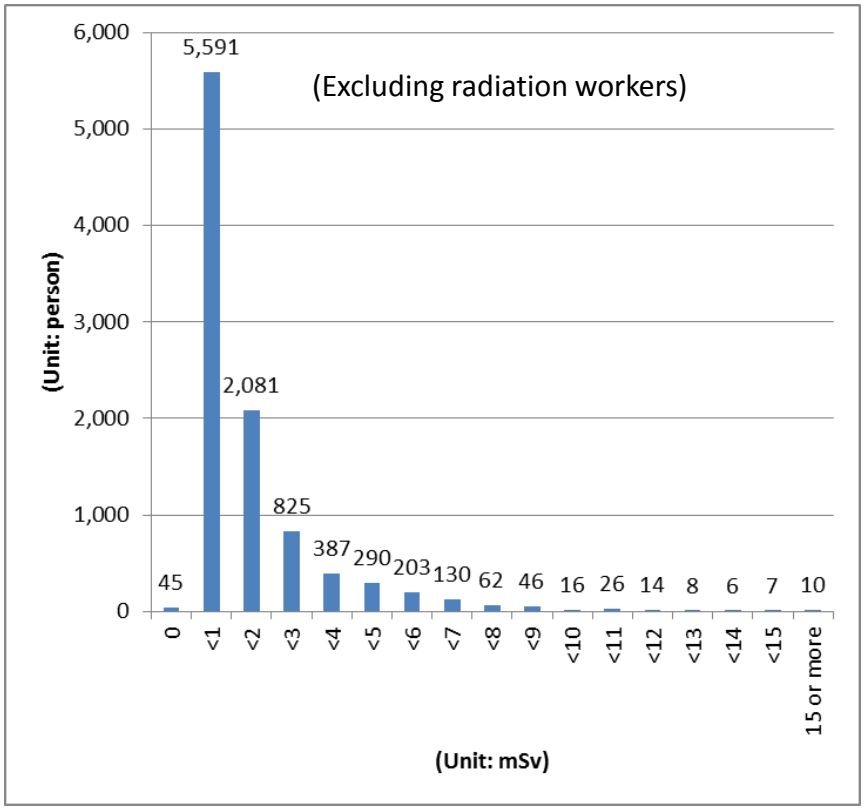
Explaining how to use a personal dosimeter.

Actual values measured with a personal dosimeter during an activity period:

Min.: 1 mSv
Max.: 21 mSv
Average: 8.7 mSv

Level of no effect on the human body.

Estimated external radiation dose



Source: Fukushima Health Management Survey. Compiled based on the preliminary report (No. 2) of "Basic Survey (Radiation Dose Estimates)"
http://www.pref.fukushima.lg.jp/uploaded/attachment/6487.pdf
(in Japanese)
http://www.pref.fukushima.lg.jp/uploaded/attachment/6488.pdf
(in Japanese)
(The chart above was translated by the Red Cross Nuclear Disaster Resource Center.)

Published by Prefectural Oversight Committee of Fukushima Health Management Survey on February 20, 2012.

Targeted population: 10,468 people from Kawamata Town (Yamakiya Area), Namie Town and Iitate Village.

Accumulated dose during the first 4 months (Calculated from the Basic Survey* results):

Less than 1 mSv: 5,636 persons (57.8%)
Less than 1-10 mSv: 4,040 persons (41.4%)
10 mSv or more: 71 persons
(20 mSv or more: 2 persons; Max. dose: 23 mSv)

Response rate to the Basic Survey: 52.1%
(Response rate of all targeted populations of Fukushima Prefecture: 21%)

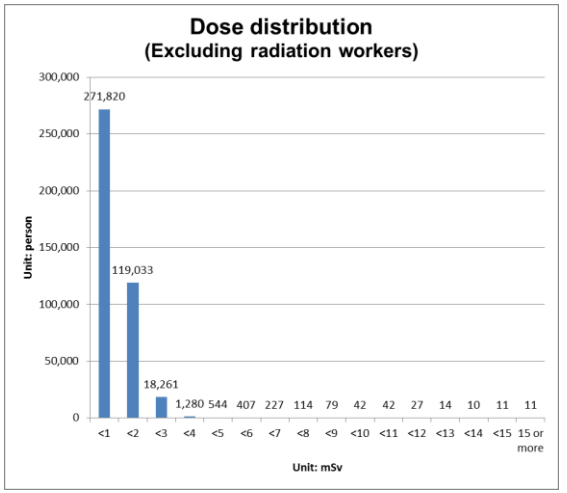
* A survey which was conducted to Fukushima citizens to ask about their movement from March 11, 2011 through July 11, 2011.

Estimated external radiation dose of Fukushima Prefecture citizens by area

日本赤十字社 Japanese Red Cross Society

Basic Survey of Fukushima Health Management Survey
Estimated external radiation doses (preceding and full-scale surveys)
(as of 31 March 2013)

Source:
Updated results of the Basic Survey of Fukushima Health Management Survey (Revised on June 25, 2013)
http://www.pref.fukushima.lg.jp/uploaded/attachment/6444.pdf (in Japanese)
(The charts were translated by the Red Cross Nuclear Disaster Resource Center.)



Extimated external radiation dose

as of 31 March 2013

Effective dose (mSv)	Total	Excluding radiation workers	By area (Exluding radiation workers)							Percentage (%) (Excluding radiation workers)		
			Kempoku	Kenchu	Kennan	Aizu	Minami-Aizu	Soso	Iwaki			
<1	277,356	271,820	38,553	59,857	21,237	33,935	3,536	54,236	60,466	66.0	94.9	99.8
<2	121,174	119,033	69,709	35,168	1,989	146	22	11,563	436	28.9		
<3	18,591	18,261	11,105	5,337	10	3	-	1,787	19	4.4	4.7	
<4	1,346	1,280	388	245	-	1	-	643	3	0.3		
<5	577	544	35	5	-	-	-	504	-	0.1	0.2	
<6	456	407	18	2	-	-	-	387	-	0.1		0.2
<7	256	227	5	-	-	-	-	222	-	0.1	0.1	
<8	145	114	1	-	-	-	-	113	-	0.0		
<9	114	79	-	-	-	-	-	79	-	0.0	0.0	
<10	66	42	-	-	-	-	-	42	-	0.0		
<11	70	42	-	-	-	-	-	42	-	0.0	0.0	0.0
<12	40	27	1	-	-	-	-	26	-	0.0		
<13	35	14	-	-	-	-	-	14	-	0.0	0.0	
<14	32	10	-	-	-	-	-	10	-	0.0		
<15	30	11	-	-	-	-	-	11	-	0.0	0.0	
15 or more	255	11	-	-	-	-	-	11	-	0.0	0.0	0.0
Total	420,543	411,922	119,815	100,614	23,236	34,085	3,558	69,690	60,924	100.0	100.0	100.0
Max value	66	25	11	5.9	2.6	3.6	1.6	25	3.9			

Percentages have been rounded.

= Low-dose exposure

Characteristics of the Fukushima Daiichi Nuclear Power Plant accident

日本赤十字社 Japanese Red Cross Society

- While the emergency shutdown at the power plant was successful, the meltdown and hydrogen explosion caused a major accident of Level 7.
- Main nuclides of the health risk and environmental contamination: I^{131}, Cs^{134}, Cs^{137}; very low level of Sr and Pu.
- Internal exposure: Sufficiently reduced due to contamination screenings/shipment restrictions of foods/water.
- There are some areas where the air dose rate is higher than the nuclear disaster and the external and internal doses combined exceeds 1 mSv. However, the doses are well reduced for the most part.
- Conclusion: Low-dose radiation exposure in a large scale.

Conclusion

日本赤十字社
Japanese Red Cross Society

Effects on the human body from exposure to radiation:

- ✓ Hiroshima and Nagasaki: Acute high-dose exposure.
- ✓ Effects on the human body from low-dose chronic exposure will unlikely occur in the light of the evidence obtained from the past experience.
- ✓ Effects on the human body from low-dose chronic exposure will be known over time of more than 50 years.