

High-dose exposure

(Exposed to a large amount of radiation)

Low-dose exposure

(Exposed to a small amount of radiation)

Acute exposure

(Radiation exposure on one occasion or in a short time)

Chronic exposure

(Radiation exposure over a long period of time)

Skin injury,
nausea, hair
loss?Acute disorders
appear when having
been exposed to a
large amount of
radiation in a short
time.

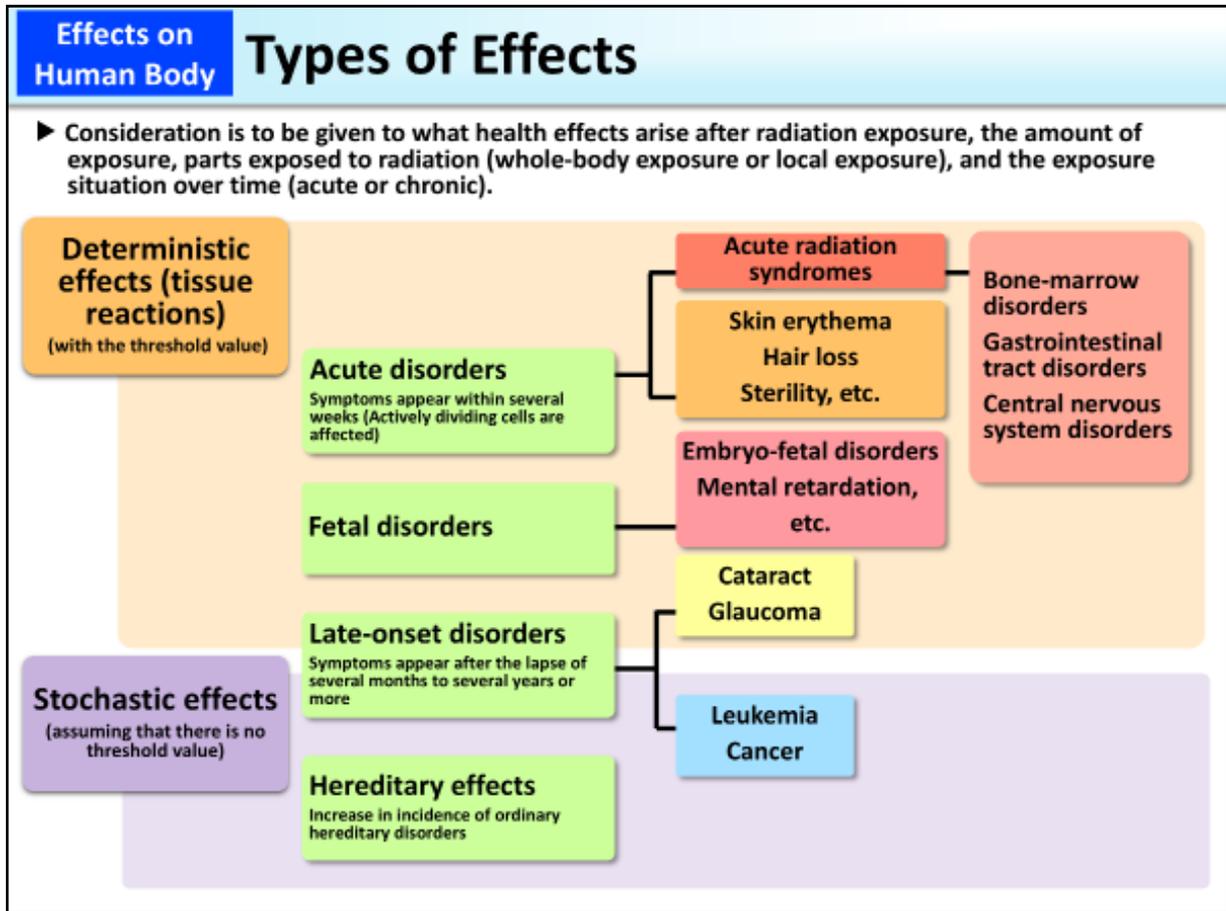
Physical effects of radiation depend on the amount of exposure, not on whether a person is ever exposed to radiation.

Whether any significant effects appear in the human body due to having been exposed to radiation depends on whether it is internal exposure or external exposure, whole-body exposure or local exposure, or which part was exposed in the case of local exposure, the amount of radiation, or the duration of exposure.

Types and levels of radiation effects on the human body can be ascertained more accurately when there is more information available.

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When considering health effects of radiation on human body, one method is to separately consider stochastic effects and deterministic effects (tissue reactions). The above figure compiles these two effects.

Deterministic effects (tissue reactions) do not appear unless having been exposed to radiation exceeding a certain level. Most of the deterministic effects are categorized into acute disorders whose symptoms appear within several weeks after exposure.

Stochastic effects are effects whose incidence cannot be completely denied even with low-dose exposure. Exposure doses are managed on the safe side in general under the assumption that there is no threshold value.

However, it has not been confirmed that hereditary disorders due to radiation exposure appear among human beings at the same frequencies as estimated from the results of tests on laboratory animals.

(Related to p.85 of Vol. 1, "Classification of Radiation Effects," and p.86 of Vol. 1, "Deterministic Effects (Tissue Reactions) and Stochastic Effects")

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Effects on Human Body		Classification of Radiation Effects		
		Incubation period	e.g.	Mechanism of how radiation effects appear
Categories of effects	Physical effects	Within several weeks = Acute effects (early effects)	Acute radiation syndromes ^{*1}	Deterministic effects (tissue reactions) caused by cell deaths or cell degeneration^{*2} 
			Acute skin disease	
		After the lapse of several months = Late effects	Abnormal fetal development (malformation)	
	Opacity of the lens			
Heritable effects	Cancer and leukemia	Stochastic effects due to mutation		
		Hereditary disorders		

*1: Major symptoms are vomiting within several hours after exposure, diarrhea continuing for several days to several weeks, decrease of the number of blood cells, bleeding, hair loss, transient male sterility, etc.
*2: Deterministic effects do not appear unless having been exposed to radiation exceeding a certain dose level.

Radiation effects are classified into physical effects appearing in a person exposed to radiation and heritable effects appearing in his/her children or grandchildren.

Radiation effects may also be classified depending on the length of time until any symptom appears after exposure. That is, there are acute effects (early effects) that appear relatively early after exposure and late effects that appear after the lapse of several months.

Another classification is based on the difference in mechanisms of how radiation effects appear, i.e., deterministic effects (tissue reactions) and stochastic effects.

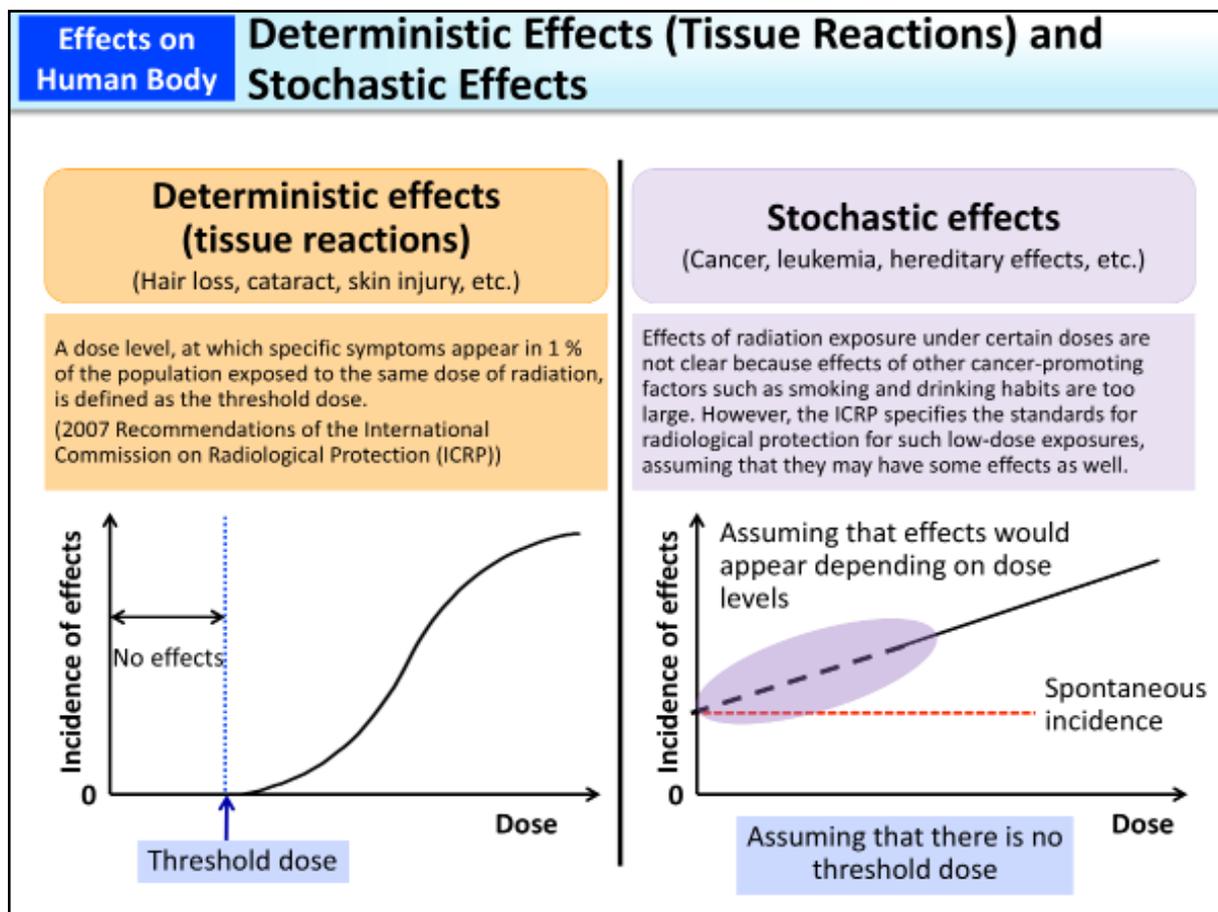
Deterministic effects (tissue reactions) are symptoms caused by deaths or degeneration of a number of cells constituting organs and tissues. For example, after exposure to a relatively large amount of radiation, a skin injury or a decrease of the number of blood cells due to deterioration of hemopoietic capacity may occur within several weeks (acute radiation syndrome). Exposure to a large amount of radiation during pregnancy may cause some effects on the fetus and radiation exposure to the eyes may induce cataracts after a while.

On the other hand, stochastic effects are caused by mutation of cell genes, such as cancer and heritable effects. Radiation may damage DNA, which may result in genetic mutation (p.88 of Vol. 1, "Damage and Repair of DNA"). Each mutation is unlikely to lead to diseases, but theoretically, the possibility of causing cancer or heritable effects cannot be completely denied. Therefore, in relation to cancer or heritable effects, exposure doses are managed on the safe side under the assumption that there is no threshold dose.

(Related to p.86 of Vol. 1, "Deterministic Effects (Tissue Reactions) and Stochastic Effects," and p.108 of Vol. 1, "Risks of Heritable Effects for Human Beings")

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One of the characteristics of the deterministic effects (tissue reactions) is the existence of the threshold dose, which means that exposure to radiation under this level causes no effects but exposure to radiation above this level causes effects. Radiation exposure above the threshold dose causes deaths or degeneration of a large number of cells at one time and the incidence rate increases sharply.

On the other hand, in radiological protection, it is assumed that there is no threshold dose for stochastic effects. Under this assumption, the possibility that radiation exposure even at extremely low doses may exert some effects can never be eliminated. It is difficult to epidemiologically detect stochastic effects due to radiation exposure at low doses below the range of 100 to 200 mSv, but the ICRP specifies the standards for radiological protection for low-dose exposures, assuming that effects would appear depending on dose levels (linear dose-response relationship) (p.165 of Vol. 1, “Biological Aspect”).

When assessing cancer risks due to low-dose exposures, results of the epidemiological studies of atomic bomb survivors in Hiroshima and Nagasaki have mainly been used. It is known that cancer risks increase almost linearly as exposure doses increase above approx. 100 mSv (p.117 of Vol. 1, “Relationship between Solid Cancer Deaths and Doses”). However, it is not clear whether risks also increase linearly in the case of radiation exposure at doses below 100 mSv (p.166 of Vol. 1, “Disputes over the LNT Model”). Additionally, it is shown that risks increase quadratically in tandem with doses above approximately 1,000 mSv (p.118 of Vol. 1, “Dose-response Relationship of Radiation-induced Leukemia”). The WHO and UNSCEAR assess risks by applying the linear-quadratic dose response model.

Furthermore, experiments using animals or cultured cells have revealed that comparing high-dose exposures in a short time as experienced by atomic bomb survivors and low-dose exposures over a long period of time, the latter poses lower risks even when the total exposure doses are the same (p.116 of Vol. 1, “Cancer-promoting Effects of Low-dose Exposures”).

(Related to p.91 of Vol. 1, “Cell Deaths and Deterministic Effects (Tissue Reactions)”).

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