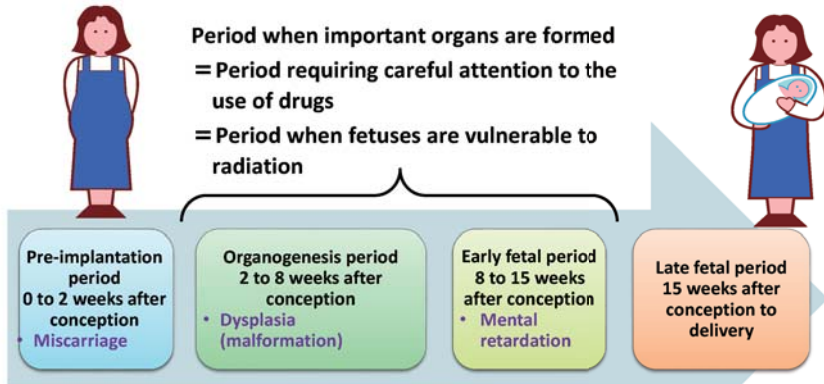


## Deterministic Effects (Tissue Reactions) and Time Specificity



The threshold dose is 0.1 Gy or more.

\* The time generally considered as two-week pregnancy is equivalent to zero weeks after conception.

Deterministic effects (tissue reactions) include fetal effects for which the threshold dose is especially low. When a pregnant woman is exposed to radiation and radiation passes through her womb or radioactive materials migrate into her womb, her unborn baby may also be exposed to radiation.

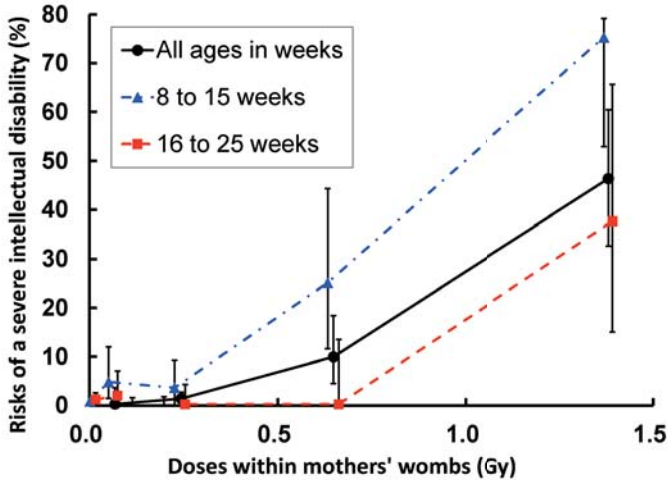
It is known that fetuses are highly sensitive to radiation and incidence of effects has time specificity. Radiation exposure exceeding 0.1 Gy at an early stage of pregnancy (pre-implantation period) may lead to miscarriage.

After this period, the possibility of miscarriage decreases, but radiation exposure exceeding 0.1 Gy during the period when important organs are formed (organogenesis period) may cause dysplasia (malformation). Radiation exposure exceeding 0.3 Gy during the period when the cerebrum is actively growing (early fetal period) poses risks of mental retardation (p.105 of Vol. 1, "Mental Retardation").

The period when fetuses are highly sensitive to radiation coincides with the period during which pregnant women are advised not to take drugs carelessly. During this period before the stable period, fetuses are vulnerable to both drugs and radiation. Fetal effects are caused by radiation exposure exceeding 0.1 Gy. Therefore, the International Commission on Radiological Protection (ICRP) states in its 2007 Recommendations that a fetal absorbed dose less than 0.1 Gy should not be considered as a ground for abortion. Exposure to 0.1 Gy of radiation is equivalent to exposure to 100 mSv of  $\gamma$ -rays or X-rays at one time. Incidentally, fetuses' exposure doses are not always the same as their mothers' exposure doses. Risks of stochastic effects such as cancer or heritable effects also increase depending on exposure dose levels.

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Source: Prepared based on "Physical and Mental Development of Children Exposed to Radiation in Their Mothers' Wombs" on the website of the Radiation Effects Research Foundation ([https://www.rerf.or.jp/programs/roadmap/health\\_effects/uteroexp/physment/](https://www.rerf.or.jp/programs/roadmap/health_effects/uteroexp/physment/))

Time specificity in fetal effects was made clear through health surveys on a group of people who were exposed to radiation in their mothers' wombs due to the atomic bombing.

This figure shows the relationship between ages in weeks at the time of the atomic bombing and its effects on fetuses' mental development.

Those aged 8 to 15 weeks show high radiosensitivity and the threshold value for exposure doses in mothers' wombs seems to be between 0.1 Gy and 0.2 Gy. In the range above this level, the incidence rate of a severe intellectual disability increases as doses increase, as observed in the figure.

On the other hand, a severe intellectual disability is not observed among those who were aged 16 to 25 weeks and were exposed to radiation at doses around 0.5 Gy, but radiation exposure exceeding 1 Gy caused mental disorders at a significant frequency.

In other words, the incidence rates of disorders differ depending on whether radiation exposure occurred at the age of 8 to 15 weeks or at the age of 16 to 25 weeks, even if the total exposure doses were the same.

(Related to p.104 of Vol. 1, "Deterministic Effects (Tissue Reactions) and Time Specificity")

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### Survey on children born from mothers who were pregnant at the time of the Chernobyl NPS Accident



#### Survey targets

- (i) 138 children who were exposed to radiation in the womb and their parents (a group of children exposed to radiation in the womb: exposed group)
- (ii) 122 children in non-contaminated regions in Belarus and their parents (control group: non-exposed group)

Children's mental development	When aged 6 to 7		When aged 10 to 11	
	(i) Exposed group	(ii) Control group	(i) Exposed group	(ii) Control group
Difficulty in speech	18.1%	8.2%	10.1%	3.3%
Disorder of emotion	20.3%	7.4%	18.1%	7.4%
IQ=70~79	15.9%	5.7%	10.1%	3.3%

- A significant difference in mental development was observed between the exposed group and the control group, but there was no correlation between exposed doses and intelligence quotients. Therefore, the difference was considered to be attributable to social factors associated with forced evacuation
- There was correlation between parents' extreme anxiety and their children's emotional disorders.

↓

**It is considered that radiation exposure during pregnancy does not directly affect intelligence quotients of fetuses and children after growth.**

Source: Prepared based on Kolominsky Y et al., J Child Psychol Psychiatry, 40 (2): 299-305, 1999

Researchers in Belarus conducted surveys targeting 138 children born from mothers who were pregnant and were residing near the nuclear power plant at the time of the Chernobyl NPS Accident and 122 children born from mothers who were pregnant at the time of the accident but were exposed to little radiation. The surveys were conducted twice when survey targets were aged 6 to 7 and when they were aged 10 to 11 in order to study effects of radiation exposure in the womb on their mental development.

In both surveys, incidences of difficulty in speech and disorder of emotion were larger among the exposed group than among non-exposed group with statistically significant differences.

Regarding intelligence quotient, fewer children in the exposed group were above the average compared with the non-exposed group and children on the borderline between normal levels and mental retardation were clearly larger in number.

However, no correlation has been found between estimated absorbed doses to the thyroid in fetal life and intelligence quotient and possibilities of other factors are suggested such as social-psychological and sociocultural factors (school education and guardians' academic levels, etc.) associated with forced evacuation from contaminated regions. The possibility that radiation exposure during pregnancy has directly affected the intelligence quotients of fetuses and children after growth is considered to be low.

A survey targeting parents using a stress evaluation index revealed clear correlation between parents' anxiety and children's emotional disorders.

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**Has the Chernobyl NPS Accident increased malformation?**

Comparison of European congenital malformation/twin registry database between before and after the Chernobyl NPS Accident



**European Surveillance of Congenital Anomalies (EUROCAT): 18 regions in 9 countries:**

**No change** in incidence of malformations before and after the accident

**Finland, Norway, Sweden:**

**No change** in incidence of malformations before and after the accident

**Belarus:**

**Increase in registration of malformations** of aborted fetuses regardless of whether from the contaminated areas or not

Possibility of reporter bias\* <sup>1</sup>

**Ukraine: participated in EUROCAT in this century**

**Increase in neural tube defects** in an isolated Polish community in the Rivne province

It is necessary to evaluate the influences of folate deprivation, alcoholism, consanguineous marriage, etc., in addition to radiation.\* <sup>2</sup>

Source : \* 1 :Stem Cells 15 (supple 1): 255, 1997 \* 2 :Pediatrics 125:e836, 2010

There have been various reports on the incidence of congenital anomalies before and after the Chernobyl NPS Accident. Comparison of databases of the European Surveillance of Congenital Anomalies (EUROCAT), and of Finland, Norway, and Sweden showed no change in incidence of malformations before and after the accident.

In the northern part of the Rivne province of Ukraine, there are people who live a self-sufficient life in a contaminated area. There is a report that neural tube defects have been increasing among them, and analysis is underway to determine whether it has been caused by radiation.

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