BBC NEWS

HEALTH

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Q&A: Health effects of radiation exposure

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BBC News

Concern remains over the potential effect on human health from radiation leaks at the stricken Fukushima Daiichi nuclear plant.

A 20km (12 mile) evacuation zone affecting about 70,000 people has been imposed around the plant, and is being extended to five communities outside the zone to the north west of the plant, where radioactive contamination is thought to be most significant.

Residents living within 30km (18 miles) have been advised to leave the area, or to stay indoors, and try to make their homes airtight.

Experts believe that swift action of this sort should have minimised the risk to human health, but are worries about the level of radiation to which emergency workers have been exposed, and about possible contamination of food and water supplies.

What are the immediate health effects of exposure to radiation?

Exposure to moderate levels of radiation - above one gray (the standard measure of absorbed radiation) - can result in radiation sickness, which produces a range of symptoms.

Nausea and vomiting often begin within hours of exposure, followed by diarrhoea, headaches and fever.

After the first round of symptoms, there may be a brief period with no apparent illness, but this may be followed within weeks by new, more serious symptoms.

At higher levels of radiation, all of these symptoms may be immediately apparent, along with widespread - and potentially fatal - damage to internal organs.

Exposure to a radiation dose of four gray will typically kill about half of all healthy adults.

For comparison, radiation therapy for cancer typically involves several doses of between one and seven gray at a time - but these doses are highly controlled, and usually specifically targeted at small areas of the body.

A sievert is essentially equivalent to a gray, but tends to be used to measure lower levels of radiation, and for assessing long-term risk, rather than the short-term acute impact of exposure. There are 1,000 millisieverts (mSv) in a sievert.

People are exposed to around 2mSv of radiation a year from the natural environment.

In the UK, the legal limit for radiation exposure from sources such as nuclear plants for members of the public is 1mSv a year, based on recommendations from the International Commission on Radiological Protection.

For accidents, the upper limit is set at 5mSv - but these figures are set conservatively, at levels far below those that would damage health.

Q&A: Health effects of radiation

Danger level	Radiation dose	Effect
	2 millisieverts per year (mSv/yr)	Typical background radiation experienced by everyone (average 1.5 mSv in Australia, 3 mSv in North America)
	9 mSv/yr	Exposure by airline crew flying New York-Tokyo polar route
	20 mSv/yr	Current limit (averaged) for nuclear industry employees
	50 mSv/yr	Former routine limit for nuclear industry employees. It is also the dose rate which arises from natural background levels in several places in Iran, India and Europe
	100 mSv/yr	Lowest level at which any increase in cancer is clearly evident.
	350 mSv/lifetime	Criterion for relocating people after Chernobyl accident
	400 mSv/hr	The level recorded at the Japanese nuclear site, 15 March
	1,000 mSv single dose	Causes (temporary) radiation sickness such as nausea and decreased white blood cell count, but not death. Above this, severity of illness increases with dose
	5,000 mSv single dose	Would kill about half those receiving it within a month

SOURCE: WORLD NUCLEAR ASSOCIATION

How is radiation sickness treated?

The first thing to do is to try to minimise further contamination by removing clothes and shoes, and gently washing the skin with soap and water.

Drugs are available that increase white blood-cell production to counter any damage that may have occurred to the bone marrow, and to reduce the risk of further infections due to immune-system damage.

There are also specific drugs that can help to reduce the damage to internal organs caused by radioactive particles.

How does radiation have an impact on health?

Radioactive materials that decay spontaneously produce ionising radiation, which has the capacity to cause significant damage to the body's internal chemistry, breaking the chemical bonds between the atoms and molecules that make up our tissues.

The body responds by trying to repair this damage, but sometimes it is too severe or widespread to make repair possible. There is also a danger of mistakes in the natural repair process.

Regions of the body that are most vulnerable to radiation damage include the cells lining the intestine and stomach, and the blood-cell producing cells in the bone marrow.

The extent of the damage caused is dependent on how long people are exposed to radiation, and at what level.

What are the most likely long-term health effects?

Cancer is the biggest long-term risk. Usually when the body's cells reach their "sell-by date" they commit suicide. Cancer results when cells lose this ability, and effectively become immortal, continuing to divide and divide in an uncontrolled fashion.

The body has various processes for ensuring that cells do not become cancerous, and for replacing damaged tissue.

But the damage caused by exposure to radiation can completely disrupt these control processes, making it much more likely that cancer will result.

Failure to properly repair the damage caused by radiation can also result in changes - or mutations - to the body's genetic material, which are not only associated with cancer, but may also be potentially passed down to offspring, leading to deformities in future generations. These can include smaller head or brain size, poorly formed eyes, slow growth and severe learning difficulties.

Are children at greater risk?

Potentially yes. Because they are growing more rapidly, more cells are dividing, and so the potential for things to go wrong is greater.

Following the Chernobyl nuclear reactor accident in the Ukraine in 1986, the World Health Organization recorded a dramatic increase in thyroid cancer among children in the vicinity.

This was because the radioactive materials released during the accident contained high levels of radioactive iodine, a material that accumulates in the thyroid.

What risk does Fukushima pose currently?

The Japanese authorities have recorded a radiation level of up 400 millisieverts per hour at the nuclear plant itself.

Professor Richard Wakeford, an expert in radiation exposure at the University of Manchester, said exposure to a dose of 400 millisieverts was unlikely to cause radiation sickness - that would require a dose of around twice that level (one sievert/one gray).

However, it could start to depress the production of blood cells in the bone marrow, and was likely to raise the lifetime risk of fatal cancer by 2-4%. Typically, a Japanese person has a lifetime risk of fatal cancer of 20-25%.

A dose of 400 millisieverts is equivalent to the dose from 50 -100 CT scans.

Prof Wakeford stressed only emergency workers at the plant were at risk of exposure to such a dose - but it was likely that they would only be exposed for short periods of time to minimise their risk.

He suggested the upper limit of their exposure would be 250 millisieverts - around 12 times the normal permitted annual exposure limit in the workplace.

However, even a dose of 100 millisieverts over a year is enough to raise the risk of cancer, and a dose of 250 millisieverts could raise lifetime risk by around 1%.

The level of exposure for the general population, even those living close to the plant, was unlikely to be anywhere near as high.

However, levels equivalent to around 25 millisieverts a year have been recorded in the village of Iitate, to the north west of the plant. Professor Wakeford said estimating the impact on human health of such a level was difficult, but there was some evidence to suggest that it could raise the risk of cancer - albeit by a small amount.

There should be no risk to people living further afield.

What radioactive materials have been released?

Experts are concerned about two types of radioactive material, created as by-products of the nuclear fission process, both of which can contaminate the soil relatively easily, and get into the food chain.

The radioactive form of iodine - iodine 131 - is easily absorbed by the thyroid, the gland which regulates growth and cell production.

This would raise the risk of thyroid cancer.

To counter that risk, people - in particular children - can be given tablets containing a stable form of iodine which would prevent the body absorbing the radioactive version.

Radioactive iodine decays quite quickly and will disappear from the environment within weeks or months.

The Japanese already have a lot of iodine in their natural diet, so that should help too.

Another potential source of contamination is the radioactive form of the metal caesium (caesium 137), which once released into the environment continues to pose a potential risk for many years.

This form of the metal is in a near-liquid state at room temperature, and can get into the soft body tissue, muscle and bone, where it can cause cancer.

How can the Japanese authorities minimise the cost to human health?

Prof Wakeford said that provided the Japanese authorities acted quickly, most of the general population should be spared significant health problems.

He said in those circumstances the only people likely to be at risk of serious health effects were nuclear workers at the plant or emergency workers exposed to high levels of radiation.

The top priority would be to evacuate people from the area and to make sure they did not eat contaminated food.

Distribution of iodine pills would also help to minimise the risk of thyroid cancer in the general population.

Is there evidence that food has been contaminated?

Yes. Japan's health ministry has urged some residents near the plant to stop drinking tap water after samples showed elevated levels of radioactive iodine - about three times the normal level.

Radioactive iodine has also been found in water supplies in Tokyo at twice the levels deemed safe in Japan for babies and infants to drink, although still some way short of the safety level for adults.

Raised radiation levels have also been found in samples of milk and spinach, in some cases well outside the 20km exclusion zone, particularly to the north west of the plant.

Japan's chief cabinet secretary Yukio Edano, said the level of radioactivity found in the spinach would, if consumed for a year, equal the radiation received in a single CAT scan. For the milk, the figure would be much less.

Professor Wakeford stressed that safe limits for radiation in food were kept extremely low, so people should not necessarily be unduly worried by reports that they had been breached.

For instance, the level of radioactive iodine recorded in water supplies in Tokyo would result in an adult being exposed to far less than the level of radiation from natural

background sources - even if they drank water contaminated at that level every day for a year.

However, Professor Wakeford said it would be advisable to stop young children from eating contaminated products. But he stressed that contmination levels have fallen sharply since mid-March.

What is the threat to Tokyo residents from contaminated tap water?"

Officials said the tap water showed 210 becquerels per litre of iodine-131 - more than twice the recommended limit of 100 becquerels per litre for infants. The recommended limit for adults is 300 becquerels. (Becquerels is a measure of radiation emitted whereas millisieverts is a measure of dosage on the body).

Professor Richard Wakeford says that infants who drank water contaminated at the Japanese limit of 100 becquerels for a year would effectively receive a dose of 0.4 millisieverts of radiation.

Adults who drank water contaminated at the Japanese limit of 300 becquerels for a year would effectively receive a dose of 0.3 millisieverts of radiation.

In comparison, the average person is exposed to 2.5 millisieverts from natural background radiation in a year.

In theory, drinking water contaminated at 210 becquerels for a year would cause a very small additional risk of cancer - but in practice nothing more than you could expect to get from normal background levels of radiation.

Is it safe to bathe or wash food in contaminated tap water?

Yes, because only small amounts of water would be ingested into the body from these practices.

What about contaminated seawater?

Levels of radioactive iodine-131 in seawater near the nuclear plant have reached 3,355 times the legal safety limit.

Japanese officials admitted the reading was a concern - but said there was no immediate threat to human health.

Professor Wakeford said it would be sensible to ensure that contaminated fish did not enter the food chain.

However, he stressed that radioactive iodine would be diluted by the ocean currents, and would, in any case, breakdown almost completely within three months.

How does Fukushima compare to Chernobyl?

Although Japan's Nuclear Safety Commission has upgraded the severity rating of the crisis from five to seven, the highest level and the same as Chernobyl, officials say emissions of radioactive materials at Fukushima currently stand at about 10% of those from the 1986 disaster.

Professor Gerry Thomas, who has studied the aftermath of the Chernobyl disaster, said: "It is very unlikely that this will turn into anything that resembles Chernobyl.

"In Chernobyl you had a steam explosion which exposed the reactor core, which meant you had a lot of radiation shooting up into the atmosphere."

Prof Thomas said although the Chernobyl disaster had led to a rise in thyroid cancer cases, the only people affected were those living in the areas of Ukraine, Belarus and Russia that lie closest to the site of the Chernobyl Power Plant, and who were young at the time.

What if the situation deteriorates?

If there were to be a meltdown or a fire at the nuclear plant, and unfavourable winds, then experts say radioactive material could reach as far as Tokyo, 150 miles (241km) away.

However, even in that situation, the level of radiation is likely to be such that simple measures, such as staying indoors with windows closed, should neutralise the risk.

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