# The Chernobyl accident

## UNSCEAR's assessments of the radiation effects



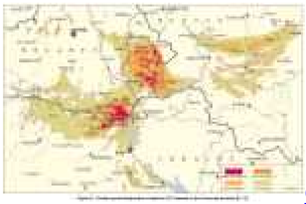
### Summary

The accident at the Chernobyl nuclear reactor that occurred on 26 April 1986 was the most serious accident ever to occur in the nuclear power industry. The reactor was destroyed in the accident and considerable amounts of radioactive material were released to the environment. The accident caused the deaths, within a few weeks, of 30 workers and radiation injuries to over a hundred others. In response, the authorities immediately evacuated, in 1986, about 116,000 people from areas surrounding the reactor and subsequently relocated, after 1986, about 220,000 people from Belarus, the Russian Federation and Ukraine. The accident caused serious social and psychological disruption in the lives of those affected and vast economic losses over the entire region. Large areas of the three countries were contaminated with radioactive elements, and radionuclides were measurable in all countries of the northern hemisphere.

Among the residents of Belarus, the Russian Federation and Ukraine, there had been up to the year 2002 about 4,000 cases of thyroid cancer reported in children and adolescents who were exposed at the time of the accident, and more cases can be expected during the next decades. Notwithstanding problems associated with screening, many of those cancers were most likely caused by radiation exposures shortly after the accident. Apart from this increase, there is no evidence of a major public health impact attributable to radiation exposure 20 years after the accident. There is no scientific evidence of increases in overall cancer incidence or mortality rates or in rates of non-malignant disorders that could be related to radiation exposure. The risk of leukaemia in the general population, one of the main concerns owing to its short latency time, does not appear to be elevated. Although those most highly exposed individuals are at an increased risk of radiation-associated effects, the great majority of the population is not likely to experience serious health consequences as a result of radiation from the Chernobyl accident. Many other health problems have been noted in the populations that are not related to radiation exposure.

## Release of radionuclides

The accident at the Chernobyl reactor happened during an experimental test of the electrical control system as the reactor was being shut down for routine maintenance. The operators, in violation of safety regulations, had switched off important control systems and allowed the reactor to reach unstable, low-power conditions. A sudden power surge caused a steam explosion that ruptured the reactor vessel, allowing further violent fuel-steam interactions that destroyed the reactor core and severely damaged the reactor building. Subsequently, an intense graphite fire burned for 10 days. Under those conditions, large releases of radioactive materials took place.


Contamination maps

The radioactive gases and particles released in the accident were initially carried by the wind in westerly and northerly directions. On subsequent days, the winds came from all directions. The deposition of radionuclides was governed primarily by precipitation occuring during the passage of the radioactive cloud, leading to a complex and variable exposure pattern throughout the affected region, and to a lesser extent, the rest of Europe.

## Exposure of individuals

The radionuclides released from the reactor that caused exposure of individuals were mainly iodine-131, caesium-134 and caesium-137. Iodine-131 has a short radioactive half-life (eight days), but it can be transferred to humans relatively rapidly from the air and through consumption of contaminated milk and leafy vegetables. Iodine becomes localized in the thyroid gland. For reasons related to the intake of those foods by infants and children, as well as the size of their thyroid glands and their metabolism, the radiation doses are usually higher for them than for adults.

The isotopes of caesium have relatively longer half-lives (caesium-134 has a half-life of 2 years while that of caesium-137 is 30 years). These radionuclides cause longer-term exposures through the ingestion pathway and through external exposure from their deposition on the ground. Many other radionuclides were associated with the accident, which were also considered in the exposure assessments.

Average effective doses to those persons most affected by the accident were assessed to be about 120 mSv for 530,000 recovery operation workers, 30 mSv for 116,000 evacuated persons and 20 mSv during the first two decades after the accident to those who continued to reside in contaminated areas. Maximum values of the dose may be an order of magnitude higher. Outside Belarus, the Russian Federation and Ukraine, other European countries were affected by the accident. Average doses there were at most 1 mSv in the first year after the accident with progressively decreasing doses in subsequent years. The dose over a lifetime was estimated to be 2-5 times the first-year dose. These doses are comparable to an annual dose from natural background radiation and are, therefore, of little radiological significance.

The exposures were much higher for those involved in mitigating the effects of the accident and those who resided nearby. Those exposures are reviewed in great detail in the assessments of the Committee.

## Health effects

The Chernobyl accident caused many severe radiation effects almost immediately. Of 600 workers present on the site during the early morning of 26 April 1986, 134 received high doses (0.7-13.4 Gy) and suffered from radiation sickness. Of these, 28 died in the first three months and another 19 died in 1987-2004 of various causes not necessarily associated with radiation exposure. In addition, according to the UNSCEAR 2000 Report, during 1986 and 1987 about 450,000 recovery operation workers received doses of between 0.01 Gy and 1 Gy. That cohort is at potential risk of late consequences such as cancer and other diseases and their health will be followed closely.


The Chernobyl accident also resulted in widespread radioactive contamination in areas of Belarus, the Russian Federation and Ukraine inhabited by several million people. In addition to causing radiation exposure, the accident caused long-term changes in the lives of the people living in the contaminated districts, since the measures intended to limit radiation doses included resettlement, changes in food supplies and restrictions on the activities of individuals and families. Later on, those changes were accompanied by the major economic, social, and political changes that took place when the former Soviet Union broke up.

For the last two decades, attention has been focused on investigating the association between exposure caused by radionuclides released in the Chernobyl accident and late effects, in particular thyroid cancer in children. Doses to the thyroid received in the first few months after the accident were particularly high in those who were children and adolescents at the time in Belarus, Ukraine and the most affected Russian regions and drank milk with high levels of radioactive iodine. By 2002, more than 4,000 thyroid cancer cases had been diagnosed in this group, and it is most likely that a large fraction of these thyroid cancers is attributable to radioiodine intake. It is expected that the increase in thyroid cancer incidence due to the Chernobyl accident will continue for many more years, although the long-term level of risk is difficult to quantify precisely.

Among Russian recovery operation workers with higher doses there is emerging evidence of some increase in the incidence of leukaemia. However, based on other studies, the risk of radiation-induced leukaemia would be expected to fall within a few decades after exposure.

Apart from the dramatic increase in thyroid cancer incidence among those exposed at a young age, and some indication of an increased leukaemia incidence among the workers, there is no clearly demonstrated increase in the incidence of solid cancers or leukaemia due to radiation in the most affected populations. Neither is there any proof of other non-malignant disorders that are related to ionizing radiation. However, there were widespread psychological reactions to the accident, which were due to fear of the radiation, not to the actual radiation doses.

There is a tendency to attribute increases in the rates of all cancers over time to the Chernobyl accident, but it should be noted that increases were also observed before the accident in the affected areas. Moreover, a general increase in mortality has been reported in recent years in most areas of the former Soviet Union, and this must be taken into account when interpreting the results of Chernobyl-related studies.

The present understanding of the late effects of protracted exposure to ionizing radiation is limited, since the dose-response assessments rely heavily on studies of exposure to high doses and animal experiments; extrapolations are needed, which always involves uncertainty. The Chernobyl accident might shed light on the late effects of protracted exposure, but given the low doses received by the majority of exposed individuals, any increase in cancer incidence or mortality will be difficult to detect in epidemiological studies. One future challenge will be to develop individual dose estimates including estimates of uncertainty, and to determine the effects of doses accumulated over a long period of time.

## Conclusions

The accident at the Chernobyl nuclear power plant in 1986 was a tragic event for its victims, and those most affected suffered major hardship. Some of the people who dealt with the emergency lost their lives. Although those exposed as children and the emergency and recovery workers are at increased risk of radiation-induced effects, the vast majority of the population need not live in fear of serious health consequences due to the radiation from the Chernobyl accident. For the most part, they were exposed to radiation levels comparable to or a few times higher than the natural background levels, and future exposures continue to slowly diminish as the radionuclides decay. Lives have been seriously disrupted by the Chernobyl accident, but from the radiological point of view, generally positive prospects for the future health of most individuals should prevail.

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The material on this page has been prepared by the UNSCEAR secretariat based on the published UNSCEAR reports and on the 2006 report of the Chernobyl forum. It does not include material from the latest draft of the UNSCEAR report on " *Health effects due to radiation from the Chernobyl accident*".

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