Twenty Years After The Chernobyl Nuclear Power Plant Accident

Dr. Elizabeth Vainrub, PhD
(On April 26, 1986 Dr. Vainrub was Chairman of the Department of Prevention Medicine for Children at the Institute of Prevention Medicine in Kiev, Ukraine.)

April 26, 2006 is the 20th anniversary of one of the largest catastrophes of the 20th century: the accident at the Number Four RBMK reactor at the nuclear power plant; an anniversary of a catastrophe that touched millions of lives.

The whole world actively participated in the remediation in the immediate aftermath and in the study of medical and biological effects of ionizing radiation on health of the population. Many national and international programs, led by well-known medical organizations and scientists were designed to study the accident and its aftermath during the years following the accident.

The scientific community in Houston did not remain indifferent to this problem. Scientists from Baylor College of Medicine and Texas Hadassah Medical Research Foundation established an International Consortium on the Health Effects of Radiation to conduct long term research on the health effects of the low-dosage radiation among immigrants from contaminated areas of Ukraine, Belarus, and Russia.

Results of research projects conducted by many international groups were recently presented during the forum: "Chernobyl's Legacy – Impact on Health, Environment and Socio-Economical Consequences." Data received from studies of the living conditions and health of the affected population, initiated by the UN agencies, aided the presentation of informative answers to a number of questions.

1. What is the real scale of the accident in the Chernobyl Nuclear Power Plant?

According to Ministry of Nuclear Energy of Russia (MinAtom), the radioactive plume which emanated from the Number Four RBMK reactor deposited radioactivity over a total area exceeding 50,180 sq. miles affecting a population base of approximately 5 million. In Russia, the aftermath of the accident affected 16 oblasts (administrative units; similar to counties in the US), and a total population of 3 million, including 600,000 children. In Belarus, more than 2,316 sq. miles of land, including 1,158 sq. miles of fertile agricultural land, were rendered useless as a direct result of the impact of the accident. People from nearly 500 towns and villages were evacuated to relatively cleaner areas.

According to data from the Ministry of Statistics of Ukraine, Chernobyl's radioactive cloud covered 12 out 25 oblasts of the country, with total population of 17.2 million people. By the middle of August 1986, about 90,000 people were evacuated from the 81 affected towns and villages. Radiation affected more than 11.36 million acres of fertile land in Ukraine.

During the hours immediately following the accident, increased levels of radiation were registered in Poland, Denmark, Sweden, Greece, Finland, Norway, Great Britain and Germany. It's worth noticing that the size of the affected area and number of affected people has changed during the years following the accident, due to radioactive decay and changes in the uptake and distribution decaying radionuclides in the food chain.

2. Which radionuclides were released into the air as a result of the accident in the reactor?

According the latest data, the reactor released about 6% of the reactive fuel, about 11 metric tons, into the atmosphere which were then carried to social and distinct regions of the world.
There are several specifics of the radioactive contamination:

- Distribution of the radionuclides over the surface;
- Different spectral composition of radionuclides at different distances from the reactor;
- Varying behavior of radionuclides in the ground-plants–human chain.

There are four distinct periods in the development of the situation:

- Early/Phase I – the release isn't completed, formation of a radioactive plume (cloud) and beginning of the formation of the radioactive imprint;
- Phase II – iodine phase (lasted 1-2 months): thyroid glands were affected during this interval;
- Phase III – (lasted 2-3 years): external radiation was dominated by short life nuclides (Ba-140, Ce-141 and -144, Ru-102). Most of the internal radiation by Ce -134 and Ce -137 occurred during this period and was found in contaminated food;
- Phase IV – (lasts up to several decades): this phase is characterized by contamination due to cesium, strontium-90 and plutonium (half-lives of cesium-137 and strontium-90 is about 30 years, plutonium 239 – 24 thousands years).

Despite the radioactive decay, the main radionuclide of the Chernobyl origins continue to be a source of danger to the population's health for many decades. Some of the alpha-emitting isotopes with long half lives, such as plutonium-239 and americium-241, will continue to remain in the environment for thousands of years, although, fortunately, they were confined almost exclusively to the zone immediately surrounding the power plant.

3. What are the current general characteristics of exposure as a result of the accident on the Chernobyl nuclear power plant?

Everyone agrees that the liquidators and populations of the surrounding contaminated areas received the most significant (acute) doses of the radiation immediately following the accident. According to data (UNSCEAR 2000), up to 90% of the cumulative dose involved prolonged (chronic) exposure received over a period from 1986-95. It's worth noting that there is disagreement among scientists regarding the nature and scale of risks for human health due to prolonged (chronic) exposure, namely due to the risk thresholds and uncertainties surrounding "low-dose" levels of radiation.

As a rule, radiation dose depend on three factors: a) level of contamination in a certain territory, b) nature of migration of radioactivity in the environment and in the human body; and c) lifestyle and behavior of the affected population.

According to reports(1), exposure rates among residents living in the most highly exposed areas have recently increased, despite the decline in the general level of radioactivity. This occurrence is mostly due to a drop in family income, which forces

people to switch to local food products, as well as a decline in the effectiveness of the protection measures.

4. How did the Chernobyl nuclear power plant accident impact the environment of cities and rural areas?

During the last two decades, the contaminated ecosystems of the areas surrounding the nuclear power plant have been studied extensively. The severity of radionuclide contamination of a particular territory or town depends mostly on the radionuclide composition of fallout received and meteorological conditions, specifically those that affected movement of radioactive plumes. The most widely used indicator of contamination in environmental conditions is the degree of radioactive Cs-137. In Belarus, Russia and Ukraine, an area is considered contaminated if the indicator exceeds 1 cu/km^2. Based on this definition, 16,791 miles^2 in Belarus, 35,898 miles^2 in Russia, and 14,513.6 miles^2 in Ukraine are considered contaminated, along with a total population of about 6 million people. In areas and territories with significant radionuclide contamination, farming and forestry is prohibited. It is known that Cs-137 and Sr-90 may migrate deep into the underground water table and therefore may become a potential long-term threat for human health.

5. What are the general characteristics of radionuclide contamination in foodstuffs of animal or vegetable origin?

After the accident on the Chernobyl nuclear power plant, there was a very high level of absorption of radionuclides by animals and plants, specifically in many forested and mountainous areas. There was a significant increase in the loss of coniferous trees, soil, and high level of death among mammals and other animals. There was a similar decline in the reproductive functions of animals and plants located 12-18 miles from the reactor in the high radiation area. However, weather conditions (mostly rainfall), radioactive decay, migration of radionuclides underground, and the destruction of elements by the micro-organisms, all resulted in a significant reduction in the uptake of radionuclides in animals and plants.

Use of food products such as milk, meat, wild berries, mushrooms, and game, containing radioactive Cesium is currently the most severe and worrisome problem. This also presents a problem for the future, as it significantly increases the doses of internal radiation in the local population.

6. What is the size of the population currently residing in the contaminated areas?

In total, 348,000 people were relocated following the Chernobyl nuclear power plant accident. Some people were evacuated immediately, but others were relocated in the following years.

The resettlement process is completed now in the areas with contamination levels of more than 1 Ci/km^2 of Cs-137, specifically around 10% of population of Belarus, 5% population of Ukraine and approximately 1% of population of Russia. Territories with very high levels of contamination (more than 40 Ci/km^2), present the most serious concern because approximately 150,000-200,000 people still reside there.

Considering the difficulties of the economic situation and the desire of the citizens, each of the three countries established its own priorities for reallocation of their populations. Each of the three countries created its own strategy for recovery that is addressed in the national programs(2).

7. What are the levels of morbidity and mortality in liquidators and employees at the Chernobyl nuclear power plant in the last twenty years?

More than 600,000 people participated in cleanup operations during the period of 1986 to 1991. The majority of "liquidators" were young military conscripts and as a result of work in the contaminated area, they received doses or radiation from 10 to 250 mGy (1 Gray = 100 rad). The largest doses of radiation occurred in from 1986 to 1987.

National and international programs in Belarus, Russia, and Ukraine provided medical and epidemiological monitoring of liquidators, and they demonstrated negative trends in health conditions, due to the impact of complex pathogenic factors. The total number of casualties as a result of the accident is expected to continue to rise in the future. Taking into account the life expectancy of liquidators and other people residing in highly contaminated territories, this number is expected to reach approximately 4000 deaths. This includes 50 employees of the Chernobyl nuclear power plant who died from acute radiation illness and nine children who died from thyroid cancer in the first five years after the accident.

8. What diseases are typical for the population that has been impacted by radiation and what is their prognosis?

There still is uncertainty regarding the long term effects of radiation on health. On one hand, the nuclear industry accepts the possibility of limited and contained proven consequences. On the other hand, scientists, physicians and activists believe the accident had severe and varied negative effects on the health of millions of people. The current health conditions in the affected territories are a result of many factors, including the impact of radiation, poverty, poor living conditions, inadequate medical services, malnutrition and psychological impacts of living in worrisome and unpredictable conditions that people are powerless to change.

Some of the latest research suggests a slight increase in the number of cases of leukemia among liquidators. There is also an increase in the number of solid tumors and a possible increase in circulatory disorders; however, further observations are necessary to exclude the possible impact of factors such as smoking, alcohol, unhealthy lifestyles and other environmental exposures.

Likewise, there is a possibility of future increases of thyroid dysfunctions, which will negatively impact the health of the population, contribute to reproductive dysfunctions, specifically in women who were young girls and adolescents at the time of the accident. It is believed by many that the first generation of people living in the contaminated areas has a higher risk of having children with birth defects and genetic illnesses.

9. What is the epidemiology of thyroid cancer among the population impacted by the radiation?

As reported by the UNSCEAR in 2000, there were 1800 cases of thyroid cancer in children residing in contaminated areas at the end of 1998. However, there is also an opinion that these numbers are too low. By conservative estimates, there are six to eight thousand cases of thyroid cancer in three countries (Ukraine, Russia, and Belarus) in people who received radiation in childhood and continued to live in contaminated areas. Some scientists (among them V.G. Tsanko), concluded that in Belarus alone, the incidence of radiation-induced thyroid cancer among those younger than 18 in 1986, may reach 12500 cases by 2036.

10. Did radiation have any impact on the psychological and cognitive health of the population?

It has become more obvious during the last several years that the accident had very severe socio-psychological consequences, which, in combination with other factors seriously impacted the population. The socio-psychological consequences are quite complex and related not only to the accident itself, but to the effects of displacement and relocation of people.

The uncertainty of medical effects played a negative role on psychological and cognitive health of liquidators, as well as that of the people residing in contaminated areas. These include increased level of stress, depression, anxiety and medically unsubstantiated psychological disorders, including self-reported ill health.

There has been significant improvement in understanding the effects of ionizing radiation on the developing brain. Analysis of data collected by scientists in Ukraine, Belarus, and Russia showed that there is an increase in cases of slight delay of cognitive development in children who received radiation during gestation, compared to children born after a normal pregnancy.

Pregnant women demonstrated higher incidents of borderline psychiatric and psychological disorders. Children who received radiation during the prenatal period had higher incidents of neurological diseases than children from “clean” areas(3).

11. Are there any effects on reproductive functions and genetic mutation? Will there be any genetic or reproductive effects in the future?

Absorption of ionizing radiation into or proximally near cells of the human body can lead to direct and indirect DNA damage, which, in turn, leads to damage of the genetic material in human cells. This damage can lead to the loss of cells and so-called, early deterministic or threshold effects, and to changes in the genetic characteristics which trigger stochastic effects such as cancers and genetic diseases.

One of the best examples of the deterministic effects after the Chernobyl nuclear power plant accident was acute exposure and death of 24 people, who received high doses of radiation and died four months later. Eleven more liquidators died by the end of 1998. Another deterministic effect, typical for people who received high doses of radiation, is the development of cataracts. Those who received smaller doses of radiation may not suffer from these deterministic effects, but may experience stochastic effects such as cancers or cell mutations which may affect future generations. Insignificant but persistent reports concerning an increase in cases of birth defects in contaminated as

well as in uncontaminated areas may be attributed not as an effect of radiation, but to the better reporting and information.

12. What is the life expectancy and birth rate of population in the territories with highest levels of contamination by radionuclides?

Twenty years after the accident, the territories contaminated by radionuclides are characterized by more complex medical and demographical situations, compared with relatively clean territories. Examples include lower birthrates, relatively higher numbers of stillbirths, and higher infant mortality. Life expectancy in contaminated areas is lower, not only in comparison with Southern and Western Europe, North America, and Japan, but also in comparison with several developing countries.

13. Is there a direct correlation with the development of malignant tumors?

Questions of the scale of stochastic effects remain highly debatable, depending on the received dose of ionizing radiation. This is especially true for the low-dose chronic exposures observed in the aftermath of the Chernobyl nuclear power plant accident. Today, at least, we can say that some effects may become evident later with a delay of several decades. As we know, each type of radiation that induces malignancy has its own latent period, which is between 2 to 15 years for leukemia and 4 to 20 or more years for solid tumors.

The impact of ionizing radiation on the population between the ages of 0 to 14 years is the most dangerous and can lead to the most severe negative consequences. Therefore, the worsening of radiation background following the Chernobyl nuclear power plant accident in Ukraine led to an increase of brain tumor cases in young children, and the number of cases grew 5.8 times in young children and 10 times in newborns.

14. What was done to remediate the environment after the accident?

In the beginning, all efforts were concentrated on protecting the population from radionuclide exposure. This was achieved by immediate evacuation of the population of town of Pripyat and neighboring towns and villages, along with clean up operations in these towns and villages. Initial evacuation was mandatory within the 30 km zone surrounding the Chernobyl nuclear power plant. Later the level of contamination by isotope Cs-137 became the main criteria for resettlement of the population. Cleanup operations included washing buildings and streets, removing top soil, and burying contaminated equipment. To prevent further discharge of radioactive material, the 4th reactor block was covered by the cement sarcophagus, which at present time is under maintenance.

Early detection of contamination levels in agricultural crops, including animal feed, became very effective in preventing further dissemination. Treating agricultural land used for cultivation with cesium binding agents led to a substantial decrease in contamination levels and resulted in decreases in the amount of radionuclides in plant and animal products.

The necessity of cleaning up after the accident caused a significant increase in international cooperation in science, humanitarian aid, and technological advances.

Countries immediately affected by the catastrophe, Ukraine, Belarus, and Russia, took the leading role in these advances. These countries expended their efforts to clean up after accident, the full scale of which still is not recognized by the rest of the world.

15. Why is the International community still interested in scientific aspects of problems associated with the Chernobyl nuclear power plant accident twenty years ago?

There are three main points that help the answer this question. First and foremost, there is an interest in the safety of nuclear power plants and the acquisition of knowledge concerning the long term effects of radionuclide contamination on human health. In the spirit of WHO's Helsinki Declaration on Biomedical Research on Human Subjects, the international community has had to take part of the responsibility for the well being of affected people, if the world is to benefit from their tragedy.

The second argument – the world community, together with scientists and politicians, are able to learn from the experiences of people affected by this tragedy. Third and last, the world community should continue to participate in solving problems associated with Chernobyl nuclear power plant accident in order to build a model for the future. Many initiatives can be used in other regions of the world, where the population suffers from the misfortunes and the deprivations, caused by catastrophes, wars, by civil disorders or by economic changes.

References

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