Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts

and

Recommendations to the Governments of Belarus, the Russian Federation and Ukraine

The Chernobyl Forum: 2003–2005

Second revised version

The Chernobyl Forum

IAEA

WHO

UNDP

FAO

UNEP

UN-OCHA

UNSCEAR

WORLD BANK GROUP

Belarus

the Russian Federation

Ukraine

Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts

and

Recommendations to the Governments of Belarus, the Russian Federation and Ukraine

The Chernobyl Forum: 2003–2005

Second revised version

Table of Contents

Summary

The accident at the Chernobyl nuclear power plant in 1986 was the most severe in the history of the nuclear power industry, causing a huge release of radionuclides over large areas of Belarus, Ukraine and the Russian Federation. Now, 20 years later, UN Agencies and representatives of the three countries have reviewed the health, environmental and socio-economic consequences.

The highest radiation doses were received by emergency workers and on-site personnel, in total about 1000 people, during the first days of the accident, and doses were fatal for some of the workers. In time more than 600 000 people were registered as emergency and recovery workers ('liquidators'). Although some received high doses of radiation during their work, many of them and the majority of the residents of areas designated as 'contaminated' in Belarus, Russia and Ukraine (over 5 million people) received relatively low whole-body doses of radiation, not much higher than doses due to natural background radiation. The mitigation measures taken by the authorities, including evacuation of people from the most contaminated areas, substantially reduced radiation exposures and the radiation-related health impacts of the accident. Nevertheless, the accident was a human tragedy and had significant environmental, public health and socio-economic impacts.

Childhood thyroid cancer caused by radioactive iodine fallout is one of the main health impacts of the accident. Doses to the thyroid received in the first few months after the accident were particularly high in those who were children at the time and drank milk with high levels of radioactive iodine. By 2002, more than 4000 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.

Apart from the dramatic increase in thyroid cancer incidence among those exposed at a young age, there is no clearly demonstrated increase in the incidence of solid cancers or leukaemia due to radiation in the most affected populations. There was, however, an increase in psychological problems among the affected population, compounded by insufficient communication about radiation effects and by the social disruption and economic depression that followed the break-up of the Soviet Union.

It is impossible to assess reliably, with any precision, numbers of fatal cancers caused by radiation exposure due to the Chernobyl accident — or indeed the impact of the stress and anxiety induced by the accident and the response to it. Small differences in the assumptions concerning radiation risks can lead to large differences in the predicted health consequences, which are therefore highly uncertain. An international expert group has made projections to provide a rough estimate of the possible health impacts of

the accident and to help plan the future allocation of public health resources. The projections indicate that, among the most exposed populations (liquidators, evacuees and residents of the so-called ‘strict control zones’), total cancer mortality might increase by up to a few per cent owing to Chernobyl related radiation exposure. Such an increase could mean eventually up to several thousand fatal cancers in addition to perhaps one hundred thousand cancer deaths expected in these populations from all other causes. An increase of this magnitude would be very difficult to detect, even with very careful long term epidemiological studies.

Since 1986, radiation levels in the affected environments have declined several hundred fold because of natural processes and countermeasures. Therefore, the majority of the ‘contaminated’ territories are now safe for settlement and economic activity. However, in the Chernobyl Exclusion Zone and in certain limited areas some restrictions on land-use will need to be retained for decades to come.

The Governments took many successful countermeasures to address the accident’s consequences. However, recent research shows that the direction of current efforts should be changed. Social and economic restoration of the affected Belarusian, Russian and Ukrainian regions, as well as the elimination of the psychological burden on the general public and emergency workers, must be a priority. Additional priorities for Ukraine are to decommission the destroyed Chernobyl Unit 4 and gradually remediate the Chernobyl Exclusion Zone, including safely managing radioactive waste.

Preservation of the tacit knowledge developed in the mitigation of the consequences is essential, and targeted research on some aspects of the environmental, health and social consequences of the accident should be continued in the longer term.

This report, covering environmental radiation, human health and socio-economic aspects, is the most comprehensive evaluation of the accident’s consequences to date. About 100 recognized experts from many countries, including Belarus, Russia and Ukraine, have contributed. It represents a consensus view of the eight organizations of the UN family according to their competences and of the three affected countries.

Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts

Highlights of the Chernobyl Forum Studies

Nearly 20 years after the accident at the Chernobyl nuclear power plant (NPP), people in the countries most affected had yet to obtain a clear scientific consensus on the health, environmental, and socio-economic consequences of the accident and authoritative answers to outstanding questions. To help fill this void and to promote better understanding and improved measures to deal with the impacts of the accident, the Chernobyl Forum was established in 2003.

The Chernobyl Forum is an initiative of the IAEA, in cooperation with the WHO, UNDP, FAO, UNEP, UN-OCHA, UNSCEAR, the World Bank[1] and the governments of Belarus, the Russian Federation and Ukraine. The Forum was created as a contribution to the United Nations' ten-year strategy for Chernobyl, launched in 2002 with the publication of *Human Consequences of the Chernobyl Nuclear Accident — A Strategy for Recovery*.

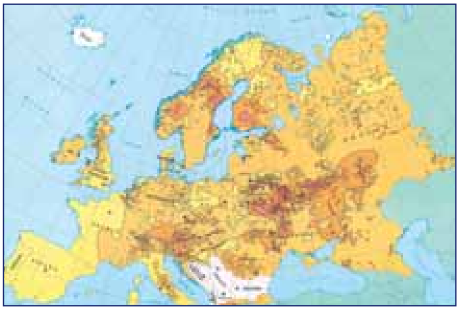
To provide a basis for achieving the goal of the Forum, the IAEA convened an expert working group of scientists to summarize the environmental effects, and the WHO convened an expert group to summarize the health effects and medical care programmes in the three most affected countries. These expert groups reviewed all appropriate scientific information that related to health and environmental consequences of the accident in Belarus, the Russian Federation and Ukraine. The information presented here and in the two full expert group reports has been drawn from scientific studies undertaken by the IAEA, WHO, UNSCEAR and numerous other authoritative bodies. In addition, UNDP has drawn on the work of eminent economists and policy specialists to assess the socio-economic impact of the Chernobyl accident, based largely on the 2002 UN study cited above.

---

[1] International Atomic Energy Agency (IAEA), World Health Organization (WHO), United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

Preface: The Chernobyl Accident

On 26 April 1986, the most serious accident in the history of the nuclear industry occurred at Unit 4 of the Chernobyl nuclear power plant in the former Ukrainian Republic of the Soviet Union. The explosions that ruptured the Chernobyl reactor vessel and the consequent fire that continued for 10 days or so resulted in large amounts of radioactive materials being released into the environment.



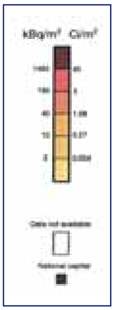


FIG. 1. Deposition of ^{137}Cs throughout Europe as a result of the Chernobyl accident (De Cort et al. 1998).

The cloud from the burning reactor spread numerous types of radioactive materials, especially iodine and caesium radionuclides, over much of Europe. Radioactive iodine-131, most significant in contributing to thyroid doses, has a short half-life (8 days) and largely disintegrated within the first few weeks of the accident. Radioactive caesium-137, which contributes to both external and internal doses, has a much longer half-life (30 years) and is still measurable in soils and some foods in many parts of Europe, see Fig. 1. The greatest deposits of radionuclides occurred over large areas of the Soviet Union surrounding the reactor in what are now the countries of Belarus, the Russian Federation and Ukraine.

An estimated 350 000 emergency and recovery operation workers, including army, power plant staff, local police and fire services, were initially involved in containing and cleaning up the accident in 1986–1987. Among them, about 240 000 recovery operation workers took part in major mitigation activities at the reactor and within the 30-km zone surrounding the reactor. Later, the number of registered "liquidators" rose to 600 000, although only a small fraction of these were exposed to high levels of radiation.

More than five million people live in areas of Belarus, Russia and Ukraine that are classified as 'contaminated' with radionuclides due to the Chernobyl accident (above 37 kBq m^{-2} of ^{137}Cs)[2]. Amongst them, about 400 000 people lived in more contaminated areas — classified by Soviet authorities as areas of strict radiation control (above 555 kBq m^{-2} of ^{137}Cs). Of this population, 116 000 people were evacuated in the spring

[2] Becquerel (Bq) is the international unit of radioactivity equal to one nuclear decay per second.

and summer of 1986 from the area surrounding the Chernobyl power plant (designated the "Exclusion Zone") to non-contaminated areas. Another 220 000 people were relocated in subsequent years.

Unfortunately, reliable information about the accident and the resulting dispersion of radioactive material was initially unavailable to the affected people in what was then the Soviet Union and remained inadequate for years following the accident. This failure and delay led to widespread distrust of official information and the mistaken attribution of many ill health conditions to radiation exposure.

Forum Expert Group Report: Health Consequences

The report of the Expert Group provides a summary on health consequences of the accident on Belarus, the Russian Federation and Ukraine and responds to five of the most important health-related questions concerning the impact of the Chernobyl accident.

How much radiation were people exposed to as a result of the Chernobyl nuclear accident?

Three population categories were exposed from the Chernobyl accident:

- Emergency and recovery operation workers who worked at the Chernobyl power plant and in the exclusion zone after the accident;
- Inhabitants evacuated from contaminated areas; and
- Inhabitants of contaminated areas who were not evacuated.

With the exception of the on-site reactor personnel and the emergency workers who were present near the destroyed reactor during the time of the accident and shortly afterwards, most of recovery operation workers and people living in the contaminated territories received relatively low whole-body radiation doses, comparable to background radiation levels accumulated over the 20 year period since the accident.

The highest doses were received by emergency workers and on-site personnel, in total about 1000 people, during the first days of the accident, ranging from 2 to 20 Gy, which was fatal for some of the workers. The doses received by recovery operation workers, who worked for short periods during four years following the accident ranged up to more than 500 mSv, with an average of about 100 mSv according to the State Registries of Belarus, Russia, and Ukraine.

Effective doses to the persons evacuated from the Chernobyl accident area in the spring and summer of 1986 were estimated to be of the order of 33 mSv on average, with the highest dose of the order of several hundred mSv.

Doses of Ionizing Radiation

Interaction of ionizing radiation (alpha, beta, gamma and other kinds of radiation) with living matter may damage human cells, causing death to some and modifying others. Exposure to ionizing radiation is measured in terms of absorbed energy per unit mass, i.e., absorbed dose. The unit of absorbed dose is the gray (Gy), which is a joule per kilogram (J/kg). The absorbed dose in a human body of more than one gray may cause acute radiation syndrome (ARS) as happened with some of the Chernobyl emergency workers.

Because many organs and tissues were exposed as a result of the Chernobyl accident, it has been very common to use an additional concept, that of *effective dose*, which characterizes the overall health risk due to any combination of radiation. The effective dose accounts both for absorbed energy and type of radiation and for susceptibility of various organs and tissues to development of a severe radiation-induced cancer or genetic effect. Moreover, it applies equally to external and internal exposure and to uniform or non-uniform irradiation The unit of effective dose is the sievert. One sievert is a rather large dose and so the millisievert or mSv (one thousandth of a Sv) is commonly used to describe normal exposures.

Living organisms are continually exposed to ionizing radiation from natural sources, which include cosmic rays, cosmogenic and terrestrial radionuclides (such as ^{40}K, ^{238}U, ^{232}Th and their progeny including ^{222}Rn (radon)). UNSCEAR has estimated annual natural background doses of humans worldwide to average 2.4 mSv, with a typical range of 1–10 mSv. Lifetime doses due to natural radiation would thus be about 100–700 mSv. Radiation doses to humans may be characterized as low-level if they are comparable to natural background radiation levels of a few mSv per year.

Ingestion of food contaminated with radioactive iodine did result in significant doses to the thyroid of inhabitants of the contaminated areas of Belarus, Russia, and Ukraine. The thyroid doses varied in a wide range, according to age, level of ground contamination with ^{131}I, and milk consumption rate. Reported individual thyroid doses ranged up to about 50 Gy, with average doses in contaminated areas being about 0.03 to few Gy, depending on the region where people lived and on their age. The thyroid doses to residents of Pripyat city located in the vicinity of the Chernobyl power plant, were substantially reduced by timely distribution of stable iodine tablets. Drinking milk from cows that ate contaminated grass immediately after the accident was one of the main reasons for the high doses to the thyroid of children, and why so many children subsequently developed thyroid cancer.

The general public has been exposed during the past twenty years after the accident both from external sources (^{137}Cs on soil, etc.) and via intake of radionuclides (mainly, ^{137}Cs) with foods, water and air, see Fig. 2. The average effective doses for the general population of 'contaminated' areas accumulated in 1986–2005 were estimated to be between 10 and 30 mSv in various administrative regions of Belarus, Russia and Ukraine. In the areas of strict radiological control, the average dose was around 50 mSv and more. Some residents received up to several hundred mSv. It should be noted that the average doses received by residents of the territories 'contaminated' by Chernobyl fallout are generally lower than those received by people who live in some areas of high natural background radiation in India, Iran, Brazil and China (100–200 mSv in 20 years).

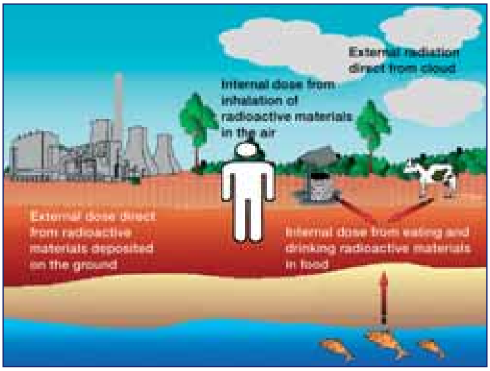


FIG. 2. Pathways of exposure to man from environmental releases of radioactive materials.

The vast majority of about five million people residing in contaminated areas of Belarus, Russia and Ukraine currently receive annual effective doses from the Chernobyl fallout of less than 1 mSv in addition to the natural background doses. However, about 100 000 residents of the more contaminated areas still receive more than 1 mSv annually from the Chernobyl fallout. Although future reduction of exposure levels is expected to be rather slow, i.e. of about 3 to 5% per year, the great majority of dose from the accident has already been accumulated.

The Chernobyl Forum assessment agrees with that of the UNSCEAR 2000 Report in terms of the individual and collective doses received by the populations of the three most affected countries: Belarus, Russia and Ukraine.

Summary of average accumulated doses to affected populations from Chernobyl fallout

Population category	Number	Average dose (mSv)
Liquidators (1986–1989)	600 000	~100
Evacuees from highly-contaminated zone (1986)	116 000	33
Residents of "strict-control" zones (1986–2005)	270 000	>50
Residents of other 'contaminated' areas (1986–2005)	5 000 000	10–20

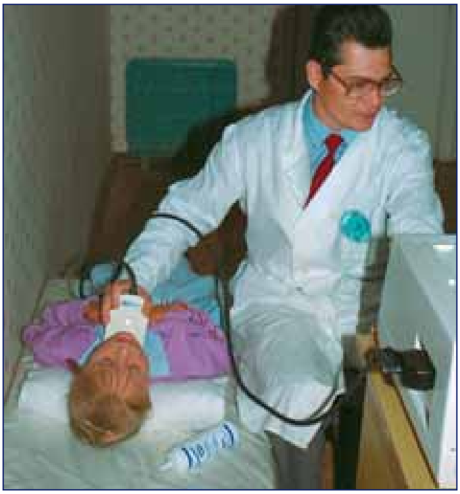
How many people died as a result of the accident and how many more are likely to die in the future?

The number of deaths attributable to the Chernobyl accident has been of paramount interest to the general public, scientists, the mass media, and politicians. Claims have been made that tens or even hundreds of thousands of persons have died as a result of the accident. These claims are highly exaggerated. Confusion about the impact of Chernobyl on mortality has arisen owing to the fact that, in the years since 1986, thousands of emergency and recovery operation workers as well as people who lived in 'contaminated' territories have died of diverse natural causes that are not attributable to radiation. However, widespread expectations of ill health and a tendency to attribute all health problems to exposure to radiation have led local residents to assume that Chernobyl-related fatalities were much higher.

Acute Radiation Syndrome mortality

The number of deaths due to acute radiation syndrome (ARS) during the first year following the accident is well documented. According to UNSCEAR (2000), ARS was diagnosed in 134 emergency workers. In many cases the ARS was complicated by extensive beta radiation skin burns and sepsis. Among these workers, 28 persons died in 1986 due to ARS. Two more persons had died at Unit 4 from injuries unrelated to radiation, and one additional death was thought to have been due to a coronary thrombosis. Nineteen more have died in 1987–2004 of various causes; however their deaths are not necessarily — and in some cases are certainly not — directly attributable to radiation exposure. Among the general population exposed to the Chernobyl radioactive fallout, however, the radiation doses were relatively low, and ARS and associated fatalities did not occur.

Cancer mortality



It is impossible to assess reliably, with any precision, numbers of fatal cancers caused by radiation exposure due to Chernobyl accident. Further, radiation-induced cancers are at present indistinguishable from those due to other causes.

An international expert group has made projections to provide a rough estimate of the possible health impacts of the accident and to help plan the future allocation of public health resources. These predictions were based on the experience of other populations exposed to radiation that have been studied for many decades, such as the survivors of the atomic bombing in Hiroshima and Nagasaki. However, the applicability of risk estimates derived from other populations with different genetic, life-style and environmental backgrounds, as well as having been exposed to much higher radiation dose rates, is unclear. Moreover small differences in the assumptions about the risks from exposure to low level radiation doses can lead to large differences in the predictions of the increased cancer burden, and predictions should therefore be treated with great caution, especially when the additional doses above natural background radiation are small.

The international expert group predicts that among the 600 000 persons receiving more significant exposures (liquidators working in 1986–1987, evacuees, and residents of the most ‘contaminated’ areas), the possible increase in cancer mortality due to this radiation exposure might be up to a few per cent. This might eventually represent up to four thousand fatal cancers in addition to the approximately 100 000 fatal cancers to be expected due to all other causes in this population. Among the 5 million persons residing in other 'contaminated' areas, the doses are much lower and any projected increases are more speculative, but are expected to make a difference of less than one per cent in cancer mortality.

Such increases would be very difficult to detect with available epidemiological tools, given the normal variation in cancer mortality rates. So far, epidemiological studies of residents of contaminated areas in Belarus, Russia and Ukraine have not provided clear and convincing evidence for a radiation-induced increase in general population mortality, and in particular, for fatalities caused by leukaemia, solid cancers (other than thyroid cancer), and non-cancer diseases.

However, among the more than 4000 thyroid cancer cases diagnosed in 1992–2002 in persons who were children or adolescents at the time of the accident, fifteen deaths related to the progression of the disease had been documented by 2002.

Some radiation-induced increases in fatal leukaemia, solid cancers and circulatory system diseases have been reported in Russian emergency and recovery operation workers. According to data from the Russian Registry, in 1991–1998, in the cohort of 61 000 Russian workers exposed to an average dose of 107 mSv about 5% of all fatalities that occurred may have been due to radiation exposure. These findings, however, should be considered as preliminary and need confirmation in better-designed studies with careful individual dose reconstruction.

What diseases have already resulted or might occur in the future from the Chernobyl radiation exposure?

Thyroid Cancer in Children

One of the principal radionuclides released by the Chernobyl accident was iodine-131, which was significant for the first few months. The thyroid gland accumulates iodine from the blood stream as part of its normal metabolism. Therefore, fallout of radioactive iodines led to considerable thyroid exposure of local residents through inhalation and ingestion of foodstuffs, especially milk, containing high levels of radioiodine. The thyroid gland is one of the organs most susceptible to cancer induction by radiation. Children were found to be the most vulnerable population, and a substantial increase in thyroid cancer among those exposed as children was recorded subsequent to the accident.

From 1992 to 2002 in Belarus, Russia and Ukraine more than 4000[3] cases of thyroid cancer were diagnosed among those who were children and adolescents (0–18 years) at the time of the accident, the age group 0–14 years being most affected; see Fig. 3. The majority of these cases were treated, with favourable prognosis for their lives. Given the rarity of thyroid cancer in young people, the large population with high doses to the thyroid and the magnitude of the radiation-related risk estimates derived from epidemiological studies, it is most likely that a large fraction of thyroid cancers observed to date among those exposed in childhood are attributable to radiation exposure from the accident. It is expected that the increase in thyroid cancer incidence from Chernobyl will continue for many more years, although the long term magnitude of risk is difficult to quantify.

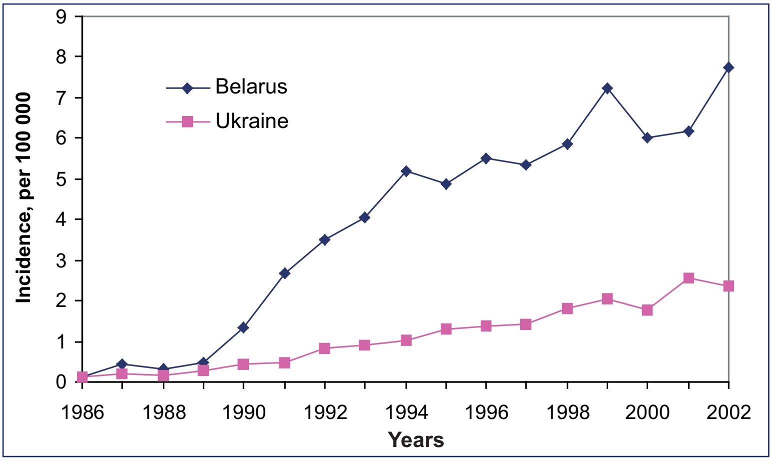


FIG. 3. Incidence rate of thyroid cancer in children and adolescents exposed to ^{131}I as a result of the Chernobyl accident (after Jacob et al., 2005).

It should be noted that early mitigation measures taken by the national authorities helped substantially to minimize the health consequences of the accident. Intake of stable iodine tablets during the first 6–30 hours after the accident reduced the thyroid dose of the residents of Pripyat by a factor of 6 on average. Pripyat was the largest city nearest to the Chernobyl nuclear plant and approximately 50 000 residents were evacuated within 40 hours after the accident. More than 100 000 people were evacuated within few weeks after the accident from the most contaminated areas of Ukraine and

[3] More recent statistics from the national registries of Belarus and Ukraine indicate that the total number of thyroid cancers among those exposed under the age of 18, is currently close to 5000. The numbers differ slightly depending on the reporting methods, but the overall number observed in the three countries is certainly well above 4000.

Belarus. These actions reduced radiation exposures and reduced the radiation related health impacts of the accident.

Leukaemia, Solid Cancers and Circulatory Diseases

A number of epidemiological studies, including atomic bombing survivors, patients treated with radiotherapy and occupationally exposed populations in medicine and the nuclear industry, have shown that ionizing radiation can cause solid cancers and leukaemia (except CLL[4]). More recent findings also indicate an increased risk of cardiovascular diseases in populations exposed at higher doses (e.g. atomic bombing survivors, radiotherapy patients).

An increased risk of leukaemia associated with radiation exposure from Chernobyl was, therefore, expected among the populations exposed. Given the level of doses received, however, it is likely that studies of the general population will lack statistical power to identify such an increase, although for higher exposed emergency and recovery operation workers an increase may be detectable. The most recent studies suggest a two-fold increase in the incidence of non-CLL leukaemia between 1986 and 1996 in Russian emergency and recovery operation workers exposed to more than 150 mGy (external dose). On going studies of the workers may provide additional information on the possible increased risk of leukaemia.

However, since the risk of radiation-induced leukaemia decreases several decades after exposure, its contribution to morbidity and mortality is likely to become less significant as time progresses.

There have been many post-Chernobyl studies of leukaemia and cancer morbidity in the populations of 'contaminated' areas in the three countries. Most studies, however, had methodological limitations and lacked statistical power. There is therefore no

[4] CLL is chronic lymphoid leukaemia that is not thought to be caused by radiation exposure.

convincing evidence at present that the incidence of leukaemia or cancer (other than thyroid) has increased in children, those exposed in-utero, or adult residents of the 'contaminated' areas. It is thought, however, that for most solid cancers, the minimum latent period is likely to be much longer than that for leukaemia or thyroid cancer — of the order of 10 to 15 years or more — and it may be too early to evaluate the full radiological impact of the accident. Therefore, medical care and annual examinations of highly exposed Chernobyl workers should continue.

The absence of a demonstrated increase in cancer risk — apart from thyroid cancer — is not proof that no increase has in fact occurred. Such an increase, however, is expected to be very difficult to identify in the absence of careful large scale epidemiological studies with individual dose estimates. It should be noted that, given the large number of individuals exposed, small differences in the models used to assess risks at low doses can have marked effects on the estimates of additional cancer cases.

There appears to be some recent increase in morbidity and mortality of Russian emergency and recovery operation workers caused by circulatory system diseases. Incidence of circulatory system diseases should be interpreted with special care because of the possible indirect influence of confounding factors, such as stress and lifestyle. These findings also need confirmation in well-designed studies.

Cataracts

Examinations of eyes of children and emergency and recovery operation workers clearly show that cataracts may develop in association with exposure to radiation from the Chernobyl accident. The data from studies of emergency and recovery workers suggest that exposures to radiation somewhat lower than previously experienced, down to about 250 mGy, may be cataractogenic.

Continued eye follow-up studies of the Chernobyl populations will allow confirmation and greater predictive capability of the risk of radiation cataract onset and, more importantly, provide the data necessary to be able to assess the likelihood of any resulting visual dysfunction.

Have there been or will there be any inherited or reproductive effects?

Because of the relatively low dose levels to which the populations of the Chernobyl-affected regions were exposed, there is no evidence or any likelihood of observing decreased fertility among males or females in the general population as a direct result of radiation exposure. These doses are also unlikely to have any major effect on the number of stillbirths, adverse pregnancy outcomes or delivery complications or the overall health of children.

Birth rates may be lower in 'contaminated' areas because of concern about having children (this issue is obscured by the very high rate of medical abortions) and the fact that many younger people have moved away. No discernable increase in hereditary effects caused by radiation is expected based on the low risk coefficients estimated by UNSCEAR (2001) or in previous reports on Chernobyl health effects. Since 2000, there has been no new evidence provided to change this conclusion.

There has been a modest but steady increase in reported congenital malformations in both 'contaminated' and 'uncontaminated' areas of Belarus since 1986; see Fig. 4. This does not appear to be radiation-related and may be the result of increased registration.

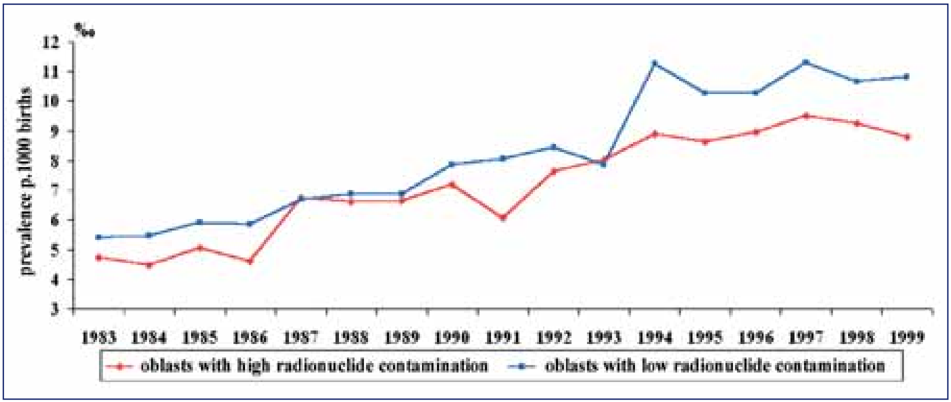


FIG. 4. Prevalence at birth of congenital malformations in 4 oblasts of Belarus with high and low levels of radionuclide contamination (Lasyuk et al., 1999).

The Chernobyl accident resulted in many people being traumatized by the rapid relocation, the breakdown in social contacts, fear and anxiety about what health effects might result. Are there persistent psychological or mental health problems?

Any traumatic accident or event can cause the incidence of stress symptoms, depression, anxiety (including post-traumatic stress symptoms), and medically unexplained physical symptoms. Such effects have also been reported in Chernobyl-exposed populations. Three studies found that exposed populations had anxiety levels that were twice as high as controls, and they were 3–4 times more likely to report multiple unexplained physical symptoms and subjective poor health than were unaffected control groups.

In general, although the psychological consequences found in Chernobyl exposed populations are similar to those in atomic bombing survivors, residents near the Three Mile Island nuclear power plant accident, and those who experienced toxic exposures at work or in the environment, the context in which the Chernobyl accident occurred makes the findings difficult to interpret because of the complicated series of events unleashed by the accident, the multiple extreme stresses and culture-specific ways of expressing distress.

In addition, individuals in the affected populations were officially categorized as “sufferers”, and came to be known colloquially as “Chernobyl victims,” a term that was soon adopted by the mass media. This label, along with the extensive government benefits earmarked for evacuees and residents of the contaminated territories, had the effect of encouraging individuals to think of themselves fatalistically as invalids. It is known that people’s perceptions — even if false — can affect the way they feel and act. Thus, rather than perceiving themselves as “survivors,” many of those people have come to think of themselves as helpless, weak and lacking control over their future.

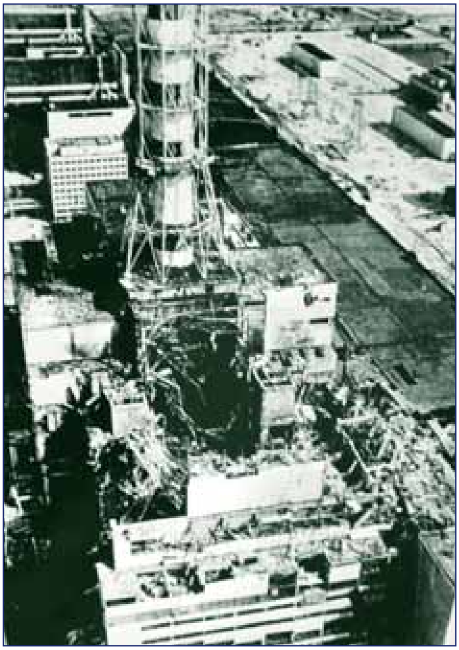
Renewed efforts at risk communication, providing the public and key professionals with accurate information about the health and mental health consequences of the disaster, should be undertaken.

Forum Expert Group Report: Environmental Consequences

The report of the Expert Group on environmental consequences covers the issues of radioactive release and deposition, radionuclide transfers and bioaccumulation, application of countermeasures, radiation-induced effects on plants and animals as well as dismantlement of the Shelter and radioactive waste management in the Chernobyl Exclusion Zone.

Release and Deposits of Radioactive Material

Major releases of radionuclides from unit 4 of the Chernobyl reactor continued for ten days following the April 26 explosion. These included radioactive gases, condensed aerosols and a large amount of fuel particles. The total release of radioactive substances was about 14 EBq[5], including 1.8 EBq of iodine-131, 0.085 EBq of ^{137}Cs, 0.01 EBq of ^{90}Sr and 0.003 EBq of plutonium radioisotopes. The noble gases contributed about 50% of the total release.



More than 200 000 square kilometres of Europe received levels of ^{137}Cs above 37 kBq m^{-2}. Over 70 percent of this area was in the three most affected countries, Belarus, Russia and Ukraine. The deposition was extremely varied, as it was enhanced in areas where it was raining when the contaminated air masses passed. Most of the strontium and plutonium radioisotopes were deposited within 100 km of the destroyed reactor due to larger particle sizes.

Many of the most significant radionuclides had short physical half-lives. Thus, most of the radionuclides released by the accident have decayed away. The releases of radioactive iodines caused great concern immediately after the accident. For the decades to come ^{137}Cs will continue to be of greatest importance, with secondary attention to ^{90}Sr. Over the longer term (hundreds to thousands of years) the plutonium isotopes and americium-241 will remain, although at levels not significant radiologically.

What is the scope of urban contamination?

Radionuclides deposited most heavily on open surfaces in urban areas, such as lawns, parks, streets, roads, town squares, building roofs and walls. Under dry conditions, trees, bushes, lawns and roofs initially had the highest levels, whereas under wet conditions horizontal surfaces, such as soil plots and lawns, received the highest levels. Enhanced ^{137}Cs concentrations were found around houses where the rain had transported the radioactive material from the roofs to the ground.

[5] 1 EBq = 10^{18} Bq (Becquerel).

The deposition in urban areas in the nearest city of Pripyat and surrounding settlements could have initially given rise to a substantial external dose. However, this was to a large extent averted by the timely evacuation of residents. The deposition of radioactive material in other urban areas has resulted in various levels of radiation exposure to people in subsequent years and continues to this day at lower levels.

Due to wind and rain and human activities, including traffic, street washing and cleanup, surface contamination by radioactive materials has been reduced significantly in inhabited and recreational areas during 1986 and afterwards. One of the consequences of these processes has been secondary contamination of sewage systems and sludge storage.

At present, in most of the settlements subjected to radioactive contamination as a result of Chernobyl, the air dose rate above solid surfaces has returned to the background level predating the accident. But the air dose rate remains elevated above undisturbed soil in gardens and parks in some settlements of Belarus, Russia and Ukraine.

.How contaminated are agricultural areas?

In the early months after the accident, the levels of radioactivity of agricultural plants and plant-consuming animals was dominated by surface deposits of radionuclides. The deposition of radioiodine caused the most immediate concern, but the problem was confined to the first two months after the accident because of fast decay of the most important isotope, ^{131}I.

The radioiodine was rapidly absorbed into milk at a high rate leading to significant thyroid doses to people consuming milk, especially children in Belarus, Russia and Ukraine. In the rest of Europe increased levels of radioiodine in milk were observed in some southern areas, where dairy animals were already outdoors.

After the early phase of direct deposit, uptake of radionuclides through plant roots from soil became increasingly important. Radioisotopes of caesium (^{137}Cs and ^{134}Cs) were the nuclides which led to the largest problems, and even after decay of ^{134}Cs (half-life of 2.1 years) by the mid-1990s the levels of longer lived ^{137}Cs in agricultural products from highly affected areas still may require environmental remediation. In addition, ^{90}Sr could cause problems in areas close to the reactor, but at greater distances its deposition levels were low. Other radionuclides such as plutonium isotopes and ^{241}Am did not cause real problems in agriculture, either because they were present at low deposition levels, or were poorly available for root uptake from soil.

In general, there was a substantial reduction in the transfer of radionuclides to vegetation and animals in intensive agricultural systems in the first few years after deposition, as would be expected due to weathering, physical decay, migration of radionuclides down the soil, reductions in bioavailability in soil and due to countermeasures, see Fig. 5. However, in the last decade there has been little further obvious decline, by 3–7 percent per year.

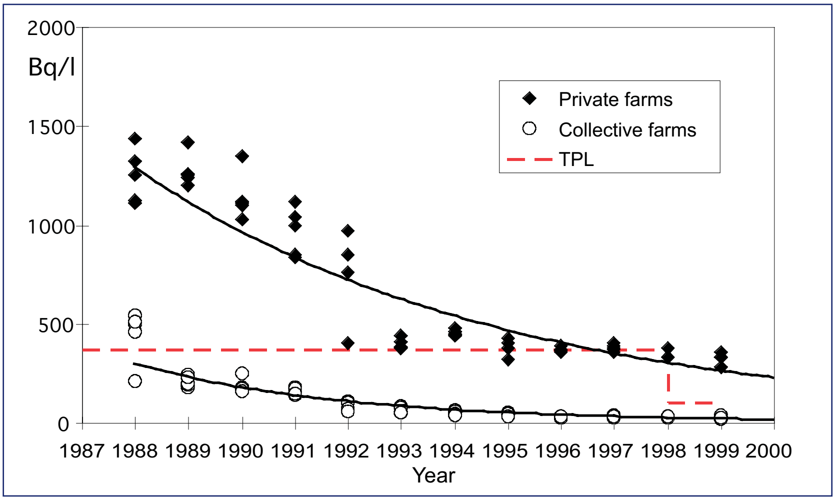


FIG. 5. Reduction with time of ^{137}Cs activity concentration in milk produced in private and collective farms of the Rovno region of Ukraine with a comparison to the temporary permissible level (TPL).

The radiocaesium content in foodstuffs was influenced not only by deposition levels but also by types of ecosystem and soil as well as by management practices. The remaining persistent problems in the affected areas occur in extensive agricultural systems with soils with a high organic content and animals grazing in unimproved pastures that are not ploughed or fertilized. This particularly affects rural residents in the former Soviet Union who are commonly subsistence farmers with privately owned dairy cows.

In the long term ^{137}Cs in milk and meat and, to a lesser extent, ^{137}Cs in plant foods and crops remain the most important contributors to human internal dose. As ^{137}Cs activity concentration in both vegetable and animal foods has been decreasing very slowly during the last decade, the relative contribution of ^{137}Cs to internal dose will continue to dominate for decades to come. The importance of other long lived radionuclides, ^{90}Sr, plutonium isotopes and ^{241}Am, in terms of the human dose will remain insignificant.

Currently, ^{137}Cs activity concentrations in agricultural food products produced in areas affected by the Chernobyl fallout are generally below national and international action levels. However, in some limited areas with high radionuclide contamination (parts of the Gomel and Mogilev regions in Belarus and the Bryansk region in Russia) or poor organic soils (the Zhytomir and Rovno regions in Ukraine) milk may still be produced with ^{137}Cs activity concentrations that exceed national action levels of 100 Bq per kilogram. In these areas countermeasures and environmental remediation may still be warranted.

What is the extent of forest contamination?

Following the accident vegetation and animals in forests and mountain areas have shown particularly high uptake of radiocaesium, with the highest recorded ^{137}Cs levels found in forest food products. This is due to the persistent recycling of radiocaesium particularly in forest ecosystems.

Particularly high ^{137}Cs activity concentrations have been found in mushrooms, berries, and game, and these high levels have persisted for two decades. Thus, while the magnitude of human exposure through agricultural products has experienced a general decline, high levels of contamination of forest food products have continued and still exceed permissible levels in some countries. In some areas of Belarus, Russia and Ukraine, consumption of forest foods with ^{137}Cs dominates internal exposure. This can be expected to continue for several decades.

Therefore, the relative importance of forests in contributing to radiological exposures of the populations of several affected countries has increased with time. It will primarily be the combination of downward migration in the soil and the physical decay of ^{137}Cs that will contribute to any further slow long term reduction in contamination of forest food products.

The high transfer of radiocaesium in the pathway lichen-to-reindeer meat-to-humans has been demonstrated again after the Chernobyl accident in the Arctic and sub-Arctic areas of Europe. The Chernobyl accident led to high levels of ^{137}Cs of reindeer meat in Finland, Norway, Russia and Sweden and caused significant difficulties for the indigenous Sami people.

How contaminated are the aquatic systems?

Radioactive material from Chernobyl resulted in levels of radioactive material in surface water systems in areas close to the reactor site and in many other parts of Europe. The initial levels were due primarily to direct deposition of radionuclides on the surface of rivers and lakes, dominated by short lived radionuclides (primarily ^{131}I). In the first few weeks after the accident, high activity concentrations in drinking water from the Kyiv Reservoir were of particular concern.

Levels in water bodies fell rapidly during the weeks after fallout through dilution, physical decay and absorption of radionuclides to catchment soils. Bed sediments are an important long term sink for radioactivity.

Initial uptake of radioiodine to fish was rapid, but activity concentrations declined quickly, due primarily to physical decay. Bioaccumulation of radiocaesium in the aquatic food chain led to significant activity concentrations in fish in the most affected areas, and in some lakes as far away as Scandinavia and Germany. Because of generally lower fallout and lower bioaccumulation, ^{90}Sr levels in fish were not significant for human doses in comparison to radiocaesium, particularly since ^{90}Sr is accumulated in bone rather than in edible muscle.

In the long term, secondary inputs by run-off of long lived ^{137}Cs and ^{90}Sr from soil continues (at a much lower level) to the present day. At the present time, activity concentrations both in surface waters and in fish are low, see Fig. 6. Therefore, irrigation with surface water is not considered to be a hazard.

While ^{137}Cs and ^{90}Sr levels in water and fish of rivers, open lakes and reservoirs are currently low, in some "closed" lakes with no outflowing streams in Belarus, Russia and

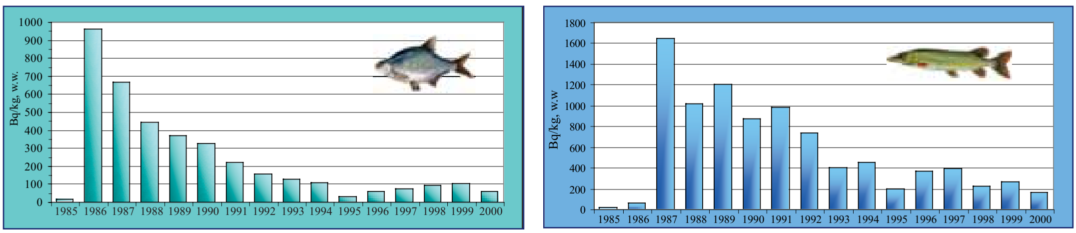


FIG. 6. Averaged ^{137}Cs activity concentrations in non-predatory (Bream, left histogram) and predatory (Pike, right histogram) fish from Kyiv reservoir (UHMI 2004).

Ukraine both water and fish will remain contaminated with ^{137}Cs for decades to come. For example, for some people living next to a “closed” Kozhanovskoe Lake in Russia, consumption of fish has dominated their total ^{137}Cs ingestion.

Owing to the large distance of the Black and Baltic Seas from Chernobyl, and the dilution in these systems, activity concentrations in sea water were much lower than in freshwater. The low water radionuclide levels combined with low bioaccumulation of radiocaesium in marine biota has led to ^{137}Cs levels in marine fish that are not of concern.

What environmental countermeasures and remediation have been implemented?

The Soviet and, later, Commonwealth of Independent States (CIS) authorities introduced a wide range of short and long term environmental countermeasures to mitigate the accident’s negative consequences. The countermeasures involved huge human, financial and scientific resources.

Decontamination of settlements in contaminated regions of the USSR during the first years after the Chernobyl accident was successful in reducing the external dose when its implementation was preceded by proper remediation assessment. However, the decontamination has produced a disposal problem due to the considerable amount of low level radioactive waste that was created. Secondary cross-contamination with radionuclides of cleaned up plots from surrounding areas has not been observed.

The most effective agricultural countermeasures in the early phase were exclusion of contaminated pasture grasses from animal diets and rejection of milk based on radiation monitoring data. Feeding animals with “clean” fodder was effectively performed in some affected countries. However, these countermeasures were only partially effective in reducing radioiodine intake via milk because of the lack of timely information about the accident and necessary responses, particularly for private farmers.

The greatest long term problem has been radiocaesium contamination of milk and meat. In the USSR and later in the CIS countries, this has been addressed by the treatment of land used for fodder crops, clean feeding and application of Cs-binders, such as Prussian blue, see Fig. 7, to animals that enabled most farming practices to continue in affected areas and resulted in a large dose reduction.

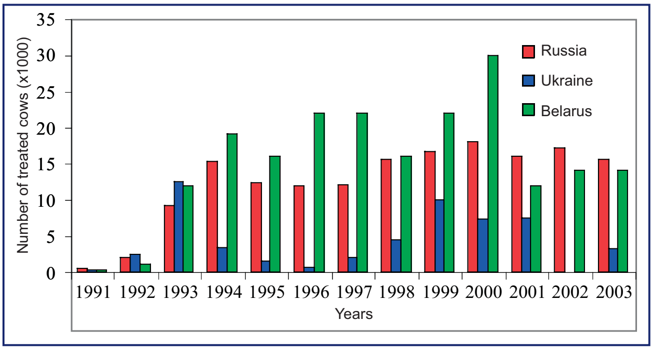


FIG. 7. Changes with time in the use of Prussian blue in the CIS countries (IAEA, 2005).

Application of agricultural countermeasures in the affected CIS countries substantially decreased since the middle of 1990s (to less extent in Belarus) because of economic problems. In a short time, this resulted in an increase of radionuclide content in plant and animal agricultural products.

In Western Europe, because of the high and prolonged uptake of radiocaesium in the affected extensive systems, a range of countermeasures are still being used for animal products from uplands and forests.

The following forest-related restrictions widely applied in the USSR and later in CIS countries and in Scandinavia have reduced human exposure due to residence in radioactively contaminated forests and use of forest products:

— Restrictions on public and forest worker access as a countermeasure against external exposure;

— Restricted harvesting of food products such as game, berries and mushrooms by the public that contributed to reduction of internal doses. In the CIS countries mushrooms are a staple of many diets and, therefore, this restriction has been particularly important;

— Restricted collection of firewood by the public to prevent exposures in the home and garden when the wood is burned and the ash is disposed of or used as a fertilizer; and

— Alteration of hunting practices aiming to avoid consumption of meat with high seasonal levels of radiocaesium.

Numerous countermeasures put in place in the months and years after the accident to protect water systems from transfers of radioactivity from contaminated soils were generally ineffective and expensive. The most effective countermeasure was the early restriction of drinking water and changing to alternative supplies. Restrictions on consumption of freshwater fish have also proved effective in Scandinavia and Germany, though in Belarus, Russia and Ukraine such restrictions may not always have been adhered to.

What were the radiation-induced effects on plants and animals?

Irradiation from radionuclides released from the accident caused numerous acute adverse effects on the plants and animals living in the higher exposure areas, i.e., in localized sites at distances up to 30 kilometres from the release point. Outside the Exclusion Zone, no acute radiation-induced effects in plants and animals have been reported.

The response of the natural environment to the accident was a complex interaction between radiation dose and radiosensitivities of the different plants and animals. Both individual and population effects caused by radiation-induced cell death have been observed in biota inside the Exclusion Zone as follows:

— Increased mortality of coniferous plants, soil invertebrates and mammals; and

— Reproductive losses in plants and animals.

No adverse radiation-induced effect has been reported in plants and animals exposed to a cumulative dose of less than 0.3 Gy during the first month after the accident.

Following the natural reduction of exposure levels due to radionuclide decay and migration, biological populations have been recovering from acute radiation effects. As soon as by the next growing season following the accident, population viability of plants and animals had substantially recovered as a result of the combined effects of reproduction and immigration from less affected areas. A few years were needed for recovery from major radiation-induced adverse effects in plants and animals.

Genetic effects of radiation, in both somatic and germ cells, have been observed in plants and animals of the Exclusion Zone during the first few years after the Chernobyl accident. Both in the Exclusion Zone, and beyond, different cytogenetic anomalies attributable to radiation continue to be reported from experimental studies performed on plants and animals. Whether the observed cytogenetic anomalies in somatic cells have any detrimental biological significance is not known.

The recovery of affected biota in the exclusion zone has been facilitated by the removal of human activities, e.g., termination of agricultural and industrial activities. As a result, populations of many plants and animals have eventually expanded, and the present environmental conditions have had a positive impact on the biota in the Exclusion Zone. Indeed, the Exclusion Zone has paradoxically become a unique sanctuary for biodiversity.

FIG. 8. A white-tailed eagle chick observed recently in the Chernobyl Exclusion Zone. Before 1986, these rare predatory birds have been hardly found in this area (Photo: Courtesy of Sergey Gaschak, 2004).

What are the environmental aspects of dismantlement of the Shelter and of radioactive waste management?

The accidental destruction of Chernobyl's Unit 4 reactor generated extensive spread of radioactive material and a large amount of radioactive waste in the Unit, at the plant site and in the surrounding area. Construction of the Shelter between May and November 1986, aiming at environmental containment of the damaged reactor, reduced radiation levels on-site and prevented further release of radionuclides off-site.

The Shelter was erected in a short period under conditions of severe radiation exposure to personnel. Measures taken to save construction time led to imperfections in the Shelter as well as to lack of comprehensive data on the stability of the damaged Unit 4 structures. In addition, structural elements of the Shelter have degraded due to moisture-induced corrosion during the nearly two decades since it was erected. The main potential hazard of the Shelter is a possible collapse of its top structures and release of radioactive dust into the environment.

To avoid the potential collapse of the Shelter, measures are planned to strengthen unstable structures. In addition, a New Safe Confinement (NSC) that should provide more than 100 years service life is planned as a cover over the existing Shelter, see Fig. 9. The construction of the NSC is expected to allow for the dismantlement of the current Shelter, removal of highly radioactive Fuel Containing Mass (FCM) from Unit 4, and eventual decommissioning of the damaged reactor.

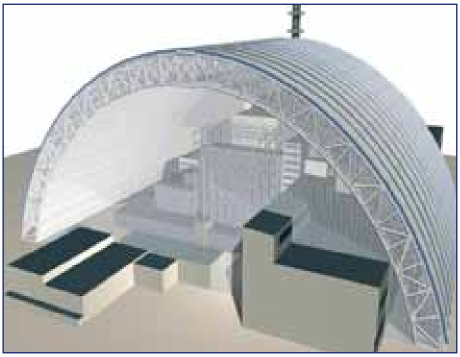


FIG. 9. Planned New Safe Confinement over the destroyed Chernobyl reactor.

In the course of remediation activities both at the Chernobyl nuclear power plant site and in its vicinity, large volumes of radioactive waste were generated and placed in temporary near-surface waste storage and disposal facilities. Trench and landfill facilities were created from 1986 to 1987 in the Exclusion Zone at distances of 0.5 to 15 km from the reactor site with the intention to avoid the spread of dust, reduce the radiation levels, and enable better working conditions at Unit 4 and in its surroundings. These facilities were established without proper design documentation and engineered barriers and do not meet contemporary waste disposal safety requirements.

During the years following the accident large resources were expended to provide a systematic analysis and an acceptable strategy for management of existing radioactive waste. However, to date a broadly accepted strategy for radioactive waste management at the Chernobyl power plant site and the Exclusion Zone, and especially for high level and long lived waste, has not yet been developed.

More radioactive waste is potentially expected to be generated in Ukraine in the years to come during NSC construction, possible Shelter dismantling, FCM removal and decommissioning of Unit 4. This waste should be properly disposed of.

What is the future of the Chernobyl Exclusion Zone?

The overall plan for the long term development of the Exclusion Zone in Ukraine is to recover the affected areas, redefine the Exclusion Zone, and make the less affected areas available for limited use by the public. This will require well defined administrative

controls on the nature of activities that may be performed in the particular areas. In some of them, restriction of food crops planting and cattle grazing, and use of only clean feed for cattle still may be needed for decades to come for radiological reasons. Accordingly, these resettled areas are best suited for an industrial use rather than an agricultural or residential area.

The future of the Exclusion Zone for the next hundred years and more is envisaged to be associated with the following activities:

— Construction and operation of the NSC and relevant engineering infrastructure;

— Defuelling, decommissioning and dismantling of Units 1, 2 and 3 of the nuclear power plant and the Shelter;

— Construction of facilities for processing and management of radioactive waste, in particular a deep geological repository for high-activity and long lived radioactive material;

— Development of natural reserves in the area that remains closed to human habitation; and

— Maintenance of environmental monitoring and research activities.

The Socio-Economic Impact of the Chernobyl Nuclear Accident

What was the economic cost of the Chernobyl nuclear disaster?

The Chernobyl nuclear accident, and government policies adopted to cope with its consequences, imposed huge costs on the Soviet Union and three successor countries, Belarus, the Russian Federation and Ukraine. Although these three countries bore the brunt of the impact, given the spread of radiation outside the borders of the Soviet Union, other countries (in Scandinavia, for instance) sustained economic losses as well.

The costs of the Chernobyl nuclear accident can only be calculated with a high degree of estimation, given the non-market conditions prevailing at the time of the disaster and the high inflation and volatile exchange rates of the transition period that followed the break-up of the Soviet

Union in 1991. However, the magnitude of the impact is clear from a variety of government estimates from the 1990s, which put the cost of the accident, over two decades, at hundreds of billions of dollars.[6]

The scale of the burden is clear from the wide range of costs incurred, both direct and indirect:

- Direct damage caused by the accident;
- Expenditures related to:
  - Actions to seal off the reactor and mitigate the consequences in the exclusion zone;
  - Resettlement of people and construction of new housing and infrastructure to accommodate them;
  - Social protection and health care provided to the affected population;
  - Research on environment, health and production of clean food;
  - Radiation monitoring of the environment; and
  - Radioecological improvement of settlements and disposal of radioactive waste.
- Indirect losses relating to the opportunity cost of removing agricultural land and forests from use and the closure of agricultural and industrial facilities; and
- Opportunity costs, including the additional costs of energy resulting from the loss of power from the Chernobyl nuclear plant and the cancellation of Belarus's nuclear power programme.

Coping with the impact of the disaster has placed a huge burden on national budgets. In Ukraine, 5–7 percent of government spending each year is still devoted to Chernobyl-related benefits and programmes. In Belarus, government spending on Chernobyl amounted to 22.3 percent of the national budget in 1991, declining gradually to 6.1 percent in 2002. Total spending by Belarus on Chernobyl between 1991 and 2003 is estimated at more than US $13 billion.

This massive expenditure has created an unsustainable fiscal burden, particularly for Belarus and Ukraine. Although capital-intensive spending on resettlement programmes has been curtailed or concluded, large sums continue to be paid out in the form of social benefits for as many as 7 million recipients in the three countries. With limited

[6] Belarus, for instance, has estimated the losses over 30 years at US $235 billion.

resources, governments thus face the task of streamlining Chernobyl programmes to provide more focused and targeted assistance, with an eye to helping those groups that are most at risk from health hazards or socio-economic deprivation.

What were the main consequences of Chernobyl for the local economy?

The affected territories are mostly rural. The main source of income before the accident was agriculture, both in the form of large collective farms (in the Soviet period), which provided wages and many social benefits, and small individual plots, which were cultivated for household consumption and local sale. Industry was mainly fairly unsophisticated, concentrated in food processing or wood products. This profile has remained largely the same after the accident, though the three countries have taken different approaches to the legacy of collective farms.

The agricultural sector was the area of the economy worst hit by the effects of the accident. A total of 784 320 hectares of agricultural land was removed from service in the three countries, and timber production was halted for a total of 694 200 hectares of forest. Restrictions on agricultural production crippled the market for foodstuffs and other products from the affected areas. “Clean food” production has remained possible in many areas thanks to remediation efforts, but this has entailed higher costs in the form of fertilizers, additives and special cultivation processes.

Even where remediation measures have made farming safe, the stigma of Chernobyl has caused some consumers to reject products from affected areas. Food processing, which had been the mainstay of industry in much of the region, has been particularly hard-hit by this “branding” issue. Revenues from agricultural activities have fallen, certain types of production have declined, and some facilities have closed altogether. In Belarus, where some of the best arable land was removed from production, the impact on agriculture has affected the whole economy.

Government policies aimed at protecting the population from radiation exposure (both through resettlement and through limitations on agricultural production) could not help but have a negative impact on the economy of the affected regions, particularly the rural economy. However, it is crucial to note that the region also faced great economic turmoil in the 1990s owing to factors completely unrelated to radiation. The disruption of trade accompanying the collapse of the Soviet Union, the introduction of market mechanisms, prolonged recessionary trends, and Russia's rouble crisis of 1998 all combined to undercut living standards, heighten unemployment and deepen poverty. Agricultural regions, whether contaminated by radionuclides or not, were particularly vulnerable to these threats, although Chernobyl-affected regions proved particularly susceptible to the drastic changes of the 1990s.

Wages tend to be lower and unemployment higher in the affected areas than they are elsewhere. This is in part the result of the accident and its aftermath, which forced the closure of many businesses, imposed limitations on agricultural production, added costs to product manufacture (particularly the need for constant dosimetric monitoring), and hurt marketing efforts. But equally important is the fact that farm workers in all three countries are among the lowest-paid categories of employees. Employment options outside of agriculture are also limited in Chernobyl-affected regions, but, again, the causes are as much a consequence of generic factors as of Chernobyl specifics. The proportion of small and medium-sized enterprises (SMEs) is far lower in the affected regions than elsewhere. This is partly because many skilled and educated workers, especially the younger ones, have left the region, and partly because — in all three countries — the general business environment discourages entrepreneurship. Private investment is also low, in part owing to image problems, in part to unfavourable conditions for business nationwide.

The result of these trends is that the affected regions face a higher risk of poverty than elsewhere. In seeking solutions to the region's economic malaise, it is important to address the generic issues (improving the business climate, encouraging the development of SMEs and the creation of jobs outside agriculture, and eliminating the barriers to profitable land use and efficient agricultural production) as well as addressing the issues of radioactive contamination.

What impact did Chernobyl and its aftermath have on local communities?

Since the Chernobyl accident, more than 330 000 people have been relocated away from the more affected areas. 116 000 of them were evacuated immediately after the accident, whereas a larger number were resettled several years later, when the benefits of relocation were less evident.

Although resettlement reduced the population's radiation doses, it was for many a deeply traumatic experience. Even when resettlers were compensated for their losses, offered free houses and given a choice of resettlement location, many retained a deep sense of injustice about the process. Many are unemployed and believe they are without a place in society and have little control over their own lives. Some older resettlers may never adjust.

Opinion polls suggest that many resettlers wished to return to their native villages. Paradoxically, people who remained in their villages (and even more so the "self-settlers," those who were evacuated and then returned to their homes despite restrictions) have coped better psychologically with the accident's aftermath than have those who were resettled to less affected areas.

Communities in the affected areas suffer from a highly distorted demographic structure. As a result of resettlement and voluntary migration, the percentage of elderly individuals in affected areas is abnormally high. In some districts, the population of pensioners equals or already exceeds the working-age population. In fact, the more contaminated a region, the older its population. A large proportion of skilled, educated and entrepreneurial people have also left the region, hampering the chances for economic recovery and raising the risk of poverty.

The departure of young people has also had psychological effects. An aging population naturally means that the number of deaths exceeds the number of births, yet this fact has encouraged the belief that the areas concerned were dangerous places to live. Schools, hospitals, agricultural cooperatives, utility companies and many other organisations are short of qualified specialists, even when pay is relatively high, so the delivery of social services is also threatened.

What has been the main impact on individuals?

As noted in the Chernobyl Forum report on *Health*, "the mental health impact of Chernobyl is the largest public health problem unleashed by the accident to date." Psychological distress arising from the accident and its aftermath has had a profound impact on individual and community behaviour. Populations in the affected areas exhibit strongly negative attitudes in self-assessments of health and well-being and a strong sense of lack of control over their own lives. Associated with these perceptions is an exaggerated sense of the dangers to health of exposure to radiation. The affected populations exhibit a widespread belief that exposed people are in some way condemned to a shorter life expectancy. Such fatalism is also linked to a loss of initiative to solve the problems of sustaining an income and to dependency on assistance from the state.

Anxiety over the effects of radiation on health shows no sign of diminishing. Indeed, it may even be spreading beyond the affected areas into a wide section of the population. Parents may be transferring their anxiety to their children through example and excessively protective care.

Yet while attributing a wide variety of medical complaints to Chernobyl, many residents of the affected areas neglect the role of personal behaviour in maintaining health. This applies not only to radiation risks such as the consumption of mushrooms and berries from contaminated forests, but also to areas where individual behaviour is decisive, such as misuse of alcohol and tobacco.

In this context, it is crucial to note that adult mortality has been rising alarmingly across the former Soviet Union for several decades. Life expectancy has declined precipitously, particularly for men, and in the Russian Federation stood at an average of 65 in 2003 (just 59 years for men). The main causes of death in the Chernobyl-affected region are the same as those nationwide — cardiovascular diseases, injuries and poisonings — rather than any radiation-related illnesses. The most pressing health concerns for the affected areas thus lie in poor diet and lifestyle factors such as alcohol and tobacco use, as well as poverty and limited access to health care. These threats may be even more acute in Chernobyl-affected areas, owing to the impact of low incomes on diet, the high share of socially deprived families, and shortages of trained medical staff.

Added to exaggerated or misplaced health fears, a sense of victimization and dependency created by government social protection policies is widespread in the affected areas. The extensive system of Chernobyl-related benefits (see below) has created expectations of long term direct financial support and entitlement to privileges, and has undermined the capacity of the individuals and communities concerned to tackle their own economic and social problems. The dependency culture that has developed over the past two decades is a major barrier to the region's recovery. These factors underscore the importance of measures aimed at giving the individuals and communities concerned control over their own futures — an approach that is both more efficient in use of scarce resources and crucial to mitigating the accident's psychological and social impact.

How have governments responded to the challenges of Chernobyl?

The Soviet Union undertook far-reaching measures in response to the Chernobyl nuclear accident. The government adopted a very low threshold with regard to the level of radioactive contamination that was considered acceptable for inhabited areas. The same caution applied to the zoning principles that were defined by the Soviet government in the wake of the accident, and that were subsequently reinforced by national legislation after the dissolution of the Soviet Union in 1991. These principles determined where people were permitted to live and imposed limitations on the types of activities that might be pursued (including farming and infrastructure investment). The zones were created based on very cautious standards for radiation risk and using measurements made very soon after the accident occurred.

In the wake of the accident, rehabilitation actions were undertaken on a huge scale (see Table). To accommodate the resettled populations, large investments were made in the construction of housing, schools, and hospitals, and also in physical infrastructure such as roads, water and electricity supply and sewerage. Because of the risk that was believed to be involved in burning locally produced wood and peat, many villages were provided with access to gas supplies for heating and cooking. This involved laying down a total of 8,980 kilometres of gas pipeline in the three countries in the fifteen years following the accident. Large sums were also spent to develop methods to cultivate "clean food" in the less contaminated areas where farming was allowed.

Chernobyl-related construction, 1986–2000

	Belarus	Russia	Ukraine	Total
Houses and flats	64 836	36 779	28 692	130 307
Schools (number of places)	44 072	18 373	48 847	111 292
Kindergartens (number of places)	18 470	3 850	11 155	33 475
Outpatient health centres (visits/day)	20 922	8 295	9 564	38 781
Hospitals (beds)	4 160	2 669	4 391	11 220

An extensive benefits system was established for the populations that were seen to have suffered as a result of the Chernobyl accident, either through exposure to radiation or resettlement. Benefits were offered to very broad categories of Chernobyl victims, defined as people who:

— Fell ill with radiation sickness or became invalids due to the consequences of the accident;

— Took part in clean-up activities at the Chernobyl site and in the evacuation zones in 1986–1987 (known colloquially as "liquidators");

— Participated in clean-up activities in 1988–1989;

— Continued to live in areas designated as contaminated; or,

— Were evacuated, or resettled, or left the affected areas at their own initiative.

Some 7 million people are now receiving (or are at least entitled to receive) special allowances, pensions, and health care privileges as a result of being categorized as in some way affected by Chernobyl. Significantly, benefits include measures that have no identifiable relation to the impact of radiation. Moreover, the benefits confer certain advantages and privileges even to those citizens who had been exposed to low levels of radiation or who continue to live in only mildly affected locations, where the level of radiation is close to natural background levels in some other European countries. In effect, these benefits compensate risk rather than actual injury.

By the late 1990s, Belarusian and Russian legislation provided more than seventy, and Ukrainian legislation more than fifty, different privileges and benefits for Chernobyl victims, depending on factors such as the degree of invalidity and the level of contamination. The system also guaranteed allowances, some of which were paid in cash, while others took the form of, for example, free meals for schoolchildren. In addition, the authorities undertook to finance health holidays in sanatoria and summer camps for invalids, liquidators, people who continued to live in highly affected areas, children and adolescents. In Belarus, almost 500 000 people, including 400 000 children, had the right to free holidays in the early 2000s. In Ukraine, the government funded 400 000–500 000 health holiday months per year between 1994 and 2000.

These government efforts were successful in protecting the overwhelming majority of the population from unacceptably high doses of radiation. They also stimulated the development of agricultural and food-processing techniques that reduced the radionuclide level in food. In the absence of alternative sources of income, government-provided Chernobyl benefits became the key to survival for many whose livelihoods were wiped out by the accident. And the health care system detected and treated thousands of cases of thyroid cancer that developed among children who were exposed to radioactive iodine in the weeks following the accident.

Alongside these successes, however, government efforts undertaken in response to the accident contained the seeds of later problems. First, the zones delineated to restrict the areas where people could live and work soon proved unwieldy. As the level of radiation declined over time, and knowledge on the nature of the risks posed by radiation became more sophisticated, the continuation of limitations on commercial activities and infrastructure development in the less affected areas became more of a burden than a safeguard. Zoning adjustments have been made in some places, but more needs to be done in light of new research.

Second, the massive investment programmes initiated to serve resettlement communities proved unsustainable, particularly under market economic conditions. Funding for Chernobyl programmes has declined steadily over time, leaving many projects half completed and thousands of half-built houses and public facilities standing abandoned in resettlement villages.

Third, the Soviet government delayed the public announcement that the accident had occurred. Information provision was selective and restrictive, particularly in the immediate aftermath of the accident. This approach left a legacy of mistrust surrounding official statements on radiation, and this has hindered efforts to provide reliable information to the public in the following decades.

Fourth, wide applicability meant that Chernobyl benefits mushroomed into an unsustainable fiscal burden. Somewhat counter-intuitively, the number of people claiming Chernobyl-related benefits soared over time, rather than declining. As the economic crisis of the 1990s deepened, registration as a victim of Chernobyl became for many the only means to an income and to vital aspects of health provision, including medicines. According to Ukrainian figures, the number of people designated as permanently disabled by the Chernobyl accident (and their children) increased from 200 in 1991 to 64 500 in 1997 and 91 219 in 2001.

In conditions of high inflation and increasing budget constraints, moreover, the value of the payments fell steadily in the early 1990s. In many cases, Chernobyl payments became meaningless in terms of their contribution to family incomes, but, given the large number of eligible people, remained a major burden on the state budget. Especially for Belarus and Ukraine, Chernobyl benefits drained resources away from other areas of public spending. By the late 1990s, however, any attempt to scale back benefits or explore alternative strategies to target high-risk groups was politically difficult, given the likelihood of protests from current recipients.

Despite this constraint, some changes to Chernobyl legislation have already been made to improve policy efficiency. In Belarus, for example, individual benefits are no longer paid to the least-affected categories of the population, and the meagre sums paid out as compensation to individual families living in the contaminated areas are now accumulated at the regional level and used by local authorities to improve medical and communal services for the affected population.

The enormous scale of the effort currently being made by the three governments means that even small improvements in efficiency can significantly increase the resources available for those in need. Governments realize that the costs and benefits of particular interventions need to be assessed more rigorously, and resources targeted more carefully to those facing true need. Resources now committed to Chernobyl health care benefits should be targeted to high-risk groups (e.g., liquidators) and those with demonstrated health conditions, or be shifted into a mainstream health care system that promotes preventive medicine and improved primary care. Similarly, Chernobyl benefits that in practice meet socio-economic needs should be folded into a nationwide means-tested social protection programme that targets the truly needy. Such changes take political courage, as reallocating resources faces strong resistance from vested interests.

Do people living in the affected regions have an accurate sense of the risks they face?

Nearly two decades after the Chernobyl accident, residents of affected areas still lack the information they need to lead healthy, productive lives, according to a range of opinion polls and sociological studies conducted in recent years. Although accurate information is accessible and governments have made many attempts at dissemination, misconceptions and myths about the threat of radiation persist, promoting a paralysing fatalism among residents. This fatalism yields both excessively cautious behaviour (constant anxiety about health) and reckless conduct (consumption of mushrooms, berries and game from areas of high contamination).

These findings were most recently confirmed by three country-specific reports prepared as part of the International Chernobyl Research and Information Network (ICRIN), a UN initiative to provide accurate and credible information to populations affected by the Chernobyl disaster. Surveys and focus group meetings involving thousands of people in each of the three countries in 2003–2004 showed that, despite concerted efforts by governments, scientists, international organizations, and the mass media, people living in the areas affected by the Chernobyl accident express deep confusion and uncertainty about the impact of radiation on their health and surroundings. Awareness is low of what practical steps to take to lead a healthy life in the region.

Overcoming mistrust of information provided on Chernobyl remains a major challenge, owing to the early secrecy with which Soviet authorities treated the accident, the use of conflicting data by different institutions, the unresolved controversies surrounding the impact of low-dose radiation on health, and the often complex scientific language in which information is presented.

Surveys showed that Chernobyl-area residents in all three countries are preoccupied with their own health and that of their children, but concern about low living standards is also extremely pronounced. Indeed, socio-economic concerns were viewed as more important than the level of radiation. Specifically, low household incomes and high unemployment cause uncertainty (see Fig. 10).

What worries you most today?

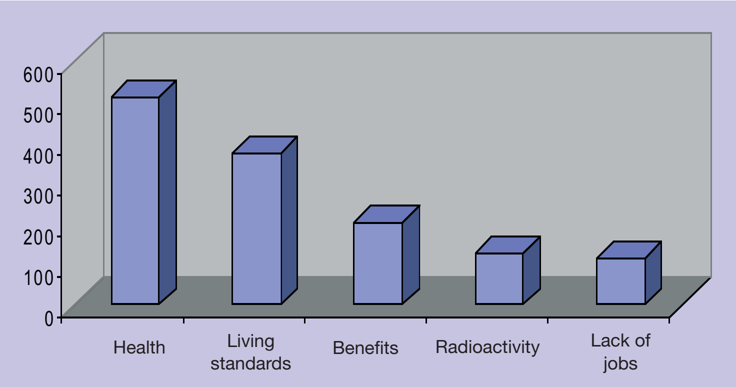


FIG. 10. Data from 2003 Russian survey, 748 respondents, multiple responses allowed

The ICRIN country studies confirm that Chernobyl-affected populations need unambiguous and comprehensible answers to a range of questions, as well as fresh policies that would focus on promoting the region's economic development. To get the message across, new ways of information delivery and education need to be found. The Chernobyl Forum findings should provide authoritative source material for creative dissemination to the affected populations, helping them both to lead healthier lives and overcome a paralyzing legacy of worry and fear.

How many people need direct assistance in coping with the consequences of Chernobyl, and how many are now in a position to help themselves?

In order best to address the human needs resulting from the accident, and to optimize the use of limited resources, it is important to understand the true nature of the threat, and the number of people actually at risk. Current scientific knowledge suggests that a small but important minority, numbering between 100 000–200 000, is caught in a downward spiral of isolation, poor health and poverty; these people need substantial material assistance to rebuild their lives. This group includes those who continue to live in severely affected areas and are unable to support themselves, unemployed resettlers, and those whose health is most at risk, including patients with thyroid cancer and other malignant cancers, and those with psychosomatic disorders. These people are right at the core of the cluster of problems created by Chernobyl. Resources should be focused on resolving their needs and on helping them to take control of their destinies in the circumstances that have resulted from the accident.

A second group, numbering several hundreds of thousands of individuals, consists of those whose lives have been directly and significantly affected by the consequences of the accident but who are already in a position to support themselves. This group includes resettlers who have found employment and many of the former clean-up workers. The priority here should be to help these people to normalize their lives as quickly and as far as is possible. They need to be reintegrated into society as a whole, so that their needs are increasingly addressed through mainstream provision and according to the same criteria as those that apply to other sections of society.

A third group consists of a much larger number of people, totalling several million in the three countries, whose lives have been influenced by the accident primarily in that they have been labelled as, or perceive themselves as, actual or potential victims of Chernobyl. Here the main need is for full, truthful and accurate information on the effects of the accident based on dependable and internationally recognized research, coupled with access to good quality mainstream provision in health care and social services; and to employment.

The approach of defining the most serious problems and addressing them with special measures, while pursuing an overall policy of promoting a return to normality, should apply to the affected territories as well as to the affected individuals and communities. Where in the light of the best scientific knowledge it is reasonably possible, measures should be adopted to integrate less severely affected areas back into productive use. This combination of measures — *focusing resources on those most in need, while actively promoting integration with mainstream provision wherever possible* — is not a second best. Within the available budgets it is really the only alternative to sweeping cutbacks in the recovery effort, wasteful dispersion of limited resources and continuing distress for the people at the centre of the problem. By fostering a process of healing, these measures will help to address the widespread psychosocial effects of the accident. They will protect the most vulnerable as Chernobyl budgets inevitably decline and will enable the authorities to promote an orderly process of recovery over the coming years.

Recommendations to the Governments of Belarus, the Russian Federation and Ukraine

Introduction

At the Chernobyl Forum meeting in April 2005 where the two reports of the expert groups —"Health", coordinated by the WHO, and "Environment", coordinated by the IAEA — were considered and approved, the Forum participants from Belarus, the Russian Federation and Ukraine requested the Forum to develop recommendations for the Governments of these three countries on special health care programmes and environmental remediation, including needs for further research, as well as for economic and social policies.

The document was prepared by the Forum Secretariat initially based on the recommendations presented in the Forum's technical reports. In addition, UNDP has contributed recommendations for economic and social policies based largely on the 2002 UN study, *Human Consequences of the Chernobyl Nuclear Accident — A Strategy for Recovery as well as on the World Bank's Belarus: Chernobyl Review* (2002). The recommendations were circulated among the Forum's participants and eventually accepted by consensus.

This document contains mostly generic advice for the Governments of the three affected countries; more detailed recommendations can be found in the respective technical reports. With regard to radiation protection of the public and the environment, the recommendations are based on current concepts of the International Commission on Radiological Protection (ICRP) and international safety standards developed by the IAEA.

Recommendations on Health Care and Research

Health care programmes and medical monitoring

Medical care and annual examinations of the workers who recovered from Acute Radiation Syndrome (ARS) and other highly exposed emergency workers should continue. This should include periodic examination for cardiovascular disease.

Current follow-up programmes for those persons with whole-body exposures of less than 1 Gy should be reconsidered relative to necessity and cost-effectiveness. From previous knowledge, these follow-up programmes are unlikely to be cost-effective or beneficial to individuals. Resources used for extensive examinations by teams of experts and blood and urine examination on an annual basis might more profitably be directed towards programmes to reduce infant mortality, reduce alcohol and tobacco use, to detect cardiovascular disease and to improve the mental health status of the affected population.

The following specific health related actions are recommended:

— Subgroups of populations known to be particularly sensitive (e.g. children exposed to significant amounts of radioiodine) that are at much higher risk than the general population should be considered for screening;

— Screening for thyroid cancer of those who were children and adolescents and resided in 1986 in the areas with radioactive fallout, should continue. However, as the population ages, many additional benign lesions will be found and there is a risk from unnecessary invasive procedures. Therefore, thyroid screening should be evaluated periodically for cost/benefit.

— For health planning purposes, continuous estimation of the predicted number of cases of thyroid cancer expected to occur in exposed populations, should be based on updated estimates of risk in those populations;

— High quality cancer registries should continue to be supported. They will be useful not only for epidemiological studies but also for public health purposes, e.g., providing reliable information to help guide the allocation of public health resources;

— Incidence rates for leukaemia in populations exposed as children to Chernobyl radiation and liquidators should continue to be monitored to detect increases that may still occur;

— Continued eye follow-up studies of the Chernobyl populations, will allow greater predictive capability of risk of radiation cataract onset and more importantly provide the data necessary to assess the likelihood of a resulting visual dysfunction. Annual monitoring for radiation cataract development may be recommended in case of occupational exposure to radiation;

— The local registers on reproductive health outcomes should be based on standard protocols for such conditions as congenital malformations and genetic disorders. It should be understood that such registers are unlikely to provide useful scientific information on radiation effects, however, may provide reassurance to the local population;

— Programs targeting minimization of the psychosocial impact on children and those who were children at the time of the accident should be encouraged and supported

— Renewed efforts at risk communication should be undertaken, providing the public and key professionals with accurate information about the physical and mental health consequences of the disaster.

Future research and follow-up studies

— In the years to come, careful studies of selected populations are needed in order to study the real effect of the accident and compare it to predictions.

— Registries of exposed persons should continue as well as studies of morbidity and mortality. These are typically for documentation or research purposes and usually will not be of direct medical benefit to the individual.

— Incidence of non-thyroid solid cancers in both the general population and cohorts of liquidators should continue to be monitored through the existing cancer registries and other specialized registries. Efforts to evaluate the quality of those registries and to reduce any deficiencies should be given high priority.

— Elevated radiation-induced morbidity and mortality from solid cancers of both emergency workers and populations of areas contaminated with radionuclides still might be expected during decades to come and requires more research. The feasibility and informativeness of studies should, however, be carefully evaluated before they are started.

— Well-designed epidemiological studies, with careful individual organ-specific dose reconstruction, should be conducted to confirm or inform recent findings about increases in leukaemia risk among accident recovery workers and in breast cancer among young women in the most affected districts.

— Presently, it is not possible to exclude an excess risk of thyroid cancer in persons exposed to Chernobyl radiation as adults. Carefully designed and appropriately analysed studies should be conducted to provide more information on ^{131}I related risks following adult exposure.

— Further work on the evaluation of uncertainties in thyroid dose estimates is strongly encouraged. This should lead to the determination of the parameters that give rise to the highest uncertainties and to research aimed at reducing those uncertainties. Cooperation and exchange of information among the dosimetrists from Belarus, Russia and Ukraine working in that area is strongly encouraged.

— A study is needed in the three affected countries on the role of radiation in the induction of cardiovascular diseases in emergency workers, using an appropriate control group, adequate dosimetry and common standardized clinical and epidemiological strategies and protocols.

— There should be continued study of immune system effects after high radiation doses (particularly on the survivors of the acute radiation syndrome). Studies of immune function in populations with less than several tens of mGy are unlikely to yield significant information.

Further information

More details and specific recommendations on Chernobyl-related health research can be found in the WHO report entitled "Health Effects of the Chernobyl Accident and Special Health Care Programmes".

Recommendations on Environmental Monitoring, Remediation and Research

Environmental monitoring and research

— Long term monitoring of radionuclides (especially, ^{137}Cs and ^{90}Sr) in various environmental compartments is required to meet the following general practical and scientific needs:

Practical:

- To assess current and predict future levels of human exposure and radionuclides in foods to assess the need for remedial actions and long term countermeasures;

- To inform the general public in affected areas about the persistence of radioactive contamination in natural food products (such as mushrooms, game, freshwater fish from closed lakes, berries, etc);

- To inform the general public in affected areas about changing radiological conditions to relieve public concerns.

Scientific:

- To determine parameters of long term transfer of radionuclides in various ecosystems and different natural conditions to improve predictive models both for the Chernobyl-affected areas and for potential future radioactive releases;

- To determine mechanisms of radionuclide behaviour in less studied ecosystems (e.g., role of fungi in the forest) and explore remediation possibilities with special attention to processes important in contributing to human and biota doses.

— Various ecosystems considered in the present report have been intensively monitored and studied during the years after Chernobyl and environmental transfer and bioaccumulation of the most important long term contaminants, ^{137}Cs and ^{90}Sr are now generally well understood. There is therefore little need for major new research programmes on radioactivity; but there is a requirement for continued but more limited targeted monitoring of the environments, and for further research in some specific areas.

— As activity concentrations in environmental compartments are now in quasi-equilibrium and change slowly, the number and frequency of sampling and measurements performed for monitoring and research programmes can be substantially reduced compared with the early years after the Chernobyl accident.

— As current human exposure levels caused by the Chernobyl fallout are generally well known and they change slowly, large-scale monitoring of foodstuffs, whole-body counting of individuals, and provision of dosimeters to members of the general population are no longer necessary. However, individual measurements should be still used for critical groups in areas of high contamination and/or high transfer of radiocaesium.

— To further develop the system of environmental protection against radiation, the long term impact of radiation on plant and animal populations should be further investigated in the highly affected Chernobyl Exclusion Zone; this is a globally unique area for radioecological and radiobiological research in an otherwise natural setting. Such studies are, except for very small-scale experiments, not possible or difficult to perform elsewhere.

Remediation and countermeasures

- A wide range of different effective long term remediation measures are available for application in the areas contaminated with radionuclides, but their use should be radiologically justified and optimized. In optimizing countermeasures, social and economic factors should be taken into account, along with formal cost-benefit analysis, so that the use of the countermeasures is acceptable to the public.

- The general public, along with the authorities, should be particularly informed about existing radiation risk factors and methods to reduce them in the long term via remediation and regular use of countermeasures, and involved in discussion and decision-making.

- Particular attention must be given to the production on private farms in several hundred settlements and about 50 intensive farms in Belarus, Russia and Ukraine where radionuclide concentrations in milk still exceed national action levels.

- In the long term after the Chernobyl accident, remediation measures and regular countermeasures remain efficient and justified mainly in agricultural areas with poor (sandy and peaty) soils where there is a high radiocaesium transfer from soil to plants.

- Among long term remediation measures, radical improvement of pastures and grasslands as well as draining of wet peaty areas is very effective. The most efficient regular agricultural countermeasures are pre-slaughter clean feeding of animals accompanied with in-vivo monitoring, application of Prussian Blue to cattle and enhanced application of mineral fertilisers in plant breeding.

- There are still agricultural areas in the three countries that are taken out of use. However this land can be safely used after appropriate remediation, for which technologies are available, but at the moment legal, economic and social constraints may make this difficult. It is desirable to identify sustainable ways to make use of the most affected areas that reflect the radiation hazard, but also revive the economic potential for the benefit of the community. To this end, the three governments should urgently revisit the classification of Chernobyl-affected zones, as current legislation is too restrictive, given the low radiation levels that now prevail in most territories.

- Technologically based forest countermeasures, such as the use of machinery and/or chemical treatments to alter the distribution or transfer of radiocaesium in the forest, will not be practicable on a large scale.

- Restricting harvesting of wild food products such as game, berries, mushrooms and fish from 'closed lakes' by the public still may be needed in areas where their activity concentrations exceed national action levels.

- Advice on diet aiming to reduce consumption of highly contaminated wild food products and on simple cooking procedures that remove radiocaesium are still important countermeasures aimed at reducing internal exposure.

- It is unlikely that any future countermeasures to protect surface waters will be justifiable in terms of economic cost per unit of dose reduction. It is expected that restrictions on consumption of fish will remain, in a few cases (such as closed lakes), for several more decades. Future efforts in this area should be focused on public information, since there are still significant public misconceptions concerning health risks due to contaminated waters and fish.

- There is nothing that can be done to remedy the radiological conditions for plants and animals residing in the Exclusion Zone of the Chernobyl NPP that would not have an adverse impact on plants and animals.

- An important issue that requires more sociological research is the perception by the public of the introduction, performance and withdrawal of countermeasures after an emergency as well as development of social measures aimed at involvement of the public in these processes at all stages beginning with the decision making.

- There is still substantial diversity in international and national radiological criteria and safety standards applicable to remediation of areas contaminated with radionuclides. Experience with protection of the public after the Chernobyl accident has clearly shown the need for further international harmonization of appropriate radiological criteria and safety standards.

Environmental aspects of the Shelter dismantlement and radioactive waste management

- Safety and environmental assessments for individual facilities at and around the Chernobyl NPP should take into account the safety and environment impact assessment for all activities inside the entire Exclusion Zone.

- During the preparation and construction of the New Safe Containment (NSC) and soil removal, it is important to maintain and improve environmental monitoring strategies, methods, equipment and staff qualification needed for adequate monitoring of the conditions at the Chernobyl NPP site and the Exclusion Zone.

- Development of an integrated radioactive waste management programme based on existing programmes for the Shelter, the Chernobyl NPP site and the Exclusion Zone is needed to ensure application of consistent management approaches, and sufficient facility capacity for all waste types. Specific emphasis needs to be paid to the characterisation and classification of waste (in particular waste containing transuranic elements) from all the remediation and decommissioning activities, as well as the establishment of sufficient infrastructure for safe long term management of long lived and high level waste at the Chernobyl NPP site and in the Exclusion Zone.

- A coherent and comprehensive strategy for rehabilitation of the Exclusion Zone in Ukraine based on existing programmes is needed with particular focus on improving safety of the existing waste storage and disposal facilities. This will require development of a prioritization method for remediation of the sites, based on safety assessment results, aimed at determining at which sites waste will be retrieved and disposed, and at which sites waste will be allowed to decay in situ.

- Return of the Exclusion Zone to limited economic use will require well-defined administrative controls as to the nature of activities that may be performed in particular areas. In some of them, prohibition of agriculture may be needed for decades to come for radiological reasons. Accordingly, these re-used areas are best suited for an industrial site rather than an agricultural or residential area.

Further information

More specific recommendations on Chernobyl-related environmental remediation, monitoring and research issues can be found in the technical report of the Chernobyl Forum entitled “Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience”, IAEA (2006).

Recommendations for Economic and Social Policy

What is to be done?

Current scientific knowledge about the impact of the disaster suggests that five general principles should underlie any approach to tackling the consequences of the accident:

— Chernobyl-related needs should be addressed in the framework of a holistic view of the needs of the individuals and communities concerned and, increasingly, of the needs of society as a whole;

— Moving away from a dependency culture in the affected areas, the aim must be to help individuals to take control of their own lives and communities to take control of their own futures;

— Efficient use of resources means focusing on the most affected people and communities. The response must take into account the limited budgetary resources at government disposal;

— The new approach should seek changes that are sustainable and long term, and based on a developmental approach;

— The international effort can only be effective if it supports, amplifies and acts as a lever for change in the far larger efforts made by local and national government agencies and the voluntary sector in the three countries.

Specific recommendations

Find new ways to inform the public

Innovative ways need to be developed to increase knowledge about how to live safely in environments that have suffered radioactive contamination, as well as to reassure people who live in areas where radiation exposure is too low to pose any real threat to health and well-being. These need to address the problems of credibility and comprehensibility that have hampered past efforts. Information provision targeted to specific audiences is needed, as well as trusted community sources.

Any new information strategy should embrace a comprehensive approach to promoting healthy lifestyles, and not simply focus on radiation hazards. Health education aiming at reducing internal and external radiation should be just one part of health promotion policies and interventions that aim at reducing the main causes of disease and rising mortality that affect Belarus, Russia and Ukraine.

Focus attention on highly affected areas. Government programmes need to be differentiated depending on radiation level, as problems are different among zones. Given that natural recovery processes along with protection measures have resulted in a significant reduction of radiation levels, governments need to make a renewed effort to revisit the classification of zones. Current delineations are far more restrictive than demonstrated radiation levels can justify.

Governments also need to clarify to the public, with the assistance of credible international agencies, that many areas previously considered to be at risk are in fact safe for habitation and cultivation. Zones with mild radiation levels can be made fit for adequate and even prosperous living with limited, cost-effective measures to reduce radiation exposure. The far smaller areas with higher levels of contamination require a different strategy focused on greater monitoring, provision of health and social services, and other assistance.

Streamline and refocus government programmes on Chernobyl. In order to meet the objectives of reducing the population's exposure to radiation and providing support to those who have been directly affected by the accident, current Chernobyl programmes need to be refocused in order to meet these objectives in a cost-effective manner. Programs should shift from those that create a victim and dependency mentality to those that support opportunity, promote local initiatives, involve the people and spur their confidence in shaping their destinies.

Adjustments to Chernobyl programmes should be guided by the following criteria:

a) Aligning programmes with new objectives;

b) Preventing the creation of perverse incentives; and

c) Matching the mandates with available resources.

These criteria suggest that certain programmes should be strengthened and expanded (e.g., supporting the production of clean food, monitoring and certification), whereas others should be revamped to target those genuinely in need (e.g., cash benefits linked to place of residence, mandatory mass screening).

— **Improve benefits targeting.** Many entitlements are not related to the health impact of radiation, but are mainly socio-economic in nature and correlated with residence rather than with any demonstrated need. These should be replaced with targeted programs for the needy. Chernobyl-related benefits and privileges should be folded into a mainstream social assistance programme that is targeted and means-tested. The definition of those who qualify as "Chernobyl victims" should be made more stringent and its application more effective, so that only those who indeed suffered from the accident benefit from this assistance. To make such a change palatable, consideration should be given to a "buy-out" plan for Chernobyl benefits that would exchange benefit entitlements for a lump-sum payout designed to encourage new small businesses.

— **Where not already done, eliminate benefits for individuals living in areas with mild contamination.** Enormous sums are currently spent on benefits that make little significant difference to individual households yet pose a huge burden on national budgets — or are not paid at all owing to revenue shortfalls. Moreover, correlating benefits with area of residence alone is unsound public policy, particularly where radiation levels are as low as natural background levels in other parts of Europe. Special health care benefits should be applicable only if individual ill health or a need for high-risk monitoring can be demonstrated. Those who need state assistance on poverty grounds should be covered by a nationwide targeted and means-tested system of social assistance.

— **Improve primary health care, including psychological support.** Strengthening of primary health care services in affected areas should receive priority. This should include promotion of healthy lifestyles; improvement in access and quality of reproductive health care, especially obstetric health care in the most contaminated areas; and provision of psychological support and diagnosis and treatment of mental diseases, especially depression.

— **Rethink health recuperation programmes.** Government-funded recuperation programmes, such as stays in sanatoria and summer camps, need to be reassessed. Such benefits are not generally effective in reducing radiation exposure, but they can offer important psychological and health benefits to residents of Chernobyl-affected areas. What is needed is to review such entitlements with the aim of linking benefit provision more tightly with diagnosed medical conditions or documented health risks. Better targeting of such benefits will yield savings that could be devoted to improving general health care provision and promoting healthy lifestyles.

Many international charities offer similar "health holidays" abroad to children of the affected regions. Such programs are popular and generally beneficial to participants. However, governments should encourage charities providing travel abroad to engage as well in the effort to promote better health outcomes in the affected communities themselves. Both government and charitable recuperation programs should ensure that travel outside the region is provided in a way that does not exaggerate the danger of living in Chernobyl-affected areas.

— **Encourage safe food production.** Continued efforts are needed to develop and promote agricultural products that can be produced safely where radionuclides are present in the soil. Know-how is available, but some countermeasures are currently not being applied due to the lack of funds. Little is being done to ensure the production of clean food on private plots, and thus to address the issue of food being produced for personal consumption or for sale on village markets. But cost-benefit analysis is essential in propagating mitigation measures, as the costs of producing "clean food" may exceed any reasonable market value.

Adopt a new approach to economic development of the affected regions

— **Put economic development aiming to make the affected communities economically and socially viable** in the medium and long term at the centre of strategies to address the effects of Chernobyl. This should be done in such a way as to give the individuals and communities concerned **control over their own futures**, which is both efficient in terms of resources and crucial in addressing the psychological and social effects of the accident. Understand that very large resources are needed to promote economic recovery in these communities, but also that achieving **economic self-sufficiency and community self-reliance** will free up large national resources, which are at present tied up in subsidies and special Chernobyl-related assistance.

— **Improve the business climate, encourage investment and support private sector development.** At the national level, sound finances and the creation of an open competitive market economy and an investment friendly business environment are preconditions for sustained recovery in the affected areas. Appropriate national policies need to be supplemented by a proactive approach to stimulating economic development at the regional and local levels. Economic incentives, such as special zones, should be used only in tandem with improvement in the business environment, as the use of tax and other incentives to attract entrepreneurial and skilled people to the region may not work in an unfriendly business environment or because badly designed instruments may lead to perverse incentives.

— **Support initiatives to promote inward investment, both domestic and international,** at the regional level, to promote employment and create a positive image for the areas concerned. The international community can play an important part in this effort by assisting in **transferring experience** from successful initiatives in other parts of the world that have been blighted by economic restructuring, high levels of unemployment and environmental contamination. Build on experience of the **local economic development agencies** already functioning in the region to build a network of intermediary organisations that are sensitive to local conditions and can act as an interface with national and international development bodies and donors.

— **Encourage the creation and growth of small and medium-size enterprises** in the affected areas and in the adjacent towns and cities using the whole range of business support techniques that have been tried and tested in other parts of the world. Because of the nature of the local economies concerned, particular efforts are needed to promote **indigenous agricultural and food processing businesses** by supporting the growth of existing enterprises (whatever their ownership status), and through new ventures.

— **Adapt examples of good practice** in the three countries and abroad, including community based solutions such as **credit unions and producer and consumer cooperatives**, to the special circumstances that apply in the affected areas. An appropriate legal and organisational framework should be developed to ensure that such businesses get the support that they need.

— **Give high priority to supporting very small-scale business development** as the local level, including village level enterprise clusters to boost the incomes of the poorest households. Such initiatives must draw on the growing body of international experience in this area and be sensitive to the very special problems affecting communities that largely depend on food production in areas suffering from radioactive contamination.

— **Promote the rebuilding of community structures** to replace those that were lost in the process of evacuation and as a result of the break up of the Soviet Union. Initiatives specifically designed to strengthen social interactions and promote community and economic leadership in towns and villages are needed to underpin sustainable recovery.

— **Explore the possibilities for promoting specialized ecological tourism** and for maximising the contribution that these areas can make to the **preservation of international biodiversity**. Little attempt has been made to exploit the reduction of human disturbance to the ecosystems and cultural landscape in a positive way and the current national plans for biodiversity protection and cultural preservation hardly refer to this potential. The territories could be used to fulfil the three countries' **international obligations on the protection of biodiversity**.

Further information

More detailed policy recommendations on improving socio-economic conditions and reviving community life in Chernobyl-affected areas can be found in the UN publication, *Human Consequences of the Chernobyl Nuclear Accident: A Strategy for Recovery* (2002), and the World Bank's *Belarus: Chernobyl Review* (2002).

Acknowledgement

Participants of the Chernobyl Forum acknowledge with gratitude the financial contribution of the World Bank and of the UNDP Regional Bureau for Europe and CIS to publication of the present report.

IAEA Division of Public Information:
D. Kinley III (Editor); A. Diesner-Kuepfer (Design)

Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria
Tel.: (+43 1) 2600 21270/21275
Fax: (+43 1) 2600 29610
E-Mail: info@iaea.org / www.iaea.org

Printed by the IAEA in Austria, April 2006
IAEA/PI/A.87 Rev.2 / 06-09181

Photo Credits: V. Mouchkin, P. Pavlicek/IAEA,
the Ukrainian Society for Friendship and Cultural Relations
with Foreign Countries/Kiev 1991 and the IAEA

IAEA
International Atomic Energy Agency
Atoms For Peace