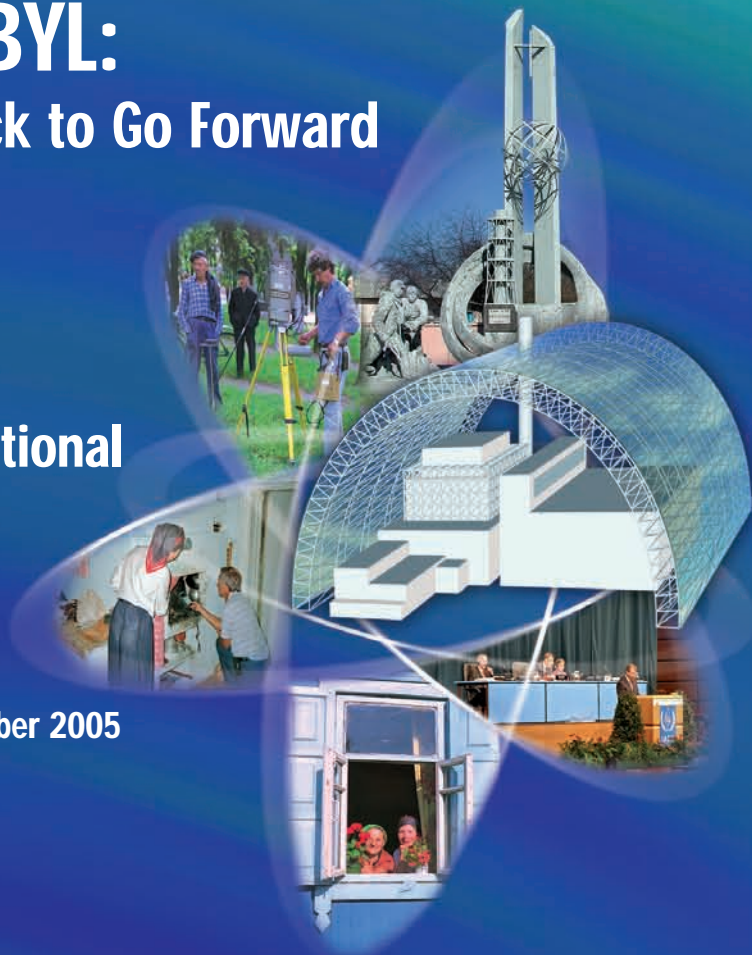


CHERNOBYL: Looking Back to Go Forward

Proceedings of an international conference

Vienna, 6–7 September 2005



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CHERNOBYL: LOOKING BACK
TO GO FORWARD

PROCEEDINGS SERIES

CHERNOBYL: LOOKING BACK TO GO FORWARD

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FOREWORD

On 26 April 1986, the most destructive accident in the history of the nuclear industry occurred at Unit 4 of the Chernobyl nuclear power plant located 100 km to the north of Kiev, in Ukraine (at that time, part of the USSR). The subsequent reactor fire, which lasted for ten days, resulted in an unprecedented release of radioactive material that contaminated more than 200 000 km² of European territory, predominantly adjacent areas of Belarus, the Russian Federation and Ukraine. The accident led to numerous immediate and long term adverse consequences for the public and the environment. It has also had substantial psycho-social and economic impacts on the affected populations and has negatively influenced the nuclear industry worldwide.

The international community was involved from the early days in the assessments and the practical efforts to overcome the consequences of the Chernobyl accident. The first post-accident review meeting was organized by the IAEA in August 1986. In 1990, at the request of the Soviet Government, the IAEA organized an assessment of the radiological consequences and an evaluation of protective measures by a large group of international experts coordinated by an International Advisory Committee. During this large scale project, called the International Chernobyl Project, about 200 experts from numerous countries contributed to both the field work and the subsequent assessment and development of recommendations. Very informative conferences organized in 1996 by the European Commission (EC), in Minsk, and jointly by the EC, the IAEA and the World Health Organization (WHO), in Vienna, summarized the results of ten years of studies and clarified the environmental, health, social and economic consequences of the accident.

Although the accident occurred two decades ago, there remains much controversy concerning its real impact. Therefore, the IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), WHO and the World Bank, as well as the competent authorities of Belarus, the Russian Federation and Ukraine, established the Chernobyl Forum early in 2003. The mission of the Forum was to generate, through a series of managerial and expert meetings, 'authoritative consensual statements' on the environmental consequences and health effects attributable to radiation exposure arising from the accident, as well as to provide advice on environmental remediation and special health care programmes, and to suggest areas in which further research was required. The Forum was established 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'.

Over a two year period, two groups of experts from 12 countries, including Belarus, the Russian Federation and Ukraine, and from relevant international organizations, assessed the accident's environmental and health consequences. Early in 2005, the Expert Group on 'Environment', coordinated by the IAEA, and the Expert Group on 'Health', coordinated by the WHO, presented their reports for the consideration of the Chernobyl Forum. At a meeting held in April 2005, the Forum approved both reports and decided, among other things:

“to consider the approved reports...as a common position of the Forum members, i.e., of the eight United Nations organizations and the three most affected countries, regarding the environmental and health consequences of the Chernobyl accident, as well as recommended future actions, i.e., as a consensus within the United Nations system.”

In addition, UNDP has drawn on the work of eminent economists and policy specialists to assess the socioeconomic impact of the Chernobyl accident.

The conference that is recorded in these proceedings was organized by the IAEA on behalf of the Chernobyl Forum. Its objective was to inform governments and the general public about the Forum's findings regarding the environmental and health consequences of the Chernobyl accident, as well as its social and economic consequences, and to present the Forum's recommendations on further remediation, special health care, and research and development programmes, with the overall aim of promoting an international consensus on these issues. The conference was held in Vienna on 6 and 7 September 2005. It was attended by 250 participants from 41 countries and 20 international organizations. The release of the Forum reports and details of the conference were accompanied by a press campaign organized by public information experts from the IAEA, WHO and UNDP. The conference summarized nearly 20 years of research and succeeded in bringing about a broad consensus on the consequences of the Chernobyl accident among the experts from all over the world who attended the meeting. As such, it was felt that its results should be widely disseminated with the aim of informing the general public and decision makers about the real impact of the accident, the lessons learned and relevant future actions.

These proceedings contain all the presentations, the discussions during the conference and the overall conference findings, presented by B. Bennett,

of the Radiation Effects Research Foundation, Japan, who was Chairman of the Chernobyl Forum and also chaired the conference.

EDITORIAL NOTE

The papers in these Proceedings (including the figures, tables and references) have undergone only the minimum copy editing considered necessary for the reader's assistance. The views expressed remain, however, the responsibility of the named authors or participants. In addition, the views are not necessarily those of the governments of the nominating Member States or of the nominating organizations.

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OPENING SESSION

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THE ENDURING LESSONS OF CHERNOBYL

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Director General,

International Atomic Energy Agency,

Vienna

Presented by T. Taniguchi

INTRODUCTION

The April 1986 accident at the Chernobyl nuclear power plant remains a defining moment in the history of nuclear energy. The enduring lessons of this tragedy are interwoven with a recurrent theme — the essential nature of international cooperation. In its recently released document, entitled ‘Chernobyl’s Legacy’, the Chernobyl Forum has solidly reinforced this theme. For the next few minutes, I would, therefore, like to use the topic of international cooperation as a lens through which to view the major impacts of the Chernobyl accident, the progress we have made since that time and, in keeping with the title of this conference, our outlook for the future.

MAJOR IMPACTS OF THE CHERNOBYL ACCIDENT

The major impacts of the Chernobyl accident fall into three categories: the physical impacts in terms of health and environmental effects; the psychosocial impacts on the affected populations; and the influence of the accident on the nuclear industry worldwide.

The physical impacts mark Chernobyl as the site of the most serious nuclear accident in history. The explosions that destroyed the Unit 4 reactor core released a cloud of radionuclides that contaminated large areas of Belarus, the Russian Federation and Ukraine. Hundreds of thousands of workers participated in efforts to mitigate the consequences of the accident, and many of these individuals were exposed to substantial radiation doses.

The definitive numbers compiled in the Chernobyl Forum report are sobering:

ELBARADEI

- Among the emergency rescue workers at the scene of the accident, some 50 individuals died, either from acute radiation syndrome in 1986 or due to other illnesses in the years since;
- About 4000 children and adolescents contracted thyroid cancer from ingestion of contaminated milk and other foods, and 15 of those children have died;
- Overall, based on statistical modelling of the radiation doses received by workers and local residents, a total of 4000 deaths will eventually be attributable to the Chernobyl accident;
- Environmental fallout from the accident affected cropland, forests, rivers, fish and wildlife, and urban centres. In the three countries most affected, nearly 800 000 ha of agricultural land was removed from service, and timber production was halted on nearly 700 000 ha of forest.

The psychosocial impacts were also devastating. Over 100 000 people were evacuated immediately after the accident, and the total number of evacuees from severely contaminated areas eventually reached 340 000. While these resettlements helped to reduce the collective dose of radiation, they were deeply traumatic for those involved.

Studies have found that exposed populations had anxiety levels twice as high as normal, with a greater incidence of depression and stress symptoms. Despite enormous relief efforts by the affected governments and outside organizations, these populations came to regard themselves not as ‘survivors’, but as helpless, weak and lacking control over their futures. This psychosocial milieu has been exacerbated by severe economic hardship, the exodus of skilled workers (especially young people), difficulty in delivering social services, the prevalence of misconceptions and myths regarding health risks, and what the report calls a ‘paralysing fatalism’ that has led to both excessive health anxieties and reckless conduct.

As a result, poverty, mental health problems, and ‘lifestyle’ diseases have come to pose a far greater threat to affected communities than radiation exposure.

The third impact I mentioned is the enormous influence of the Chernobyl accident on the nuclear industry. A decade earlier, the accident at Three Mile Island had already cast doubt on the ability of nuclear power plant operators to prevent severe accidents. Chernobyl had a far greater impact: the accident imprinted itself on public consciousness as proof that nuclear safety was an oxymoron. Some countries decided to reduce or terminate further construction of nuclear facilities, and the expansion of nuclear capacity came to a near standstill. It has taken nearly two decades of strong safety performance to repair the industry’s reputation.

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INTERNATIONAL COOPERATION: THE KEY FACTOR

The key point in understanding each of these impacts, in turn, is that they were all driven, in a sense, by a lack of international cooperation. The Chernobyl accident revealed a sharp disparity in nuclear design and operational safety standards. The first lesson that emerged from Chernobyl was the direct relevance of international cooperation to nuclear safety. The accident also made clear that nuclear and radiological risks transcend national borders. As Hans Blix, Director General of the IAEA at that time said, “an accident anywhere is an accident everywhere.”

Since that time, international cooperation has become a hallmark of nuclear safety, resulting in innumerable peer reviews, safety upgrades, bilateral and multilateral assistance efforts, safety conventions, and the body of globally recognized IAEA safety standards. In short, what might be called the most ‘positive’ aspect of ‘Chernobyl’s legacy’ is today’s global nuclear safety regime. Had this level of cooperation already been in place in the mid-1980s, the Chernobyl accident could arguably have been prevented.

However, it was also a lack of international cooperation in the months and years following the Chernobyl accident that helped to exacerbate the social effects of the disaster. As the Chernobyl Forum reports have rightly pointed out, poor analysis of the health and environmental risks to affected populations led to substantial unnecessary resettlement and economic disruption. Moreover, the perpetuation of conflicting information about the accident, and the resulting health and environmental risks has led to widespread distrust of ‘official’ information — including, notably, among the affected populations.

It was in an effort to correct this situation — to set the record straight on Chernobyl through clear scientific consensus — that the Chernobyl Forum was established. Once again, international cooperation has been a key factor in its success. The joint contributions of hundreds of scientists, economists and health experts, supported by eight specialized United Nations agencies, together with the Governments of Belarus, the Russian Federation and Ukraine, are what grant this compilation of research its authority. To highlight this effort, and to publicize the conclusions of these reports, the IAEA, the World Health Organization (WHO) and the United Nations Development Programme (UNDP) have launched a joint press campaign, coinciding with this conference. This type of cooperation will continue to be essential as we look to the future.

TECHNICAL COOPERATION TO MEET HUMAN NEEDS

In the 20 years since the accident, nature has healed many of the effects. Near the closed down Chernobyl nuclear power plant, a new forest has matured where the so-called 'red forest' stood in 1986. Wildlife abounds in the nature reserve created in the exclusion zone. Human exposure levels in contaminated areas have dropped exponentially and will continue to decline.

Nevertheless, approximately 10 000 km² of land in the three most affected countries will remain substantially contaminated for decades to come. Radio-nuclide concentrations in crops, animals and natural food products (such as wild berries and lake fish) will remain elevated for a long period, as will the associated levels of human exposure. These abnormal human exposure levels, as well as the continuing thyroid cancers, will still require regular monitoring and, in some cases, continued intervention and treatment.

From the time of the accident, the IAEA has been continuously involved in technical assistance and research projects to mitigate the environmental and health consequences in affected areas. Since 1990, more than \$15 million has been disbursed through the IAEA technical cooperation programme on a broad range of these projects, often in cooperation with other organizations represented here today. We will continue those efforts, and we are committed to the UN Strategy for Recovery, launched in 2002. We strongly support the United Nations focus on developing new initiatives to address "the human needs of the affected individuals", with a view to progressively restoring life to 'normal' to the degree possible.

CONCLUSION

In closing, I would like to thank all of the organizations that have contributed, willingly and cooperatively, to the achievements to date of the Chernobyl Forum. I cannot begin to introduce all of those representing these organizations, much less the dozens of scientists and experts present today whose inputs have been central to these reports, but I will at least name the organizations: WHO and UNDP that I have already mentioned; the Food and Agriculture Organization of the United Nations (FAO), the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the World Bank.

In addition, I would like to thank the governments of the three most affected countries for the cooperation we have received. We are honoured to have with us today Mr. V. Tsalko, Chairman of the Committee on the Problems

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of the Consequences of the Catastrophe at the Chernobyl Nuclear Power Plant of the Republic of Belarus; Ms. N. Gerasimova, Deputy Minister for Emergencies of Russia; and Ms. Amosova, First Deputy Minister of Ukraine's Ministry for Emergencies and Affairs of Population Protection from the Consequences of the Chernobyl Catastrophe.

Finally, I would like once again to thank Dr. B. Bennett for his leadership as Chairman of the Chernobyl Forum. I wish all of you every success in the conference we are jointly opening today.

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V. Tsalko

Chairman of the Committee on the Problems of the Consequences
of the Catastrophe at the Chernobyl Nuclear Power Plant
of the Republic of Belarus,
Minsk, Belarus

First of all, allow me to commend the Director General of the IAEA, Dr. Mohamed ElBaradei, on providing the impulse and ensuring the successful fruition of the initiative to launch the United Nations International Scientific Forum on Chernobyl. This initiative of the IAEA's Director General came about in the course of a visit to Belarus, and as a result our country has taken part in the work of the Forum with a special sense of responsibility. The work of the Forum and its final documents have considerable practical value in optimizing State policy as regards overcoming the consequences of the Chernobyl catastrophe and sustainable development of the areas affected, and also the development of international Chernobyl cooperation.

Outlining the conclusions of the work of the Chernobyl Forum, which we are starting today, is an important milestone in solving the problems associated with overcoming the consequences of the catastrophe at the Chernobyl nuclear power plant. The Republic of Belarus expects that the results of the work of the Forum will enable the world community and the three most severely affected States to pursue an agreed policy on how to deal with the consequences of this, the largest, human-made catastrophe in the history of humanity, which has changed the lives of the present generation and will also change the lives of future generations.

Over the past years, the Republic of Belarus has done a great deal of work to overcome the consequences of the Chernobyl catastrophe. A number of State Chernobyl programmes have been implemented. A legislative and regulatory basis has been established in virtually all the necessary spheres. At its foundation are the laws of the Republic of Belarus on the social security of citizens affected by the catastrophe at the Chernobyl nuclear power plant, on the legal regime for territories subjected to radioactive contamination as a result of the catastrophe at the Chernobyl nuclear power plant, and on the radiation safety of the population.

A total of 137 600 people were moved out of the regions subjected to radioactive contamination. More than 66 000 apartments and houses were built for the people who were resettled, and 239 settlements were established in

clean regions of Belarus. Improvements to the living environment have been made in the settlements and in densely populated resettlement areas. Comprehensive schools, kindergartens, polyclinics and hospitals were built, and work is continuing to supply gas to the affected regions.

Nevertheless, the Government of the Republic of Belarus is still faced with the need to continue large scale activities to overcome the consequences of the Chernobyl catastrophe. This can be illustrated, for example, by the fact that it is planned to allocate around \$2 billion to implement the regular State programme for 2006–2010. However, as has been vividly shown by the almost 20 years of experience so far in overcoming the consequences of the Chernobyl catastrophe, the efforts of Belarus alone are not enough.

The basic goal of State policy in the sphere of overcoming the consequences of the Chernobyl catastrophe is to ensure public safety, to provide health care for the 1.5 million people who continue to live in radioactively contaminated areas, including some 100 000 of those who took part in ameliorating the consequences of the accident.

To attain this goal, a number of measures for radiation protection of the population are being carried out; these are aimed at limiting doses and maintaining them within the legal limits. Protective measures are continuously being taken in the agro-industrial sector and in forestry, aimed at production that meets national permissible levels. Agricultural activities are now being pursued on 1.3 million ha of contaminated land. The methods and techniques developed by our specialists enable production on this land to meet radiation standards.

As the years go by, the number of settlements where the radiation control system detects cases of milk production with a higher than permissible ^{137}Cs content is decreasing. These 'critical' settlements are in an area under special observation by the State authorities and it is to this area that the funds necessary for taking protective measures are preferentially directed.

The highest priority in State policy is attached to health problems in the affected population, in people who took part in ameliorating the consequences of the accident and in children living in areas contaminated with radionuclides. The system developed by scientists and financed from the State budget for medical monitoring, for providing dispensaries, diagnosis and treatment of diseases, and for recuperation and rehabilitation does, to a certain extent, compensate for the health damage brought about by the Chernobyl catastrophe.

According to our specialists' predictions, however, in addition to the continuing rise in thyroid gland cancers and diseases caused by exposure to radioactive iodine, in the coming years we can expect an increase in other types of malignant neoplasms and an increase in the number of heart–circulatory and

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other non-oncological diseases. Thus, the health of the affected population remains at the forefront of the Government's attention. We are continuing to work on improving the medical services to the population, and equipping health institutions with up-to-date equipment, medicines and better qualified medical staff in the affected regions.

With a view to solving Chernobyl issues, the Republic of Belarus is working closely with the United Nations, the IAEA, the World Health Organization and other international organizations, and governmental and non-governmental organizations in a large number of countries.

On behalf of the Government, I should like to express thanks to all of those who have held the Chernobyl tragedy close to their hearts, and who have given and continue to give us assistance in overcoming the consequences of the Chernobyl catastrophe.

I should like to underline that the United Nations International Scientific Forum on Chernobyl has made a significant step forward in understanding all the long term consequences of the Chernobyl catastrophe. At the same time, both the work of the Forum and its final documents show that a number of questions, including those related to the medical consequences of the accident at the Chernobyl nuclear power plant, remain open and require further detailed study.

For our country, the criterion for the effectiveness of the Forum is not only the set of recommendations to the Governments of the affected States, but also future joint work on their practical realization. The Republic of Belarus is prepared to collaborate actively to this end with all the international organizations participating in the work of the Forum.

We have to take account of the fact that many problems still need to be resolved; above all, the population remains concerned about their health, the production of clean products, the return to normal conditions of life and work, and radiation safety.

In our view, the main focus of the future strategy for overcoming the consequences of the Chernobyl catastrophe should be a stage by stage rehabilitation of the contaminated areas and of the population living in them. The goal of this strategy is to create the conditions for full-value life and for the pursuit of profitable economic activities that are not limited by the radiation factor. To attain this goal, we require approaches, approved by the world community, to rehabilitation measures that are based on a cost-benefit analysis.

The issue of rehabilitating contaminated areas is tightly bound up with radioecological, economical, demographical and socio-psychological factors. The experience in our country shows that rehabilitation issues can only be solved successfully on the basis of a detailed assessment of all the components determining the situation in a specific settlement, State-run, collective or

TSALKO

privately owned farm. Furthermore, we need to take into account the fact that the success of our efforts depends largely on how the measures being taken are accepted by the population, and so informing the public and local executive authorities is a particularly pressing issue.

In developing the State programme for overcoming the consequences of the Chernobyl catastrophe for 2006–2010, the Government of the Republic of Belarus is faced with the task of ensuring real economic revival and sustainable development in the affected regions. What is needed is not only ‘clean’, but also profitable production based on the introduction of scientifically validated technologies. The new State programme will take into account the main recommendations of the Chernobyl Forum and we hope that they will help us to take yet another step towards overcoming the consequences of the Chernobyl catastrophe in our country.

In conclusion, as the co-Chair of the International Organizing Committee, I would like to invite you all to take part in the international conference entitled 20 Years after Chernobyl: Strategy for Recovery and Sustainable Development of the Affected Regions, which will be held from 19–21 April 2006 in Minsk.

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LONG TERM CONSEQUENCES OF THE CHERNOBYL CATASTROPHE AND REMEDIATION PROGRAMMES IN THE RUSSIAN FEDERATION

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Let me express our thanks to the IAEA and United Nations organizations for arranging and supporting the fruitful activity of the Chernobyl Forum.

The unprecedented scale of the radiological emergency at the Chernobyl nuclear power plant has left us with a legacy of extremely difficult tasks aimed at eliminating the negative consequences and creating a return to normal life in contaminated areas.

Due to the accident, more than 56 000 m² of the Russian Federation's territory, including about 2 million ha of agricultural land and about 1 million ha of forest, were contaminated with radioactivity. The four regions Bryansk, Kaluga, Orel and Tula were contaminated to the largest extent. More than 3 million people lived in those areas and more than 52 000 citizens were relocated in an organized way or resettled independently. More than 200 000 Russian citizens were involved in the response to the emergency.

The Government of the Russian Federation has charged the Russian Ministry for Emergencies (EMERCOM) with coordinating activities for the mitigation of consequences of the Chernobyl accident. The Ministry has undertaken the function of a State customer of federal target programmes for eliminating effects of radiological emergencies and catastrophes. Federal ministries and agencies, as well as executive authorities of the Russian Federation are involved in implementing the programmes. Joint Russian–Belarus projects to mitigate effects of the Chernobyl catastrophe have been under way since 1998.

Large scale work on radiological, medical and social protection for citizens, and remediation of land has been performed within the scope of federal target programmes. Since 1991, more than \$5 billion has been spent on the activities to mitigate the consequences of the accident, as well as on paying out benefits and compensation.

The key element of EMERCOM's policy is to comprehend the role of a radiation factor in the entire package of vital objectives. As a result, protective actions are directed towards the most contaminated areas and priority attention is focused on the development of social aspects and health care.

The main programme trends are as follows:

- Social and economic remediation of the areas;
- Public health protection;
- Radiation monitoring;
- Public exposure dose reduction;
- Remediation of agricultural/forest land;
- Providing information and social-psychological rehabilitation for the public.

Let me summarize the results of our work. Our 20 years of experience in research and practical activities has allowed us to conclude that the severest consequences of the Chernobyl accident have been social in nature and are not as a consequence of radiological events. Proper protective action, mainly in agriculture and forestry, have only been implemented in the four most contaminated regions. The running foodstuff monitoring shows that it is only in the Bryansk and Kaluga regions that samples taken recently have not met radiological and hygienic requirements. As for the other areas, practically all foodstuffs did meet hygienic standards.

A considerable number of buildings of social value, such as housing, schools, preschool institutions, gas and water supply networks, hospitals, polyclinics, gym and sanitary complexes etc., have been commissioned on contaminated lands.

A large amount of research has been performed in the areas of radiation epidemiology, health care, radiation hygiene and agricultural radiology. The Russian State Medical and Dosimetry Registry holds data on more than 600 000 people. The research results have contributed a lot to the work of the Chernobyl Forum.

Activities on information work and social-psychological rehabilitation are under way. Three centres created jointly with UNESCO and designed to work with the public from the most affected areas, such as the Bryansk, Orel and Tula regions, have been in operation for more than ten years. The centres have won public confidence and have gained considerable experience in social and psychological assistance to different categories of people. An analysis of the centres' activity in the Russian Federation has shown that they efficiently contribute to the reduction of social tension. To improve the public information work, a network of regional information and analytical centres is currently

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being created. Their task is to provide information and consulting assistance to the public in aspects of radiation safety and to inform them of the current status of the affected areas. The Russian-Belarus Information Centre for Chernobyl Issues has been established at the Institute of Nuclear Safety. It will become part of the International Chernobyl Research and Information Network (ICRIN).

Of special significance are the activities that serve to draw the attention of the international public to the issues of the affected regions, implementation of joint international projects on elimination of radiological emergency effects, rehabilitation of people and remediation of the areas. For the past two decades, international assistance and cooperation has been multifaceted. It covered scientific cooperation and practical action in the areas of health care, agriculture, information activity and other fields, as well as children's rehabilitation and many other humanitarian projects. The Russian Federation highly appreciates the international community's assistance rendered in eliminating long term effects of the Chernobyl catastrophe.

The most vital thing for the successful mitigation of the consequences of the catastrophe is scientific justification for the strategy aimed at a return to normal life in contaminated areas. Today, it is possible to state that basic forecasts elaborated by the international scientific community have proved to be correct. The conclusions and recommendations of the 1986 Vienna conference, the 1991 International Chernobyl Project, the Vienna conference "10 years after Chernobyl", joint projects of the European Commission, the IPHECA project of WHO as well as the results of activities under the Franco-German Initiative, reports of UNSCEAR and the UNDP Evaluation Commission work towards a common goal.

The Chernobyl Forum has set the task of systematically reviewing the entire volume of accumulated data with the aim of achieving an efficient scientific consensus on the effects of the accident. The solution will allow us to move forward with more confidence. In the forthcoming days, we will consider the basic results of the Forum's activity and outline future objectives.

As for the Forum's recommendations, they will, undoubtedly, be very useful. Still, I would like to point out that scientific recommendations cannot always be implemented immediately and fully. A scientific vision of the situation is only part of the problem. State policy represents public compromise and we ought to take into account all the liabilities taken by the State in the social protection of the citizens affected by the accident. Overall, all the activities in the Russian Federation to mitigate the consequences of the Chernobyl catastrophe adhere to the Chernobyl Forum's recommendations which represent an integral system of measures for eliminating medical, ecological and socioeconomic consequences of the Chernobyl accident.

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During the period of almost 20 years that have passed since the Chernobyl catastrophe, work on a huge scale has been performed to rehabilitate the public and remediate the areas affected by radiation. Nevertheless, due to the long term nature of the consequences such as long-lasting radioactive contamination and distant medical effects for public health, the issue of checking and agreeing results of the research will remain on the agenda in the future.

Dissemination of the Chernobyl Forum's results is one of the most urgent objectives in the near future. Our experience shows that the task of harmonizing radiation risk perception is extremely difficult.

I would like to point out another significant trend in international cooperation, which is an increase in preparedness to radiological emergency response. This task is beyond the Forum's scope; however, it is of vital importance under conditions of new threats and challenges to civilization. EMERCOM's experience in the area and readiness for international cooperation are well known.

To conclude, on behalf of EMERCOM and of the Russian Federation's Minister Sergey Shoigu, I wish all participants of the Conference successful and fruitful work for the sake of the well-being and health of those people who have suffered in the Chernobyl catastrophe. We hope that cooperation within the Chernobyl Forum's framework will provide an effective solution for the issues we are facing with respect to eliminating the consequences of the Chernobyl accident.

OPENING ADDRESS

T.V. Amosova

First Deputy Minister,

Ukrainian Ministry for Emergencies and Affairs of Population Protection from
the Consequences of the Chernobyl Catastrophe,
Kiev, Ukraine

On behalf of the Government of Ukraine and our delegation, allow me to welcome you and wish you successful and fruitful work at the conference.

For almost 20 years now the Chernobyl catastrophe has been in the public eye. It has led to considerable changes not only in Ukraine, Belarus and the Russian Federation, but also worldwide. The catastrophe has had a significant political impact and has altered perceptions with regard to nuclear power. The international standards and rules for radiation protection and national strategies for nuclear power development, for strengthening nuclear safety and for managing radioactive waste have undergone review.

The scale of the consequences of the Chernobyl catastrophe as regards the environment, human health and socioeconomic development has been enormous. One twelfth of the entire territory of Ukraine has, in accordance with Ukrainian legislation, been designated as radioactively contaminated, that is an area of 53 500 km². There are 2293 settlements located on this territory. Today, there are more than 2.2 million people living on this territory. Virtually all of Ukraine's forest tract, covering 16% of its total area, has been subjected to radioactive contamination.

I shall not dwell any more on the details of specific figures characterizing the scale of the radioecological consequences that echo those in the reports from the Russian Federation and the Republic of Belarus, because they have been published often in official documents and scientific publications.

However, there is a fundamental difference in how the consequences of the Chernobyl catastrophe are being overcome in Ukraine. This is because the Chernobyl nuclear power plant and its 'shelter', which has already been covering the nuclear accident site for 19 years, are located on Ukrainian soil. For many years, world attention has been focused on how the consequences of the accident are being dealt with on these sites.

At enormous cost and effort, the 'sarcophagus' was built over the destroyed reactor, three units at the nuclear power plant were brought into operation, all necessary measures were taken to improve the safety level of the

reactors and the new town of Slavutich was built for the nuclear power plant workers.

In 1994, the international community, represented by the leaders of the G7 and the European Union (EU), proposed to Ukraine that the Chernobyl nuclear power plant be shut down. In 1995, a Memorandum of Understanding was signed whereby Ukraine undertook to shut down the Chernobyl nuclear power plant. The parties acknowledged that final closure of the Chernobyl plant would have a negative economic impact on Ukraine.

Ukraine fulfilled its obligations — in 2000 the plant was shut down, despite the fact that Ukraine was neither technologically nor financially prepared to do so. There was no plan for decommissioning the Chernobyl nuclear power plant, which, according to the regulations, should have been approved five years prior to plant shutdown, nor had any decommissioning fund been set up.

Thus, under a joint Ukraine–G7 action plan to support closure of the Chernobyl nuclear power plant, it was proposed that a series of international projects, funded by grants, be undertaken to improve safety. At the current time, four major projects are being implemented on the Chernobyl nuclear power plant site. They vary in scope, period of implementation and sources of funding. The donors for these projects include virtually all the developed countries in the world.

However, there are delays of between four months to six years in implementation of these projects. The key project for decommissioning the Chernobyl nuclear power plant — construction of spent nuclear fuel repository No. 2 — is experiencing the longest delay. The original construction schedule envisaged completion in March 2003.

This is a turnkey project that is being implemented by the State-owned Framatome ANP. Work was brought to a halt when the number of errors in the project exceeded all admissible limits. The new completion date now being put forward by the company is 2010 and the cost has increased threefold as compared with the original estimate. This is an unprofessional approach and one that we cannot condone.

As a result, five years after shutdown of the Chernobyl nuclear power plant, there is still fuel left in the reactors. We have to take a decision now about removing the spent fuel and putting it into the existing interim repository whose service lifetime is about to expire. There are a total of 22 000 spent fuel assemblies at the plant. Each year of delay in decommissioning the plant because the new repository is not yet ready means additional outgoings from the Ukrainian State budget of some €15 million.

I should like to dwell briefly on another — the biggest — international project, referred to in the agreement between Ukraine and the G7. This is the

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project for transforming the shelter into an environmentally safe system. Implementation of this project is also lagging several years behind.

Implementation of the Memorandum of Understanding, in accordance with the recommended action plan for transforming the shelter developed in the framework of a European Commission TACIS project, should result in removal of the fuel-containing masses and the establishment of regulatory control. The first part of this task, the construction of a New Safe Confinement (NSC), is currently under way in the framework of the Shelter Implementation Plan (SIP). The second part, the removal itself, should be conceptually formulated as a joint task by all the States party to the Memorandum.

This task poses a greater challenge with regard both to complexity and cost as, according to expert evaluations, the shelter contains more than 150 t of fuel from the destroyed reactor, approximately 5.5 t of fresh fuel and 15 t of spent fuel. A considerable quantity of as yet unidentified fuel may be located in the debris of the central hall of the destroyed unit. All this means that the process of removing the fuel-containing masses involves work with a very high risk of exposure and needs to be addressed through the joint efforts of specialists in the field of nuclear safety and radiation protection from all developed countries.

Amongst the territories affected as a result of the accident, the exclusion zone occupies a special place. It is characterized by:

- The highest radionuclide concentrations at the soil surface;
- The presence of large localized sources of radiation — the shelter, long term and interim radioactive waste disposal sites;
- The fact that there is a large network of Dniepr tributaries on its boundaries;
- The agricultural conditions of the Polesye area, which promote radionuclide migration;
- The curtailment of traditional economic activities.

According to evaluations made in recent years, the total radionuclide activity from the accident discharge in the natural and man-made systems of the exclusion zone is around 20 million Ci. For the zone's natural systems, that figure is up to 0.2 million Ci. In spite of this large quantity of radionuclides in the natural and man-made systems of the exclusion zone, their annual transfer beyond the zone's boundary is, owing to the implementation of scientifically validated measures, fairly limited. In recent years, the transfer amounts are approximately hundredths of a percent (10^{-2} %) from the natural system and ten millionths of a percent (10^{-7} %) from the man-made system of the exclusion zone (including the shelter).

Consequently, the barrier properties of the natural/man-made system of the exclusion zone are rather effective. The hazard level posed by this zone to the populated areas is dependent on the reliability of the barriers. All this predetermines the special position occupied by the zone as regards the system of measures aimed at minimizing the consequences of the accident at the Chernobyl nuclear power plant.

On the whole, in the 19 years that have passed since the accident at the Chernobyl nuclear power plant, the radiation situation in the contaminated areas of Ukraine has improved. This has been helped both by natural processes and by the implementation of a programme of protective measures, by decontamination work, the introduction of countermeasures in agricultural production, and so on. The situation has to a certain degree stabilized and is reliably controlled by monitoring systems such that we can now make a balanced evaluation of the effectiveness of the countermeasures taken and plan further work.

The size of the area where the radionuclide content of foodstuffs exceeds permissible levels is becoming smaller and smaller. The Ukrainian Polesse remains a critical area. Even now, we see milk produced in settlements in this area with a ^{137}Cs content ranging from 200 to 600 Bq/L. Although the number of such settlements is diminishing, they still exist. In 2004, there were 450 such settlements. Special rehabilitation programmes have been developed for these areas, countermeasures are being introduced and agricultural production is being restructured.

Annual dosimetric “passportization” of the settlements is done in the radioactively contaminated areas, with determination of the total effective dose and monitoring, using whole body counters, of the individual internal doses to the population. It should be noted that thyroid dosimetric passportization has been carried out in all settlements in Ukraine; that is, the radiation dose to the thyroid gland has been reconstructed for all the inhabitants of Ukraine, split up into seven age groups. Children whose radiation dose exceeded the established limits, were certified under Ukrainian legislation as affected by the Chernobyl catastrophe and have since been kept under observation by specialists in endocrinology.

Over the past 19 years, Ukraine has done a great deal of work in all spheres to mitigate the consequences of the accident. A basic premise of the Government of Ukraine is that overcoming the consequences of the Chernobyl catastrophe will remain a State policy priority. There are now, in accordance with Ukrainian legislation, more than 2.646 million people who are recognized as affected by the consequences of the Chernobyl catastrophe and are receiving social security.

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To this end, approximately 800 legislative acts have been drawn up and are in force in Ukraine for regulating various aspects of the lives of Ukrainian citizens with respect to the Chernobyl catastrophe. Fundamental among these are the Ukrainian laws on the legal regime in territory subjected to radioactive contamination as a result of the Chernobyl catastrophe, and on the status and social security of citizens who have suffered as a consequence of the Chernobyl catastrophe.

Just in the years since independence, more than \$7 billion has been spent from Ukraine's budget on mitigating the consequences of the Chernobyl catastrophe.

International organizations and the international community have provided considerable assistance in dealing with the consequences of the Chernobyl tragedy. The Government of Ukraine and the entire Ukrainian population would like to express their sincere acknowledgement and gratitude for the assistance received.

The accident has demonstrated convincingly that the cost of ensuring the safety of nuclear facilities is considerably lower than the cost of dealing with the consequences of possible accidents, and has also demonstrated the need for establishing and maintaining a highly effective national response system in the event of potential man-made accidents.

One approach to future resolution of pressing issues associated with dealing with and minimizing the consequences of the Chernobyl catastrophe is to find a comprehensive solution to pending tasks and a systematic approach by the executive authorities to establishing socioeconomic and organizational conditions, and assurances for the social security of the affected population and for the development of areas which have been radioactively contaminated. The way to address this problem is by harmonizing the regulatory documents and also by bringing their requirements, conditions and assurances into line with the real situation and the socioeconomic capabilities of the State.

In this connection, we have worked to bring about changes in the national programme for minimizing the consequences of the Chernobyl catastrophe and have developed all-State programmes, such as decommissioning of the Chernobyl nuclear power plant and transformation of the shelter into an environmentally safe system, comprehensive socioeconomic development of areas subjected to radioactive contamination as a result of the accident at the Chernobyl nuclear power plant and of densely resettled areas. Amendments and additions to Ukraine's chief 'Chernobyl' laws are being drafted.

The priority tasks in State policy for minimizing the consequences of the Chernobyl catastrophe up to 2010 have been determined as:

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- Health care for people who suffered as a result of the Chernobyl catastrophe;
- Decommissioning of the Chernobyl nuclear power plant and transformation of the shelter into an environmentally safe system;
- Strengthening and supporting the radiation safety barriers, radiation protection of the population in contaminated areas, limiting the transfer of radionuclides beyond the boundaries of the exclusion zone;
- Social security for the population and economic rehabilitation of contaminated areas.

On the basis of the 19 years of experience acquired in reducing the negative medical consequences of the accident, the priority groups for medical care in the current decade will be people who took part in liquidation of the consequences of the accident, individuals who received considerable exposure from radioactive iodine as children, and persons who are now living in contaminated areas.

The main challenges for social security of the population in the new phase should be:

- Improving the legislative and regulatory basis for strengthening targeted assistance for affected people and more active rehabilitation of contaminated areas;
- Raising the level of the radioecological knowledge and awareness of the population in contaminated areas;
- Implementing a State programme to change contaminated areas into ‘clean’ areas with investment incentive.

It should be kept in mind that partial resettlement in many cases led to destruction of people’s life support structure, limitations in farming activities, loss of workplaces, high unemployment and to the exacerbation of social problems. Thus, economic rehabilitation of the contaminated areas is becoming a priority in the field of the social security of the affected population. Much of the radioactively contaminated land can already be used for agricultural purposes. With the help of specialists, detailed business plans can be drawn up for utilizing this land, and for profitable agricultural production and processing. In so doing, account should be taken not only of the radiation, but also of the economic and socio-psychological factors.

The experience gained through the efforts of many countries (Ukraine, Belarus, Russian Federation, countries of the European Union, USA, Japan and others) and international organizations (the United Nations, the World Health Organization and the IAEA) aimed at scientific cooperation in

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studying the consequences of the Chernobyl catastrophe in the field of nuclear and radiation safety, radioecology and nuclear medicine have helped achieve important scientific results of considerable practical significance. At the national and international levels, there is a need to develop and intensify scientific research programmes taking into account the long term challenges.

The 20th anniversary of the Chernobyl catastrophe falls on 26 April 2006. To commemorate this tragic date in the history of mankind, an international conference entitled “20 Years after the Chernobyl Catastrophe: Future Outlook” will be held on Ukrainian soil in Kiev. The Ukrainian National Report presented at this Conference will set forth:

- The results and evaluation, from today’s point of view, of the 20 years of multidisciplinary work in dealing with the consequences of the Chernobyl catastrophe;
- The pressing problems of the future in overcoming the consequences of the Chernobyl catastrophe, and ways of resolving them in the near and long term.

The conference should provide an outline of what has already been done, determine an action programme for both the international community and national bodies for dealing with the consequences of the catastrophe and solving Chernobyl problems, and assess the impact of the consequences of the catastrophe on the development of nuclear power engineering as a whole.

We consider that today’s Forum is important for summarizing the ‘Chernobyl experience’ and we hope that the results of the work of the Forum will be presented at the international conference in Kiev and serve as a basis for policy recommendations aimed at minimizing the largest ever human-made catastrophe. We invite you to take part in the work of the conference.

OPENING ADDRESS

T. Taniguchi

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In his opening speech, the Director General Dr. ElBaradei expressed his deep thanks to all the participants of the Chernobyl Forum for their active cooperation that made this undertaking a success. I would like to add my thanks, particularly to the World Health Organization (WHO), whose constructive work in assessing the Chernobyl-related health effects especially attracting public interest was crucially important. We are also grateful to our colleagues from the United Nations Development Programme (UNDP) who complemented the IAEA and WHO technical analyses of the Chernobyl accident environmental and health consequences with analysis of its social and economic consequences, and practical recommendations in this sensitive area. Without consideration of humanitarian aspects of this multifaceted problem, the Forum's report would not be an integrated, comprehensive and useful document for a broad audience.

The Forum aims to disseminate its findings and recommendations widely through United Nations organizations and the mass media. All of you received today the Forum's main document entitled 'Chernobyl's Legacy' that presents the health and environmental impacts of the accident as well as its social and economic impacts as specifically prepared by UNDP experts. This brief report is based on two detailed technical reports on health and environmental issues, in total about 400 pages of unique consolidated scientific information, and the aforementioned United Nations report 'Strategy for Recovery'.

In total, the documentation is quite comprehensive. At the request of the Governments of Belarus, the Russian Federation and Ukraine, the Forum has included very practical recommendations for further actions. A press campaign organized by public information experts from the IAEA, WHO and UNDP is covering the release of the Forum reports and this conference.

During the last two years, two expert groups — one on the Environment coordinated by the IAEA, and one on Health coordinated by WHO — did an excellent job reviewing the most updated published information on their respective Chernobyl consequences. Each group consisted of highly qualified

experts from all over the world, including the three most affected countries. During the two year operation, 11 meetings of expert groups were held. Their work was very productive and intensive in light of the large volume of information they had to process. More detailed information on the findings and recommendations of those two expert groups can be found in the technical reports now available as working materials.

In all cases, the scientists from the United Nations organizations, the international community and the three most affected countries have been able to reach a consensus in the preparation of their respective draft documents. The reports were approved by the Forum in April 2005 and represent the common position of the eight United Nations organizations and the three most affected countries regarding the environmental and health consequences of the Chernobyl accident. The recommended actions are also the result of consensus within the United Nations system.

I would like to express special thanks to participants of the Expert Group on Environment coordinated by the Agency that prepared a very comprehensive technical report entitled 'Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience'. In several months, just prior to the 20th anniversary of the Chernobyl accident, the Agency will publish the edited technical report of about 250 pages in the Agency's regular Radiological Assessment Reports Series. The Chair of this expert group, Dr. Lynn Anspaugh from Utah State University, played a crucial role in preparing and editing this report. I would like to thank him especially on behalf of the Agency and the Chernobyl Forum.

The IAEA, as a specialized, nuclear-related, technical United Nations agency, has been involved in the mitigation of the Chernobyl accident consequences since early May 1986 when former Director General Hans Blix visited Chernobyl in order to observe the physical damage and to discuss further actions. The IAEA took on many projects related to technical assistance, technical cooperation and research — with several immediate and longer term goals: first, to mitigate the accident's radiological, environmental and health consequences; second, to improve the overall safety of other RBMK reactors; and third, to understand and disseminate globally those lessons that could be learned from the Chernobyl experience. The projects executed between 1986 and 2005 covered the full range of topics: radiation, waste and nuclear safety; monitoring human exposure; environmental restoration of contaminated land; treatment of people living in the affected areas; and development of special measures to reduce exposure levels.

The largest project took place in 1990. Over a two year period, the Agency coordinated the efforts of some 200 international experts to complete an independent assessment of the consequences of the Chernobyl accident.

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Many missions to the three most affected countries were conducted and many meetings were held.

The Agency has also organized or supported numerous international meetings to foster information exchange and to promote further assessment of the accident's radiological consequences.

The Agency continues its ongoing activities regarding the mitigation of the accident's radiological consequences as part of the United Nations strategy 'Human Consequences of the Chernobyl Accident: A Strategy for Recovery' launched in 2002. Further IAEA commitment in continued Chernobyl related activities, mainly in nuclear and radiation safety fields, may involve the following areas:

- Safety of shelter decommissioning;
- Safety of radioactive waste management in the Chernobyl exclusion zone;
- Safety of remediation of contaminated land, especially in the Chernobyl exclusion zone;
- Radiation safety of the general public residing in contaminated areas;
- Environmental monitoring and monitoring of human exposure in contaminated areas, and safety of operating and new nuclear power plants.

The Agency will not be directly involved in the technological aspects of shelter decommissioning and radioactive waste management in the Chernobyl Exclusion Zone, since these issues are strongly supported by the European Commission (EC) through the European Bank for Reconstruction and Development (EBRD). However, application of the Agency's international safety standards could contribute to the radiation safety of both the general public and the personnel involved in these operations. Let me describe in more detail our current and possible future cooperation with the three most affected countries, primarily through the Agency's technical cooperation programme.

Regarding the safety of shelter decommissioning, the Agency and the Ukrainian Regulatory Body are already cooperating on this in the framework of a current national technical cooperation project. The project is focused on safe management of residual radioactivity contained in damaged Chernobyl Unit 4. While Shelter decommissioning is a long term process, more cooperation between the Agency and Ukraine might be foreseen. One of the topical issues for consideration is provision of radiation safety for workers participating in the construction of the New Safe Confinement under specific occupational conditions.

Concerning the safety of radioactive waste management in the Chernobyl Exclusion Zone, as you will hear later in the conference, the Chernobyl Forum

recommended that “development of an integrated radioactive waste management programme 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.” This programme should consider a number of waste safety issues, such as assessment of total exposure from the numerous existing storage and disposal facilities, changes of radiation conditions due to construction of modern facilities and subsequent waste transfer to them, and other potential interventions. There is definitely room for further cooperation between the Agency and Ukraine on these waste safety topics. In particular, the Agency possesses relevant safety standards and modern assessment methodology for various designs of near surface waste disposal facilities.

Regarding the safety of remediation of contaminated land, especially in the Chernobyl Exclusion Zone, the Agency recently issued a Safety Guide entitled Remediation Process for Areas Affected by Past Activities and Accidents (IAEA Safety Standards Series No. WS-G-3.1). This Guide is based on the recent recommendations of the International Commission on Radiological Protection and could be used as the methodological basis for Chernobyl remediation. The Agency has substantial experience in the application of its safety approaches to remediation of former uranium and thorium mining and milling as well as at some nuclear weapons test sites; this experience could be useful for Chernobyl-related projects.

Concerning the radiation safety of the general public residing in contaminated areas, the Agency cooperates with the three most affected countries in the frame of a regional technical cooperation project that covers both countermeasure strategies and monitoring of human exposure in rural areas affected by the Chernobyl accident. The Agency considers this project an opportunity for the three countries to harmonize their approaches to both countermeasures/remediation and radiation monitoring. As decontamination of settlements now — 20 years after the fallout — may not be justifiable, the project mainly covers agricultural countermeasures and remediation aiming to reduce internal exposure.

On the subject of radiation monitoring, the Agency recently issued a Safety Guide entitled Environmental and Source Monitoring for Purposes of Radiation Protection (IAEA Safety Standards Series No. RS-G-1.8) that covers chronic exposure conditions such as in the Chernobyl affected areas in the long term. This guide is now being implemented in the three countries through the regional technical cooperation project. The project includes procurement of monitoring equipment and training of personnel.

Regarding the safety of operating and new nuclear power plants, the IAEA has brought together major nuclear power countries to discuss the safety

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of long term operation. Both the Russian Federation and Ukraine, since they have substantial programmes for life extension of their nuclear power plants, have been active participants in these discussions. The Russian Federation is also an active exporter of nuclear power plants and the IAEA has a very open and close relationship with the Russian Federation designers and exporters of nuclear power plants in the area of design reviews. Recently, the IAEA performed design reviews for the Tianwan nuclear power plant in China and the Bushehr plant in the Islamic Republic of Iran.

I have briefly characterized the most promising areas for cooperation between the Agency and Belarus, the Russian Federation and Ukraine. These are only illustrative examples; we will be happy to discuss the collaboration priority issues with our counterparts in the three countries. We should also consider the need for additional research on environmental issues as recommended by the Chernobyl Forum in its report and in the area of nuclear safety.

Rest assured that the IAEA, as part of the United Nations family, will continue to support activities aimed at overcoming the adverse radiological effects of the largest nuclear accident in human history.

I look forward to a successful conference and I expect that the results of your discussions will help shape the IAEA's future work in nuclear and radiation safety.

OPENING ADDRESS

M. Danzon

Director, Regional Office for Europe,
World Health Organization,
Copenhagen

Presented by R. Bertollini

First of all I would like to bring you the greetings and the apologies of the WHO Regional Director for Europe Dr. Marc Danzon who for unpredictable, last minute impediments has not been able to attend the Conference.

Twenty years ago, the Chernobyl accident hit the heart of Europe with what has been defined as the greatest “nuclear catastrophe in human history”. When the severity of the accident became clear, affecting millions of people and involving many nations, we in the WHO initiated a 20 year effort to support the countries in their attempt to respond first to the emergency and then to address the health effects of the radiation exposure at the scientific, technical, policy and humanitarian levels.

The first WHO response was immediate. Already on 6 May 1986, ten days after the accident, a group of leading experts in radiation science was convened in Copenhagen by the WHO Regional Office for Europe (WHO/EURO) to assess the situation and prepare recommendations. On 10 May, the WHO Director General informed the World Health Assembly of the actions being taken by the organization. In June 1986, WHO/EURO convened a meeting in Bilthoven, for making provisional estimates of the doses of radioactivity received by the population in Europe and the USSR. Many questions needed to be addressed. How large was the population exposure? Which diseases were expected or had already occurred? Which interventions and actions could mitigate the consequences of the exposure to the people? In other words, what could be done concretely to help support the affected countries to respond to the need of the communities hit by the disaster.

In 1990, the WHO International Programme on the Health Effects of the Chernobyl Accident (IPHECA) was launched. The programme aimed at assisting national health authorities in Belarus, the Russian Federation and Ukraine to address the health consequences of the accident, and improve the scientific understanding of the effects of radiation exposure. The programme lasted until 1998 and was mostly supported by the generous contribution of the Japanese Government, which we would like to acknowledge on this special occasion.

In the meantime, the health effects of the accident became manifested, somewhat earlier and differently than previous knowledge in radiation science had predicted. A WHO/EURO mission, early in 1992, gathered the first data on the early increase of thyroid cancer among children exposed to radioactive iodine at the time of the accident. These data, which were promptly published in the international literature, were later confirmed by further observations. Subsequently, WHO/EURO launched a programme called the International Thyroid Project, with the generous support of Switzerland and other countries to follow-up the investigations on the increase of thyroid cancer and to support an effective medical response.

At the end of 1991, a meeting organized in Solothurn, Switzerland addressed, among other issues, the psycho-social consequences of the disaster drawing attention to the role of risk communication and credibility of the information in the aftermath of an environmental accident. This was somehow a relatively new perspective, whose impact was not properly considered initially both at the national and international level.

In recent years, the WHO has continued to support the international efforts to help the affected countries through programmes addressing scientific, epidemiological and clinical issues. These additional efforts were complemented by the activities carried out in the framework of the bilateral agreements and collaboration of the WHO with the countries, aiming to provide technical assistance for the implementation of the National Environmental Health Action Plans and the reform of the public health systems.

Over the years, the estimates of the health effects of the accident have ranged enormously and this uncertainty has contributed in increasing the alarm in the affected communities as well as the sense of hopelessness towards a threat to health which was there, was perceived as uncontrollable, threatening present and future generations. We have to recognize that, in many cases, Chernobyl has become the 'explanation' for a number of problems, indeed attributable to broad public health causes and aggravated by the difficult political, economic and social transition that the affected countries have gone through over the past few years.

In this respect, the work carried out by the Chernobyl Forum represents a true breakthrough. It finally sets a solid and shared evidence base reference for the evaluation of the real impact of the Chernobyl accident on health, environment and society. We have to thank the thousands of scientists and public authorities in the countries and international organizations that over the years have made this assessment possible through their daily efforts, gathering data, treating patients and accumulating the knowledge that was necessary to move away from myths and perceptions.

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The health study provides the number of deaths, thyroid cancer cases, leukaemia and other diseases that are attributable to the radiation released at the time of the accident. These numbers shed light on the extent of human suffering and death that this environmental catastrophe has had on people. It has been argued that the health impact is much lower than predicted in earlier years. While this is true, we should not convey the message that the health consequences of Chernobyl have been mild or acceptable. The thousands of deaths and cancers are an unacceptable price paid by these communities to economic development.

On the top of these deaths and illnesses, the largest quantitative impact on health of the Chernobyl accident in terms of number of people affected is on mental health. Exposed populations have anxiety levels that are twice as high as controls and they are 3–4 times more likely to report multiple, unexplained physical symptoms and subjective poor health than unaffected control groups. Overall, mental health problems manifest as negative self assessment of health, belief in a shortened life expectancy, lack of initiative, and dependency on assistance from the State. The report attributes these problems to a lack of accurate information at the time of the accident and afterwards.

This level of psycho-social impact was unexpected. The Chernobyl accident has perhaps been the first case showing, to this extent, the importance of public communication on public health risk management not only for ethical and political reasons, but also as an instrument to prevent public concerns, health effects and long term expensive studies. In recent years, several health crises were amplified or even caused by a wrong or dramatized perception of risk, often associated with a lack of confidence in national and local authorities. Chernobyl has shown us how dramatic and how large this impact can be on health, social and community welfare. Recent worldwide alarms, such as that associated with SARS, have certainly benefited from the Chernobyl lessons in the way that information was handled and managed with the public and governments.

The report of the Chernobyl Forum poses the basis for future actions. It stresses the need to move the policy agenda from the Chernobyl-related needs towards a more holistic view of the requirements of the individuals and communities concerned. This would allow the transition from a dependency culture in the affected areas towards broad developmental policies. International efforts can only be effective if they support and amplify this need, and act as a lever for change.

The impact on mental health of the Chernobyl accident continues to represent the main challenge for public health. In order to deal with it, affected areas and populations, especially in rural areas, media and NGOs need to be provided with accurate and credible information. This is a clear, although

challenging, priority for all involved, both at the international and national level to overcome the lack of credibility that has spread in the affected communities. Putting the radiation risks in proper perspective would allow public health authorities and citizens to address resources towards pressing public health problems of these communities, which lie in poor diet and lifestyle factors such as alcohol and tobacco as well as poverty and limited access to primary health care.

However, specific health needs of the affected populations will continue to require attention and follow-up such as medical care of the workers who recovered from acute radiation syndrome and other highly exposed emergency workers. Population subgroups known to be particularly sensitive (e.g. children exposed to significant amounts of radioiodine or who resided in 1986 in the areas with radioactive fallout) should be considered for screening of specific outcomes, such as thyroid cancer, keeping in mind the cost-benefit of each programme. Population health should continue to be monitored through cancer registries and follow-up studies to describe trends and address priorities

The impact of the Chernobyl accident on health has been dramatic but different than expected. It has posed a tremendous health, social and economic burden on the people of Belarus, the Russian Federation and Ukraine. Now the picture of the impact of the accident on health and environment is clearer and the agenda can further move towards development and focused health programmes. The work of the Chernobyl Forum, which allowed this important objective to be reached, is an example of the multiplied added value that different United Nations agencies working together can achieve when addressing complex problems affecting large communities in an independent, comprehensive and credible way.

This model should be the basis for future action with the Member States towards reconstruction, development and better health.

OPENING ADDRESS

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As many of you know, last year saw the transfer of coordination responsibilities for Chernobyl issues from the United Nations Office of the Coordinator for Humanitarian Affairs (UN-OCHA), the humanitarian arm of the United Nations, to the United Nations Development Programme (UNDP), my own organization. This shift in responsibility was a long overdue recognition that, after 18 years, the challenges facing the communities of Chernobyl were best served by a focus on economic development and the creation of new livelihoods rather than on the provision of emergency humanitarian aid. This transfer was one of the many consequences of the ‘new strategy’ on Chernobyl adopted by the United Nations in 2002. The creation of the Chernobyl Forum, the distinguished body that is now concluding its work with the impressive findings announced today, was another.

At the ceremony commemorating the 18th anniversary of the disaster, and marking this United Nations handover of responsibilities, the then UNDP Administrator, Mr. Mark Malloch Brown, began his speech by remarking that everyone remembers where they were in 1986 when they first heard about the nuclear accident at the Chernobyl nuclear power plant. Everyone remembers the terrifying news that a radioactive cloud was moving slowly over Europe — news that emerged belatedly and haltingly owing to the initial Soviet silence on the accident. This was truly a global shock, when everyone shared the fear of an invisible menace that threatened millions of people.

With a few notable exceptions — and here we would like to recognize with gratitude the engagement and financial support of the governments of Japan, Switzerland, Canada, the USA and the EU, as well as the tireless efforts of countless Chernobyl charities — those outside the region forgot about the issue years ago. Most people outside the region assume the problem has long been solved. For insiders, however, Chernobyl remains frozen in time. As one of the Belarus scientists put it during a Chernobyl Forum meeting this year, people in her country divide time into life before the accident and life after it. Chernobyl changed things utterly.

Entire communities in affected areas have long felt themselves marked by Chernobyl; they have felt they faced a death sentence cast by radiation. The message of the Chernobyl Forum is thus a profound breakthrough, a real milestone. This message is a hugely reassuring and hopeful one. As we will hear in more detail in the expert sessions, for the vast majority of people, the fears associated with exposure to radiation from Chernobyl have been exaggerated. The damage, both to human health and the natural environment, has been much smaller than is commonly assumed and still propagated by many. People in the affected communities can, with very few exceptions, pursue normal lives.

We owe a debt of gratitude to the scientists assembled by the IAEA and the WHO, who have sifted through volumes of evidence to bring us such a welcome, and well documented, message. Although there are some caveats, footnotes and unknowns, as well as recommendations for further research, the message is clear. We got off lightly. The impact was much smaller than anybody could have predicted. The danger of radiation has largely passed.

It is important to stress, however, that this message of reassurance does not in any way diminish the suffering that the affected communities have experienced. Their suffering is real, it continues to this day, and it would be a mistake to dismiss it as somehow 'irrational', 'imagined' or 'self-induced'. To find solutions to the suffering that these communities have experienced, however, it is essential to understand the causes, and that is what the Chernobyl Forum has helped us to do.

UNDP'S CONTRIBUTION TO THE CHERNOBYL FORUM

UNDP's contribution to the Chernobyl Forum has been to assess the socioeconomic impact of the accident, and to make policy recommendations in this area to the three Governments. These findings are available in a more detailed form in the Chernobyl Forum "Digest" and in our 2002 "Strategy for Recovery" report.

In summary, the accident had an enormous socioeconomic impact. Some effects are a direct result of the accident and the policies adopted in its aftermath: the shutdown of the reactor; the cost of alternate energy supplies; the cost of relocating 350 000 people; the cost of constructing new homes and infrastructure for those relocated; the cost of developing and applying 'clean' cultivation and farming techniques; the cost of a vast system of radiation monitoring; and the overwhelming burden of benefits and privileges for those classified as victims of Chernobyl — a group that now numbers an estimated seven million people.

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However, it is crucial to remember that the Chernobyl accident was followed in a few short years by the disintegration of the Soviet Union, the creation of three new independent states with significant Chernobyl-affected territories, the breakdown of the old command economy and Soviet era trade ties, and their replacement with a range of market-oriented reforms and ‘transition’ economic policies. These factors were disruptive everywhere, but in the ‘contaminated’ regions the disruption they caused tended to be blamed entirely on Chernobyl.

Economic transition hit rural communities hard everywhere, particularly where collectivized agriculture had functioned with very large subsidies from the State. Since in Chernobyl-affected regions most communities relied upon farming, this posed a double burden: first radiation made much agricultural production off-limits, then market forces made cheap inputs and preferential pricing vanish. Even after radiation receded to safe limits, Chernobyl-area ‘branding’ hampered sales. Investors stayed away. High unemployment and, particularly, underemployment were the result. For many, dependence on State benefits became a way of life.

Lack of opportunity and fear of radiation prompted an exodus of young and skilled people from the region. The demographic profile of the region became badly skewed. An ageing population meant that deaths exceeded births, further fuelling fears that the region was somehow a poisonous death trap. As was the case across much of the former Soviet Union, life expectancy fell precipitously — though in Chernobyl, radiation rather than cardiovascular ailments or lifestyle causes such as alcohol and tobacco abuse, and accidents wrongly took the blame.

As a result of all these factors, a ‘culture of dependency’ developed in many communities affected by Chernobyl — though here too the legacy of Soviet over-centralization also played a role. People tended to wait for the State to come to the rescue, and when it did not, to sink into apathy and fatalism. A sense of abandonment took root, and the self-reliance needed to compensate was lacking.

The bottom line message, then, that UNDP brings to the Chernobyl Forum is that poverty, not radiation, is the real danger. This problem is not unique to the Chernobyl-affected communities, but they face it in a particularly acute form.

WHAT IS UNDP DOING? WHAT SOLUTIONS DO WE HAVE TO OFFER?

For the world of science, the Chernobyl Forum is an end point of sorts, as it resolves most of the long running debates about the impact of Chernobyl. For the development community, however, it is really something of a starting point. That is why our contribution to the conference is entitled “The Way Forward”. Radiation fears have been laid to rest, but the plight of communities remains dire. Thus, UNDP’s contribution to this Forum takes the form of proposed solutions to some of the problems faced by affected countries, communities and individuals.

These solutions, which build on both field work in Chernobyl-affected communities and UNDP’s development experience worldwide, fall into three areas, which our presenters will describe in greater detail at tomorrow’s session.

First, information. This has been a central challenge from the start. For outsiders, the Soviet failure to inform the rest of the world about the Chernobyl nuclear accident was a sign of the lurking menace of communism. For insiders, for citizens of the Soviet Union, who learned of the peril only over time, and in limited doses, and often only after their frustration found an outlet in the *glasnost* period and forced officials to disclose more information, the lack of prompt and proper information created a sense of betrayal and mistrust that persists to this day. In this sense, such serious publications as *The Economist* have even argued that it was Chernobyl that ultimately brought down the Soviet system.

Recent research has shown that people in the Chernobyl region still lack the information they need to lead healthy, productive lives. Information itself is not in short supply; what is missing are creative ways of disseminating information in a form that induces people to change their behaviour. The Chernobyl Forum findings on radiation suggest, moreover, that propagation of healthy lifestyles is at least as important as providing information on how to live safely with low dose radiation. To improve the mental health of the population and ease fears, credible sources need to dispel the misconceptions surrounding Chernobyl.

The Chernobyl Forum findings are invaluable raw material here. The fledgling International Chernobyl Research and Information Network — about which you will be hearing more tomorrow — is the vehicle we envisage for disseminating this information in a way that is both credible and accessible to local residents.

Second, policy. The findings of the Chernobyl Forum should facilitate a major reorientation in government policies. Let me cite a few examples:

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- The mild impact of radiation should prompt an overhaul of zoning definitions and regulations, as many areas now classified as too dangerous for human habitation or commercial activity are in fact quite safe;
- The reassuring prognosis for radiation-related diseases should provide yet another argument for channelling investment away from specialized hospital facilities and towards better primary and preventive health care;
- The low, virtually riskless levels of radiation risk faced by most Chernobyl-area residents should prompt a radical overhaul of Chernobyl benefits and privileges, so that the truly needy are covered by an efficient, targeted mainstream social welfare programme that covers the entire population and the ailing are similarly assisted by mainstream health care provision — and so that scarce budgetary resources can be channelled to more productive spending that promotes growth, employment and investment.

The point is not just to change policies specific to Chernobyl, but also to adjust broader economic and social policies in ways that will spur economic development nationwide, including, inevitably, in the Chernobyl regions. The development of sturdy local businesses depends heavily on sensible regulations at the national level, including straightforward rules on founding and registering companies, simplification of licensing and inspection rules, provision of affordable finance, and market-oriented training and education policies.

Third, community development. Here we draw heavily on our recent experience in Ukraine, where a holistic approach we call ‘Area-Based Development’ aims essentially to restore a sense of community self-reliance by showing local residents that they themselves hold the key to their own recovery, whether in the field of health, employment or communal services such as heating and water. We find this an especially exciting prospect because the methodology is simple, the costs are modest and the impact can be stunning, as towns and villages once reduced to paralysis and resignation rediscover the true meaning of ‘community’.

Going forward, these are three areas — information, policy and community development — around which UNDP intends to organize its efforts in supporting the three Governments on Chernobyl recovery. Cooperation among the three countries, assisted by our three Country Offices and our coordination efforts at United Nations headquarters, is crucial to this effort. Since funding is in short supply, successes in one area should be shared and replicated in others.

CONCLUDING THOUGHTS

Chernobyl has long inspired nothing but despair. Yet, the Chernobyl Forum findings have shown conclusively that fear of radiation is a far greater threat to the affected individuals and communities than is radiation itself. We at UNDP are both honoured and proud to have taken part in an undertaking that we believe will help to transform a generation of defeated ‘victims’ into a generation of proud ‘survivors’. We intend to devote every effort to transform what has haunted the region as a symbol of fear and destruction into a triumph of human perseverance.

ENVIRONMENTAL AND HEALTH CONSEQUENCES
OF THE CHERNOBYL ACCIDENT

(Session 1)

Chairperson

B.G. BENNETT

Radiation Effects Research Foundation
Japan/USA

CHAIRPERSON'S INTRODUCTORY REMARKS

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As is well known and has been stressed by speakers in the first session of this conference, the Chernobyl accident was an unprecedented disaster of very large scale. There was widespread radioactive contamination of the environment, harmful consequences to human health, and also substantial social and economic costs. It was the most devastating accident that could ever occur at a nuclear power plant, with total destruction of the reactor core and release to the environment of enormous quantities of radioactive materials.

Surely this was a unique event that will never be allowed to occur again. This one accident has given indelible lessons on reactor safety and on how to manage the response to such a catastrophe with effective countermeasures, protective actions and recovery strategies.

The accident was so serious and consequences so diverse and complex that questions still remain on the actual effects caused by the accident and on what further measures of protection or surveillance might still be needed. Authoritative assessments of the many outstanding issues are needed to guide governments with useful and cost effective measures to continue to deal with the accident, and to advise and reassure the residents of the contaminated areas.

To contribute to better understanding of these issues and more effective management of the limited resources that can or must continue to be directed at the recovery process, the Chernobyl Forum was established as an initiative of the IAEA and sponsored by a number of international organizations.

The Chernobyl Forum has involved representatives of the Governments of the affected region, who have been dealing with the social and economic aspects of the accident, and scientists who have experience in evaluating the health and environmental aspects of the accident. There has been a great desire to look back at the experience of the past two decades and then to continue forward in positive and effective ways to improve the health and economic well-being of the residents of the three countries. We desperately need to reach consensus on this to make useful and sensible progress in dealing with the issues of the accident that still remain, and that require and demand continued attention.

BENNETT

At the beginning of the Forum's activities, we could all agree on the basic issues to be addressed. We all recognized the serious consequences of the Chernobyl accident, both in scope and duration of the distress and disruption that resulted.

We all appreciated the extensive efforts that have gone into the cleanup, remediation, monitoring and, in general, dealing with the complex impacts on human health and on the environment.

We all understand that complex issues remain, and decisions must be made to ensure further recovery and the well-being of the affected population. Although radiation exposure is part of the problem, there are many other factors involved, including social disruptions, depressed economic development and psychological stress that detract from the well-being of the populations of the affected regions.

We all desire a wider public understanding of the consequences of the accident and clear priorities for further research, and to continue to effectively manage the recovery process.

We all hope that the Chernobyl Forum can contribute in a positive way to achieve consensus on disputed issues, to promote public understanding and to make realistic suggestions to help alleviate the lingering consequences of the accident.

METHOD OF WORK OF THE FORUM

Many scientists as well as representatives from United Nations organizations and Governments of affected regions participated in the work of the Chernobyl Forum. Several meetings of the Forum were necessary to initiate the work and monitor the progress of the expert groups. Two expert groups formulated comprehensive reports — one on environmental issues organized by the IAEA, and one on health issues organized by the WHO. Experts from throughout the world were invited to contribute to these evaluations. The representatives of governments and the staff of international organizations then reviewed the results of these groups to be sure that the reviews were complete and the evaluations reasonable, so that they could serve as the basis for consensus agreements and effective recommendations for further dealing with the consequences of the accident.

One person was selected as chairman of the Forum. Let me introduce myself. I am Burton Bennett, and at the time of my selection, I was Chairman of the Radiation Effects Research Foundation (RERF) in Japan, the binational US–Japan organization studying the effects of radiation in survivors of the atomic bombings of Hiroshima and Nagasaki. RERF is the foremost

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contributor in the world of understanding radiation effects and establishing the risks of radiation exposure. The epidemiological study at RERF is a lifetime follow-up project. So far, the work has continued for nearly 60 years, starting in 1947 shortly after the bombings. I am happy that RERF staff have been able to apply the knowledge gained there to other situations in need of careful study and evaluation.

I served as chairman of RERF for a four year term from July 2001 until June 2005. I am thus only recently retired. Prior to my service at RERF, I served as Director of the Secretariat for the UNSCEAR. My whole career has been devoted to studying and understanding the sources and effects of radiation. It has been my great pleasure to participate in the Chernobyl Forum.

BASIS FOR FORUM ASSESSMENT

The work of the Chernobyl Forum did not materialize from a clean slate of absent information and unknown facts. Of course, we have built on the work of other efforts to review and assess the consequences of the Chernobyl accident. It was a tribute to Soviet scientists to have an assessment ready for international presentation here in Vienna by August 1986, just a few months after the accident. This started an effort to be open and factual with the information then available.

The first assessment of the accident was published by UNSCEAR in 1988. Good estimates could be made at that time from numerous measurements in countries throughout Eastern and Western Europe, and in other countries of the northern hemisphere of the amounts of radioactive materials released and their spread throughout the hemisphere. Experience in treating the highly exposed workers could also be described in the 1988 UNSCEAR report.

In 1990 and 1991, the IAEA conducted the International Chernobyl Project, in which scientists from many countries who were experts on environmental and health aspects of radiation met with their counterparts in the Soviet Union to compare methods of evaluating radiation exposures and to conduct an extensive screening of health effects in the exposed population. This was an ambitious and highly successful project from the scientific point of view. Dr. Itsuzo Shigematsu served as Chairman of the International Chernobyl Project. Dr. Shigematsu at the time was serving as Chairman of the RERF. I am following him both at RERF and in the international Chernobyl evaluations. I would like to pay tribute to the very capable leadership of Dr. Shigematsu of the International Chernobyl Project. As he is attending this conference, I would like to ask him to stand and accept a tribute from all of us for his

outstanding efforts in Japan and in the world to understand radiation effects. Thank you Dr. Shigematsu.

The person at the IAEA who was most responsible for the conduct of the International Chernobyl Project and has been very much involved in supporting international efforts to establish radiation protection guidelines and advice was Dr. Abel González. He always gave us energy and inspiration to devote our very best efforts to our endeavours. I would like to thank Abel for his leadership of IAEA Chernobyl work over so many years until his retirement earlier this year.

Many of my colleagues, as did I, participated in the International Chernobyl Project, and these physicians and scientists continue to contribute their experience and expertise to the Chernobyl Forum. We will soon hear from three of them: Dr. Lynn Anspaugh, who will present the findings of the Expert Group on Environment, and Dr. Fred Mettler and Dr. Elizabeth Cardis, who will present the findings of the Expert Group on Health. I would like to recognize these individuals as representatives of the many physicians and scientists who have been contributing for many years to Chernobyl evaluations.

During the time of the International Chernobyl Project and for some years after, the Sasakawa Foundation of Japan provided substantial support for Chernobyl projects, especially the IPHECA project of the WHO. Many Japanese experts were able to contribute to the international work through this project, including Dr. Shigenobu Nagataki, my immediate predecessor as Chairman of the RERF during the period 1997–2001. He was active in contributing to thyroid evaluations, his specialty, in giving overall support to the international efforts.

This conference happens to be an occasion for a reunion of chairmen of the RERF in Japan. Dr. Shigematsu and Dr. Nagataki, who preceded me as chairmen, are here. Let me introduce the newly appointed chairman of RERF who succeeded me, Dr. Toshiteru Okubo. Dr. Okubo became chairman on 1 July this year. Prior to this, he was President of the University of Industrial and Occupational Health in Kitakyushu, Japan. Dr. Okubo is attending this conference, and I would like to encourage his participation in international radiation assessment work.

Let me conclude my introduction by saying once again thank you to all of the scientists and physicians who participated in the expert groups, who have prepared the basis for our conclusions and recommendations. I would like to turn now to the presentations of the findings of the expert groups.

ENVIRONMENTAL CONSEQUENCES OF THE CHERNOBYL ACCIDENT AND THEIR REMEDIATION: 20 YEARS OF EXPERIENCE

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Abstract

The Chernobyl Forum was organized by the United Nations to examine the health and environmental effects of the accident at the Chernobyl Nuclear Power Station Unit Number 4. This paper is concerned with the environmental effects, including human exposure, as determined by the Expert Group on Environment. The accident on 26 April 1986 resulted in the release of a large amount of radioactive materials over a period of ten days. These materials were deposited throughout Europe (and to a minor extent throughout the remainder of the northern hemisphere) with the three more affected countries being Belarus, the Russian Federation and Ukraine. The more important radionuclides from a human dosimetric standpoint were ^{131}I , ^{134}Cs and ^{137}Cs , with half-lives of 8 d, 2 a and 30 a, respectively. More than five million persons lived on territories in these three countries judged to be contaminated at $>37\text{ kBq/m}^2$. Many countermeasures were employed to mitigate the effects of the accident, with the main focus being on urban and agricultural areas. The collective effective dose to the residents of the contaminated territories is estimated to be about 55 000 man Sv; the collective thyroid dose is estimated to be 1.6×10^6 man Gy. Effects on non-human biota were observed that ranged from minor to lethal; a notable effect was the killing of a pine forest near the accident site. The current increase in the number and diversity of species in the most contaminated area is due to the absence of human pressure. The current shelter over the damaged reactor was constructed under time pressure, and it has significant leakage of airborne radionuclides and inflow of rainwater. The immediate waste management practices were chaotic and remediation is needed. It is planned to build an NSC structure over the top of the existing structure and to eventually dismantle the damaged reactor. This will put additional pressure on waste management, including the need for a new site for geologic disposal of transuranic waste.

1. INTRODUCTION

This paper provides an up to date evaluation of the environmental effects of the accident which occurred on 26 April 1986 at the Chernobyl nuclear power plant. Even though it is now nearly 20 years after the accident, there are still many conflicting reports and rumours concerning its consequences.

For this reason, the Chernobyl Forum was initiated by the IAEA, in cooperation with the WHO, the UNDP, the FAO, the UNEP, the UN-OCHA, the UNSCEAR, the World Bank and the Governments of Belarus, the Russian Federation and Ukraine. The Chernobyl Forum was established as a series of managerial and expert meetings with the purpose of (a) generating authoritative consensual statements on the health effects attributable to radiation exposure arising from the accident and the environmental consequences induced by the released radioactive materials; (b) providing advice on remediation and special health care programmes; and (c) suggesting areas where further research might be required.

The working practices of the Chernobyl Forum have been described by Dr. B. Bennett in his Introductory Remarks. The summary of the environmental consequences of the accident presented in this paper is based on the results of two years of operation of the Forum's Expert Group on Environment. The Expert Group on Environment included 35 scientists (whose names are listed in the Acknowledgements section of this paper); persons involved were from the three more affected countries of Belarus, the Russian Federation and Ukraine, and from the international community of persons who have performed environmental work related to the deposition of Chernobyl debris. The latter included a large number of scientists from European countries, including the Scandinavian countries, France, Germany and the United Kingdom.

Members of the Expert Group on Environment met seven times in Vienna in order to carry out their work. The work of the Expert Group on Environment is being published by the International Atomic Energy Agency [1]; the full report is nearly 200 pages long and provides extensive information. In this paper, only brief summaries will be presented of the releases of radioactive materials, the distribution of these materials, the countermeasures that were employed to mitigate the effects, the doses that were received by the persons residing in the more affected territories, the effects upon biota, and issues relevant to the environmental safety of the shelter over the damaged reactor and radioactive waste produced by the accident.

2. RELEASES

The accident occurred shortly after midnight on 26 April 1986 at Unit 4 of the Chernobyl nuclear power plant. The cause of the accident was human error, and the accident occurred after prolonged operation of the reactor in a non-design configuration. One or more steam explosions blew the reactor apart with an initial large release of radioactive materials. The graphite within the now exposed core of the reactor caught fire and burned for ten days despite heroic efforts to extinguish the blaze. Releases of radioactive material continued for this time period; the radionuclide content of the releases varied markedly with time and temperature of the burning reactor.

Major releases included radioactive gases, condensed aerosols and a large amount of fuel particles. The total release of radioactive substances was about 14 EBq¹ (as of 26 April 1986), which included 1.8 EBq of ¹³¹I, 0.085 EBq of ¹³⁷Cs and other Cs isotopes, 0.01 EBq of ⁹⁰Sr and 0.003 EBq of Pu radioisotopes. The noble gases contributed about 50% of the total release of activity. The best estimates of the releases of representative and important radionuclides are shown in Table 1.

3. CONTAMINATION

3.1. Radionuclide deposition

Large areas of Europe were affected to some degree by the radionuclide mixture released from the Chernobyl accident. An area of more than 200 000 km² in Europe was contaminated with radiocaesium (above 37 kBq of ¹³⁷Cs/m²) of which 71% was in the three more affected countries, Belarus, the Russian Federation and Ukraine. The deposition was highly heterogeneous; it was strongly influenced by the presence or absence of rain during passage of contaminated air masses. For convenience in mapping deposition, ¹³⁷Cs was chosen as a representative radionuclide, because it was easy to measure and was of radiological significance. Most of the strontium and plutonium radioisotopes were deposited close (less than 100 km) to the reactor, due to their being contained within larger particles.

¹ 1 EBq = 10¹⁸ Bq.

TABLE 1. REVISED RELEASE ESTIMATES^a OF THE PRINCIPAL RADIONUCLIDES DURING THE COURSE OF THE CHERNOBYL ACCIDENT DECAY CORRECTED TO 26 APRIL 1986

Radionuclide	Inert gases		Volatile elements			Elements with intermediate volatility				Refractory elements (including fuel particles) ^c					
	⁸⁵ Kr	¹³³ Xe	¹³¹ I	¹³³ I	¹³⁴ Cs	¹³⁷ Cs	⁸⁹ Sr	⁹⁰ Sr	¹⁰³ Ru	¹⁰⁶ Ru	¹⁴⁰ Ba	²³⁸ Pu	²³⁹ Pu	²⁴⁰ Pu	²⁴¹ Pu
Half-life	10.72 a	5.25 d	8.04 d	20.8 h	2.06 a	30.0 a	50.5 d	29.12 a	39.3 d	368 d	12.7 d	87.74 a	24.07 a	6.537 a	14.4 a
Activity released (PBq)	33	6500	~1800	2500	~47 ^b	~85	~115	~10	>168	>73	240	0.015	0.013	0.018	~2.6

^a Condensed from [1]. Most of the data are from Refs [2] or [3].

^b Based on a ¹³⁴Cs:¹³⁷Cs ratio of 0.55 as of 26 April 1986 [4].

^c Based on fuel particle release of 1.5% [5].

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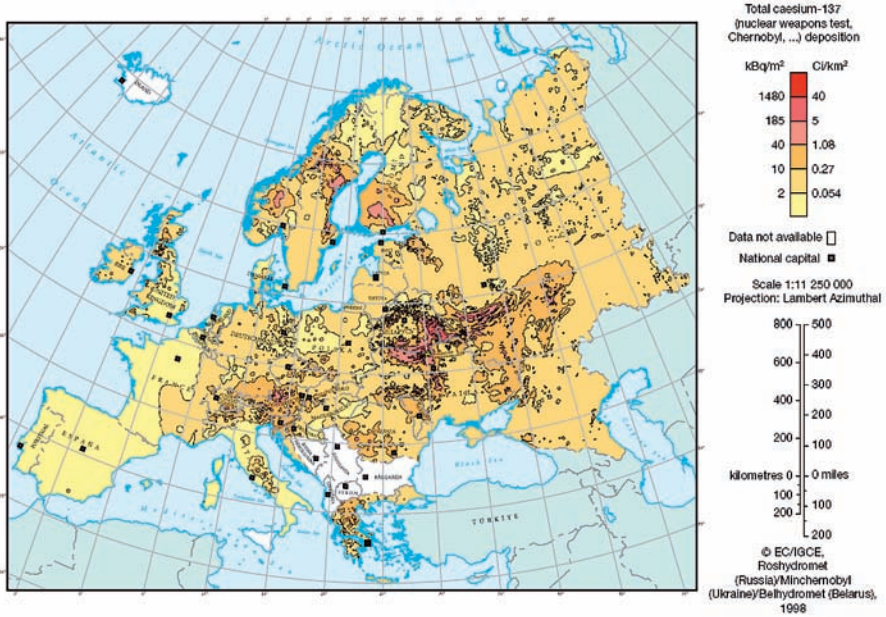


FIG. 1. Surface-ground deposition of ^{137}Cs throughout Europe as a result of the Chernobyl accident [6].

TABLE 2. AREAS CONTAMINATED AT ^{137}Cs -SOIL DEPOSITION OF $>37 \text{ kBq/m}^2$ (1 Ci/km^2) [1].

Country	Area (km ²)
Russian Federation	57 900
Belarus	46 500
Ukraine	41 900
Sweden	12 000
Finland	11 500
Austria	8 600
Norway	5 200
Bulgaria	4 800
Switzerland	1 300
Greece	1 200

Two atlases of contaminated areas have been published [6, 7]; one example of the maps produced is given in Fig. 1 [6]. In Table 2, countries with the larger areas of land considered to be contaminated, which was defined at the time as areas contaminated with $>37 \text{ kBq/m}^2$ (1 Ci/km^2) of ^{137}Cs are indicated. In the three more contaminated countries of Belarus, the Russian Federation and Ukraine, more than five million persons lived in such areas.

Much of the release was comprised of radionuclides with short physical half-lives; long lived radionuclides were released in smaller amounts. Thus, many of the radionuclides released by the accident have already decayed. The releases of radioactive iodines caused concern immediately after the accident. After the initial period, ^{137}Cs became the nuclide of greatest radiological importance, with ^{90}Sr being of lesser importance. For the first few years, ^{134}Cs was also important. Over the longer term (hundreds to thousands of years), the only radionuclides anticipated to be of interest are the plutonium isotopes and ^{241}Am .

Airborne radionuclides from the Chernobyl release contaminated urban, agricultural, aquatic, and forest areas.

3.2. Urban environment

In urban areas, open surfaces such as lawns, parks, streets, roads, squares, building roofs and walls became contaminated. Under dry conditions, trees, bushes, lawns and roofs were contaminated; under wet conditions, horizontal surfaces, such as soil plots, lawns etc. received the higher contaminations. Particularly high ^{137}Cs -activity levels were found around houses where rain had transported radioactive materials from roofs to the ground. The deposition in urban areas in the nearest city of Pripjat and surrounding settlements could have initially given rise to substantial external radiation doses, but this was partially averted by the evacuation of the people.

Due to wind and rain, and human activities, including traffic, street washing and cleanup, surface contamination by radioactive material was reduced significantly in inhabited and recreational areas during 1986 and afterwards, as shown in Fig. 2. One of the consequences of these processes was the secondary contamination of sewage systems and resulting sludge storage.

At present, in most of the settlements subjected to radioactive contamination, the dose rate in air above solid surfaces has returned to the pre-accident background level. An elevated dose rate in air remains mainly over undisturbed soil in gardens, kitchen gardens and parks.

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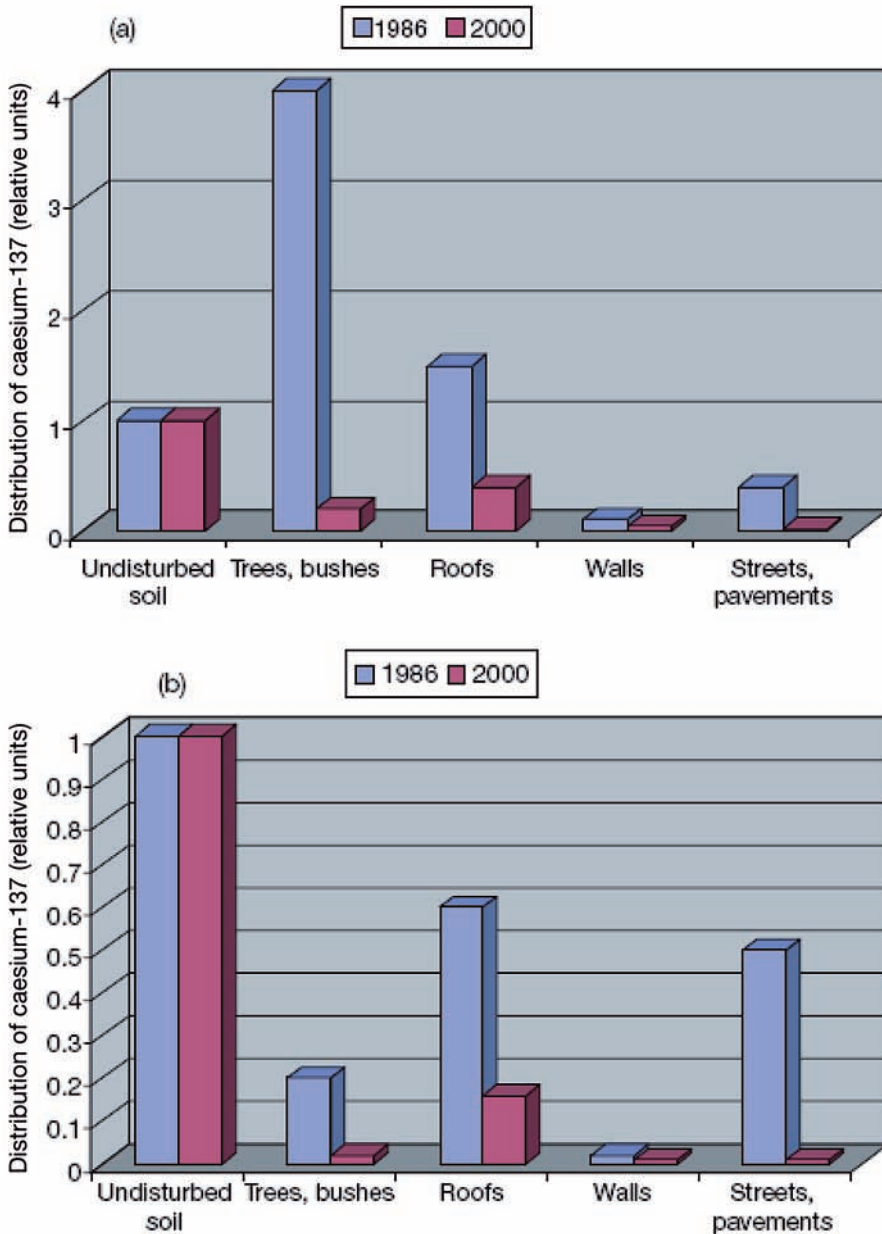


FIG. 2. Typical distribution of ^{137}Cs on different surfaces within settlements in 1986 and 14 years after deposition of the Chernobyl fallout. (a) Dry deposition; (b) Wet deposition [8].

3.3. Agricultural environment

In the early phase, the direct surface deposition of many different radionuclides dominated the contamination of agricultural plants and of animals consuming them. The release and deposition of radioiodine isotopes caused the most immediate concern, but the problem was confined to the first two months, as shown in Fig. 3, because of the short physical half-life of eight days of the most important iodine isotope. The radioiodine was rapidly transferred to milk at a high rate in the Russian Federation, Ukraine and Belarus, and led to significant thyroid doses to those consuming milk, especially children.

After the early phase of direct contamination, uptake of radionuclides through plant roots from soil became increasingly important and showed strong time dependences. Radioisotopes of caesium (^{137}Cs and ^{134}Cs) were the nuclides which led to the greater problems, and, after the decay of ^{134}Cs , ^{137}Cs remains to cause problems in some Belarus, Russian Federation and Ukrainian areas. In addition, ^{90}Sr causes problems in the near field of the reactor, but at longer distances the deposition levels were too low to be of radiological significance. Other radionuclides, such as plutonium isotopes and ^{241}Am , were present at very low deposition levels and did not have significant transfer from soil through roots to plants.

In general, there was a substantial initial reduction in the transfer of radionuclides to vegetation and animals in the first few years due to weathering, physical decay, migration of radionuclides down the soil column and reductions in radionuclide bioavailability in soil; this reduction is indicated in Fig. 4. On average, the levels of ^{137}Cs contamination were about 100 times less than initial values after about ten years. This decrease with time was much more rapid than that due to radioactive decay alone. However, in the last decade, there has been little further obvious decline and long term effective half-lives have been difficult to quantify.

The radiocaesium concentrations in foodstuffs after the early phase were influenced not only by deposition levels, but also by soil types, management practices and types of ecosystems. Major and persistent problems in the affected areas occurred in extensive agricultural systems in soils with high organic content and where animals grazed in unimproved pastures which were not ploughed or fertilized. Effects were particularly notable for rural residents in the former Soviet Union who were commonly subsistence farmers with privately owned dairy cows.

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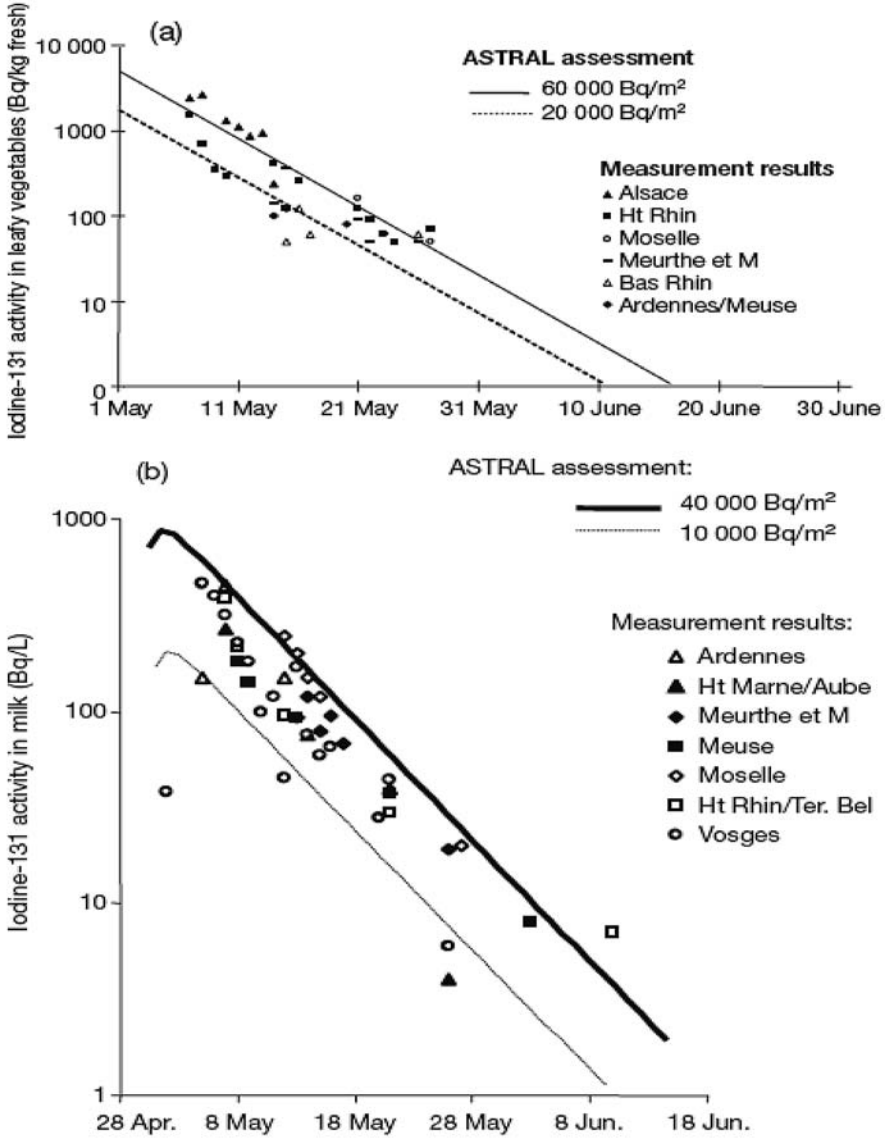


FIG. 3. Changes with time in ¹³¹I activity concentrations in (a) cow milk and (b) leafy vegetables, in different regions of France, May–June 1986 [9].

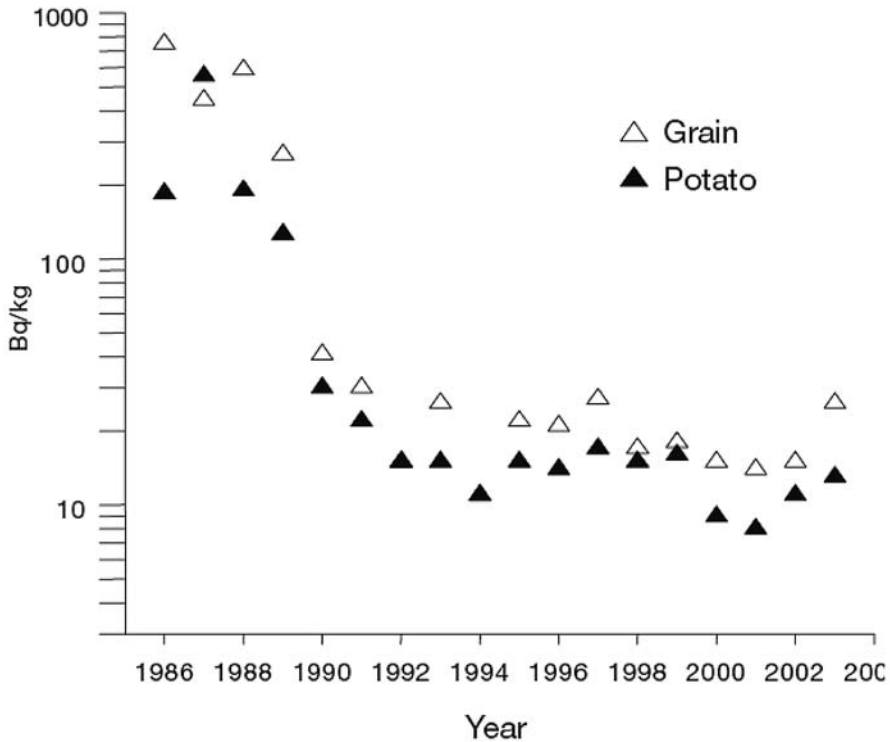


FIG. 4. Changes with time of ^{137}Cs concentrations in grain and potatoes, as measured in contaminated areas of the Bryansk region (Bq/kg) [10].

3.4. Forest environment

Following the Chernobyl accident, vegetation and animals in forests and mountain areas showed particularly high uptake of radiocaesium, with the highest recorded ^{137}Cs concentrations being found in forest products, due to the persistent recycling of radiocaesium in forest ecosystems. Particularly high ^{137}Cs -activity concentrations have been found in mushrooms, berries and game, and these high levels have persisted since the accident; this is demonstrated in Fig. 5. Therefore, the relative importance of forests in contributing to the radiation exposures of the populations of several affected countries has increased with time. This can be expected to continue for several decades to come.

The high transfer of radiocaesium in the pathway lichen–reindeer meat–humans was demonstrated again after the Chernobyl accident in arctic

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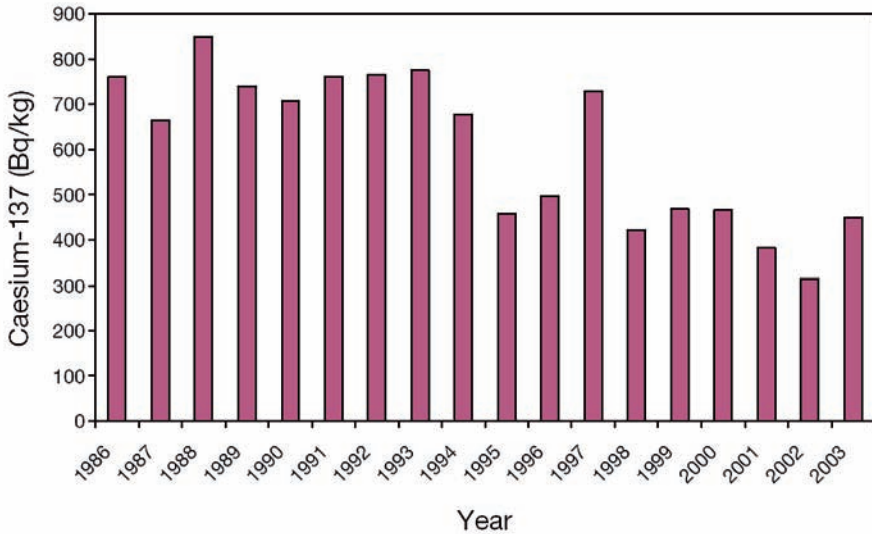


FIG. 5. The average concentration of ^{137}Cs in moose in one hunting area in Sweden, based on approximately 100 animals/a [11].

and subarctic areas of Europe. The Chernobyl accident led to contamination of reindeer meat in Finland, Norway, the Russian Federation and Sweden, and caused significant problems for the Sami people.

The use of timber and associated products only makes a small contribution to the exposure of the general public, although wood ash can contain high amounts of ^{137}Cs and could potentially give rise to higher doses than other uses of wood. ^{137}Cs in timber is of minor importance, although doses to persons in the wood pulp industry are of concern.

Widespread forest fires in 1992 caused increased air-activity concentrations, but not to a significant extent. The possible radiological consequences of forest fires have been much discussed, but these are not expected to cause any problems of radionuclide transfer from contaminated forests, except, possibly, in the nearest surroundings of a fire.

3.5. Aquatic environment

Radionuclides from Chernobyl contaminated surface-water systems, not only in areas close to the site, but also in many other parts of Europe. The initial contamination of water was due primarily to direct deposition of radionuclides onto the surface of rivers and lakes, and was dominated by short lived radionuclides (most importantly ^{131}I). In the first few weeks after the accident, activity

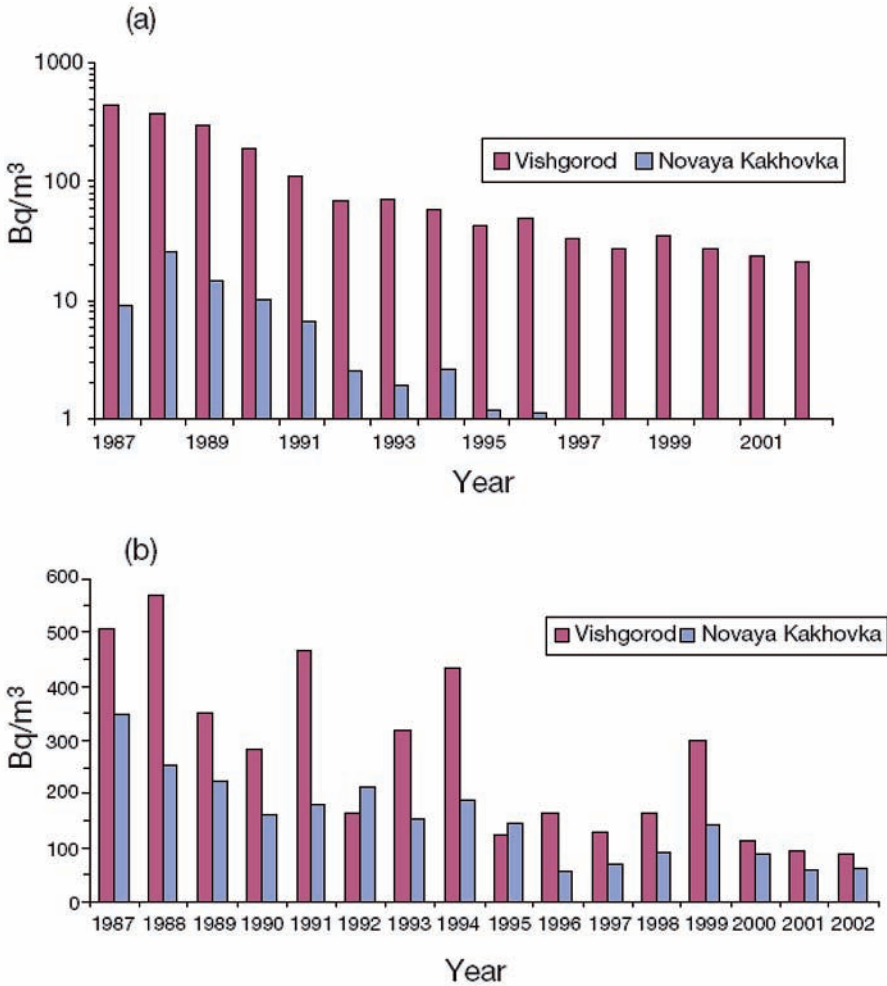


FIG. 6. Annually averaged (a) ¹³⁷Cs and (b) ⁹⁰Sr activity concentrations in the water of the Kiev Reservoir (Vishgorod) and the Kahovka Reservoir of the Dnieper cascade [12].

concentrations in drinking water from the Kiev Reservoir were of particular concern.

The contamination of water bodies decreased rapidly during the weeks after fallout through dilution, physical decay and absorption of radionuclides by catchment soils, as shown in Fig. 6. For lakes and reservoirs, the settling of suspended particles to the bed sediments also played an important role in reducing levels in water.

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The 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 concentrations in fish in the most affected areas and in some lakes as far away as Scandinavia and Germany.

S contamination by washoff of long lived ^{137}Cs and ^{90}Sr from contaminated soils and remobilization from bed sediments continues (at a much lower level) to the present day. Catchments with high organic content (peat soils) release much more radiocaesium to surface waters than those with mostly mineral soils. At the present time, surface-water activity concentrations are low. Therefore, irrigation with surface water is not considered to be a problem.

While concentrations of ^{137}Cs and ^{90}Sr in water and fish of rivers, open lakes and reservoirs are currently low, as indicated in Fig. 7, the more contaminated lakes are those few lakes with limited inflowing and outflowing streams ('isolated' lakes) in Ukraine, Belarus and the Russian Federation, and which have a poor mineral-nutrient status. Activity concentrations of ^{137}Cs in fish in some of these lakes will remain elevated for a significant time in the future. In a population living next to a 'closed' lake system (e.g. Kozhanovskoe Lake, Russia), consumption of fish has dominated the total ^{137}Cs ingestion for some people.

Owing to the large distance of the Black and Baltic Seas from Chernobyl, and the dilution in these systems, activity concentrations in sea water have been much lower than in freshwater. The low radionuclide concentrations in water combined with low bioaccumulation of radiocaesium in marine biota has led to activity concentrations in marine fish which are not of concern.

4. COUNTERMEASURES

After the Chernobyl accident, the authorities in the former USSR introduced a range of short and long term countermeasures to reduce the effects of the environmental contamination. Countermeasures included the urgent evacuation of about 116 000 persons from the highly contaminated areas; diversion of food supplies; removal of contaminated soil from urban areas; washing of building and other surfaces in urban areas; restrictions on access to some natural areas (e.g. lakes and forests); remediation of agricultural lands; changes in crops grown in some areas; application of caesium binders in ruminant animals; and long term monitoring of soil, food and persons. The application of any countermeasure can result in negative consequences, so an optimization process was implemented to the extent permitted by the current knowledge.

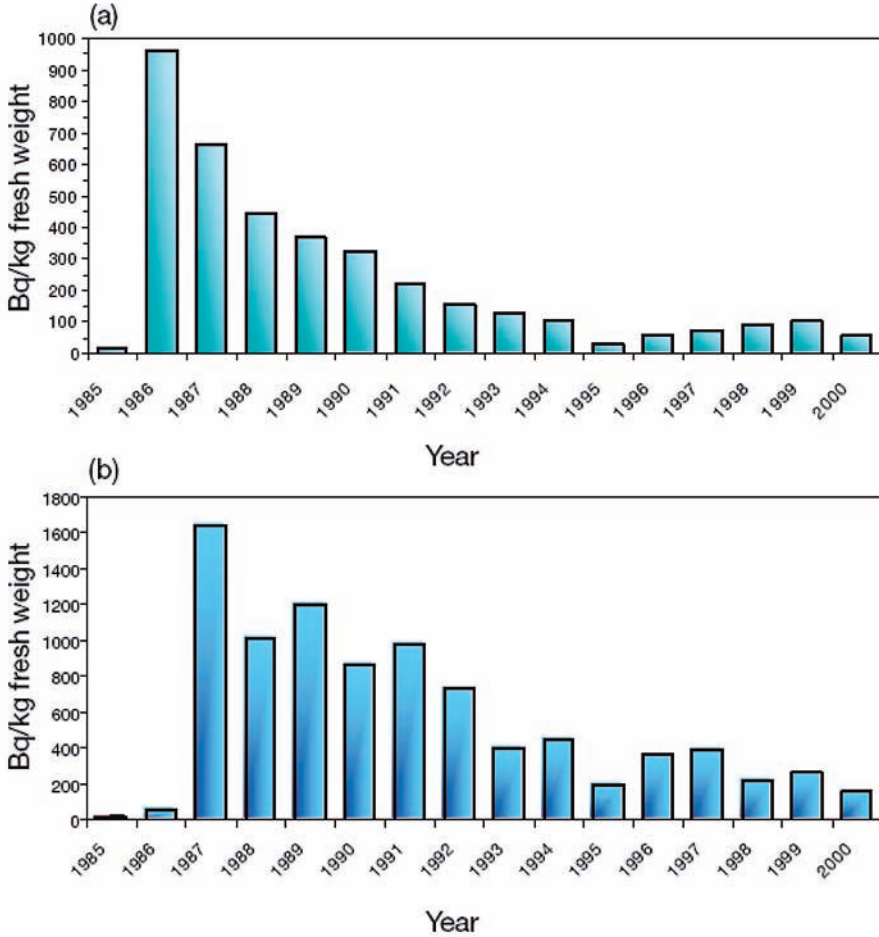


FIG. 7. Average ^{137}Cs activity concentrations in non-predatory bream (a) and predatory pike (b) fish from the Kiev Reservoir [13].

The unique experience of countermeasure application after the Chernobyl accident has already been widely used both at national and international levels in order to improve preparedness in the event of future radiological emergencies.

4.1. Urban countermeasures

The decontamination of settlements was widely applied in contaminated regions of the former USSR during the first years after the Chernobyl accident

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TABLE 3. ACHIEVABLE REDUCTION OF DOSE RATE (DRRF, DIMENSIONLESS) ABOVE URBAN SURFACES DECONTAMINATED WITH VARIOUS TECHNIQUES [14]

Surface	Technique	DRRF, dimensionless
Windows	Washing	10
Walls	Sandblasting	10–100
Roofs	Hosing and/or sandblasting	1–100
Gardens	Digging	6
Gardens	Removal of surface	4–10
Trees and shrubs	Cut back or remove	~10
Streets	Sweeping and vacuum cleaning	1–50
Streets (asphalt)	Lining	>100

as a means of reducing the external exposure of the public and the inhalation of resuspended radioactive substances. Decontamination was cost effective with regard to reduction of external dose, when its planning and implementation were preceded by a remediation assessment based on cost–benefit techniques and dosimetry data. Since the areas have been cleaned up, no secondary contamination of cleaned up plots has been observed. Achievable decontamination factors for various urban surfaces based on Chernobyl experience and experimental studies are presented in Table 3 [14].

The decontamination of urban environments has produced a considerable amount of low level radioactive waste which, in turn, has created a problem of disposal.

4.2. Agricultural countermeasures

The more effective countermeasures in the early phase were exclusion of contaminated pasture grasses from animals' diets and the rejection of milk. Feeding animals with clean fodder was effectively implemented in some countries; however, this countermeasure was not widely applied in the former USSR due to a lack of uncontaminated feeds. The slaughtering of cattle was frequently carried out, but this was unjustified from a radiological point of view and caused significant hygienic, practical and economic problems.

Several months after the accident, long term agricultural countermeasures against radiocaesium and radiostrontium were effectively implemented in all contaminated regions; these included feeding animals with

clean fodder and obligatory processing of milk. This enabled most farming practices to continue in affected areas and resulted in a large reduction in dose. The most important precondition was the radiation monitoring of agricultural lands, feeds and foodstuff, including *in vivo* monitoring of caesium-activity concentrations in the muscle of cattle.

The greatest long term problem has been radiocaesium contamination of milk and meat. In the former USSR and, later on, in the three independent countries, this was addressed by the treatment of land used for fodder crops, clean feeding and the application of caesium binders to animals. Clean feeding was one of the more important and effective measures used in countries where animal products had ^{137}Cs -activity concentrations exceeding action levels. In the long term, environmental radiation conditions are changing only slowly; however, the efficiency of environmental countermeasures remains at a constant level.

The application of agricultural countermeasures in the three more affected countries has substantially decreased since the middle of the 1990s, as shown in Fig. 8, because of economic problems. This has resulted in an increase of radionuclide content in plant and animal agricultural products. At the present time, the use of agricultural countermeasures continues but contaminated lands are being returned to active production with the continued use of countermeasures and monitoring.

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

For the first time, practical, long term agricultural countermeasures have been developed, tested and implemented on a large scale; these have included radical improvement of meadows, pre-slaughter clean feeding, the application of caesium binders, and soil treatment and cultivation. Their implementation on more than 3 billion ha of agricultural land has made it possible to minimize the amount of products with radionuclide-activity concentrations above action levels in all three countries.

4.3. Forest countermeasures

The principal, forest-related countermeasures applied after the Chernobyl accident were management based (restrictions of various activities) and technology based.

Restrictions, widely applied in the three more affected countries, and partially in Scandinavia, included the following actions that have reduced

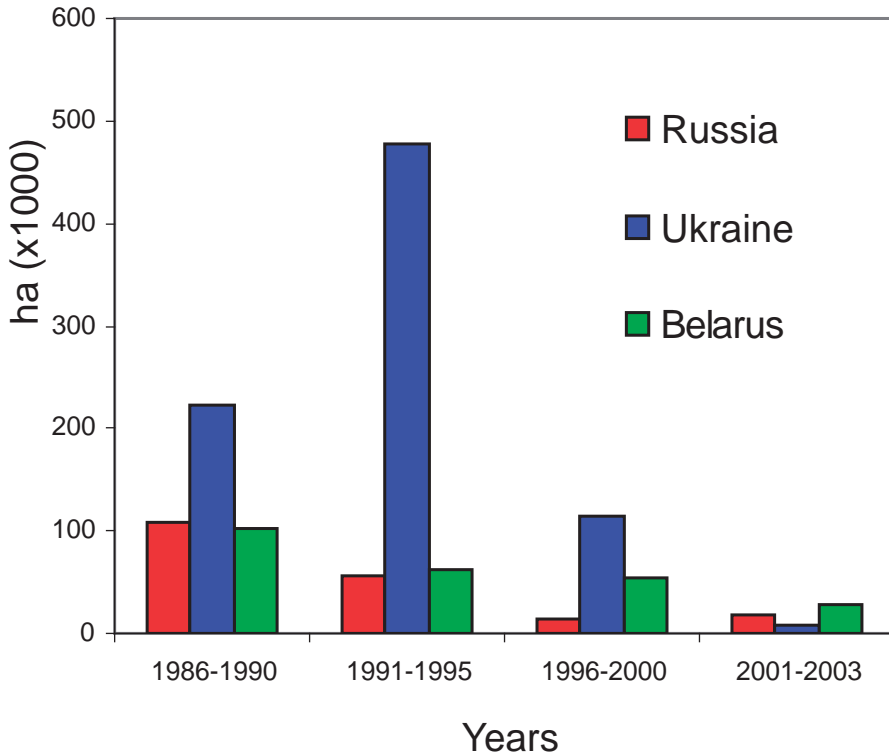


FIG. 8. Areas of radical improvement in the countries most affected by the Chernobyl accident [15].

human exposure due to residence in radioactively contaminated forests and the use of forest products:

- Restrictions on public and forest worker access, as a countermeasure against external exposure;
- Restrictions on the harvesting of food products, such as game, berries and mushrooms (see Fig. 9);
- Restrictions on the collection of firewood by the public, in order to prevent external exposures in the home and garden, where wood is burned and ash is disposed of or used as a fertilizer;
- Alteration of hunting practices, aimed at avoiding the consumption of meat with high seasonal levels of radiocaesium; and
- Fire prevention, especially in areas with large scale radionuclide deposition, aimed at the avoidance of secondary contamination of the environment.

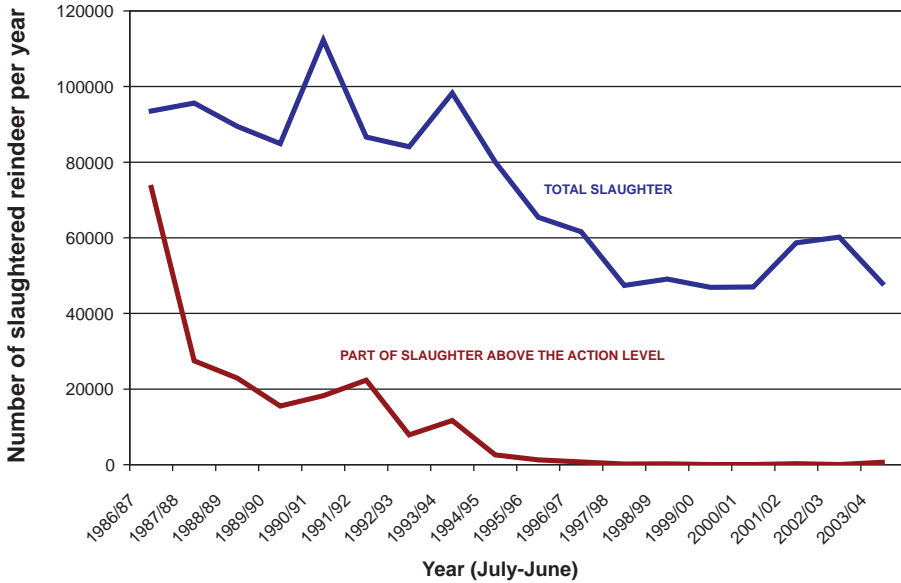


FIG. 9. Change with time in the number of reindeer in Sweden with radiocaesium-activity concentrations above action levels and the number of slaughtered animals [16].

It is unlikely that any technologically based forest countermeasures, i.e. the use of machinery and/or chemical treatments to alter the distribution or transfer of radiocaesium in the forest, will be practicable on a large scale.

4.4. Aquatic countermeasures

Numerous countermeasures were put in place in the months and years after the accident to protect water systems from the transfer of radionuclides from contaminated soils. In general, these measures were ineffective and expensive, and led to relatively high exposures to the workers implementing the countermeasures.

The most effective countermeasure was the early restriction of drinking water abstraction and the change to alternative supplies. Restrictions on consumption of freshwater fish have also proved effective in Scandinavia and Germany, though in Belarus, the Russian Federation and Ukraine such restrictions may not always have been adhered to.

It is unlikely that any future countermeasures to protect surface waters would be justifiable in terms of economic cost per unit of dose reduction. It is expected that restrictions on the consumption of fish will remain, in a few cases (in so-called closed lakes), for several more decades.

5. HUMAN EXPOSURE LEVELS

In terms of human exposure, the focus of the Expert Group on Environment report was on collective dose to persons living in contaminated areas of Belarus, the Russian Federation and Ukraine. Other reports have given attention to individual and collective doses to evacuated persons, cleanup workers and persons enrolled in epidemiological studies [2, 17].

Radiation doses were delivered to the exposed population primarily through the pathways of external dose (i.e. exposure to the radiation field created by the deposition of radionuclides on soil and other surfaces) and from the consumption of contaminated food. A feature of both pathways is that the dose received per unit time, even in the absence of countermeasures, decreases substantially with time due to natural processes. Radioactive decay is one of the important processes, but even for long lived radionuclides there is a substantial decrease with time in dose per unit time. This is explained for external dose by the weathering of radionuclides into the soil column, and the resulting shielding afforded by soil. For example, Golikov et al. [18] observed that about half of the initial external gamma exposure rate due to ^{137}Cs decreased with an 'ecological' half-life of 2.4 a, and the other half is decreasing with a half-life of about 37 a (the latter value is uncertain). This relationship is shown in Fig. 10.

Similar results were observed for dose from the consumption of contaminated agricultural products. Of course, the dose from ^{131}I decreases very rapidly due to this radionuclide's short half-life of eight days. The dose rate from consumption of agricultural products containing ^{134}Cs and ^{137}Cs also declines rather rapidly due to the fixation of caesium by clay minerals in soil. Thus, soil type is an important parameter in any actual situation of interest. As a general rule, however, a very large fraction of the total expected dose from consumption of contaminated agricultural products had already been delivered within the first ten years after the accident, and only a small contribution (about 10% of the total) can be expected to be delivered in the post-2006 period [1].

Doses to humans were reduced significantly by a number of countermeasures. Official countermeasures included evacuations and relocations of persons, the blockage of contaminated food supplies, the removal of contaminated soil, the treatment of agricultural fields to reduce the uptake of radionuclides, the substitution of foods, and the prohibition of usage of 'wild' foods. Unofficial countermeasures included the self-initiated avoidance of foods judged to be contaminated.

Estimates of the collective, effective (not including the contribution of the dose to the thyroid) dose delivered up through 2005 are shown in Table 4 for persons living within the contaminated areas of the three more contaminated

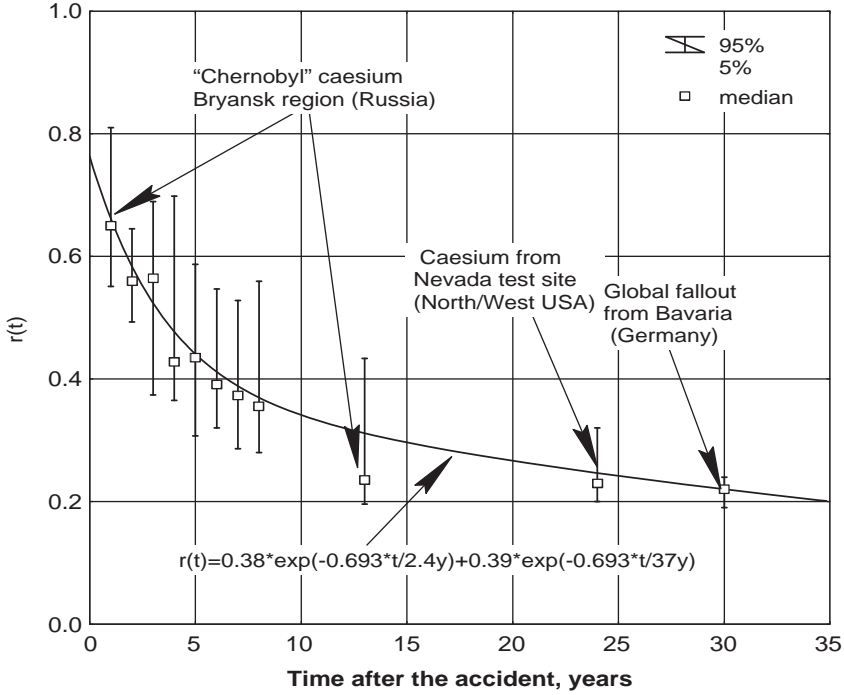


FIG. 10. Reduction of the ^{137}Cs gamma exposure rate in air due to caesium migration in undisturbed soil relative to the dose rate caused by a plane source on the air–soil interface (from Ref. [18]).

countries. An additional 3000 man Sv is estimated to be delivered to persons using the water from the Dnieper River reservoirs; such a dose would have accrued to a much larger group of persons, and its value is uncertain [19, 20]. Collective doses from the external and internal pathways are approximately equal, but there were great variations from location to location depending upon lifestyle, soil factors etc.

The thyroid dose from intake of ^{131}I was mainly due to the consumption of fresh cows' milk and, to a lesser extent, of green vegetables. Children, on average, received a dose that was much greater than that received by adults, because of their small thyroid mass and a consumption rate of fresh cow's milk that was similar to that of adults.

The range in thyroid dose in different settlements and in all age–gender groups is large, between less than 0.1 Gy and more than 10 Gy. In some groups, and especially in younger children, doses were high enough to cause both short term functional thyroid changes and thyroid cancer in some individuals. The collective thyroid dose to the population of the contaminated areas of the three

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TABLE 4. ESTIMATES OF COLLECTIVE EFFECTIVE DOSE FOR RESIDENTS LIVING IN THE CONTAMINATED TERRITORIES OF THE THREE COUNTRIES OF INTEREST DURING 1986 THROUGH 2005 [1]

Country	Population (million persons)	Collective effective dose (thousands of man Sv)		
		External	Internal	Total
Belarus	1.9	11.9	6.8	18.7
Russian Federation	2.0	10.5	6.0	16.5
Ukraine	1.3	7.6	9.2	16.8
Total	5.3	30	22	52

TABLE 5. ESTIMATES OF COLLECTIVE THYROID DOSE TO RESIDENTS LIVING IN THE CONTAMINATED AREAS OF THE THREE MORE CONTAMINATED COUNTRIES [1]

Country	Estimated collective thyroid dose (thousands of man Gy)
Belarus	550
Russian Federation	300
Ukraine	740
Total (rounded)	1600

countries is estimated to be 1.6 million man Gy [1, 2]; details are shown in Table 5.

6. EFFECTS ON NON-HUMAN BIOTA

Irradiation from radionuclides released from the Chernobyl accident caused numerous acute adverse effects in the biota located in areas of highest exposure, i.e. up to a distance of a few tens of kilometres from the release point (Fig. 11). Beyond the exclusion zone, no acute radiation-induced effects on biota have been reported.

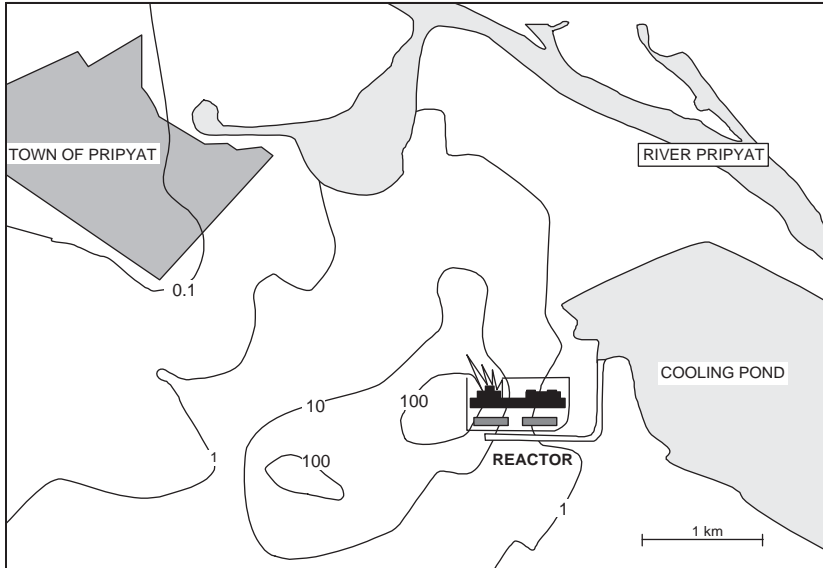


FIG. 11. Measured exposure rates in air on 26 April 1986 in the local area of the Chernobyl reactor. Units of isolines are R/h (1 R/h is approximately 0.2 Gy/d) [2].

The environmental response to the Chernobyl accident was a complex interaction among radiation dose, dose rate and its temporal and spatial variations, as well as the radiosensitivities of the different taxons. Both individual and population effects caused by radiation-induced cell death have been observed in plants and animals as follows:

- Increased mortality of coniferous plants, soil invertebrates and mammals (rodents);
- Reproductive losses in plants and animals; and
- Chronic radiation syndrome of animals (mammals, birds etc.).

No adverse radiation-induced effects have been reported in plants and animals exposed to a cumulative dose of less than 0.3 Gy during the first month after the radionuclide fallout.

Following the natural reduction of exposure levels due to radionuclide decay and migration, populations have been recovering from acute radiation effects. By the next growing season after the accident, the population viability of plants and animals substantially recovered as a result of the combined effects of reproduction and immigration. A few years were needed for recovery from major radiation-induced adverse effects in plants and animals. One dramatic

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effect was the loss of a pine forest in the heavily exposed area; it will take decades for the forest to be re-established.

The acute radiobiological effects observed in the Chernobyl accident area are consistent with radiobiological data obtained in experimental studies or observed in natural conditions in other areas affected by ionizing radiation. Thus, rapidly developing cell systems, such as meristems of plants and insect larva, were predominantly affected by radiation. At the organism level, young plants and animals were found to be the most sensitive to acute effects of radiation.

Genetic effects of radiation, in both somatic and germ cells, were 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 have any detrimental biological significance is not known.

At the present time, the most remarkable effect on non-human biota is due to the absence of human pressure on the ecological system within the 30 km zone. Plant and animal species are flourishing.

7. ENVIRONMENTAL ASPECTS OF THE DISMANTLING OF THE CHERNOBYL SHELTER AND RADIOACTIVE WASTE MANAGEMENT

Construction of a shelter over the reactor between May and November 1986 was aimed at environmental containment of the damaged reactor, reduction of radiation levels on-site and the prevention of further release of radionuclides off-site. The shelter was erected in an extremely short period of time under conditions of severe radiation exposure to personnel. As a result, the measures taken to save time and cost during the construction led to imperfection in the newly constructed shelter as well as to a lack of comprehensive data on the stability of the damaged Unit 4 structures. The main potential hazard associated with the shelter is a possible collapse of its top structures and release of radioactive dust into the environment.

In order to avoid the effects of a potential collapse of the shelter in the future, measures are planned to strengthen unstable structures. In addition, an NSC with more than 100 years of service life is planned to be built as a cover over the existing shelter as a longer term solution. A rendition of the NSC is shown in Fig. 12. The construction of the NSC is expected to allow for the dismantlement of the current shelter, removal of highly radioactive fuel

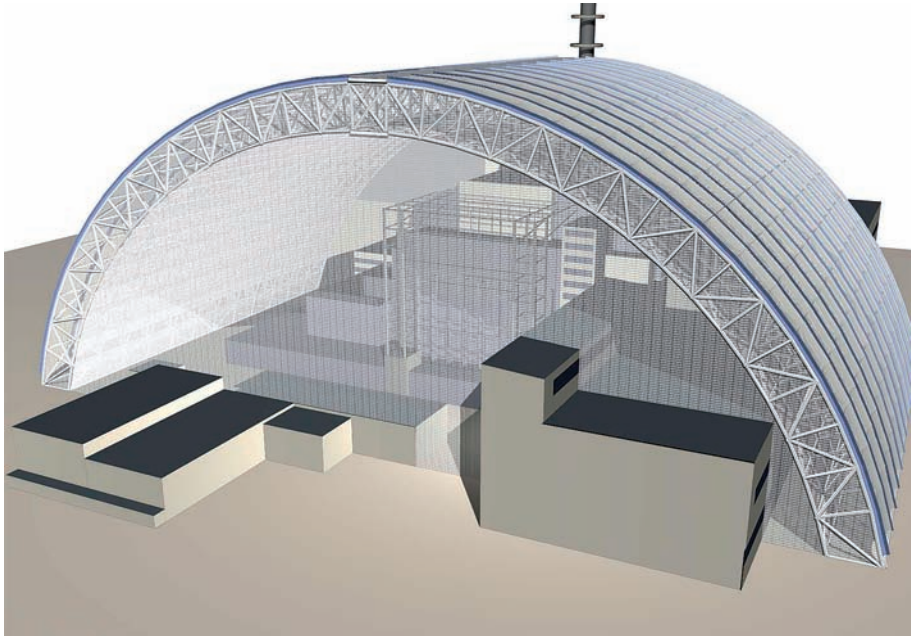


FIG. 12. Planned New Safe Confinement (NSC).

containing mass (FCM) from Unit 4, and the eventual decommissioning of the damaged reactor.

Both at the Chernobyl nuclear power plant site and its vicinity, large volumes of radioactive waste were generated, as a result of the cleanup of contaminated areas, and placed in temporary near surface waste storage and disposal facilities. These facilities were established without proper design documentation, engineered barriers or hydrogeological investigations and do not meet current waste safety requirements.

More radioactive waste is expected in the years to come. Waste will be generated during the construction of the NSC, possible dismantling of the original shelter, removal of FCM and decommissioning of Unit 4. This waste will consist of different categories, and waste of each category must be properly managed.

According to the Ukrainian National Programme on radioactive waste management, the long lived waste is planned to be placed in interim storage. Different storage options are being considered, and a decision has not yet been made. After construction of the NSC and decommissioning of the shelter facilities, it is envisaged that shelter dismantling and further removal of FCM will occur. High level radioactive waste is planned to be partially processed in

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place and then stored at a temporary storage site until a deep geologic disposal site is ready.

The future development of the exclusion zone as an industrial site or natural reserve depends on the future strategy for conversion of Unit 4 into an ecologically safe system, i.e. the development of the NSC, the dismantlement of the current shelter, the removal of FCM and the eventual decommissioning of the Unit 4 reactor site.

8. GENERIC RECOMMENDATIONS FOR FUTURE RESEARCH, REMEDIATION AND MONITORING

8.1. Radioactive contamination of the environment

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

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

The deposits of ^{137}Cs and a number of other long lived radionuclides in the 30 km zone should be used for radioecological studies of various ecosystems located in this highly contaminated area. Such studies are, except for very small scale experiments, not possible or difficult to perform elsewhere.

8.2. Countermeasures

Long term remediation measures and countermeasures should be applied in the areas contaminated with radionuclides, if they are radiologically justified and optimized.

Members of the general public should be informed, along with the authorities, about the existing radiation risk factors and the technological possibilities to reduce them in the long term by remediation and countermeasures. Members of the public should be involved in discussion and decision making.

In the long term, after the Chernobyl accident, remediation measures and countermeasures remain efficient and justified — mainly in the agricultural areas with poor (sandy and peaty) soils, where high radionuclide transfer from soil to plants can occur. Particular attention must be given to the subsistence farming of several hundred settlements and about 50 intensive farms in Belarus, the Russian Federation and Ukraine, where radionuclide concentrations in milk still exceed national action levels.

Among long term remediation measures, radical improvement of pastures and grasslands, as well as the draining of wet peaty areas, is highly efficient. The more efficient agricultural countermeasures are pre-slaughter clean feeding of animals accompanied by in vivo monitoring; application of Prussian Blue to cattle; and enhanced application of mineral fertilizers.

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

Advice should continue to be given on individual diets as a way of reducing consumption of highly contaminated wild food products, and on simple cooking procedures to remove radioactive caesium.

The unique experience of countermeasure application after the Chernobyl accident should be carefully documented and used for the preparation of international and national guidance for authorities and experts responsible for radiation protection of the public and the environment.

Recommendations for decontamination of the urban environment in the event of large scale radioactive contamination should be distributed to the management of nuclear facilities having the potential for substantial accidental radioactive release (nuclear power plants and reprocessing plants) and to authorities in adjacent regions.

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

There still is substantial diversity in the international and national radiological criteria and safety standards applicable to the remediation of areas affected by environmental contamination with radionuclides. The Chernobyl experience has clearly shown the need for further international harmonization of appropriate radiological criteria and safety standards.

8.3. Human exposure

Large scale monitoring of foodstuffs, whole body counting of individuals and provision of thermoluminescent detectors to members of the general population are no longer necessary. The critical groups in areas of high contamination and/or high transfer of radiocaesium to foods are known. Representative members of these critical groups should be monitored by dosimeters for external dose and by whole body counting for internal dose.

Sentinel or marker individuals in more highly contaminated areas not scheduled for further remediation might be identified for continued periodic whole body counting and monitoring for external dose. The goal would be to follow the expected continued decrease in external and internal dose rate, and to determine whether such decreases are due to radioactive decay alone or to further ecological elimination.

8.4. Radiation-induced effects on plants and animals

In order to develop a system of environmental protection against radiation, the long term impact of radiation on plant and animal populations should be further investigated in the exclusion zone of the Chernobyl accident; this is a unique area for radioecological and radiobiological research in an otherwise natural setting.

In particular, multigenerational studies of radiation effects on the genetic structure of plant and animal populations might bring fundamentally new scientific information.

There is a need to develop standardized methods for the reconstruction of dose to non-human biota, e.g. in the form of a unified dosimetric protocol.

Protective actions for farm animals in the event of a radiological emergency should be developed and internationally harmonized based on modern radiobiological data, including the experience gained in the Chernobyl exclusion zone.

It is likely that any technologically based remediation actions aimed at improving the radiological conditions for plants and animals in the exclusion zone of the Chernobyl nuclear power plant would have adverse impacts to biota.

8.5. Environmental aspects of dismantling the Chernobyl shelter and radioactive waste management

Because safety and environmental assessments have only been performed for individual facilities at and around the Chernobyl nuclear power

plants, a comprehensive safety and environmental impact assessment that encompasses all activities inside the entire exclusion zone should be performed.

During the preparation and construction of the NSC and soil removal, special monitoring wells are expected to be destroyed. Therefore, it is important to maintain and improve environmental monitoring strategies, methods, equipment and staff qualifications needed for adequate performance of the monitoring of the conditions at the Chernobyl nuclear power plant site and the exclusion zone.

The development of an integrated radioactive waste management programme for the shelter, the Chernobyl nuclear power plant site and the exclusion zone is needed to assure application of consistent management approaches, and sufficient facility capacity for all waste types. Specific emphasis needs to be paid to the characterization and classification of waste (in particular waste with transuranic elements).

A coherent and comprehensive strategy for the rehabilitation of the exclusion zone is needed with particular focus on improving safety of the existing waste storage and disposal facilities. This will require development of a prioritization approach for the remediation of the sites, based on safety assessment results.

ACKNOWLEDGEMENTS

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CANCER EFFECTS OF THE CHERNOBYL ACCIDENT*

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Abstract

Today, nearly 20 years after the Chernobyl accident, there is (apart from the dramatic increase in thyroid cancer incidence among those exposed in childhood and adolescence) no clearly demonstrated increase in the incidence of cancers in the most affected populations that can be attributed to radiation from the accident. Increases in incidence of cancers in general and of specific cancers (in particular breast cancer) have been reported in Belarus, the Russian Federation and Ukraine, but much of the increase appears to be due to other factors, including improvements in diagnosis, reporting and registration. Recent findings indicate a possible doubling of leukaemia risk among Chernobyl liquidators and a small increase in the incidence of premenopausal breast cancer in the very most contaminated districts, which appear to be related to radiation dose. Both of these findings, however, need confirmation in well-designed analytical epidemiological studies with careful individual dose reconstruction. The absence of demonstrated increases in cancer risk, apart from thyroid cancer, is not proof that no increase has in fact occurred. Based on the experience of atomic bomb survivors, a small increase in the relative risk of cancer is expected, even at the low to moderate doses received. Such an increase, however, is expected to be 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, the absolute number of cancer cases caused by even a small increase in the relative risk could be substantial, particularly in the future. At present, the prediction of the cancer burden related to radiation exposure

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from Chernobyl must be based on the experience of other populations exposed to radiation and followed up for many decades. Such predictions are uncertain as the applicability of risk estimates from other populations with different genetic and environmental backgrounds is unclear. They do, however, provide an idea of the order of magnitude of the likely impact of the accident; among the nearly six million persons in the most exposed populations (liquidators, evacuees, residents of strict control zones and residents of contaminated areas of Belarus, the Russian Federation and Ukraine), predictions currently available are of the order of 9000 to 10 000 deaths from cancers and leukaemia over life. In the next years, careful studies of selected populations are needed in order to study the real effect of the accident and compare it to predictions.

1. INTRODUCTION

Over the last two decades, there have been many reports of increased incidence of cancer and of other health effects attributed to the Chernobyl accident. Within the framework of the United Nations Chernobyl Forum, the WHO convened expert groups to review published studies on the health consequences of the accident with the aim of assessing the impact of the accident, identifying gaps in knowledge and making recommendations concerning health care programmes in Belarus, the Russian Federation and Ukraine [1].

The basis for the evaluation was the comprehensive review conducted by the UNSCEAR and published in 2000. This was updated with a review of the peer-reviewed scientific literature published since then, presentations at scientific meetings, and recent reports and statistics provided by national authorities.

The expert groups provided a consensus opinion and recommendations for the topics below:

- Doses received from the accident;
- Thyroid cancer and other thyroid pathologies;
- Leukaemia;
- Solid cancers other than thyroid;
- Non-cancer and non-thyroid health effects;
- Medical and health care programmes in Belarus, the Russian Federation and Ukraine.

The current paper addresses the first issues — doses, thyroid diseases, leukaemia and other cancers, and the main long term effects expected as a

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result of radiation exposure [2, 3]. The other issues are the topic of a separate presentation in this session [4].

2. METHODOLOGICAL CONSIDERATIONS IN INTERPRETING REPORTS OF HEALTH EFFECTS AFTER CHERNOBYL

There are a number of limitations in what the epidemiological studies of the radiological consequences of the Chernobyl accident can establish. Indeed, to be informative to evaluate the effect of radiation exposure following Chernobyl, studies must fulfil several important criteria:

- They must cover very large numbers of exposed subjects;
- The follow-up must be complete and non-selective and precise; and
- Accurate individual dose estimates (or markers of exposure) must be available.

In particular, the feasibility and the quality of epidemiological studies largely depend on the existence and the quality of basic population-based registries, and on the feasibility of linking information on a single individual from different data sources. These requirements are particularly important in the context of the Chernobyl accident, where most people received relatively small doses of radiation and the resulting health effects are, therefore, expected to be relatively small and, hence, difficult to identify against background incidences more heavily influenced by other risk factors such as tobacco smoking, alcohol consumption, diet, lifestyle and some occupational exposures.

Although the first of these criteria is clearly fulfilled, given the large number of persons residing in contaminated areas, the absence of high quality disease registries in many of the contaminated regions at the time of the accident, recent changes in the longevity of the populations in the affected countries (both in contaminated and uncontaminated regions) and the absence of individual dose estimates for the majority of exposed persons makes the conduct of informative epidemiological studies — and the interpretation of published reports — very difficult.

One of the notable exceptions to the low doses received by Chernobyl populations is the dose to the thyroid, which, for a relatively large number of children, reached high levels in the most contaminated territories. These high thyroid exposures, which were mainly due to the consumption of milk contaminated with radioactive isotopes of iodine, were delivered within a few weeks after the accident and are the cause of extensive studies of thyroid cancer among the affected populations.

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The expert groups reviewed many reports of associations in which the numbers of cases and/or controls were too small to determine whether radiation was the cause of the health outcome. Further, results of a number of studies were presented to the expert group without the necessary supporting information to allow a judgement of the scientific merits of the findings.

In addition, most of the health effects considered have a wide variety of risk factors which, if not adequately taken into account, can significantly bias the results of the studies. For example, it is well known that smoking and alcohol consumption are responsible for large increases in the mortality and morbidity from many diseases, including various cancers [5], cardiovascular disease and, for tobacco, chronic respiratory diseases. In addition, radiation or accident-related stress may lead people to smoke more, which in turn can lead to more cancer and cardiovascular disease, without radiation having had any direct effect.

3. RADIATION DOSES FROM THE ACCIDENT

The main populations exposed to radiation from the Chernobyl accident are the:

- (a) *Liquidators*: also referred to as ‘cleanup workers’. They include persons who participated in the cleanup of the accident (cleanup of the reactor, construction of the sarcophagus, decontamination, building of roads, destruction and burial of contaminated buildings, forests and equipment), as well as many others, including physicians, teachers, cooks, interpreters who worked in the contaminated territories. About 240 000 liquidators took part in 1986–87 in major mitigation activities specifically at the reactor and within the 30 km zone surrounding the reactor. This includes the early reactor workers and the ‘emergency’ cleanup workers who intervened in the first hours or days after the accident. Large numbers of liquidators also worked outside the 30 km zone, where they received lower doses. Residual mitigation activities continued on a relatively large scale until 1990. All together, about 600 000 persons (civilian and military) have received special certificates confirming their status as liquidators, according to laws promulgated in Belarus, the Russian Federation and Ukraine.
- (b) *Inhabitants who were evacuated or relocated from contaminated areas*: Massive releases of radioactive materials into the atmosphere brought about the evacuation of about 116 000 people from areas surrounding the reactor during 1986, and the relocation, after 1986, of about

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220 000 people from, what were at this time, three independent republics of the former Soviet Union: Belarus, the Russian Federation and Ukraine.

- (c) *Inhabitants of contaminated areas who were not evacuated:* Many persons continue to live in vast territories of those three republics that were contaminated. The population of those areas, from which no relocation was required, amounts to about five million people.

Table 1 presents a summary of the number of persons exposed and the levels of doses received in these population groups. Residents of contaminated areas have been divided into residents of the strict control zones and residents of less contaminated areas.

3.1. Doses to liquidators

The liquidators, either emergency or cleanup workers, were subjected mainly to external exposure with gamma and beta radiation during their work on-site. Most of the information on the doses received by liquidators is in the Chernobyl State Registries of Belarus, the Russian Federation and Ukraine. The doses recorded in the registries range up to more than 500 mGy, with an average of more than 100 mGy for the 1986–87 liquidators who worked on the reactor site and in the 30 km zone.

It is estimated that early reactor and emergency workers received, on 26 April 1986, much higher doses of a few Gy up to 16 Gy; 28 of them died within the first four months due to acute radiation sickness.

TABLE 1. ESTIMATES OF MEAN EFFECTIVE DOSES FOR POPULATION GROUPS OF INTEREST [1]

Population	Approximate size of population	Mean effective dose (mSv)
Liquidators (1986–1987, 30 km zone)	240 000	100
Evacuees of 1986	116 000	33
Persons living in contaminated areas:		
Deposition density of ^{137}Cs >555 kBq/m ² *	270 000	50**
Deposition density of ^{137}Cs >37 kBq/m ²	5 200 000	10**

* Strict control zones — included in the areas with deposition density >37 kBq/m².

** For the period 1986–2005.

The dosimetric information available from the Chernobyl State Registries for liquidators is subject to controversy as the personal dosimeters in use in the early days after the accident were too few and generally too sensitive. For the purpose of epidemiological studies, these dose estimates need to be supplemented using other information and verified using other methods. The best method currently available to estimate the doses received by the liquidators is a time and motion assessment, called RADRUE [6]. One of the main advantages of this method is that it can be applied to any worker.

3.2. Doses to the general public

The general public was exposed to radioactive materials externally from the radioactive cloud and later from radionuclides deposited in the soil and other surfaces, and internally, from inhalation during the cloud's passage and from re-suspended materials, and consumption of contaminated food and water.

As the major health effect reported after the accident was an elevated thyroid cancer incidence in children and adolescents, much attention has been paid to estimating radiation dose to the thyroid.

A wide range of thyroid doses was received by the inhabitants of the contaminated areas of Belarus, the Russian Federation and Ukraine. Doses varied with age at exposure, level of ground contamination, milk consumption rate, and origin of the milk that was consumed. Reported individual thyroid doses varied up to about a few tens of Gy, while average doses are in the range of a few tens of milligray to a few Gy, depending on the age and area where people lived and were exposed (Table 2).

The main basis for the estimation of thyroid doses resulting from the intake of ^{131}I are the results of 350 000 measurements of exposure rate performed using radiation detectors placed against the neck of residents of Belarus, Ukraine and the Russian Federation within a few weeks following the accident [2, 11–13]. Intake of stable iodine tablets during the first 6–30 h after the accident reduced the thyroid dose of the residents of Pripyat by a factor of six on average [7, 14]. Pripyat was the largest city close to the Chernobyl nuclear power plant and residents were evacuated the day after the accident.

Although the intake of ^{131}I is the most important contributor to the thyroid dose, there are other components in the thyroid doses resulting from the Chernobyl accident that contribute to a few percent of the thyroid dose. These are: internal dose from intakes of short lived radioiodines (^{132}I , ^{133}I and ^{135}I) and of short lived radiotelluriums ($^{131\text{m}}\text{Te}$ and ^{132}Te); external irradiation from radionuclides deposited on the ground and other materials; and internal irradiation resulting from the intake of radionuclides other than radioiodines (essentially ^{134}Cs and ^{137}Cs). The thyroid doses from intake of radionuclides

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TABLE 2. ESTIMATES OF THYROID DOSES [2, 7–10; ZVONOVA, PERSONAL COMMUNICATION 2005]

Population	Size of population	Mean thyroid dose (Gy)		
		0–7 years	Adults	Total
Evacuees of 1986 including:	116 131	1.82	0.29	0.48
Villages, Belarus	24 725	3.1	0.68	1.0
Pripyat town	49 360	0.97	0.07	0.17
Villages, Ukraine	28 455	2.7	0.40	0.65
Belarus				
Entire country	10 000 000	0.15	0.038	0.053
Gomel region	1 680 000	0.61	0.15	0.22
Ukraine				
Entire country	55 000 000	—	—	0.013
Region around Chernobyl nuclear power plant	500 000	—	—	0.38
Kiev city	3 000 000	—	—	0.037
Russian Federation				
Entire country	150 000 000	—	—	0.002
Bryansk region	1 457 500	0.16	0.026	0.041
Orel region	860 500	0.046	0.010	0.015
Tula region	1 796 300	0.033	0.007	0.011
Kaluga region	1 061 100	0.009	0.002	0.006

other than ^{131}I , and from external radiation only represent a small percentage of the thyroid dose due to ^{131}I for most individuals.

The effective dose estimates for individuals in the general population accumulated over the 20 years following the accident (1986–2005) range from a few mSv to some hundred mSv depending on location, age and behaviour. These doses are mainly due to external exposure from a mixture of deposited radionuclides as well as to internal exposure from intake of ^{134}Cs and ^{137}Cs . As indicated in Table 1, the mean effective dose accumulated up to 2005 among residents in the strict control zones (with ^{137}Cs deposition density of 555 kBq/m² or more) is of the order of 50 mSv (40 mSv up to 1995 [2]) while in less contaminated areas it is of the order of 10 mSv (8 mSv up to 1995 [2]). For comparison, the average effective dose from natural background radiation to an average person is about 2.4 mSv/a. So during an entire life, each of us accumulates a dose of 100–200 mSv.

4. THYROID DISEASE

The main health effect of radiation from the accident observed to date is a dramatic increase in the incidence of thyroid cancer in young people, which started to be documented in 1991 in Belarus and continues until now in the most contaminated areas of Belarus, the Russian Federation and Ukraine [9, 15, 16]. Fig. 1 illustrates the temporal trends of childhood, adolescent and adult thyroid cancer in Belarus since the accident. The highest incidence of childhood thyroid cancer was about 40 per million children per year (compared to pre-accident rates which were of the order of 0.3–0.5 cases per million per year) in 1995. The childhood thyroid cancer rates have declined to zero as the population has aged (by 2002, none of those who were children at the time of the accident were children anymore) and parallel increases have been seen in the incidence of thyroid cancer in adolescents and then in young adults.

During the period 1986–2002 in Belarus, the Russian Federation and Ukraine, nearly 5000 cases of thyroid cancer were diagnosed among those who were children and adolescents (0–18 years) at the time of the accident (Table 3). Close to 4000 of these cases were children below the age of 15 at the time of exposure.

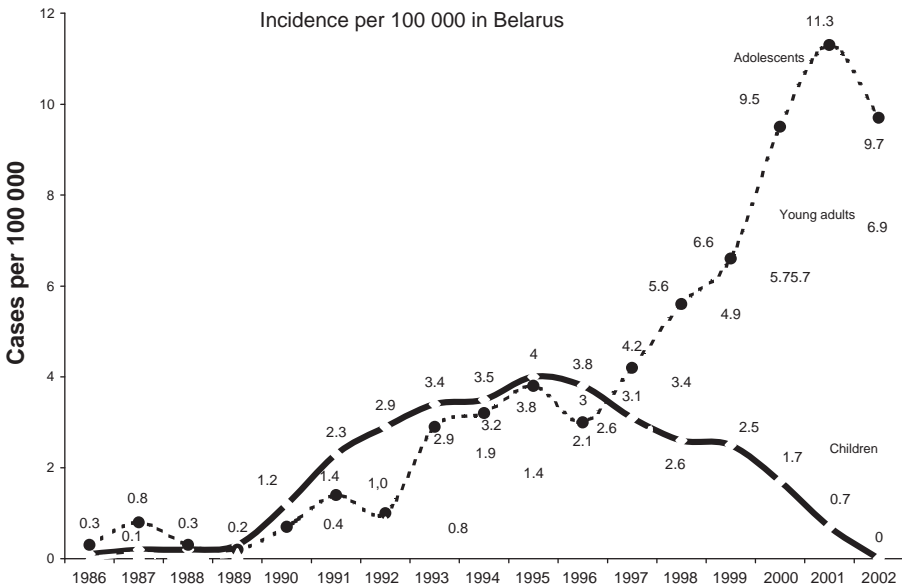


FIG. 1. Annual incidence of childhood, adolescent and adult thyroid cancer in Belarus among those who were children (below 15 years of age) at the time of the Chernobyl accident (courtesy of Yu. E. Demidchik).

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TABLE 3. NUMBER OF CASES OF THYROID CANCER BY COUNTRY AND AGE AT EXPOSURE (1986–2002). REPORTED NUMBER OF DEATHS ARE SHOWN IN ITALICS (PERSONAL COMMUNICATIONS, CANCER REGISTRIES OF BELARUS AND UKRAINE 2006, AND CANCER SUBREGISTRY OF THE RUSSIAN NATIONAL MEDICAL AND DOSIMETRIC REGISTRY 2006)

Age at exposure		Belarus	Russian Federation ^a	Ukraine	Overall
0–14	Cases	1711	349	1762	3822
	<i>deaths</i>	<i>8</i>	<i>1</i>	<i>6</i>	<i>15</i>
15–18	Cases	299	134	582	1015
Total		2010	483	2344	4837

^a Bryansk, Tula, Kaluga and Orel regions (1986–2000).

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 risks estimates derived from epidemiological studies, it is most likely that a large fraction of thyroid cancers observed to date among those exposed in childhood is attributable to radiation exposure from the accident.

Although the impact on thyroid cancer risk of the accident is large, the prognosis of the disease is fortunately very good. Only 15 individuals of the cases of childhood cancer have been reported to have died (eight in Belarus, six in Ukraine and one in the Russian Federation).

4.1. Thyroid cancer epidemiological studies

The Chernobyl experience has provided a unique opportunity to learn about the effects of exposure to doses from radioactive iodines on thyroid cancer risk. Careful epidemiological and dosimetry studies should provide important evidence for radiation protection measures.

A large number of epidemiological studies of thyroid cancer have been carried out in Belarus, the Russian Federation and Ukraine since the accident. The majority of studies are ecological or descriptive epidemiological studies, in which estimates of dose are available at the population rather than individual level. Only three analytical case control studies with individual dose estimates have been published at the time of this review.

It is important to consider the strengths and limitations of each study in interpreting results regarding the risk of thyroid cancer after Chernobyl.

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Numerous ecological studies have been published [9, 16–21]. Most of these studies have clearly shown an association between thyroid cancer incidence in young people and average dose to the thyroid. Risk estimates have been derived in these studies — the most comprehensive, based on combined analyses of data from the three countries were presented by Jacob et al. [18]: EAR 2.1 per 10 000 Py–Gy (95% CI 1.0–4.5); ERR 23 per Gy (95% CI 8.6–82). The ERR is much larger than that reported in studies of populations exposed to external radiation in childhood (ERR 7.7 per Gy [22]). Results of ecological studies in areas with good dosimetry are more closely related to the radiation risk in the population. However, their results may be influenced by ecologic bias, related to the absence of data on potential confounding factors, in particular on the intensity of screening.

Results of analytical studies (e.g. case control and cohort studies) with good individual dose reconstruction provide more informative quantitative estimates of risk of thyroid cancer after the Chernobyl accident than ecological studies. Three studies have been published to date [23–25]. The most recent study was conducted in Belarus and the Russian Federation, covers 276 cases and 1300 controls, and provides direct estimates of the effects of I¹³¹ [25]. The ERR per Gy in that study ranges from 4.5 to 7.4, depending on the model used, slightly lower than, but consistent with, the estimates from studies of external exposures in children. Results of the first two case control studies [23, 24], although based on fewer cases and, for the Astakhova study, less detailed dosimetry are consistent with this.

No direct information is available at present to evaluate the pattern of thyroid cancer risk over time. Based on studies of other populations exposed to external radiation that have been followed-up for several decades [22], it is expected that thyroid cancer risk from Chernobyl will continue for many more years, although the long term magnitude of risk is difficult to quantify.

Large scale screening programmes were initiated in contaminated areas shortly after the accident [2]. Screening programmes, in general, increase the apparent incidence of thyroid cancer by advancing the time of diagnosis of tumours that would otherwise become clinically apparent only at some later date, and possibly by identifying tumours that would never become clinically manifest. Screening therefore has important implications in the areas of public health and thyroid cancer risk estimation, yet we lack quantitative data regarding their effects in either of these areas.

New studies indicate that iodine deficiency at the time of exposure may increase the risk of radiation-induced thyroid cancer [20, 25] and stable iodine supplementation in the years after exposure may reduce this risk [25]. Further studies are needed to replicate these findings.

While the increased risk of thyroid cancer in those exposed in childhood and adolescence is clear, there is much less information on the effects of exposure as an adult.

4.2. Biology of thyroid cancer

Papillary cancer is the primary pathological type of thyroid cancer in those exposed as children and adolescents to fallout from the Chernobyl accident. There are a variety of subtypes of papillary cancer, and it appears that these may be related to latency and, therefore, change with time since exposure. It is not clear whether this change in morphology is related to clinical presentation or outcome.

At the molecular level, it would appear that the earlier suggestion that specific rearrangements of the *ret* oncogene may be a marker for radiation exposure has not been substantiated. Analysis of mutations in individual genes has not identified differences between radiation-associated thyroid cancers, and age matched non-irradiation related cancers of similar morphology. However, it is clear that there are major differences in the molecular biology and pathology of papillary cancers as a function of age at clinical presentation. From initial studies on multiple gene expression analysis, it is not clear that a radiation signature can be identified at this time.

The molecular biology and the pathomorphology of post-Chernobyl thyroid cancer is dynamic, and a considerable effort needs to be maintained in monitoring both of these features with time post-Chernobyl. Attention must also be paid to the interpretation of the molecular biology studies, in particular the sensitivities of the different techniques used.

4.3. Treatment of childhood thyroid cancer

Thyroid cancer in children is a rare disease, so the experience worldwide related to diagnosis, treatment and follow-up of this tumour disease is limited. Up to now, our knowledge about the natural course of radiation-induced thyroid carcinoma is sparse. At the time of diagnosis, many children present with extraglandular tumour spread, lymph node and distant metastases. Even in children with advanced tumour stages, treatment with thyroidectomy, followed by high dose radioiodine therapy and consecutive levothyroxine TSH-suppressive hormone replacement is effective. In general, the prognosis for young patients with papillary thyroid carcinoma can be considered as excellent. Concerning the side effects of treatment, our knowledge about the consequences of hypoparathyroidism frequently accompanying thyroidectomy

is limited. Only few data are available about the late side effects of high dose radioiodine therapy and lifelong TSH-suppressive levothyroxine medication.

4.4. Other thyroid diseases

Radiation-induced thyroid disorders other than thyroid carcinoma, including benign thyroid nodules, non-autoimmune thyroid hypothyroidism and autoimmune thyroiditis have been reported after environmental exposure to radioisotopes of iodine. The information available regarding thyroid function abnormalities and development of thyroid nodules as the result of the Chernobyl accident is rather inconsistent. While some epidemiological evidence of an association with thyroid autoimmune reactions (possibly transient) has been obtained, long term studies are needed in order to evaluate possible associations between environmental exposure and non-neoplastic thyroid diseases.

5. LEUKAEMIA

Leukaemia (excluding chronic lymphocytic leukaemia) has been associated with exposure to ionizing radiation in a number of studies, including atomic bomb survivors, patients treated with radiotherapy and occupationally exposed populations in medicine and the nuclear industry [2]. In populations with high dose rate exposures, increases in leukaemia risk appear early (within two to five years of exposure) and the excess relative risk per Gy (particularly in children) is one of the highest, with that of thyroid cancer, among all radiation-inducible cancers [2, 3]. Leukaemia incidence and mortality are therefore often considered as ‘markers’ of radiation risks in exposed populations.

5.1. Effect of exposure in utero

It has been suggested in ecological studies in Europe, particularly in Greece [26], that exposure in utero may increase the risk of infant leukaemia. These results have not been confirmed in a similar study in Germany [27], and results of studies in Belarus [28] and Ukraine [29] where this has also been investigated are not consistent. The statistical power of these studies was low, however, for detecting moderate sized effects and the exposure measures were quite crude. It is therefore not possible at present to conclude about the presence or absence of an effect of in utero exposure.

Studies of other populations exposed to X rays in utero [30] indicate that the prenatal period may be one of increased susceptibility to radiation damage.

Analytical studies with individual dose estimates are therefore needed to assess the existence of such an effect after radiation exposure from the Chernobyl accident. However, because of the relatively small doses, and rarity of leukaemia as an outcome, it is not clear that such studies would have sufficient statistical power to yield meaningful results.

5.2. Effect of exposure in childhood

Several ecological studies have examined the association between leukaemia risk and exposure to radiation from the Chernobyl accident. These include the European Childhood Leukaemia-Lymphoma Study (ECLIS – the largest and most comprehensive study to date, coordinated by the IARC [31, 32]), and a number of national incidence studies in Belarus [33–36], Finland [37], Sweden [38, 39] and Greece [26, 40]. Although the incidence of leukaemia significantly increased in Europe in the years after the accident, there was no evidence that the increase was related to radiation exposure from the accident in the ECLIS study. Further, the national studies do not in general provide evidence for an increase in the incidence of childhood cancer, even in Belarus or the Russian Federation. It should be noted, however, that ecological studies of this type are not generally sufficiently sensitive to detect small changes in the incidence of rare diseases such as childhood leukaemia; further, they are subject to a number of methodological problems, such as ecological bias which limit the interpretation of the findings.

Only one case control study of childhood leukaemia has been published to date [41]. Analyses are based on 98 cases from Ukraine and their matched controls. Although increased risk of acute leukaemia was found in subgroups of the subjects, it is difficult to interpret these results due to a number of methodological problems.

Up to now, therefore, there is no adequate evidence to conclude about the existence or not of a measurable increase in risk of leukaemia following childhood exposure from Chernobyl.

5.3. Effects of exposure to adults

Studies of leukaemia risk have been conducted both among liquidators of the accident and among persons residing in contaminated areas.

Studies about liquidators were conducted in Estonia, the Russian Federation and Ukraine. The Estonian study was very small and therefore provides little information about risks [42]. The incidence of leukaemia in a large cohort of Ukrainian liquidators [43] appeared to be increased among liquidators, but this increase was not related to dose. In the Russian Federation,

although studies of small cohorts did not indicate an increased risk [44, 45], studies of a large cohort of liquidators indicated an approximately twofold increased risk among those with a registered radiation dose between 150 and 300 mGy [46]. Dose estimates in these studies are uncertain, however, and more precise information is expected from case control studies with individual dose reconstruction. To date, only one case control study has been published in the Russian Federation, based on a small number (34) of cases. Non-statistically significant increases in risk were seen among the most highly exposed liquidators in that study. Ongoing studies of liquidators are expected to provide additional information on the magnitude of a possible increased risk of leukaemia, based on individual estimates of radiation dose.

There are very few published studies of leukaemia risk among adult populations living in highly contaminated areas [47–49]. Although most of these studies indicate an increase in leukaemia incidence over time, this increase does not appear to be related to contamination. The epidemiological designs used in these studies, however, are relatively insensitive and such studies therefore have little power to detect an increase if it exists. Although there is currently no evidence to evaluate whether a measurable risk of leukaemia exists among those exposed as adults in the general population, the possibility of conducting studies of these adults with adequate power seems remote so that risk estimates in the future will have to be based upon sources other than direct observation of the Chernobyl population.

6. SOLID CANCERS OTHER THAN THYROID CANCER

Ionizing radiation has been shown to increase the risk of cancers at many sites, based on studies of atomic bomb survivors, medically irradiated and occupationally exposed populations [2, 3]. At present, epidemiological data from atomic bomb survivors and from persons having received very high doses from radiotherapy remain the most important basis for our estimation of radiation risk in humans [3] and the effects of low dose/low dose rate exposures (<100 mSv) are estimated from these, using extrapolation models that are the subject of continued controversy.

Since the publication of the UNSCEAR report, which concluded that the occurrence of radiation-related solid cancers other than thyroid cancer had not so far been demonstrated [2], few additional studies have been published.

Two studies of cancer risk among Russian liquidators have been published [45, 50]. A slight non-significant increase in all solid cancer risk was seen among over 55 000 liquidators from 1991 on; the authors estimated the ERR per Gy in that study to be 0.19, 95% CI–0.66, 1.27, although there was no increase in solid

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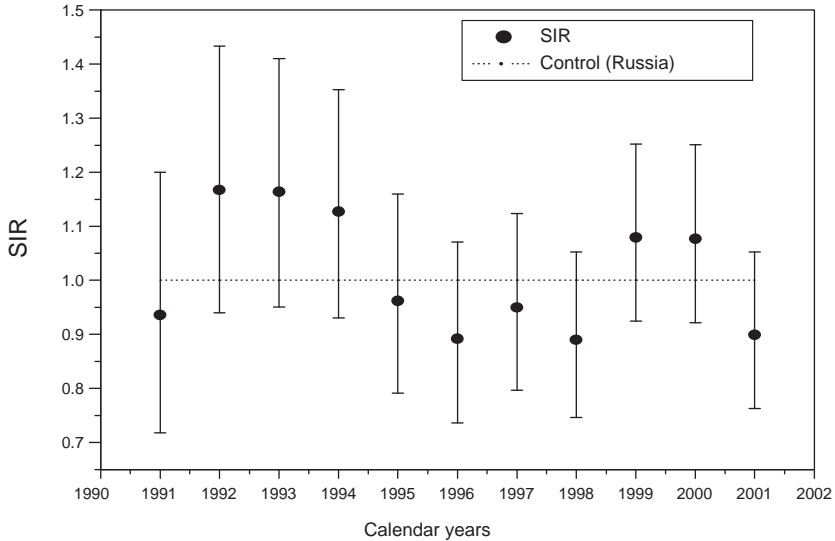


FIG. 2. Standardized incidence ratio (SIR) for solid cancers comparing Russian emergency workers (data points with error bars) with the general Russian population (straight line) for the years 1990–2001 [50].

cancer incidence among liquidators compared to the whole Russian population (Figure 2 [50]). A non-significant increased risk was also reported in a smaller cohort of 8650 nuclear workers who participated in the cleanup of the accident. The incidence of solid cancers among residents of the heavily contaminated region of Bryansk in the Russian Federation was not significantly different from that of the general Russian population (Fig. 3 [51]).

Analyses of rates of breast cancer among Ukrainians included in the Chernobyl registry indicated a significantly increased incidence among women residents in the contaminated areas, among evacuees from the 30 km zone and among women liquidators, compared to the general population [52]. As in a previous Belarus report of increased incidence over time in the Mogilev region, these increases are difficult to interpret as no information about radiation dose level was available in the study [53]. An ecological epidemiological study was conducted to describe the spatial and temporal trends in breast cancer incidence in the regions of Belarus and Ukraine most contaminated by the Chernobyl accident, and to evaluate whether the reported increases correlate with radiation exposure [54]. An increase in incidence was seen in all areas, reflecting improvements in cancer diagnosis and registration (Fig. 4). In addition, a significant twofold increase in risk was observed, during the period 1997–2001, in the most contaminated districts (average cumulative dose of 40.0 mSv or

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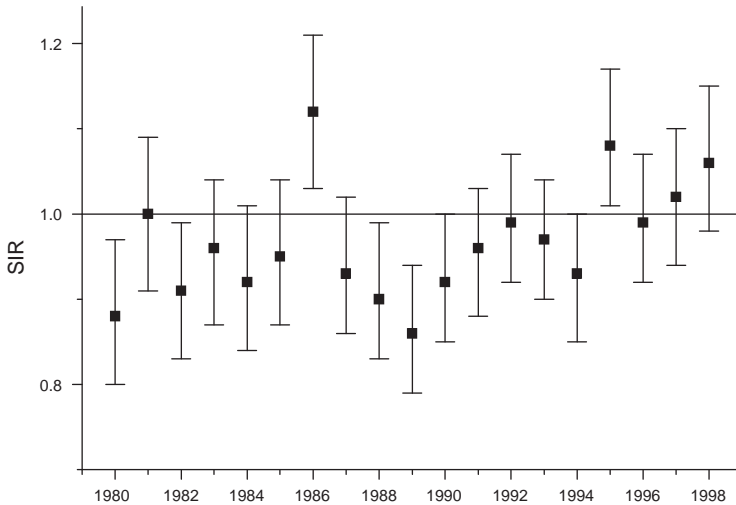


FIG. 3. Dynamics of standardized incidence ratios (SIR) for all forms of solid cancer among residents of five districts of the Bryansk region (both sexes) [51].

more) compared to the least contaminated districts (RR in Belarus 2.24, 95% CI 1.51–3.32 and in Ukraine 1.78, 95% CI 1.08–2.93) (Fig. 5). The increase, though based on a relatively small number of cases, appeared approximately ten years after the accident, was highest among women who were younger at the time of exposure and was observed for both localized and metastatic diseases. These findings therefore merit further investigation.

At present, there remains a lack of evidence of any demonstrated effect of Chernobyl radiation exposures on any solid cancers except for thyroid cancer. As noted above, however, studies of these effects are few and have methodological limitations. Doses to most organs outside the thyroid tended to be low, moreover, and studies lacked statistical power. Further, it is thought that for most solid cancers, the minimum latent period is likely to be much higher than that for leukaemia or thyroid cancer – of the order of 10 to 15 years or more – and it may therefore be too early to evaluate the full radiological impact of the accident.

Recent evidence indicates that there may be a radiation-related increase in the incidence of pre-menopausal breast cancer in the most exposed districts of the contaminated regions. Studies of other exposed populations have shown that the relative risks of breast cancer for women exposed to external radiation in childhood and adolescence are among the highest known radiation-related risks for any cancer type along with leukaemia and thyroid cancer following exposure in childhood and young adulthood [2, 3]. Further, careful analytical

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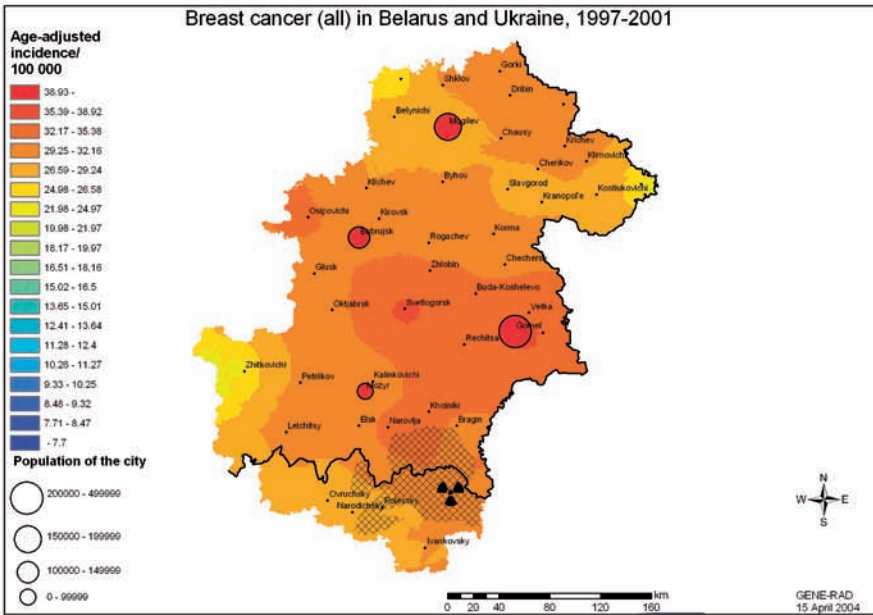
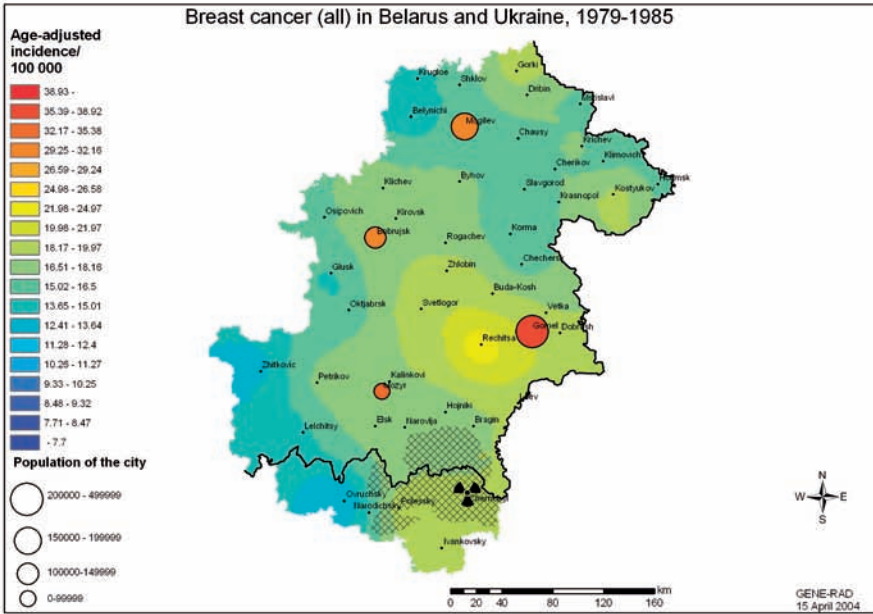


FIG. 4. Smoothed maps of age-adjusted breast cancer incidence in Belarus and five districts of Ukraine, before and after the Chernobyl accident [54].

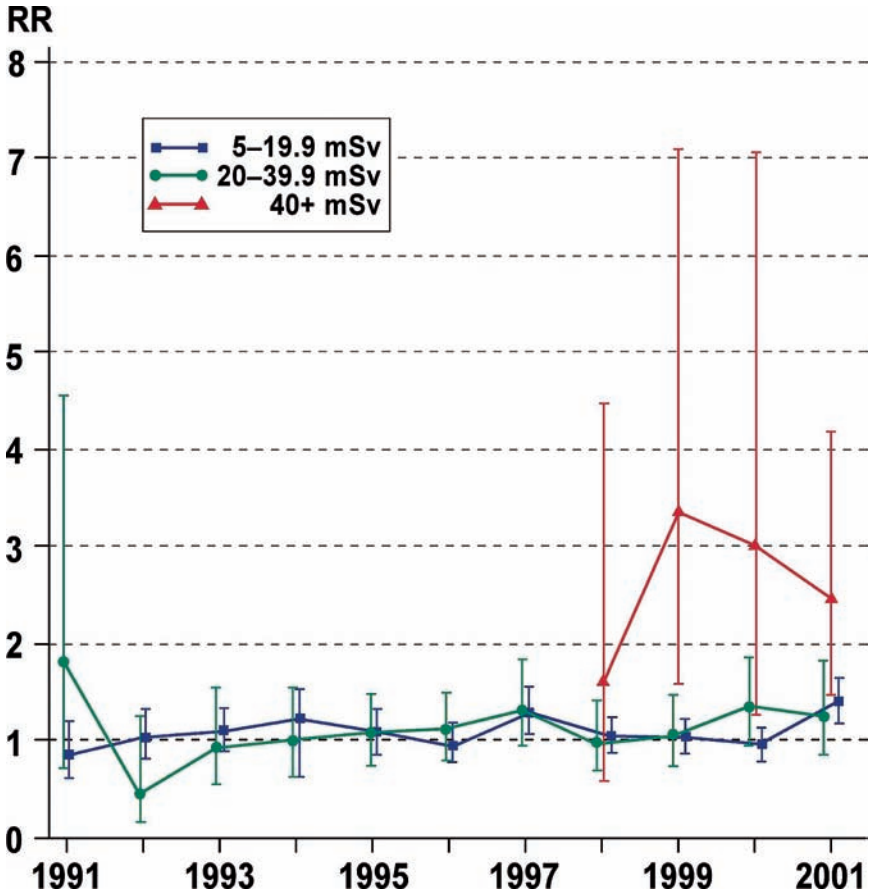


FIG. 5. Time trend in breast cancer relative risk (RR) by average cumulative dose category in territories of Belarus and Ukraine most contaminated by the Chernobyl accident (doses lagged by five years; age at exposure <45) [54].

epidemiological studies (preferably case control studies), with detailed individual dose reconstruction, are therefore needed to investigate the apparent increased breast cancer risk in young women in the most contaminated areas.

7. PREDICTING THE CANCER RISK
FROM THE CHERNOBYL ACCIDENT IN THE FUTURE

The fact that no significant increased cancer risk, apart from thyroid cancer, has been scientifically demonstrated to date among populations most exposed to the Chernobyl accident does not imply that no increase in risk has occurred.

Indeed, based on the experience of other populations exposed to ionizing radiation, it is expected that the low to moderate doses received will have led to a small increase in the relative risk of cancer. Given the large number of individuals exposed, the absolute number of cancer cases caused by a small increase in the relative risk could be substantial, particularly in the future.

The question of estimating the number of cancer cases which could occur due to the Chernobyl accident is of particular importance for public health planning purposes. At present, given the lack of demonstrated increases and the relatively short follow-up for solid cancers (diseases with a very long latency period) of the populations, any such estimation must be based on risk estimates derived from other populations exposed to radiation, most notably the atomic bomb survivors. This implies a number of uncertainties. Major questions relate to the choice of models for transfer of risk between populations with different background cancer rates, for projection of risk over time and for extrapolation of risks following primarily external high dose and high dose rate exposure to low dose and low dose rate exposures involving a mixture of external and internal radiation. These factors limit the accuracy and precision of such projections.

If such projections are made for public health reasons, it is essential that the uncertainty in these predictions be recognised. In 1996, Cardis et al. [55] presented their predictions of the health effects of Chernobyl radiation in the above mentioned four most exposed populations of Belarus, the Russian Federation and Ukraine. These predictions were derived from models of radiation-induced risk developed from epidemiological studies of other populations exposed to radiation, mainly the Japanese atomic bomb survivors (Life Span Study, (LSS)). Although these predictions were made in 1996 (and the size of the populations and average doses used differ somewhat from those shown in Table 1), there is no reason, given the inherent uncertainties in modelling data and doses, to believe these estimates should be changed significantly at this time.

In these predictions, the estimates based on the atomic bomb survivor data were applied directly to the populations exposed as a result of the Chernobyl accident assuming that, for a given radiation dose, the resulting cancer risk is the same regardless of the pattern and type of exposure. It is

noted that, in extrapolating the risk estimates based on high dose and high dose rate exposure to low dose and low dose rate exposures, the International Commission for Radiological Protection (ICRP) has used a reduction factor (the dose and dose-rate effectiveness factor (DDREF)) of two [56]. Lifetime risk estimates (through age 95 years) were computed for solid cancers and leukaemia (excluding CLL) for the liquidators and the populations living in contaminated areas of Belarus, the Russian Federation and Ukraine. The methods used follow those of the UNSCEAR 1994 Report, allowing for the modifying effects of age at exposure and sex (for leukaemia). Table 4 presents the predictions of lifetime risk (numbers of deaths) from solid cancers and leukaemia. The number of deaths predicted in the first ten years after the accident are also presented for leukaemia but not for solid cancers as the model assumes a ten year latency period between exposure and the resulting increase in cancer.

As shown, for both solid cancers and leukaemia, the predicted proportions of excess deaths among all deaths from these diseases (i.e. the ‘attributable fractions’) are small compared to the background number of deaths expected in the absence of any exposure. For solid cancers, they range from less than 1% among the populations evacuated from the 30 km zone and the residents of contaminated areas outside the strict control zones to about 5% for the liquidators who worked in 1986 and 1987. The lifetime attributable fraction for leukaemia is greater than that for solid cancers in each population, ranging from 2 to 20%; the excess cancer deaths from leukaemia are much smaller, however, than for all solid cancers because of the much greater rarity of this neoplasm. A large proportion of the excess leukaemia deaths is predicted to have occurred in the first ten years after the accident.

Overall, therefore, the predicted lifetime excess in cancer and leukaemia deaths due to radiation from the Chernobyl accident is of the order of 2200 for liquidators, 160 for evacuees, 1600 among residents of the strict control zones and about 5000 among residents of other contaminated areas — a total of about 9000 deaths (about 4000 of these predicted among the three most exposed populations: liquidators, evacuees and residents of strict control zones) (Table 4). These predictions are only meant to provide an indication of the possible impact of the accident and should not be taken at face value because of the important uncertainties listed above.

8. CONCLUSIONS

Today, nearly 20 years after the Chernobyl accident, there is (apart from the dramatic increase in thyroid cancer incidence among those exposed in

TABLE 4. PREDICTIONS OF BACKGROUND AND EXCESS DEATHS FROM SOLID CANCERS AND LEUKAEMIA IN POPULATIONS EXPOSED AS A RESULT OF THE CHERNOBYL ACCIDENT (FROM [55])

Population	Population size/ average dose	Cancer type	Period	Background number of cancer death ^a	Predicted excess cancer deaths	AF ^b (%)
Liquidators, 1986–1987	200 000	Solid cancers	Lifetime (95 years)	41 500	2000	5
	100 mSv	Leukaemia	Lifetime (95 years)	800	200	20
			First 10 years	40	150	79
Evacuees from 30 km zone	135 000	Solid cancers	Lifetime (95 years)	21 500	150	0.7 ^c
	10 mSv	Leukaemia	Lifetime (95 years)	500	10	2
			First 10 years	65	5	7
Residents of SCZs	270 000	Solid cancers	Lifetime (95 years)	43 500	1500	3
	50 mSv	Leukaemia	Lifetime (95 years)	1 000	100	9
			First 10 years	130	60	32
Residents of other 'contaminated' areas	6 800 000	Solid cancers	Lifetime (95 years)	800 000	4600	0.6
	7 mSv	Leukaemia	Lifetime (95 years)	24 000	370	1.5
			First 10 years	3 300	190	5.5

^a All figures are rounded to avoid giving an illusion of too great precision.

^b AF: attributable fraction = (excess deaths/total death from the same cause) × 100.

^c Note that a misprint has been corrected which appeared in the Proceedings of the Conference "One Decade after Chernobyl: Summing up the Consequences of the Accident" held in 1996 (Cardis et al. 1996) and in the WHO report to the Chernobyl Forum in 2006 (WHO 2006).

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childhood and adolescence) no clearly demonstrated increase in the incidence of cancers in the most affected populations that can be attributed to radiation from the accident. Increases in incidence of cancers in general and of specific cancers (in particular breast cancer) have been reported in Belarus, the Russian Federation and Ukraine, but much of the increase appears to be due to other factors, including improvements in diagnosis, reporting and registration.

Recent findings indicate a possible doubling of leukaemia risk among Chernobyl liquidators and a small increase in the incidence of pre-menopausal breast cancer in the very most contaminated districts, which appear to be related to radiation dose. Both of these findings, however, need confirmation in well designed, analytical epidemiological studies with careful individual dose reconstruction.

The absence of demonstrated increases in cancer risk, apart from thyroid cancer, is not proof that no increase has in fact occurred. Based on the experience of atomic bomb survivors, a small increase in the relative risk of cancer is expected, even at the low to moderate doses received. Such an increase, however, is expected to be 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, the absolute number of cancer cases caused by even a small increase in the relative risk could be substantial, particularly in the future.

At present, the prediction of the cancer burden related to radiation exposure from Chernobyl must be based on the experience of other populations exposed to radiation and followed-up for many decades. Such predictions are uncertain as the applicability of risk estimates from other populations with different genetic and environmental backgrounds is unclear. They do, however, provide an idea of the order of magnitude of the likely impact of the accident; for the four most exposed populations considered here, predictions currently available are of the order of 9000 to 10 000 deaths from cancers and leukaemia over life.

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

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NON-CANCER HEALTH EFFECTS OF THE CHERNOBYL ACCIDENT AND SPECIAL HEALTH CARE PROGRAMMES

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Abstract

In September 2004, the Expert Group on Health of the Chernobyl Forum specifically focused on non-cancer diseases and mortality associated with the Chernobyl accident as well as on medical follow-up. The group considered the following topics: cataracts, cardiovascular disease, cytogenetic markers, immunological effects, reproductive effects and children's health, psychological and mental effects, mortality due to the accident, and medical programmes and medical monitoring. The issues of potential cataracts at low doses as well as follow-up of liquidator's disease incidence and mortality should be continued. Cytogenetic effects may be used to assess doses above 0.2 Gy but are unlikely to be useful at lower doses. There is no clear evidence of radiation-related adverse clinical effects on the immune system of the general public or on hereditary or reproductive outcomes (particularly congenital malformations). Lifespan reduction and death rates of the general public are higher in both contaminated and clean areas than in other countries as is infant mortality, but these are not felt to be radiation related. Although the major potential radiation-related health effect is felt to be the cancer risk, screening programmes are not felt to be useful when absorbed doses are in the range of tens of mGy or lower. Psychological effects are real and represent the biggest public health impact of the accident. These will need continuing attention for the foreseeable future. While the paper is focused entirely on potential adverse effects of the accident, one should recognize the efforts of the Governments of Belarus, the Russian Federation and Ukraine to protect and take care of the affected populations.

1. INTRODUCTION

This presentation represents the work and consensus of the 3rd meeting of the Expert Group on Health of the Chernobyl Forum held at the WHO Headquarters in Geneva in September 2004 and is specifically directed at non-cancer diseases and mortality as well as at medical follow-up. The members of

the group were¹: V. Bebeshko, Ukraine; E. Bromet, USA; D. Darroudi, Netherlands; A. Grakovich, Belarus; J. Havenaar, Netherlands; E. Kapitonova, Belarus; N. Korol, Ukraine; V. Ivanov, Russian Federation; F. Mettler, USA; K. Neriishi, Japan; Y. Shibata, Japan; G. Soushkevich, Russian Federation; B. Worgul, USA.

The expert group acknowledged and used a number of documents as a historical basis including the report of the International Chernobyl Project [1], the proceedings of the IAEA/WHO/EC [2], the WHO IPHECA report [3], and the 2000 UNSCEAR report [4]. The group also reviewed several recent books on health effects from experts in the Russian Federation [5] and Ukraine [6].

The topics included for review are diverse and have different underlying biological mechanisms. Many of the papers and studies that we reviewed only had descriptive or subjective rather than objective findings. In other studies, the diagnostic criteria used to make a diagnosis were inconsistent or not presented. The data were sometimes presented without a useful context. For example, a percentage increase may have been found but the exact number, the baseline and the timeframe were often not available. Appropriate control groups were only available in some studies. Most studies did not have a dose response analysis and some did not even provide organ dose estimates at all.

The data were commonly also only available from one country. For example, most infant health data was available from the Ukraine, malformation data from Belarus and liquidator data from the Russian Federation. A final issue that has complicated data analysis in a number of areas is the reduction in lifespan which has occurred over the last decade in the three affected countries due to factors unrelated to the Chernobyl accident. The average lifespan in 2000 for males in the Russian Federation was 58.4, Belarus 62.6 and Ukraine 66.7 years compared to 70.6 years in nearby Poland (Table 1). As a result of the above caveats, the conclusions regarding non-cancer effects are scientifically less rigorous than the cancer and leukaemia data presented by the other expert groups.

The group was not able to review every alleged health effect due to the accident. A number of non-cancer topics were chosen as they were felt to have the most information and to be the most important for public health. They were:

- Cataracts;
- Cardiovascular disease;

¹ Observers included: M. Balonov, IAEA; E. Bodnar, USA; B. Greenebaum, USA; J. Hendry, IAEA; R. Lee, USA; Z. Carr, WHO; S. Yamashita, WHO.

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TABLE 1. COMPARATIVE POPULATION DEMOGRAPHICS FOR BELARUS, THE RUSSIAN FEDERATION, UKRAINE AND POLAND*

Indicator	Belarus	Russian Federation	Ukraine	Poland
Population (total), millions	10.3	147	49	39
Age 0–14	19%	18%	18%	19%
15–64	68%	69%	68%	69%
65+	13%	13%	14%	12%
Birth rate/1000	9	9	9	10
Death rate/1000	14	15	16	10
Infant mortality/1000 live births	15	19	22	10
Life expectancy at birth	68	67	66	73
For males	62.6	58.4	66.7	70.6
For females	74.3	72.1	72.9	78.7

* US Census Bureau International data base (www.census.gov/ipc/www/idbnew.html) and WHO (www.who.int/countries) as of 2000.

- Cytogenetic markers;
- Immunological effects;
- Heritable, reproductive effects and children’s health;
- Psychological mental and nervous system effects;
- Mortality due to the accident;
- Medical programmes and medical monitoring.

2. CATARACTS

Clinically significant radiation-induced cataracts after high doses have been known for many years. The current Chernobyl and other data suggest that early lens opacities can be found at lower doses (perhaps as low as 0.25 Gy) when the studies use coherent criteria, well-trained observers and good equipment. Some difficulties remain in determining the actual dose to the lens of the eye (especially from beta particles). In addition, the questions of the ultimate clinical effect and whether there is significant progression of the lesions still needs more research. The expert group has recommended continued ocular follow-up of liquidators and highly exposed radiation workers, and to continue the studies on those subjects already recruited. Ocular examinations of the public living in contaminated areas was felt to be unwarranted and possibly wasteful of resources.

3. CARDIOVASCULAR DISEASE

Changes to the heart, coronary arteries and small vessels has also been well documented after high radiation doses (particularly after radiation therapy of the chest). Most data relative to cardiovascular disease is potentially confounded by tobacco use. Most people are not aware that smoking causes more cardiovascular deaths than lung cancer deaths.

Data from the atomic bomb survivors has suggested a possible relation between radiation exposure and cardiovascular disease. The only Chernobyl data on cardiovascular disease available to the expert group was for the Russian liquidators [5] and the data had not been evaluated for potential smoking bias. While there was a slight increase reported for cardiovascular mortality for the group as a whole, there was no correlation with subsets of the data (i.e. myocardial infarction and ischemic heart disease) which one might reasonably expect would be associated with mortality.

The conclusion was that the acute radiation sickness survivors may well be at an increased risk of cardiovascular disease. The Russian liquidator findings need to be validated and further evaluated. A radiation effect was not fully substantiated but a small effect could not be excluded. Further studies of liquidators in other countries with appropriate control groups, individual dosimetry, standardized protocols and common diagnostic criteria were suggested.

4. CYTOGENETIC MARKERS

There are a number of markers that can be found in the genetic material of peripheral circulating lymphocytes which are related to radiation bone marrow dose. These include dicentrics and to a lesser extent mini- and microsatellite mutations. These methods have been used for years to perform biodosimetry. Both dicentric and fluorescent in situ hybridization (FISH) analysis can detect doses as low as 0.25 Gy. The reviewed Chernobyl data regarding mini- and microsatellite mutations was inconsistent.

The main question posed to the expert group was: "Are there any clinically significant effects associated with these genetic changes?" The group concluded that there is no evidence of current clinical effects directly attributable to these changes. It is clear, however, that since the changes are a marker of absorbed dose, they do provide an indication of the magnitude of potential risk for some future effects (such as cancer).

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A recommendation for the future was that biodosimetry studies be combined with health outcome studies to help analyse for the existence of a possible dose response relationship.

5. IMMUNOLOGICAL EFFECTS

As with many of the effects mentioned so far, high doses of radiation can also adversely affect the function of the immune system. At low doses of radiation, the scientific literature indicates that while there may be laboratory findings there do not appear to be significant clinical changes. There are many different cell subtypes involved in mediating the immune response.

The expert group reviewed quite a number of studies of immune cell function that had been published; however, the results of the studies were often contradictory and not coherent particularly with the temporal sequence of findings. The cause of the varied effects reported was possibly felt by some of the authors to potentially be due to confounding factors (including diet, chemicals, chronic effects or radiation). Many of the Chernobyl studies were also in conflict with the detailed studies that have been performed over decades on the atomic bomb survivors. In any case, at doses of less than several tens of mGy, no clinical effects related to the immune system effects have been reported.

It was recommended that studies of the immune system continue on those exposed to high doses (more than tens of mSv) but that doses at lower dose levels would be unlikely to yield useful information. The exception to this might be children who have individually estimated doses and only when studied with appropriate control groups and a blind analysis.

6. HERITABLE, REPRODUCTIVE EFFECTS AND CHILDREN'S HEALTH

Heritable effects of radiation in humans have not been reported in the scientific literature. This does not mean that effects might not be present, but if present, they have eluded detection. Changes in fertility have been previously reported but not at doses below 0.2 Gy. Thus, heritable or fertility issues were not expected in the general population around Chernobyl. With regard to birth rate, the data is confounded by the general practice of a high rate of medical abortions that occurred both before and after the accident. Also, from the previous extensive scientific literature, congenital malformations as a result of in utero radiation were not expected at foetal doses of less than 0.1–0.2 Gy.

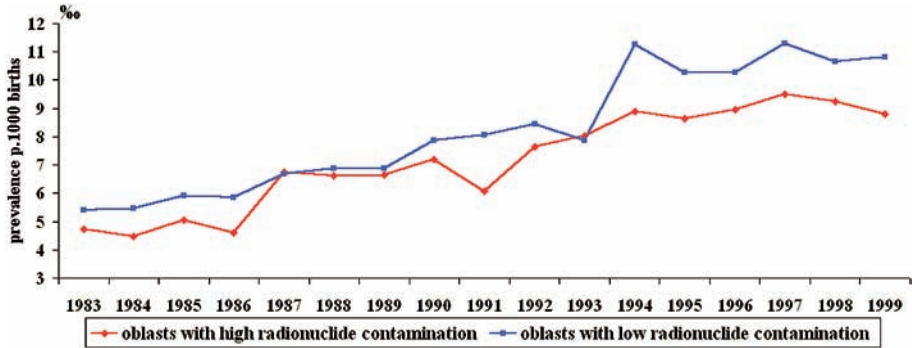


FIG. 1. Prevalence at birth of nine types of congenital malformations in four regions (oblasts) with high and low levels of radionuclide contamination [7].

Such fetal doses were not incurred by the general population living in contaminated regions.

After reviewing the available data, the expert group concluded that there was no evidence of radiation effects on infant mortality, although quite a high rate of infant mortality compared to other countries was noted in both contaminated and non-contaminated regions. There was excellent data from Belarus on well defined congenital malformations. This data registry was in place long before the Chernobyl accident and the data show a relatively constant rise in reported congenital malformations over the period 1984–1999 [7]. Actually, the rise was similar but slightly higher in the less contaminated areas (Fig. 1). Evaluation of the incidence of Down's syndrome in Belarus is unremarkable with the exception of a spike in January 1987 and another in May 1990 [8], which the expert group could not explain.

Infant mortality data for the year 2000 was 15 per 1000 live births in Belarus, 19 in the Russian Federation and 22 in the Ukraine compared to 10 in Poland. Data comparing infant mortality in clean and contaminated regions were only available from the Ukraine. These showed a general decrease over time, but in all areas infant mortality remains high for reasons that are unrelated to radiation exposure. There were not enough data to evaluate stillbirths and similar pregnancy complications. Several reports suggested the general health of children was decreasing for reasons other than radiation exposure. There was no evidence of hereditary effects in offspring nor would they be expected based on other scientific literature.

Recommendations included investigating the underlying cause of high infant mortality in both clean and contaminated areas, and to continue registries on reproductive health measures primarily as a public health measure and not relative to radiation effects. Actions to reduce the psychological effects

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in children and adolescents were also recommended. Studies that do not provide baseline data, the time period of observation, estimates of absorbed dose and blind evaluation of the data should be discouraged.

7. PSYCHOLOGICAL MENTAL AND NERVOUS SYSTEM EFFECTS

Data sought by the expert group included information on possible mental retardation after in utero exposure, direct effects on the brain in highly exposed individuals and psychological effects. While there were some studies on the first two topics, the series was small and the data unconvincing with little evidence of a dose response relationship, and most lacked good control groups.

The expert group agreed that psychological effects represent the largest public health impact from the accident. It was not felt to be possible to distinguish psychological effects due to the accident from other stressors occurring over the last two decades including the breakup of the Soviet Union and economic issues. It is clear that high levels of anxiety continue up to the present. There have been few studies that have integrated mental and physical health, and future studies should attempt to do this. Knowledge gaps remain with regard to systematic studies of highly exposed workers, studies of children and adolescents, and what the best interventions are to reduce anxiety.

It was concluded that serious mental problems exist but that these are at a subclinical level with implications for subjective health, reproductive health and medical service utilization. It is also clear that after future accidents some of these issues might be reduced through provision of timely and accurate information.

The group recommended that a general public health policy be generated for the population due to high rates of psychiatric and substance disorders in the population. There might also be a benefit in conducting additional research on cognitive changes in the group of acute radiation sickness survivors, hopefully with imaging or pathological correlation. There is also a need for an increase in mental health training for primary physicians and nurses, and a need to move the locus of care to primary care settings.

8. MORTALITY DUE TO THE ACCIDENT

Mortality due to the accident has been an area of intense media and public interest. The deaths which occurred due to radiation in the short term are relatively well known. Data on mortality in the liquidator population occurring from 1987 to 1998 is almost exclusively derived from the Russian

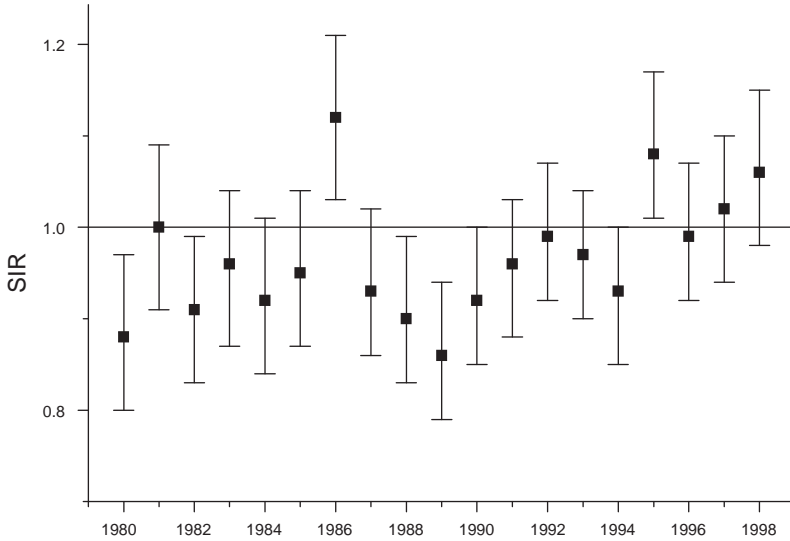


FIG. 2. All solid cancer standardized incidence ratio (SIR) among residents (both sexes) of five radioactively contaminated districts of the Bryansk region [5].

studies. Potential mortality from cancers in the future has been discussed by Dr. Cardis in her report of the 1st and 2nd meetings of the Expert Group on Health of the Chernobyl Forum [9]. The Russian liquidator studies indicate that the standardized mortality ratio (SMR) for all causes, malignant neoplasms and non-cancer diseases has been less than that of the general population ($SMR < 1.0$). When the liquidators are compared internally, there may be a slight excess of cancers [5]. The mortality from cardiovascular diseases was discussed earlier.

As mentioned earlier, analysis of the mortality data in the general public is confounded by the general reduction in lifespan. The death rate per 1000 in 2000 was 14 in Belarus, 15 in Russia, 16 in the Ukraine and 10 in Poland (see Table 1). When the death rate in contaminated areas of the Ukraine was examined, it averaged about 18.5 per 1000; however, these data are not age adjusted and the younger population probably has preferentially left the contaminated areas. The standardized incidence ratio (SIR) of neoplasms among the general public in contaminated districts in the Bryansk region has generally been slightly less than unity where the control was the population of other, non-affected districts of the same region (Fig. 2).

In the acute phase of the accident, there were 28 deaths due to acute radiation sickness and two deaths due to the explosion and thermal burns [4]. Another 19 acute radiation sickness patients died in 1987–2004 from various

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causes and in the Russian liquidators there is a slight dose dependent increase in mortality of 4.6% or 216 excess deaths from solid cancer and cardiovascular diseases attributable to radiation in a study group of about 70 000 people up to 1998 [5].

Long term estimates of future cancer mortality among the highly exposed liquidators, evacuees from the 30 km zone and residents of strict control zones are in the range of about 4000 [2, 9].

9. MEDICAL PROGRAMMES AND MEDICAL MONITORING

Follow-up of persons who have been exposed to radiation was the final issue considered by the expert group, specifically the nature, need and cost of such programmes. Currently, there is monitoring in place for liquidators, asymptomatic children and the general public of contaminated territories.

There is no question that the initial medical triage immediately after the accident saved hundreds of lives. The medical treatment in the weeks after the accident also saved many lives. There remains a need to evaluate the treatment of the acute radiation sickness survivors to determine which were the most effective treatment methods.

Long term medical follow-up is undoubtedly needed for those who are acute radiation sickness survivors and who have clear deterministic radiation injuries. Long term follow-up of the general public has been done now for almost 20 years and may be potentially useful for scientific reasons (epidemiological studies) in carefully selected populations, but to date there is little evidence that general medical screening has altered most individual outcomes. Cancer is the major radiogenic effect at doses below 1 Gy and the problem is that there are few effective screening tests for the majority of radiogenic cancers and leukaemia. The expert group concluded that continued medical screening was unlikely to provide significant medical benefit and may actually increase anxiety in those persons who received doses of less than several tens of mGy.

It was recommended that the cost-benefit of the current screening programmes be evaluated particularly for those programmes being performed on low dose asymptomatic populations. There is no question that symptomatic persons should receive evaluation and medical care as needed. The issue of whether thyroid cancer screening is useful is unclear and it was recommended to continue these programmes and evaluate their effectiveness.

10. CONCLUSION

The issues of potential cataracts at low doses as well as follow-up of liquidators' disease incidence and mortality should be continued. Cytogenetic effects may be used to assess doses above 0.2 Gy but are unlikely to be useful at lower doses. There is no clear evidence of radiation related adverse clinical effects on the immune system of the general public or on hereditary or reproductive outcomes (particularly congenital malformations). Lifespan reduction and death rates of the general public are higher in both contaminated and clean areas than in other countries as is infant mortality, but these are not felt to be radiation related. For the general public, the major radiation-related future health effect is felt to be the potential cancer risk (discussed by Dr. Cardis; [9]); however, screening programmes for cancer and other diseases are not felt to be useful when absorbed doses are in the range of tens of mGy or lower.

Psychological effects are real and represent the biggest public health impact of the accident. These will need continuing attention for the foreseeable future. Finally, while this report is focused entirely on potential adverse effects of the accident, one should recognize the efforts of the Governments of Belarus, the Russian Federation and Ukraine to protect and take care of the affected populations. The magnitude of the effect of the protective measures and interventions is difficult to evaluate but was clearly extremely large.

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PANEL DISCUSSION

RECOMMENDATIONS OF THE CHERNOBYL FORUM ON THE ENVIRONMENTAL AND HEALTH ISSUES

Chairperson: **B.G. Bennett** (RERF)
Members: **A.J. González** (Argentina)
Y. Kenigsberg (Belarus/WHO)
J. Repussard (France)
Yu. Izrael (Russian Federation)
F.A. Mettler (USA/WHO)
M. Repacholi (WHO)

INTRODUCTORY REMARKS OF THE PANELLISTS

A.J. González

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I have been requested to summarize the recommendations to the three Governments on environmental monitoring, research and remediation.

We have learned that only two radionuclides of importance were released in the Chernobyl accident: ^{137}Cs the long term problem, and ^{131}I the short term problem. On this basis, the recommendation on environmental monitoring and research to the three Governments is: as we believe that the environmental transfer and bioaccumulation of ^{137}Cs (and ^{90}Sr) are now well understood, there is little need for major new research programmes. However, some recommendations for continued but more limited targeted monitoring of the environment are provided to the Governments.

The long term monitoring of ^{137}Cs , in particular, is necessary for practical reasons to assess levels of human exposure and food contamination, and to inform the general public about these levels and give dietary advice.

There are scientific as well as practical reasons. The report says that “to determine parameters of long term transfer of radionuclides in various ecosystems and different natural conditions to improve predictive models” could be one objective of this environmental monitoring. Another one, which I consider much more important, is to determine the mechanisms of radionuclide behaviour in less studied ecosystems, for example, forest fungi.

The most important recommendation relates to remediation. Different effective long term remediation measures are available to the three Governments, but their application should be justified and optimized, and the general public should be informed and involved in the decision making processes.

What the report does not say, but Mr. Taniguchi said in his statement, is that there are international recommendations available regarding justification and optimization. The ICRP has, particularly in its Publication 82, addressed this issue, and that publication could be a useful reference for the three Governments.

Remediation may be justified in agricultural areas with sandy and peaty soils, where there might be high transfers of ^{137}Cs from soil to plants. Efficient agricultural countermeasures are the radical improvement of pastures and grasslands, the draining of wet peaty areas, the enhanced application of mineral

fertilizer, the application of Prussian Blue to cattle, and the pre-slaughter and clean feeding of animals in combination with in vivo monitoring.

There are still agricultural areas in the three countries which are out of use, but the report says that the land there can be safely used after appropriate remediation in line with the recommendations made in the report. Restricting the consumption of wild products such as game, berries, mushrooms and fish may still be necessary.

What does this mean in the case of fish? The report says that it is unlikely that future measures to protect the surface waters of lakes will be justifiable and that the consumption of fish from only a few closed lakes will need to be restricted. Predatory large fish in the Kiev Reservoir and some other predatory fish had high ^{137}Cs levels initially, but since 1991 the levels have fallen to well below the Codex Alimentarius maximum levels for radioactivity in food. The situation is even better for non-predatory fish, such as bream, in which the ^{137}Cs levels were never above the Codex Alimentarius maximum levels.

In the case of milk, ^{137}Cs may exceed action levels. However, it was only until 1991 and only on some private farms, as opposed to collective farms, that they were above the Codex Alimentarius maximum, and then not by very much.

What is the main problem? It is that radionuclides released during the Chernobyl accident were incorporated into a wide variety of commodities, including food, and until recently we did not have an international agreement on what was acceptable. In September 2000, the Agency's General Conference, following a request from Belarus, called for the development of radiological criteria for radionuclides in commodities. The criteria were developed and they were accepted by the General Conference last year. It is now for Agency Members States to apply the criteria in whose acceptance they participated during the General Conference's 2005 session. The criteria for commodities which are not edible have been published by the Agency in a Safety Guide. Those for food were already in the Codex Alimentarius, and they are currently being revised, but they will not change much. Those for drinking water were developed by the WHO, and they were incorporated in the relevant resolution of the General Conference. Thus, the three countries now have a basis for deciding whether or not countermeasures are necessary.

As regards the Chernobyl shelter, a comprehensive safety and environmental impact assessment should be performed, an integrated radioactive waste management programme should be formulated, a strategy for the rehabilitation of the exclusion zone should be developed, and an overall plan for the long term development of the exclusion zone should be worked out.

My epilogue is the following. We have seen during this conference that a vast amount of knowledge has become available thanks to the Chernobyl

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Forum exercise. Some of this knowledge is written down in reports, but some is not. What can be done to preserve this unrecorded knowledge? This is a challenge for all of us, not only for the three Governments most directly involved, but I believe that this conference has set us on the right track.

INTRODUCTORY REMARKS OF THE PANELLISTS

M. Repacholi

World Health Organization,
Geneva

I should like to preface my summary of the recommendations to the Governments of Belarus, the Russian Federation and Ukraine that have come out of the Chernobyl Forum's Expert Group on Health by saying that one of the key aims of the Chernobyl Forum was to provide the best possible scientific information available on the health and environmental effects of the Chernobyl accident, and I think it is now becoming clear what we know and what we do not know.

The WHO had the responsibility of providing recommendations to the three Governments on their health care programmes. The recommendations that have come out of the Chernobyl Forum Expert Group on Health are based on that scientific information and on experience with those health care programmes.

We know, from what Mr. Mettler has said, that some people need to be monitored while other people do not because the doses which they received were so low that it is very unlikely, first, that they are going to contract a radiation-induced illness and, second, that the screening programmes would be cost effective and beneficial to the population.

Obviously, as Mr. Mettler said, the acute irradiation survivors will need to have continuous medical care — particularly cardiovascular examinations, because studies are showing that effects on the cardiovascular system are likely in highly exposed people.

If you have medical follow-up programmes for people exposed to less than 1 Gy and living in not highly contaminated areas, such people will come to expect that they are going to contract a radiation-induced disease, although in fact they almost certainly, in most cases, will not contract such a disease. The programmes would be wasteful of resources better used in improving the general health care systems of the three countries, where there are major public health issues such as heavy smoking, alcoholism and bad dietary habits.

Thyroid cancer screening should continue for people who were exposed as children, but its usefulness should be assessed periodically because in some cases benign disorders of the thyroid are going to be detected and an intervention would not be beneficial. As Ms. Cardis has mentioned, the number of cases of thyroid cancer among people who were exposed as children seems to

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be increasing, but for such people what one needs is just a good health care system able to detect when something has gone wrong.

It is very important to maintain high quality cancer registries, which can assist national authorities with the allocation of resources for public health programmes and also for research.

We have heard that a lifelong study is continuing on the Hiroshima and Nagasaki bombing survivors, and that the information gathered forms a basis for radiation protection activities and for investigations of the health effects of ionizing radiation. The Chernobyl experience is quite different from the experience of the Japanese survivors. In general, the people exposed as a result of the Chernobyl accident have received much lower doses, although in some cases they have been exposed to radiation levels much higher than normal background levels. Thus, we are looking at chronic exposures to relatively high or to medium radiation levels rather than at acute exposure to high radiation levels. We need to gain as much information as we can about the people exposed as a result of the Chernobyl accident.

Epidemiologists like to carry out studies with large numbers of people who have received high doses. However, we should also be trying to devise techniques for determining radiation-induced effects at lower dose levels, so that we can make much better predictions than we can at the moment of what could occur in accidents.

Regarding childhood leukaemia, although an increase in the incidence rate among those who were highly exposed has not been found, it is still likely, so we need to continue to monitor these people. Eye examinations should continue in the case of cleanup workers and other highly exposed groups, because they could produce new information about radiation induced opacities and cataracts that occur at lower doses.

The registries of information on reproductive effects may not be very useful for research purposes, but they could be useful for reassuring people that, as in the case of the atomic bombing survivors, such effects are not going to occur.

It is important that local populations be informed of the Chernobyl Forum results, and this can be done very effectively through health care professionals, who tend to be trusted in the communities that they serve. They should therefore be provided with all the necessary information.

As regards future research, the three Governments should cooperate closely with scientists around the world. The aim should be the study of a single large population group covering all three countries, with a single protocol so that we can maximize the statistical power and the sensitivity of the study.

With the emergency workers and the residents of highly contaminated areas, we need to ask what the incidence of various cancers is going to be? For

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example, is there an excess risk of thyroid cancer in adults? It has been clearly demonstrated in children, but in the case of adults we are still uncertain — we need more information. Furthermore, there are uncertainties in the estimates of thyroid doses. Here again, we need more information so that we can accurately estimate the probability of a person contracting thyroid cancer as a result of a certain radiation dose.

What is the role of radiation in the induction of cardiovascular diseases and what is the effect of high doses on the immune system? It takes doses significantly higher than the doses resulting from the Chernobyl accident to affect the immune system, but there are certain people — particularly the acute radiation syndrome survivors — who will have to be kept under continuing surveillance.

Finally, WHO is definitely going to participate in activities related to the health consequences of the Chernobyl accident, including research; we want to be involved and to assist wherever possible. Moreover, the Chernobyl Forum's goal of providing scientifically sound information to the affected Governments and recommendations on how to ensure more effective health care is a good model, and I think WHO will use this model in connection with other major accidents, such as ones which have occurred in the Southern Urals, in Kazakhstan and in Japan. In my view, synthesizing research results and making the resulting information available in a simple form at the local level will benefit the populations that have been exposed, because there will always be people who fear that they have been exposed to radiation, and we should give them the soundest information possible and dispel the myths that tend to arise, so that that they can take control of their lives again.

INTRODUCTORY REMARKS OF THE PANELLISTS

B.G. Bennett

Radiation Effects Research Foundation,
Hiroshima

The recommendations to the three Governments are fairly basic. You should continue to study the consequences of the Chernobyl accident. However, except for the workers who suffered acute radiation sickness and the children who contracted thyroid cancer, the consequences of the accident were essentially the consequence of a low dose event, and you should plan your continuing countermeasures and protective measures accordingly.

INTRODUCTORY REMARKS OF THE PANELLISTS

Yu. Izrael

Institute of Global Climate and Ecology,
Moscow, Russian Federation

As regards the report which we are considering now, to me it is quite satisfactory. It presents the main ideas. It is written in a professional manner and contains sufficient information. I am saying that on behalf of those experts who worked during the first years after the Chernobyl accident. The report confirms the main conclusions that we presented to our Government before 1990. However, I have some comments.

I was disappointed, first of all, that in the report there is very little material on the research done by the scientists of the former Soviet Union. I have not heard the names of any Russian scientists mentioned here. Ten years ago we applauded many Russian scientists, but today we have not even heard their names. I do not think that is right.

As regards the different radiation maps — for example, the maps with the famous ‘butterfly’ pattern that was shown — they were prepared by Soviet scientists, but there is an IAEA copyright sign on them. They were prepared by our experts (ten helicopters and aircraft participated), and this ‘butterfly’ was published in the newspaper Pravda in 1989, but I do not see our experts’ names on the maps in the report.

I would say a critical word to the representatives of the three countries who described very well the social and economic problems, but the period before 1991 was not covered. What does that mean? Was the State (the USSR) not spending any money on those problems? In reality, there was enormous work performed. However, in the social and economic reports, we have not heard about it, and the UNDP representatives even said that the Soviet Government did not intend to contribute to the social and economic recovery efforts.

I would like to point out some scientific inaccuracies. For example, the figures for ^{137}Cs soil deposition given in the atlas made by the experts from 31 countries (with me as scientific coordinator) are not reproduced exactly in the Forum report. As for plutonium, its deposition is mentioned in one place in the report as extending out to 100 km and in another place to 30 km. I am stressing this because 30 km is correct. This is important, because plutonium does not create a big dose; it influences in a different way — it influences the

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lungs of human beings, and the monitoring of plutonium should therefore be carried out very carefully.

Information was made available to the public. It was not published in newspapers immediately, but the population had the information — they knew why they were being resettled and they knew that they would be compensated financially, although not in a huge way. We collected more than 100 000 samples, and those who wanted information on caesium contamination on their plot of land could have that information.

Regarding the recommendations, I would again stress the plutonium issue. In May 1986, Academician Ilyn, myself and some others determined the highest permissible level of plutonium in soil for human safety, namely 0.1 Ci/km^2 . All the areas contaminated with plutonium above this level are within the 30 km zone. We have heard rumours that people are going to be resettled in part of this zone. I would like to see the recommendation in which it is stated that where plutonium soil concentration is higher than 0.1 Ci/km^2 , there should be no resettlement, or that we re-examine this figure scientifically.

Finally, the political situation is very complicated in the world today, with the risk of nuclear terrorism. Taking into account all the unique scientific information collected recently by the scientific community, I suggest that within the IAEA and the three States most affected by the Chernobyl accident that there be groups created dedicated to this nuclear terrorism problem.

INTRODUCTORY REMARKS OF THE PANELLISTS

J. Repussard

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I think there is a very broad consensus in this room and outside that enough knowledge has been gathered since 1986 to guide risk management and rehabilitation strategies in the territories contaminated by the Chernobyl accident — maybe with the exception of the long lived radioactive waste in the exclusion zone, where it is in trenches and has so far been only partly characterized.

Some public health screening of populations, and some environmental monitoring will remain necessary, not only for the acquisition of further knowledge but also in order to create public confidence in the medium term. Public confidence is essential in order to increase the effectiveness of counter-measures and limit the overall impact of the accident, including its psychological impact. Information, including statistical data, presented in comprehensible terms and not conflicting owing to different methods of acquisition will be important both for science and the well-being of the populations involved.

We have heard that although we know enough to carry out risk management, there are a number of gaps in our scientific knowledge, primarily for two reasons: first, we are beginning to discover that the Hiroshima models, and therefore implicitly the ICRP rules, may not be fully applicable at very low dose levels, particularly in cases of internal contamination; second, epidemiological observations are not powerful enough, and may not always be made with enough surrounding details, for the identification of potential effects. Very low dose, internal contamination due to chronic exposure is an issue not only in the areas affected by the Chernobyl accident. It could occur elsewhere in the world as a result of an accident or of terrorism, and it is therefore important to understand the mechanisms at work. Our institute has, for several years, been engaged in research on contamination due to chronic low dose exposure to radionuclides, and the first international publications on this research will appear within the next few months. I would like to call for international cooperation in this research area.

My last comment relates to the preservation of knowledge. Under the initiative which was launched by the French and German Governments, together with Belarus, the Russian Federation and Ukraine, in 1996 and which

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involved 35 institutes of the three affected countries, a large amount of data was gathered and organized with great care. What will happen to this body of knowledge? After the Hiroshima and Nagasaki bombings, the USA and Japan established a foundation which, for years, has been providing valuable information to the scientific community and those responsible for risk management within the populations affected by the bombings. We need to do the same with regard to information about the consequences of the Chernobyl catastrophe.

An official letter from our institute and the French Government, and I hope the German Government, is to be sent to the IAEA offering to place our databases under the IAEA umbrella, possibly with the support of the European Union, so that the results of all the work which has been done by our institute, plus all the results of the work done in the three affected countries beforehand, can be safeguarded and the knowledge preserved, together with the unrecorded knowledge to which Mr. González referred. That we owe to the victims of the Chernobyl accident.

INTRODUCTORY REMARKS OF THE PANELLISTS

Y. Kenigsberg

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National Commission of Radiation Protection,
Minsk, Belarus

I would like to comment on the role of medicine in the aftermath of the Chernobyl accident. A lot has been said about health consequences of the accident. Let us see what has been done for those people who became sick after the accident and for those who are healthy now but could potentially become sick.

The mortality rate among those who contracted radiation-induced thyroid cancer is low, thanks to the joint efforts of medical personnel of different countries in making early diagnoses and caring for those with thyroid cancer. We were able to diagnose thyroid cancer in the early stages because we had good equipment and well-trained personnel, and the same should be done in the other areas of health care if the necessary equipment was available.

The medical doctors who work in the area of radiation protection play an extremely important role. Unfortunately, we were unable to establish a good radiation protection system in the first days after the accident and are now seeing the results in terms of thyroid cancer among people in many age groups. However, we subsequently developed a sound policy and reduced the exposure levels, so that the children born in the contaminated areas incur radiation doses not exceeding 1 mSv/a and in the future there will be no radiation risk to the health of those children. Thus, we have been able to focus our scarce resources and the efforts of our health workers on those who received higher exposures.

The protective measures that were taken by our medical experts have made it possible to prevent high exposures. In Belarus, we introduced strict norms for ^{137}Cs in foodstuffs. By that means, according to models based on the internationally available data, we prevented at least 800 cancer deaths.

Thus, in the aftermath of the Chernobyl accident, the joint efforts of medical doctors from different countries produced good public health results. That is why I call for extensive cooperation in the health area in the interests of the present generation and of future generations.

DISCUSSION

A.J. GONZÁLEZ (Argentina): I should like to comment on the press release that was issued yesterday, because the general public will learn about this conference through the press release, not through the reports of the Chernobyl Forum.

The press release opens with the statement that up to 4000 people could eventually die of radiation exposure as a result of the Chernobyl disaster and goes on to state that as of mid-2005 fewer than 50 deaths had been directly attributed to radiation resulting from the disaster. The problem is that the two numbers relate to two completely different concepts. The 50 relates to dead persons whose names have been recorded and whose deaths have been attributed by physicians to the Chernobyl accident. The 4000, the result of a multiplication, relates to persons whose deaths will not show up statistically given the levels of dose that have been prevailing in the affected region.

As regards the 4000, our knowledge is very limited. The only thing we know is that 4000 is the upper boundary of a calculation. We do not know whether the eventual number will be 4000, 2000 or even less, and it is wrong to suggest to the general public that the 4000 number is as solid a number as the 50.

B.G. BENNETT (Chairperson): We realized that the first sentence of the press release was a risky statement to make, but we felt that there were enough qualifications in the later paragraphs to clarify matters. Regrettably, it looks as if those qualifications may be overlooked or ignored, so I hope that people will be careful with their use of what is just a very rough estimate.

W. BINNER (Austria): Ms. Cardis mentioned that the risk assessment is based on the Hiroshima and Nagasaki atomic bombing consequences. In the case of the Chernobyl accident, however, what the general public has been exposed to is protracted radiation. Perhaps more attention should be paid to studies dealing with protracted exposure to natural radiation — for example, the study of a Chinese province, where two cohorts of 75 000 persons were monitored and it was found that fewer cancers occurred in the cohort living in the higher dose (5.5 mSv/a) region.

R. ALEXAKHIN (Russian Federation): I agree with Mr. Izrael. The Soviet Ministry of Agriculture alone took about a million samples, which were reflected in the map shown by Mr. Anspaugh during his presentation.

As regards Mr. González's comments about commodities, exposed agricultural produce is the biggest contributor to human exposure in the contaminated areas, and this produce is therefore well regulated. Unfortunately, in the Russian Federation, Belarus and Ukraine, while the food products are still below radionuclide limits, there is no more financing for

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countermeasures, and as a result, the radionuclide concentrations in produce are increasing. This is a problem, at least psychologically.

My second comment, I am surprised that the recommendations do not explicitly mention the fact that currently there is no scientific problem with flora and fauna protection. That is why one hears rumours about the lower productivity of animals. We have shown that we have no problems in Belarus, the Russian Federation and Ukraine outside the exclusion zone, where milk production per cow is lower than normal and so on.

I understand that the IAEA is implementing an action plan relating to the rehabilitation of affected areas. What would be the end of rehabilitation? Is it green fields? In the ICRP Publication 82 there were some recommendations about the end of rehabilitation activities, but there has been no criterion for a final decision.

S. NAGATAKI (Japan): It is not difficult to explain scientifically demonstrated health effects such as thyroid cancer. On the other hand, although an increase in leukaemia incidence has not been demonstrated, that does not mean there is no leukaemia effect. Providing decision makers and the public with a clear explanation about the scientific uncertainties with leukaemia as an example should be one of the most important tasks of this conference.

As regards the press release, I have looked at three Japanese newspapers, and each one talks about 4000 deaths — nothing else. So, it is a very important to explain about uncertainty.

F.A. METTLER (USA/WHO): We have to be careful when saying “we are uncertain”, because sometimes that is taken to mean “we know nothing”.

An estimate based on a multiplication clearly has uncertainties, which people have tried to quantify. Warren Sinclair has written that when you look at the uncertainty in the risk estimates, where is the 95% confidence interval likely to be? I think it was about a factor of three at the end of the day.

The uncertainties in the contamination or dose measurements are fairly small, and we explain that the cancer projection is a multiplication process with — as Ms. Cardis pointed out — limitations. However, one thing we are certain about is that at many of the dose levels in question the radiation effect is so small that we cannot see it in spite of looking for it — that it is buried in the other confounding things which are going on — that the signal to noise ratio is very small.

So, I think it is important to say: “Yes, we have uncertainties, but we know that the number of projected radiation-induced cancer deaths is not 100 000 or a million.”

A.J. GONZÁLEZ (Argentina): I agree with Mr. Mettler that we have uncertainties, but the uncertainties are not very great — we know that the upper boundary will not be higher than 4000. The issue is that we shall not be

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able to pinpoint the individuals in question as the risk is so low that they will disappear in the statistical background. That is a very important message for the public.

K. BECKER (Germany): This morning I scanned some German newspapers and saw headlines such as “4000 people will die from Chernobyl.” Moreover, Ms. Cardis said that the eventual figure may be 8250, not 8260 or 8240, and that is what a normal non-scientist will assume the eventual figure is going to be.

However, those two numbers — 4000 and 8250 — are fictitious, and in citing them we get very close to those people who say that the final number will lie somewhere between 10 000 and 100 000, numbers without any scientific meaning.

B.G. BENNETT (Chairperson): In the basic group of 600 000 there will be 600 000 deaths, unless someone achieves immortality, and of these at least a quarter will be due to cancer. That is certain. About 15% will die of smoking-related lung cancer, and I do not know how many will die of cardiovascular diseases.

We could have said in the first sentence of the press release “12 000 deaths will occur as a result of smoking” but we were dealing with radiation.

R. HARMS (European Parliament): For a long time, the official figure for deaths connected with the Chernobyl accident was 28 or 29. Now we hear that eventually there will be 4000 deaths. Why did you choose that figure and not the figure of 8000 that was suggested in the full health report?

For me it is not a question of uncertainties, but maybe one of not very good scientific work or a not very good summary presented to the public. What will be the eventual number of deaths caused by the Chernobyl accident — 8000, 4000, more or less?

M. REPACHOLI (WHO): Scientists like to talk in shades of grey, whereas the media like to talk in terms of black or white — did it happen or did it not happen? When scientists say something, they incorporate caveats — the uncertainties in their estimates — and that has always been a problem for scientists trying to convey a message to the public.

The Chernobyl Forum’s Expert Group on Health was asked how many people had died and how many were likely to die in the future as a result of radiation exposure due to the Chernobyl accident. Most members of the expert group did not want to answer that question, because of the uncertainties and because the numbers could be misinterpreted. The best available risk model that we knew is based predominantly on the Japanese data relating to the atomic bombing of Hiroshima and Nagasaki, where there were high acute exposures. We could not predict with any certainty by extrapolating down to

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the Chernobyl experience, which was really not covered by the model. We had to make an assumption that the dose response was basically linear when going down to lower doses, where the uncertainties are much larger, and we only considered the population groups which had been most exposed. We felt that we could not make any estimates for less exposed groups.

There have been estimates made for less exposed groups using a linear model, where the uncertainties are even larger, and the numbers have been published. What we did, however, was to say that we knew with some precision, given all the uncertainties, that in the most exposed group there would be an increase in cancer-related deaths in the future.

When a person dies of cancer, we cannot say that that person died because of the Chernobyl accident, but it is probable that 4000 people in the most exposed group of 600 000 people will contract cancer due to radiation released during the accident. We tried to say that clearly, but we also said that if you extrapolate the model down to much lower dose levels you increase the number of exposed people but, given the lower doses, these people are much less likely to contract cancer, so the uncertainties are even larger.

B.G. BENNETT (Chairperson): The estimates are not new estimates. They were published ten years ago. They are basic risk estimates and basic dose estimates, and nothing has changed from our point of view.

D. WILLIAMS (United Kingdom): I have concerns about the excessive certainty reflected in the press release. For example, it is stated that the death rate from thyroid cancer is less than 1%, although we do not know what the death rate is even for those who already have thyroid cancer. We know how many have died of thyroid cancer, but we do not know how many more will die in the future, because unfortunately thyroid cancer can continue to cause death decades after it is first clinically diagnosed.

It has been implied that there is no more need for scientific studies, but it is essential that the ongoing scientific studies continue. Otherwise, emotions of the type generated by Greenpeace will have more influence on the public than the scientific data. Also, do not forget that politicians are elected by the public and not by scientists, and politicians must listen to public opinion. So, I would be interested in knowing whether consideration has been given to conveying risk to the public not just in terms of becquerels and millisieverts but also in terms of — say — the number of cigarettes smoked in a week. If we were to say to the public that the risk from a given level of exposure is equivalent to the risk from smoking one cigarette a week, ten cigarettes a week or 100 cigarettes a week, possibly that would get through to the public.

Finally, if you are talking about increases in the number of deaths, I wish you would give percentage increases, not overall figures, which sound much worse.

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YA. KENIGSBERG (Belarus/WHO): Regarding the death rate from thyroid cancer, in Belarus, the Russian Federation and Ukraine all cases of death due to thyroid cancer have been thoroughly documented.

The picture is clearest for Belarus — my home country, where about 2200 people contracted thyroid cancer out of those who were 18 years old or younger at the time of the Chernobyl disaster. Eight of them have died so far — a very low figure. In two cases, the parents refused permission for their children to be operated. In one case, the girl in question did not undergo screening, and physicians were consulted only when there were metastases. One child had both thyroid cancer and leukaemia, and the cause of death was leukaemia.

The risk model forecasts 10% mortality among those who contracted thyroid cancer, but the actual rate turned out to be less than 1% — a great success achieved by many people from many parts of the world.

Of course, forecasting is dangerous, and we have to be very careful. However, our forecasts for thyroid cancer are fairly reliable because we can diagnose this kind of cancer much better than other kinds. For example, although everyone knows that 80% of those who contract lung cancer die of it, we cannot yet say how many people will contract lung cancer among those affected by radiation released during the Chernobyl disaster.

As regards speaking to the public, we are trying to solve the communication problem through programmes of radioecological education using people such as physicians and teachers, who tend to be trusted by the public. Sometimes it helps and sometimes it does not.

As regards comparisons with, for example, cigarette smoking, we know that every year more people die in traffic accidents than as a result of the Chernobyl disaster, but that does not make life easier for those who were affected by the disaster. That is why I think such comparisons are not helpful.

V. BEBESHKO (Ukraine/WHO): First, I would like to thank the three keynote speakers in this session for their excellent presentations.

With regard to the first of the three presentations, as a physician I would stress that it all depends on the actual dose incurred by an affected individual. Unfortunately, we have not heard anything about the doses incurred by those affected. We have just about 40% of the dose measurements made on liquidators, which makes life difficult for all those who are participating in research work. We need to improve the accuracy of our measurements and assessments.

Ms. Cardis very intelligently addressed issues which are clear to epidemiologists — issues due to the fact that there is a difference in the published data between leukaemia morbidity among adults and leukaemia morbidity among children. I greatly welcome her approach. We shall have certainty only when our objectives are clearly formulated regarding the modern methodologies for case control studies and cohort studies.

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We are about to conclude the first stage of the project being implemented within the framework the Ukraine–USA protocol. We now have more accurate dose measurements and more accurate diagnoses. That is why we expect that the results will be the most accurate so far, thanks to the efforts of the American and Ukrainian scientists working at our centre.

As regards Mr. Mettler's brilliant presentation, he covered the most difficult issues and pointed the way ahead in a very unbiased manner.

I am somewhat worried because the keynote speakers said that the number of monitored cases could be reduced. We are monitoring some 48 000 people — liquidators, evacuees, children and so on. They never complain when we ask them to come to our clinic, where we try to diagnose 68 different types of cancer with different localizations, and the monitoring helps to improve their health. Otherwise, we would be able to monitor only people in the late stages of cancer without being able to help them.

Some have said that spa treatment is not effective, but we have found that a period of leading a healthy life in a mountainous area, drinking mineral water and so on is very beneficial. In that connection, we should not depict all those affected in the Russian Federation, Ukraine and Belarus as alcoholics or chain smokers who are affected only because they drink and smoke.

Chernobyl was not just a radiological and environmental disaster, it was also a psychological and social one. However, through the Chernobyl Forum we have taken a step ahead. Still, there is a need for further future oriented radiobiological studies.

P. DANESI (Italy): For 16 years, I was the Director of the IAEA's Seibersdorf Laboratory. Now I am Professor of Comparative Risk Analysis at the University of Pavia, Italy.

First, I have a very mild criticism. None of the data we have been shown — for example, the 1250 extra cancer deaths in a population of five to six million people — indicated the uncertainty, by which I mean not common sense uncertainty but mathematical uncertainty. Nowadays, no scientific papers should be presented without an indication of the mathematical uncertainty, even if it is very low. However, my criticism is very mild as I have myself in the past failed to indicate the mathematical uncertainty in papers presented by me.

Regarding the press release, it will determine how the world perceives the outcome of the Chernobyl Forum exercise. Now, 8250 deaths in a population of five to six million people means an increase of 0.12% plus or minus 5%. This means that there could even be a decrease in the number of deaths. This should be reported. Otherwise, it does not mean anything and can be misinterpreted.

Somebody mentioned plutonium. There is a lack of really complete information. It is well known, as the British have conducted very extensive studies, that the internal dose from the ingestion of plutonium particles is not any

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different from the external dose, and there are good reasons for that, because alpha radiation is high-LET radiation but is self-absorbed. So, if you know the dose, you can predict consequences. Radiotoxicological studies have shown that plutonium is at least a thousand times less radiotoxic than people estimated. So, I invite you to be very careful when communicating with the public about concepts that are already well established scientifically.

C.G. FISCHER (Switzerland): I should like to start by saying that I am not a scientist. I work in the area of communication with the public.

You mentioned 4000 probable deaths. For you, as scientists, that may be a huge number, but the public has been told over the years that the Chernobyl accident was a terrible catastrophe and has come to expect a far higher number. The public will not accept a number as low as 4000. How can one overcome the gap between the public perception and the scientific information?

B.G. BENNETT (Chairperson): By widely disseminating our findings, in the hope that the media will convey the correct message to the public.

C.G. FISCHER (Switzerland): But the public will not believe those findings.

B.G. BENNETT (Chairperson): All we can do is make the information available.

B.S. PRISTER (Ukraine): I fully agree with the assessment of the radiation situation in the contaminated areas, but I should like to make the following point. At virtually all places where people are living, and where the caesium concentration in the milk exceeds 100 Bq/L (our national limit), the effectiveness of the known countermeasures is sufficient for reducing it to a permissible level. The basic problem is insufficient implementation of the countermeasures, and it is necessary to go back to what was being done earlier in that regard.

G.N. KELLY (EC): I think the Chernobyl Forum has been extremely successful in addressing the health issue and the environment issue, but one of the key issues in terms of social and economic effects in the affected region is the radiological norms or standards which have been utilized. Why did the Forum not address that issue?

B.G. BENNETT (Chairperson): Were you speaking about the economic and social issues?

G.N. KELLY (EC): No, I was speaking about the radiological criteria for determining the social and economic impact today. That issue has not been addressed.

A.J. GONZÁLEZ (Argentina): Mr. Kelly is right, but the issue was probably not addressed because it was necessary for some expert from the European Community to explain why the European Community was pushing for such low standards.

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B.G. BENNETT (Chairperson): Also, it is strange that compensation is being paid to people who are receiving doses as low as 1 mSv/a. This is a very ambitious goal but let us leave this issue for tomorrow's discussion.

V.M. SHESTOPALOV (Ukraine): In our press releases and our reports, we should talk not only about negative experiences but also about positive ones, such as the return of people to areas that used to be considered to be contaminated.

At the conference held to mark the 20th anniversary of the Chernobyl accident, there may well not be a single Russian, Belarusian or Ukrainian participant — only participants from countries such as France, Germany, Japan and the USA. Why? Because the financing of work performed in Belarus, the Russian Federation and Ukraine on the aftermath of the disaster leaves much to be desired. However, I believe that our counterparts in those countries would like to see us at that and similar conferences.

I.P. BLOKOV (Greenpeace): The report that we have been talking about is, in my view, only preliminary. It does not cover things such as the very interesting work being done by organizations like the Union of Chernobyl and the Widows of Chernobyl. According to such organizations, 22–36% of the liquidators are still dying from the effects of radiation exposure, but the analysis in the report relates to only some regions of Russia, not all of them.

Then there are some incorrect statistics in the report — 10% of the dosimetric data about the military are falsified, and some numbers are claimed to be blown up out of proportion. Do you really believe that that happened, especially back in the Soviet Union?

In 2003, at a conference held in Kiev on the Chernobyl accident, the WHO, UNICEF, the IAEA and so on interpreted the data differently. The data presented here, at this conference, differ very much from the data presented in Kiev, only two years ago. I accept the fact that very different sets of data will be presented at conferences ten years apart, but not two years apart, and I believe that we should not call for a full stop here. What we now have are still just preliminary data.

A.J. GONZÁLEZ (Argentina): As regards the 2003 conference held in Kiev, the IAEA did not co-sponsor it and did not accept responsibility for the many false statements that were made there.

CHERNOBYL: THE WAY FORWARD

(Session 2)

Chairperson

K. MIZSEI

UNITED NATIONS DEVELOPMENT PROGRAMME

INTRODUCTORY REMARKS

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I think we can conclude from yesterday's discussions that regardless of the precise numbers, science clearly tells us that risks besides the radiation risk — the risks associated with lifestyle phenomena such as excessive alcohol consumption, very excessive smoking and increasing drug consumption among the young — and the fear of radiation due to misperceptions are the really big challenges to the quality of life in the Chernobyl-affected areas.

As you know, the UNDP has been entrusted with carrying forward the main Chernobyl-related work within the United Nations system, and under our new Administrator, Kemal Dervis, who is ex officio the Chairperson of the International Commission for Chernobyl, the UNDP fully intends to draw attention to the future of the people in the Chernobyl-affected territories. We are now going to focus on the future.

There is a lot we can do for the victims of Chernobyl. One thing we can do is to counter misinformation — even myths — with good science that is presented to people in the form of simple messages that the layman can fully understand.

The second thing we can do is assist with the development of sound policies, particularly health and economic policies.

The third thing we can do, which we have done in Ukraine and we are very eager to do in the other countries, is to focus on 'the bottom of the pyramid', on the people in villages and small towns who are stuck in a lack of development and of trust, and have been stigmatized — and see how their communities can be revitalized and how they can regain self-confidence, the spirit of entrepreneurship and the will to live full lives.

MAKING SENSE OF SCIENCE: MEETING THE PUBLIC'S INFORMATION NEEDS

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What does the public want to know and need to know with regard to the consequences of the Chernobyl disaster? The International Chernobyl Research and Information Network (ICRIN) recently initiated a public information needs study to gain a better understanding both of what specific information people lack, and how they perceive the issue of radioactive contamination relative to other regional problems. The study was conducted in 2003–2004 in affected territories of Belarus, the Russian Federation and Ukraine.

While three teams in three respective countries each used a different combination of methods, the results obtained have very much in common. Moreover, where the same questionnaire was used, respondents in Belarus and the Russian Federation noted similar answers to the majority of key questions (Table 1).

The survey concluded the following:

- *Information is lacking*: After almost two decades, residents have not obtained either complete or reliable information on the consequences of the Chernobyl accident;
- *There is concern about the health effects of radiation*: With respect to Chernobyl, fear of health deterioration prevails;
- *Poverty is a worry*: Low living standards are top of the list of concerns among all the problems people face.

Why are health issues so acute? Lack of information on or knowledge of radiation effects is only part of the answer. There are also substantial economic reasons. With low living standards, people's health is their primary resource.

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TABLE 1. PERCENTAGE OF AFFIRMATIVE RESPONSES TO POLLING IN BELARUS AND THE RUSSIAN FEDERATION

Question	Belarus	Russian Federation
<i>What information do you need most?</i>		
Health effects of radiation	53	49
How to protect oneself from radiation	41	53
Radiation units	4	5
<i>What worries you most today?</i>		
Health	74	69
Living standard	51	50
Radioactivity	29	17

Good health makes it possible to work hard on the land or migrate to find a seasonal job to support one's family. Moreover, with an imperfect system of social protection, loss of health can precipitate greater poverty.

The results obtained by the survey are very much consistent with the ideas of the 2002 United Nations report "Human Consequences of the Chernobyl Accident: A Strategy for Recovery". The report stresses the need to make local economic development a priority in a future strategy towards Chernobyl-affected regions. Respondents considered low living standards as their biggest worry and supported economic projects as a way to improve them. On this particular issue there is a consensus among local people, local administrations, experts and national governments.

The following questions remain outstanding:

- What kind of information should be disseminated?
- How can information be adapted for dissemination purposes?
- Who should disseminate information?

People need a clear message on the health effects of Chernobyl radiation. The Chernobyl Forum findings on the health impact of the accident should be a core of such a message.

Mailing copies of scientific reports to every resident is not enough. First, people need information to be relevant to their own life. They ignore general conclusions as well as any other information that does not answer their specific concerns. Thus, a booklet on radiation units seems of no use if more vital information is not disseminated. Second, people want 'yes or no' answers. They ignore, misunderstand or do not trust precise figures and professional terms.

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Third, people believe information that comes from the sources they trust, namely environmental organizations, health professionals and opinion leaders. Finally, scientific findings are not enough to dispel such statements as “I do not believe” or “I live in poverty”.

People do not feel responsible for maintaining their own health and they neglect the role of personal behaviour in reducing risk. In recent decades, few, if any, efforts have been devoted to reduce alcohol consumption and smoking or to make sports and recreational activities available and attractive to the youth. Against this social background, information on the risk of radiation is only part of the information on leading a healthy, purposeful lifestyle that must be communicated to people.

In adapting information for communication, experts should do their best to communicate in understandable terms. Compare the two statements and possible results in the accompanying table. Another way to adapt information is to use ‘negative proof’. If a person eats 1 kg of ‘dirty’ mushrooms every day for a month or two, this will lead to an upset stomach but not a lethal dose of radiation.

Who should disseminate information? Noticeably, 25–30% of the respondents are eager to be personally involved in disseminating information on Chernobyl. Respondents perceive that local administrations, health professionals and teachers are a trustful source of information. However, as the Ukraine study stresses, these groups themselves suffer from insufficient information. They also do not have the slightest idea about forms and methods of communication activities. If positive change is to occur, these groups and the youth should be addressed first.

Without educating the above mentioned key stakeholders and making information easily accessible, even perfect informational materials cannot reach their audience. Perhaps this is one of the main reasons why previous efforts to inform the population (even with excellent information products developed under TACIS project ENVREG 9602) have not been sufficient. Information products also require ‘marketing’ activities analogous to consumer goods, and investments in information technologies and in social institutions to ‘sell’ them.

TABLE 2. EXAMPLES OF COMMUNICATION NUANCES

Statement	Result
There is only a minor risk of having radiation-related cancer, which is assessed as 5.5×10^{-7} .	Denial, Lack of trust
There are many factors that increase cancer risk, radiation exposure is one of them. Cancer risk can be substantially reduced by healthy diet, avoiding smoking, etc.	Education, Decision sharing

The following two conclusions are drawn:

- Considerable efforts should be undertaken and resources allocated into information dissemination, including its adaptation to public needs;
- Without obvious signs of improvements in living conditions and economic prospects, any informational activities will bring, at best, only modest results.

Is it possible to disseminate information and provide better knowledge together with fighting poverty? What can be suggested? A new computer equipped with educational programmes on radiation protection is a powerful means to fight both poverty and ignorance. For older people, this is a sign of things getting better; for the youth, it is a way to keep up to date. A Xerox machine may help both to copy fact sheets on radiation when necessary and to make copies of personal documents instead of having to take a bus to the nearest town as must be done now.

We suggest that investments in information technologies are as essential as dissemination of information as such and call on the international community to support these activities. To conclude, while most scientists are ready to close the discussion on a majority of issues with regard to Chernobyl consequences, most people are only at the very beginning. These people start with a legacy of misconceptions, information concealment, wrong facts and inability to assess or assemble facts and figures for themselves. The challenge is to help people make rational choices about their lives two decades after Chernobyl.

ENHANCING CHERNOBYL POLICIES TO PROMOTE DEVELOPMENT

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1. BASELINE CONDITIONS

Immediately after the Chernobyl catastrophe in April 1986 until 1991, Governments placed priority on preventing new nuclear explosions, evacuation, resettlement, cleanup and immediate medical treatment. In the second stage of handling the aftermath of the explosion, in 1991–2001, the first priority was to mitigate human consequences of the catastrophe and to respond to an unfolding public health crisis; the current legal and institutional framework for handling the disaster was established at this time. The present third stage started in 2002. It goes beyond minimizing the consequences of the catastrophe, rather aiming to maximize social and economic recovery, and sustainable human development of the affected population and territories. The new strategy under preparation stresses the need to put the affected communities and individuals on the road from welfare dependence to social and economic growth. This strategy mobilizes and supports the people of the affected communities in organizing self-governing structures to take the lead in planning, managing and implementing their own social, economic and ecological rehabilitation and development.

2. LEGAL AND INSTITUTIONAL FRAMEWORK

In Ukraine, the 1991 “Law on the Status and Social Protection of the Population Who Suffered from the Chernobyl Catastrophe” provided the legal foundation for assistance to Chernobyl sufferers. The 1991 “Law on Legal Regime of Territories Radioactively Contaminated Following the Chernobyl Catastrophe” defined radiation-affected zones and their classification, their safety standards, work and living conditions in each category of zones, and

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economic and research activities permitted in them. The latter is of a prohibitive nature defining what may not be done in each zone category. The former is the only law that offers benefits. A large body of secondary legislation that is not always consistent supplements these two laws. In 2001, the Information Bank on the CHNPS Catastrophe Sufferers was established. It provides central and local administrators with reliable information on the movements of sufferers, and on changes in their medical, social and radioactive assistance to support the transition from a system of general assistance to a system of targeted monetary assistance. As of early 2004, it covered 93% of all eligible in Ukraine.

3. THE VICIOUS CIRCLE OF IRREVOCABLE COMMITMENTS AND INADEQUATE MEANS

Financial commitments to the sufferers of the Chernobyl catastrophe have always been far beyond the financial potential of the affected countries. This is due in part to a humanitarian impulse and political pressures, and the expectation that the Soviet Union's budget would foot the bill. The disaster response operation to contain the immediate effects of the nuclear reactor explosions had a military command. It was highly centralized in administration, and there was little attention to costs and medium term social and economic consequences. In addition, there was a long tradition of central planning and administering, no tradition of self-government, no market economy rules of operation, and no participation in the process of devising and implementing social and economic development projects. As a result, not only were financially over ambitious volumes of assistance and privileges granted by law, but they were subsequently reiterated by the Constitution of Ukraine. Article 16 of the constitution declares that "to overcome the consequences of the Chernobyl catastrophe ... and to preserve the gene pool of the Ukrainian people, is the duty of the state", and article 22 requests that "the content and scope of existing rights and freedoms shall not be diminished in the adoption of new laws or in the amendment of laws that are in force."

Thereby, benefits and privileges, once granted, become irrevocable with no respect for financial constraints. Consequently, the vicious circle of inadequate means and irrevocable commitments offers no chances of overcoming either the economic consequences of the Chernobyl catastrophe, or — no less important — its social consequences.

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4. SQUARING THE CIRCLE: REVISING THE PARADIGM

A turning point in discussions on revising the priorities for overcoming the Chernobyl aftermath was marked only in 2002 by the UNDP–UNICEF commissioned report “Human Consequences of the Chernobyl Nuclear Accident: A Strategy for Recovery”. This report was prepared with significant participation of Ukrainian, Belarus and Russian experts and addressed all three countries affected by the catastrophe. The “Strategy for Recovery” proposed a new approach that would:

“Focus on enabling the individuals and communities affected by the disaster to enter fully into society by taking control of their own lives and acquiring the means for self-sufficiency through economic and human development. Chernobyl related assistance ... should increasingly be measured against more holistic view of individual and community needs and, where possible, be progressively integrated into mainstream provision. ... Those exceptional needs that cannot be adequately addressed through mainstream provision should be carefully defined and be the subject of agreement between the governments concerned and the international community.” (p. 15)

In line with these recommendations, the 2002–2004 UNDP Chernobyl “Recovery and Development Programme”, while building on previous assistance to the three community development centres, reoriented its priorities towards community governance and development, and institutional support through partnership. The “Ukrainian Chernobyl National Programs Enhancement: Analytical Study” prepared in 2004 for the UNDP Ukraine, aims at supporting the Government of Ukraine, the interested regional and district authorities, regional and local leaders, NGOs, and the media, to revise the present strategy of mitigating the aftermath of the catastrophe, and to support effective enhancement and implementation of a new strategy of social and economic rehabilitation, and development of the Chernobyl-affected territories instead.

5. DE-ZONING

The status of ‘contaminated territories’ should now be lifted and no other restrictions of allowed operations imposed instead. Radiation spillover protection measures are no longer required in most of the areas to which the

“Law on Legal Regime” gave the status of ‘contaminated territories’. Moreover, this status restricts economic activities that, in turn, limit the human, social and economic development potential. Lifting of the status should be preceded by:

- Development of a methodology of quantitative testing of environment and radiation safety, especially:
 - Examination of the present ecology and radiation safety of these territories; and
 - Establishing rules of regular monitoring.

The “Law on the Status” should also be revised. However, since the revisions relate first and foremost to social assistance, they should be seen in a broader context of a new system of targeted assistance to the Chernobyl sufferers.

6. THE NEED FOR FAIR INFORMATION

Sound information on the levels of present radiological contamination is badly needed. Information on economic output produced in the affected region, whether for local consumption or export is also necessary. This information must be reliable, sufficiently disaggregated, open to public and media scrutiny, and supported by a close monitoring system. It should include increased involvement of national and international experts, nuclear radiation rating agencies, as well as community-based groups and NGOs. It must record both deterioration as well as improvements. Its undisputed reliability is an absolutely essential condition for success in shifting the Chernobyl strategy priorities, for targeting the assistance system to genuine Chernobyl sufferers, and for economic recovery and development projects.

7. REVISING OTHER LEGISLATION

Government Chernobyl programmes presently under operation are based on outdated legislation that deters development of new strategies. Revision of this legislation must go far beyond harmonization of other laws, such as taxation, regional development, land use and environmental protection. Developing a new legal framework suitable for and compatible with the new strategy of social and economic rehabilitation, and development of Chernobyl territories should focus on improving the economic environment.

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Legislation that encourages business operations and investments must be applied to the affected area. Moreover, in light of the special difficulties of these territories, special provisions should apply only to the Chernobyl territories, such as special powers attributed to local governments there, more fiscal decentralization, the right of districts' councils to impose local contributions, greater use of present legislation regarding special economic zones, and territories of priority development. Considering that attracting private credits could be a problem because of, among other things, lack of collateral, legislation that would help to establish trust funds and similar financial institutions should also be enacted. Legislation and institutional arrangements that would facilitate access to small credit schemes, such as credit unions or cooperative banks, should also be promoted.

8. REDESIGNING FINANCIAL TRANSFERS FOR INDIVIDUALS

The system of social assistance, including medical and resettlement assistance, should undergo not only improved targeting but, more importantly, a conceptual redesigning lest it continues to be underfinanced, corrupt and hardly manageable. Chernobyl-related social assistance could be usefully divided into assistance to individuals and to territories. Radiation, once absorbed by an individual, is an indisputable claim for social, medical and other assistance. The total value of legitimate State liabilities, however, may well be outside the limits of the State budget. Assistance could be in the form of lump sum payments such as seed money, and technical assistance to generate income in exchange for irrevocably surrendering claims to social assistance. The scheme could help to turn inaction and social apathy into action and taking individual responsibility.

9. REDESIGNING FINANCIAL TRANSFERS FOR LOCAL ADMINISTRATION

Nearly all payments to Chernobyl sufferers are transferred through local budgets and are administered by local administration. There is anecdotal evidence on misuse of these transfers. State budgets also finance such public infrastructure as gasification, road construction, and the construction of medical and social centres. Until recently, zone decontamination programmes included a very efficient component of roof and fence replacements, and the replacement of the upper soil layer. Local governments administered the budgets for these works as well. Although radioactivity protection measures

and natural recovery processes caused significant reduction in the numbers of contaminated settlements in all contamination zones, local leaders continue to press for assistance from the State budget. The benefits to contaminated territories should be re-examined to represent the present day contamination marks. A deal between the Treasury on the one hand, and representatives of local communities on the other hand, may be attempted. Its essence could be a trade-off between surrendering legitimate claims related to territory contamination plus claims for additional investments outlays for public services infrastructure related to resettlements, in exchange for leaving some of these potential transfers at the disposal of the local governments and local communities in question, in order to help them finance their own development plans and initiatives.

10. DONOR COMMUNITY ASSISTANCE TOWARDS SQUARING THE CIRCLE

The June 2002 “National Workshops on Chernobyl” attended by many donor representatives, concluded that it was:

“...necessary to assist the people in the region affected by the Chernobyl disaster in creating a perspective of sustainable socio-economic development while paying proper attention to the specific needs of the people in health care, psycho-social and rehabilitation services.”

To follow-up this recommendation and to maintain policy development processes regarding Chernobyl recovery, the UNDP Chernobyl Programme works towards:

- Intensifying policy dialogue with concerned government agencies on macro and sector policy issues related to the elaboration of the new Chernobyl strategy concept paper;
- Prioritizing the Chernobyl region within the United Nations Country Offices by selecting areas for pilot interventions, and developing and implementing special policy instruments;
- Enhancing the integration of United Nations activities, and local and national government initiatives, particularly with those that support the implementation of the new strategy;
- Strengthening local partnerships with donors and related resource mobilization; and

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- Enhancing public relations activities to support policy dialogue and promote the new paradigm of the United Nations strategy for Chernobyl recovery.

REVIVING SELF-RELIANCE: COMMUNITY-DRIVEN DEVELOPMENT IN CHERNOBYL REGIONS

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1. CONTEXT

There is a broad consensus that among the darkest legacies of Chernobyl is the accident's continuing effect on the lives of around six million people in Belarus, the Russian Federation and Ukraine, for whom the accident's long term effects continue to present real challenges to overcome. They live in poor communities, where many young people grow up with a sense of powerlessness and lack of control of their future. Unsure how to solve problems, many lose hope and resort to alcohol and drug abuse, violence and other high-risk behaviour. Many of these people may well not suffer any direct health consequences due to radiation, but face numerous problems nonetheless. Economic decline and dependence on government subsidies undermined their motivation and capacity to work towards solving their own social, economic and ecological problems. The resettlement of populations from contaminated areas following the disaster, presented affected settlements with additional challenges, resulting in a collapse of social infrastructure and a reduced sense of community.

2. THE UNDP SOLUTION

The UNDP found its solution through working with the Governments of the affected countries on implementation of the "Strategy for Recovery" report from 2002. It emphasized a focus on building the knowledge and skills of those living in the region so that they come to play a leading role in their own recovery efforts. The UNDP is working through application of what we call Area-Based Development (ABD) and supporting affected communities to develop self-governing community-based organizations (CBOs) to lead the local efforts for social, economic and ecological recovery and development.

3. ABD: APPROACH TO SUCCESS

Our experience shows that the ABD approach to implementing Chernobyl recovery projects is most promising. ABD is a holistic, comprehensive approach, targeting a specific geographical area of the country characterized by a particular developmental problem, through an integrated, inclusive, participatory and flexible approach. It takes a territorial and people centred approach, rather than focusing on target groups or sectors. It is about working with and establishing linkages between people and places on priorities and opportunities, and about building support institutions at all levels to respond to people's needs. It fully takes into account the complex interplay between all actors and factors, which requires a multi-sector approach, maximizing the involvement of all stakeholders. ABD programmes apply a bottom-up approach through building linkages between different levels of planning and decision making, feeding into policy and institutional reform at the national level. ABD provides a range of tools to tackle issues of poverty, exclusion, governance, decentralization and democratization holistically.

The lessons of ABD implementation we derived from other successful global and regional experiences where it was applied in areas characterized by e.g. recent military conflict, geographical isolation, poor soil, a large number of IDPs or industrial restructuring. In particular, we have been building linkages with such programmes as the UNDP/Ukraine Crimea Integration and Development programme where ABD targeted an area with a high prevalence of minority groups feeling marginalized and excluded from the rest of society which, in turn, created a potential for conflict.

As a result, a successful example of an ABD approach to tackle the human consequences of Chernobyl emerged through implementation of the UNDP/Ukraine Chernobyl Recovery and Development Programme. At present, it is operating in four affected regions of Ukraine; 127 community organizations were formed in 93 villages, involving over 12 000 members. Sub-regional cooperation between the three affected countries is strengthening and currently Belarus expressed interest in adopting the same approach. Cross-border cooperation is shaping up between Belarus, the Russian Federation and Ukraine with a focus on the opportunities that such cooperation and knowledge sharing can bring.

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4. HOW DOES ABD WORK?

Empowerment, initiative and participation are key words. Our emphasis is on community regeneration, building a spirit of activism and helping people undertake their own recovery.

Our experience shows that there are ten steps which the CBOs need to take to make their initiative a success story.

Each CBO develops its statute and establishes a self-help fund from which to support the projects and provide tiny loans to its members. They then identify and prioritize the needs of the settlement and make plans to address these needs. These plans typically include water supply, health posts, community centres, gas supply, and other social and communal services that are important for the entire community. CBOs then mobilize their own resources, after which they present their plans to local authorities asking them to get on board. Subsequently, the UNDP provides seed grants that on average constitute only around 30% of the entire project cost. Finally, each community organization takes full responsibility for the implementation as well as the operation and maintenance of their projects.

5. RESULTS: FROM 'VICTIM SYNDROME' TO SELF-RELIANCE AND RECOVERY

The close involvement and active participation of community members in implementing their joint initiatives has obvious benefits:

- People are highly motivated to make their project a success and feel true ownership of the result;
- In the course of planning and designing the project, people's expectation levels become more realistic;
- Communities and authorities become partners in governance;
- Local authorities become ready to share the costs and the risks. As a result, many local authorities have started reserving funds from their budgets for community initiatives and are actively encouraging other settlements under their jurisdiction to form CBOs;
- Networks of economic support institutions (business associations) provide existing and aspiring entrepreneurs with much increased access to opportunities for income and employment generation, thereby promoting recovery and development;
- Internal and external resources for projects are mobilized. Our experience of the UNDP Chernobyl Recovery project in Ukraine sets a

good example of successful resource mobilization for an ABD programme. Donors appreciate the comprehensive, multi-sectoral nature of ABD since it provides them with an opportunity to address their priorities in the country, while being part of a larger initiative in which their efforts are being coordinated with other donors. Thus, our programme in Ukraine acquired \$3.3 million, which has allowed us to move from successful pilots to interventions of scale. The fresh approach to the region's problems has helped overcome the 'donor fatigue' that now hampers Chernobyl efforts. Finally, ABD provides excellent opportunities for mobilizing local resources. As you can see from the chart, for the average community project, the UNDP's contribution is only 35%, while communities and local authorities provide the bulk of the remaining resources;

— New forward looking mentality is emerging in empowered communities.

6. LOOKING TO THE FUTURE

The UNDP's outlook on Chernobyl is consistent with the Chernobyl Forum finding that at the community level poverty is a bigger threat than radiation. The legacies of Chernobyl such as apathy, passivity and 'victim syndrome' can only be tackled through addressing the overall crises and destruction of the social fabric in Chernobyl-affected settlements. Only with leadership of national and local governments, active participation of the people and maximum involvement of all the stakeholders and institutions, can our programmes make a real difference in people's lives.

The next speakers will show how the ABD solutions are working on the ground. Communities and authorities are working together on helping people to take the future into their own hands, to mobilize resources for local priority projects, and to leverage modest funds for large impact. The key to their success is a strong commitment to work together and overcome Chernobyl stigma, promote self-reliance and self-help, forward-looking mentality and bring normalcy and eventual prosperity to their settlements.

UNDP CHERNOBYL RECOVERY AND DEVELOPMENT PROGRAMME IN THE BORODYANKA DISTRICT OF THE KIEV REGION

D. PETRUSHENKO

Borodyanka Rayon State Administration,
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Ukraine

The accident that happened at the Chernobyl nuclear power plant on 26 April 1986 appeared to be a real tragedy not only for millions of people in Ukraine, Belarus and the Russian Federation but for the whole world. The affected population had to leave their homes and property, and move to other cleaner and safer places. It caused changes in their lifestyle and their lives were broken.

Borodyanka Rayon (district) is situated 57 km away from Kiev to the west of the Kiev Oblast (region). The overall territory of the district is about 934 km² with a population of about 57 800 people. Besides the territories affected by radioactive contamination, there are many people resettled from the Chernobyl exclusion zone who live in the Borodyanka district, where seven settlements were built for them.

After research into the paramount needs and problems of all the people of the Borodyanka district, it was concluded that there is no difference between the problems of people who were removed from the Chernobyl exclusion zone and the problems of the local population.

First of all, these problems were social, economic, psychological and ecological: unemployment, absence of a gas and water supply in many villages, apathy, passivity of the population, poverty, shortage of health recovery local points, a shortage of village clubs and youth centres where the youth could spend its leisure time, and many other problems that needed to be solved. There were so many economic problems that they seemed to be much greater and dangerous than radiation itself.

The population understood that there were many problems that had to be solved. People showed interest and took the initiative to organize communities and began to act, to look for ways of solving their problems. The population defined its priority needs on its own. While actively searching for support for their initiatives among different organizations, the communities got in touch with the UNDP Chernobyl Recovery and Development Programme.

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Local authorities gave a prompt reply to the population initiatives and to the UNDP's support to work jointly on the implementation of the projects that are vitally necessary for people resettled from the Chernobyl zone as well as for the local population. It is necessary to emphasize that in the course of the cooperation, people completely changed their attitude to life. The population became more active and took initiative; the apathy began to disappear, and an interest in life appeared. People understood that they are able to improve their lives and the lives of their families through their own efforts.

People saw real results from their work, of the efforts they had made. Native residents of Borodyanka district's villages understood that they are able to revive their own land where many of their ancestors lived. They are able to revive their village, their motherland, their roots. Due to their own initiative and their cooperation with different organizations, people resettled from the Chernobyl zone integrate easily into a new place and feel as though they are part of the population of the district.

People understood that such respectable organizations as the United Nations and Governmental authorities trust them. People have realized that the international community is not indifferent to them and their problems. They realize that they have not been forgotten and left to struggle with their problems on their own. The population feels that society is taking care of them.

In the Borodyanka district of the Kiev region, the Chernobyl Recovery and Development Programme of the UNDP launched its activity in April 2002 in three settlements: Druzhnya village, Novyi Korogod village and Shybene village where communities defined their priorities and implemented four pilot projects. Due to the active position of the population, the projects were successfully implemented. This served as an example for other villages. As a result, new villages – Nova Byda village, Zdvyzhyvka village, Vablya village, Nova Greblya village, Nove Zalissya village – joined the programme's activities. Within the framework of the UNDP Chernobyl Recovery and Development Programme, 20 community organizations in nine settlements of Borodyanka district were organized.

At present, these communities work on implementing projects aimed at solving social, economic and ecological problems within their territories. To be precise:

- Vablya village: “Improvement of Health Recovery Local Post (FAP)” project;
- Nova Greblya village: “School Improvement” project;
- Nova Byda village: “Youth Center Establishment” and “Water Supply System Improvement” projects;
- Zdvyzhyvka village: “School Improvement” project;

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- Shybene village: “Water Supply System Improvement” project;
- Novyi Korogod village: “Water Supply System Improvement” project.

While expressing their initiative and cooperating actively with the UNDP, communities gained necessary experience. Now they are able to work on their own, to define priority projects, to look for donors and to apply for grants. They become economically independent. That was one of the principle goals of cooperation with the UNDP – to make communities self-dependent, active and self-sufficient.

However, we are not going to rest on our successes. We have big plans for the future. Borodyanka district State administration has already elaborated plans on social and economic recovery of our land. Social and economic recovery will contribute to increasing the district budget incomes and investments in the region. It will help us to solve social and economic problems.

To pursue this aim, we have created the Centre for Promoting the Economic Development in Borodyanka Rayon in our region. The centre was created in June 2005. Since then, the centre has realized two investment projects that added 200 000 UA HR (that is about \$40 000) to the district budget. Furthermore, the Centre for Promoting the Economic Development in Borodyanka Rayon in cooperation with the Borodyanka district State administration began to work on establishing a system of simplified registration of private entrepreneurs, a so-called ‘common window’.

Another direction of the centre’s activity is working with so-called ‘subjects of economic activity’ on launching of new enterprises. To ensure regular work of the centre, it gathers information for an extensive database. Information for databases such as “Land Resources”, “Geography of the Region”, “Enterprise” and “Infrastructure” has already been selected.

Through the mass media, the Borodyanka district State administration in cooperation with communities, shares its successful experience of project implementation. It is necessary that the population of other districts and regions of Ukraine learn more about Borodyanka’s positive experience and implement social and economic projects that are vitally important for people and for the well-being of their families.

YOUTH PROJECTS IN ZAMGLAY VILLAGE IN THE RIPKYNSKY DISTRICT OF THE CHERNIHIV REGION

N. NASON

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The population of Zamglay village is 1985 and about 400 inhabitants are young people. The village is located 70 km from the Chernobyl nuclear power plant and experienced radioactive contamination during the disaster.

As the years passed, radiation conditions fortunately improved, but unemployment and poverty caused by the closure of local enterprises became much worse. Impoverishment of the population has caused alcoholism and drug addiction of young people. Apathy and passivity towards life developed in people. People became accustomed to receiving low subsidies from the State authorized to “chernobylytsy” (Chernobyl-affected people) and to doing nothing, dragging out a passive existence.

People who were looking for a better life began to leave the village. The situation was difficult. People finally understood that they should not rely on the help of others. People said: “If we don’t help ourselves, who will help us?” — “We can help ourselves!” was the answer. We have understood that our power lies in our unity.

In March 2003, the population of the village united in two organizations: ‘Pobeda’ (Victory) community organization and ‘Ogonyok’ (Light) community organization. We have jointly defined priorities and common projects for village recovery. We started by putting the cemetery in order, cleaning the streets, repairing the fences, water supply systems, wells and reconstruction of the local market.

We then implemented projects on reconstruction of health clinics, repairing the school’s workshop and sports ground, and laying a gas supply system. We implemented these projects with the assistance of the UNDP’s Chernobyl Recovery and Development Programme.

Young people from the village had their own problems and priorities. First of all, there were problems with organized leisure time, with sports, education, computer literacy and business for beginners, communication with people of the same age in the district, Ukraine and in the whole world.

To solve these problems, the youth of Zamglay village, seeing the results of the adults' work, established its own 'TEMP' youth organization. The acronym TEMP translates as 'tempo' and stands for Talented Erudite Young Generation. TEMP is a movement towards achieving a goal. Practically all of the active youth of our village have joined this community organization.

The project that was implemented with the assistance of the UNDP is Youth Service Centre Establishment. This initiative was supported by several local authorities, and above all by the village council. Due to the joint efforts of our organization and local authorities, we managed to mobilize the resources needed to implement the project.

At present, the centre is a reality. We have premises repaired by ourselves; we have sport and computer equipment. We have received literature on the consequences of the Chernobyl catastrophe. There are classes for people with different interests. There is a computer class, a local newspaper is published, and trainings and seminars are held.

Most importantly, the youth now comes together to pursue their interests, drawing them away from harmful pursuits. Due to the existence of the youth centre, the youth has stopped leaving the village. The youth has become more active and purposeful, because they saw real results from their work. They have become more independent and self-sufficient. The local government now elaborates new projects, and looks for sponsors and donors.

We plan to develop the youth centre into a resource centre at the district level. Young people from our district and also from other Chernobyl-affected regions of the country come to the centre to adopt its methods. One of the main factors of achieving success is education. Especially needed is knowledge in business development, economic recovery of the village as well as skills in using computers and internet technologies.

The youth centre is known for improving access to information. By participating in trainings organized by the UNDP and other organizations, and having received knowledge ourselves, we do everything possible to share our knowledge with our younger friends and people of the same age from other villages. To this end, we have elaborated and implemented a training plan. The goal is for the youth centre to continue its development in the hands of a new generation.

Last year, young people actively participated in the Rayon Economic Forum on economic recovery and development of villages. Together with representatives from the district administration, heads of villages, representatives of communities and business, they discussed the economic problems of the region and developed ways to solve them. Young people are already working on elaborating small business projects. If there is a possibility to work

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and to earn money, the youth will not rely on State subsidies. Of course, it is understood that it will not be easy to realize our plans.

There are also problems. The absence of telecommunications infrastructure does not allow reliable modern access to the internet. To implement business plans, available credit lines, training and experience are needed. This requires the assistance of the international community and the State. However, we have already learned the most important lesson — the most important source of recovery and renewal comes from relying on ourselves.

TOWARDS A NEW APPROACH FOR THE REHABILITATION OF LIVING CONDITIONS IN THE CONTAMINATED AREAS

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In speaking today about community-driven development in the Chernobyl regions of Belarus, I will be using the Cooperation for Rehabilitation (CORE) programme as a practical example created to answer the concerns and needs of those who live in the contaminated territories. Before starting to talk about the CORE programme and its objectives, let me show some of the faces of the programme, which best illustrate its projects.

1. BACKGROUND

The CORE programme was developed in 2003 on the basis of a number of international evaluations including reports from the United Nations, the World Bank, the heads of missions/delegations of the EU and ETHOS. The programme is supported by Belarus' Chernobyl Committee.

The reports concluded among other things that:

- Rehabilitation is possible only if local people are heavily involved in the process;
- An integrated approach should be applied, i.e. project activities in all affected spheres of life: health, economy, education and memory of the Chernobyl tragedy and radiological quality;
- Rehabilitation needs to occur on three levels: local, national and international.

2. CORE PROGRAMME

CORE is an umbrella mechanism whose overall aim is to improve the living conditions of the people in affected territories. CORE was and is one of

the turning points as it is the first mechanism that involves people and encourages them to participate in their own development.

CORE has been initially implemented in four of the most affected districts of Belarus for five years (2003–2008). It aims at integrating four key priority areas — socioeconomic development, health care, education and memory of the tragedy and radiological quality.

The Declaration of Principles is the guiding document of CORE, providing a framework for cooperation between partners. According to the declaration, three main bodies have been established and have been working since February 2004: an Approval Board, a Preparation and Assessment Committee and a Coordination Team. These are structured to enable full participation by all interested stakeholders and to ensure that projects address local needs and that resources reach the population. International involvement has substantially increased over time. The signatories of the CORE Declaration have risen from the original 11 to 29 signatories in one and a half years. These include international organizations such as United Nations agencies (UNDP, UNFPA, UNICEF, UNESCO), the European Commission, the OSCE, nine EU Member States, the Swiss Agency for Development and Cooperation, NGOs from France, Germany, the United Kingdom, Ireland and the USA. So far, international donors have contributed just over €3 500 000.

3. RESULTS AND ACHIEVEMENTS

Despite the fact that CORE is a relatively young programme, some notable results have already been achieved.

First, four sessions of AB and three sessions of PAC were organized in the target districts of the programme. PAC sessions gathered over 150 participants each time including delegations of four districts comprised of local authorities and community representatives, such as farmers, mothers, teachers, doctors, entrepreneurs; international representatives; national authorities; and scientific institutes. These events have helped create a growing CORE community of stakeholders whose interest is in the development of participating districts. They have also brought exposure and attention to these areas by physically attracting high level representation from the capital and abroad.

Second, in terms of concrete projects, the CORE programme has so far approved 71 projects, of which 18 are topical, large scale projects and 53 small scale local initiatives. To date, six of the topical, large scale projects are under implementation with an overall value of €4 million. Donor contributions to these projects is just over €1 700 000. The six ongoing topical projects are Agriculture and Economic Sustainable Development (CORE-AGRI), Health

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and Maternity, Health Quality: Contribution to the Reduction of Sanitary Risks, Practical Radiological Culture, Intergenerational and International Memory and Education, Support for Radiological Education and Implementation of an Inclusive Radiation Monitoring System in the Bragin District.

There are also 35 local initiatives with an overall value of €272 000 at different stages of implementation. Donor contributions to these projects amount to €246 500. Some examples of these local initiatives are a children's recreational centre in Stolín, provision of drinking water, the creation of a local radiation club in Chechersk, and the creation of a public, cultural centre in Bragin to mention just a few.

Lastly, although none of the projects has yet come to an end, a significant outcome has been that as local communities see more attention concentrated on them by the projects, they themselves become more encouraged to take part as exemplified by the increase in project submissions and the large scale participations in CORE events at the local level.

4. UNDP ROLE

I would now like to turn to the role of the UNDP in this programme. The UNDP was a pioneer in the development of the CORE approach by elaborating, along with other partners, the CORE procedures.

The UNDP's most important contribution is the support project to CORE. Launched in 2004, it provides the financial, administrative and technical support for the coordination structures, facilitates the preparation, assessment and selection of the projects, and coordinates the implementation of the CORE programme while helping to mobilize resources and attract new partners to CORE. The project is co-supported by ComChernobyl, the Swiss Agency for Development and Cooperation, the UNOCHA and various French NGOs.

The UNDP is now looking to introduce an integrated ABD approach of the sort that my Ukrainian colleagues have just described. This would assist in organizing the priorities of the communities and help them to develop projects building on the lessons learned by the UNDP in similar programmes in other regions of the world.

If CORE is successful in the four pilot districts, it can be extended to the other affected districts as well as to other affected countries. For that to happen, increased donor support will be required. We invite the present representatives to join and support the CORE programme in its future efforts.

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V. VORONIN (World Bank): I would like to provide some information about the World Bank's activities and concerns in relation to the Chernobyl problems in Belarus, where the problems of radiological safety were and are exacerbated, as in the other affected countries, by the hardships of economic transition.

In Belarus, the World Bank started with the preparation of the Belarus: Chernobyl Review, which was finalized in 2002. It produced recommendations that were broadly discussed with the Government, with NGOs and with international organizations. The main thrust of the recommendations was that the Government should review its priorities, switching from an exaggerated emphasis on social programmes to economic re-development, away from subsidies and other benefits that were counterproductive, creating a sense of victimization.

The World Bank has worked closely with the Government of Belarus on revising and streamlining the system of subsidies and other benefits and improving their targeting. As a result, according to governmental sources, there were savings of about \$30 million which were directed to other priorities within the Chernobyl mitigation programme of the Government.

The World Bank's 2002–2004 country assistance strategy for Belarus also provided for a loan of about \$50 million to Belarus for dealing with Chernobyl problems. Unfortunately, for various reasons, the Government failed to use that money during the 2002–2004 period. In the light of the lessons learned from its failure to use the money, the Government approached the World Bank with a request for financial and technical assistance with investment projects in five areas identified by the World Bank in consultation with the Government: agriculture, water quality, forest management, improving the supply of heat to the rural population, and improving energy utilization efficiency in those four areas.

The first projects to get under way were the energy utilization efficiency project and the heat supply (gas distribution project). The projects, the scope of which is fully compliant with the World Bank's criteria and with the priorities of the Government, are intended to improve the quality of life especially in rural areas.

The overall operation is expected to cost \$50–60 million, of which 80% is to be financed by a World Bank loan. Gas mains will be extended so that gas can be supplied to more than 8000 households in rural areas. This will lead to reduced usage of wood for heating and cooking, thus reducing the radioactive contamination risk.

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Energy utilization efficiency is being pursued quite successfully by the Government, with a target of a 25% improvement by the year 2010. In the Chernobyl-affected areas, increasing energy utilization efficiency is of major importance because energy bills of public buildings, such as hospitals, schools and orphanages usually account for about 40% of local budgets. We are going to provide something like \$40 million for this purpose.

The next steps will be projects aimed at improving the employment situation and increasing fiscal revenues in the affected areas; for example, a project aimed at reducing the risks of forest fires and thereby providing additional revenues for local budgets through exports. It is expected that these projects will cost around \$60 million.

A. JANSSENS (EC): Mr. Osiatyński rightly said that in order to start up commercial activities in the affected areas, you need to ensure, through monitoring, that the activities comply with certain standards. Also, he mentioned the need for international certification of the products that are produced in those areas. In my view, the standards for foodstuffs and other products are very important for the acceptance of those products not only by the people in the affected areas but also by the overall population of the three countries affected by the Chernobyl accident. Is there not a need for sensitization of the overall population in the interests of solidarity?

J. OSIATYŃSKI (UNDP): I think there is such a need. Credibility is not less important than constant monitoring.

One result of the Chernobyl Forum could be the establishment of authorities which certify that products produced in the affected areas meet the standards and whose certifications may not be disputed or, if disputed, could be defended.

B.S. PRISTER (Ukraine): I think we can say with satisfaction that, although it has taken 20 years, the press release and the recommendations reflect the objective truth about what happened. However, I think we should say more about the need to concentrate our priorities, which was so badly done in the former Soviet Union, including Ukraine. The fact that dose was not recognized as the main risk criterion led us to spread our priorities over a vast territory and a vast number of people. Today, 20 years on, we still continue to combat milk contamination in territories where the soil contamination is 0.1 Ci/km² in terms of ¹³⁷Cs. This was what we scientists talked about from the very first days, whereas many politicians talked about overall danger, something not very specific, and just increased people's fear. It is important today to tell people that we scientists have enough information to be able to advise our governments about priorities. The fact that we had not carried out in depth studies of low dose effects does not mean that we did not know how to act immediately after the accident. In Ukraine, our norms and legislation were

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only amended five years later, when we were told that the level of soil contamination with radionuclides and radiation dose were the relevant criteria. Had they been amended straight away, we would have avoided many mistakes with many victims. The Rovno and Volyn regions in Ukraine were only recognized as being affected in 1987, and it was not until 1988 that we started to take countermeasures there. Today, we have 200 to 600 Bq/L of ^{137}Cs in milk in those regions, and even up to 3600 Bq/L in some villages. So, it is important that we say that the financial resources should be aimed at reducing the dose.

B.G. BENNETT (Chairperson): Clearly, over-regulation is damaging, and it will take all our efforts to put things into their proper perspective.

A.F. TSYB (Russian Federation): I have the feeling that we scientists who have spent 20 years working on the Chernobyl issue since the accident are now considered irrelevant, as if nobody needs us any more. The programme for this conference does not feature a single well-known scientist who has been working all this time in contaminated areas. I myself am a director of a large clinic that is treating about 400 patients at any given time. Of them, about 200 live in contaminated areas, and all of them go through my hands and benefit from my brain. I am in daily contact with these people, and I have some ideas, proposals and thoughts of my own — some proposals as to what should be done in order that we can move on.

Whatever we do, we should not forget all the research that has been done and is still being done. Yesterday, we heard a very interesting discussion regarding how many cases of cancers — 4000, 8000 etc. — are expected. Today, we heard that most scientists are ready to end the discussion about the Chernobyl consequences, but that is not the truth. If we cannot forecast risks well, how can we end the discussion? In no way am I contradicting all the colleagues who spoke today — not at all. I fully support the strategic reorientation of our policy, but we must not throw the baby out with the bathwater — the baby is alive and kicking, and we should be looking after it. I will give you an example. We have not, to this day, created a joint three-state register, although one of the most important issues for us is the statistical power of the groups featuring in the registers. If we do not have enough statistical power, we will continue floating about with the risk factors.

What is going to happen to the vast amount of data we have accumulated in the past 20 years? We run the risk of losing the data altogether. For example, there is a single register for the Russian Federation and Belarus for thyroid conditions and blood conditions of the liquidators, but we do not have a joint register for all three of the affected countries.

What is the incidence of cerebral and cardiovascular diseases and of cataracts due to the Chernobyl accident? Mr. Mettler talked about certain inclusions in the crystal of the eye being encountered. What kind of inclusions?

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This is a problem of low doses that our American and Japanese colleagues have spent a lot of time studying, and we must continue studying it if we do not wish to continue floating.

And how will nuclear power develop in the future? Is nuclear power safe? Yesterday, one speaker said that it would be much better if ionizing radiation did not exist at all. That, of course is an optimum scenario. We need to study all kinds of radiation effects on people in great detail.

I hope that I have convinced you, and I hope that we will be able to reflect my views in the conclusions of Mr. Bennett, who is perhaps more familiar with this matter than other people.

There is a question that arises from all of this: Where is the targeted medical assistance we keep talking about? In the former Soviet Union, we had total clinical coverage but that has disappeared. We do not have enough resources for everyone to be examined and treated in the same way, but we have the concept of risk groups. We have different risk groups, and the concept is based on the dose criterion — the dose that people have been exposed to — among other criteria, of course.

If we organize a preventive health service targeted at the risk groups, we shall be hugely useful in promoting people's health and helping to prevent diseases. Targeted medical assistance should become the cornerstone of our future work.

We know the doses that people are exposed to today in every village. We are aware of the individual doses, and on the basis of this information we can take appropriate countermeasures.

Finally, the children of the liquidators — nobody wants to finance the programme aimed at them. The liquidators have so many children, and so many of these, in Ukraine and the Russian Federation, require our attention. I think we must pay special attention to this issue.

B.G. BENNETT (Chairperson): We recognize your concerns. However, the scientists who participated in the work of the Chernobyl Forum were in close touch with colleagues in the three affected countries, many of whom contributed directly to that work, so their voices were heard.

There is much important work under way in the three affected countries which must continue. We are not saying that it must stop — only that this work should be more focused — there should be some change in direction and perspective.

P. KAYSER (Luxembourg): Mr. Osiatyński, speaking about an action programme for Ukraine, said that the first step should be radiation monitoring. In my view, however, there is a risk that too much time would be lost in re-determining contamination levels which are sufficiently well known. Moreover,

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the monitoring might well give rise to polemics about how the measurements should be interpreted.

J. OSIATYŃSKI (UNDP): The products produced in the affected area must be marketable, and you therefore need monitoring — credible monitoring.

B.G. BENNETT (Chairperson): I agree.

D. WILLIAMS (United Kingdom): I agree with Mr. Tsyb that we need a “Chernobyl Institute” to continue the scientific study of those effects which we are still unclear about.

Is there any coordination between the donor efforts of the World Bank and the donor efforts of the UNDP as far as the aftermath of the Chernobyl accident is concerned?

B.G. BENNETT (Chairperson): I am sure there is, and I expect Mr. Mizsei will touch on that in his concluding statement.

J.T. SMITH (United Kingdom): I have a question about the many Chernobyl children’s charities that exist in Western Europe and North America.

Each year, thousands of children from the three affected countries are treated to holidays in Western Europe and North America organized by those very generous charities. This may benefit the children by giving them an experience of life in a developed country. On the other hand, we know that the radiological benefit of such holidays is practically zero. We also know that many of the claims made by the charities are not in accordance with the scientific consensus regarding the Chernobyl accident. The charities exaggerate the radiation risk to the children.

Would anyone care to comment on the positive and negative aspects of such holidays?

B.G. BENNETT (Chairperson): Clearly, there is no link between the holidays and the radiation risk. Perhaps the resources expended on them could be used in a more productive way.

D. WILLIAMS (United Kingdom): Regarding the children’s charities, I think the recommendation “Rethink health recuperation programmes” on page 49 of the excellently written report of the Chernobyl Forum is very sound. I suggest that copies of the booklet be sent to all Chernobyl-related charities in Western Europe and North America so that they can read that recommendation and the report as a whole. After all, there are no longer any children who were alive at the time of the Chernobyl accident.

B.G. BENNETT (Chairperson): That is a good suggestion.

K. BECKER (Germany): Many people are still talking about the Chernobyl ‘catastrophe’ or ‘disaster’, but I believe that, for such terminology to

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be justified, a couple of zeros would have to be added to the casualty figures. In my view, we should talk about the Chernobyl 'accident'.

Part of the problem is the divergence between the facts and the highly speculative statements of epidemiologists based on the assumption that there is a linear non-threshold valid down to doses not detectable against natural background fluctuations.

In my view, we should focus on public health issues requiring more attention than the radiation effects of the Chernobyl accident. Every study concludes that further studies are necessary; that is one of the 'rules of the game', but this never ending story must be brought to a stop sooner or later.

B.G. BENNETT (Chairperson): I agree with that, although some health-related assistance is still needed in the affected areas.

SUMMARY OF SESSION AND CLOSING COMMENTS

K. MIZSEI

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First, I would like to congratulate the panellists for very credibly demonstrating what we can do in the very important area of community development from the bottom up.

There has been a very welcome agreement that the scientific consensus should be put forward in local communities.

When we talk about the local communities, we should remember that the international assistance provided to them is just a tiny fraction of the total assistance provided. We should humbly recognize the enormous role that national, regional and local governments play day by day in trying to help people to cope with the psychological, health and environmental effects of the Chernobyl catastrophe. I would like to pay a particular tribute to them. Here, the point is that when we engage in policy discussions with governments, we are trying to generate the policy change that can make their work even more efficient than in the past.

There was a question about how UNDP coordinates with the World Bank. I would like to expand this question to how UNDP coordinates with the whole United Nations system. The UNDP's resident representatives in the three affected countries are also resident coordinators for the whole United Nations system, and two of them — Mr. Sultanoglu and Mr. O'Donnell — are with us here. Their task is to make sure that the whole United Nations system, including the World Bank, is engaged in the work with the governments — again with the local and regional governments as well — that is very important — to help them to eliminate the consequences of Chernobyl.

I was particularly impressed by the recommendations of Mr. Osiatyński about revitalizing the economies of the areas that, for bureaucratic reasons, are suffering unnecessarily. I am not talking about the exclusion zone, but about very large areas that are wrongly deemed to be contaminated and therefore have acquired a stigma that they do not deserve.

I was also very impressed by his focus on the role of the regional and local governments in the pursuit of economic revitalization and in offering hope to the people, which is vital, through means such as infrastructure investments and

the granting of tax benefits in support of business creation. Although Mr. Osiatyński has been engaged in only one of the three countries, Ukraine, I think that his recommendations are highly relevant to the other two countries, and the United Nations — and UNDP specifically — is ready to work with the governments of the other two countries as well.

I would like to conclude by saying that I think we have reached a remarkable consensus about the need to look ahead and to be very optimistic about the future of the affected areas. The Russian Federation, Ukraine and Belarus are countries with people possessing excellent educational backgrounds and technical skills, and we can really be hopeful that gloom will be replaced by a very positive future for those who have been affected by radiation and by the psychological trauma of Chernobyl.

In conclusion, I extend my special thanks to our Chairperson, who has guided the Chernobyl Forum and also the proceedings of this conference. Also, I am very grateful to the IAEA and WHO for their partnership and to the Scientific Secretaries, who have been the true grey eminences of this conference.

I received many congratulations for what I said yesterday, but that was written by my dear colleague Ms. Vinton. So, 90% of the praise should go to her.

It has been a wonderful conference, and UNDP — through its resident coordinators — and the United Nations system as a whole are going to remain fully engaged with governments, with communities, with NGOs and with the people in the three affected countries, and I hope that from now on we can concentrate on the new agenda.

Just one more point, our 2002 report was mentioned many times. Anyone looking into it will find that everything was already there. In the past three years, we have been only relatively successful in moving the agenda forward, and now we have to show more resolve and more stamina in transforming the conversations, the policy actions and the information flow into something more productive that all the people of the Chernobyl-affected areas deserve.

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Chairperson

B.G. BENNETT

Radiation Effects Research Foundation,
Japan/USA

GENERAL DISCUSSION

M. CRICK (UNSCEAR): The work of the Chernobyl Forum was initiated to some extent in response to criticisms by certain States, in the United Nations General Assembly, of the UNSCEAR 2000 report. How do the findings of the Chernobyl Forum compare with those in the UNSCEAR 2000 report? What are the major differences?

B.G. BENNETT (Chairperson): In my view, the UNSCEAR 2000 report was very objective and accurate, and the Chernobyl Forum's studies have substantiated the findings in that report and built on their results. The scientific assessment remains more or less unchanged.

V. IVANOV (Russian Federation/WHO): Ten years ago, here in Vienna, we discussed the results of the first ten years of Chernobyl related investigations. Now, at this well-organized, high level international conference, we have been discussing the latest results of such investigations.

I would say that 20 years is not sufficient for arriving at final conclusions about cancer and non-cancer morbidity due to the Chernobyl accident. We should remember that the average dose received by people in Hiroshima and Nagasaki was 240 mSv, while the average dose of the population in the Chernobyl accident area is ten times lower. There is a great deal of uncertainty in the evaluation of risks associated with low doses. However, evaluating such risks is very important.

As regards practical recommendations, we have identified high-risk groups among the liquidators and within the population of the contaminated areas, and this information is of special importance for the Governments of Belarus, Ukraine and the Russian Federation when deciding how to use the limited financial resources in the most efficient way.

It is good that we discussed the non-radiological consequences of the Chernobyl accident. Even within the Russian national registry, we have not yet managed to evaluate the radiological and the non-radiological consequences of the Chernobyl accident separately but we clearly understand the importance of the non-radiological consequences.

The conclusions mentioned today will be of great importance for the continuation of post-Chernobyl studies. Less than 20 years have passed since the Chernobyl accident, whereas more than 50 years have passed since the bombing of Hiroshima and Nagasaki, and the consequences are still being studied. Here we see a time period of 20 years. Much remains to be done in connection with the Chernobyl accident.

I. LABUNSKA (Greenpeace): On behalf of Greenpeace, I thank all those who have worked on the issues connected with the Chernobyl disaster. I also thank the organizers of this conference for allowing us to display a small

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part of our Nuclear Impact photo exhibition. You are all invited to Kiev in April 2006 to see the entire exhibition.

In a statement made on the occasion of the 15th anniversary of the Chernobyl disaster, Kofi Annan, Secretary General of the United Nations, said that at least three million children in Belarus, Ukraine and the Russian Federation required medical treatment because of the Chernobyl accident and that not before 2016, at the earliest, would we know the full number of those likely to develop serious medical conditions. What has changed in the four years since Mr. Annan said that?

B.G. BENNETT (Chairperson): In my view, that statement of the Secretary General was unfounded and influenced by United Nations bodies which have played a less than positive role in connection with the Chernobyl accident, engaging in sensationalism. There are a lot of health problems in the affected region, but they are not due to radiation. That has to be clearly recognized, and people at the top, including Mr. Annan, would be well advised to base their statements on factual information.

As to Greenpeace, I urge it to look carefully at the information provided by the Chernobyl Forum and to make constructive use of it.

I. LABUNSKA (Greenpeace): I agree with all those scientists who have said that it is too early to stop the research on the health impacts of the Chernobyl accident. The research must continue, with a view to determining the full scale of those impacts.

B.G. BENNETT (Chairperson): Much work remains to be done, but the ongoing research has to be redirected and founded on facts and sound scientific principles.

Y. KENIGSBERG (Belarus/WHO): In view of the discussions yesterday and today, I believe we have to alter in some way the main conclusions of the Chernobyl Forum. First of all, the mortality projection of some 4000 or 8000 deaths. This is unfounded scientifically and should be deleted. Also, there should be changes relating to targeted aid for the population of affected areas and the development of local initiatives. In addition, it should be stated clearly that further studies on the Chernobyl accident consequences are absolutely essential.

B.G. BENNETT (Chairperson): That mortality projection has led to a lot of confusion, but I think we have clarified it as best we can. It has been treated in a reasonable manner by the media, so I am not sure what more we can do.

A.J. GONZÁLEZ (Argentina): Regarding Mr. Crick's questions about the much criticized UNSCEAR 2000 report, I would like to go back further in time.

A few months after the Chernobyl accident, the IAEA's International Nuclear Safety Advisory Group made a prediction — on the basis of the little

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information available at that time — which was basically the same as what the Chernobyl Forum has said.

Subsequently, after the Soviet Union had opened its doors to the international community, the International Chernobyl Project took place — and the findings were basically the same as the findings of the Chernobyl Forum.

In 1996, ten years after the Chernobyl accident, the IAEA, with the backing of the United Nations system as a whole, organized a major conference whose conclusions were again basically the same as the Chernobyl Forum's findings.

Why did the Chernobyl Forum carry out the studies reported on here? Because politicians in the three affected countries and officials within the United Nations system created a mess by not accepting what the scientists had told them.

A good outcome of the Forum's work is that ultimately science has prevailed after nearly 20 years, and I hope that this time those politicians and officials will follow the advice of the scientists.

B.G. BENNETT (Chairperson): I hope so too.

A. NYAGU (Physicians of Chernobyl, Ukraine): During all the discussions since the Chernobyl accident, we have seen three main points of view being put forward — the point of view of the nuclear lobby, the point of view of scientists and medical doctors who have worked during the 20 years in the contaminated areas and in research laboratories of the affected countries, and the point of view of the affected people. In 2002, the United Nations system tried to bring all three points of view together in one report calling for all three points of view to be heard. I do not think we should criticize Kofi Annan for saying that people in Ukraine, Belarus and the Russian Federation need help.

Meetings held during the past three years have helped to clarify matters, but there are still flaws in the latest recommendations. As scientists from the three affected countries are saying, the Chernobyl-related research should not be terminated. The many people who were living in the affected areas are still fearful of the effects of the Chernobyl accident. We should continue the Chernobyl-related research, so that the international community may make use of the results.

B.G. BENNETT (Chairperson): We do not deny that significant assistance is needed in the affected region, to improve the health and the economic situation of the people living there, and that much of the ongoing scientific and social work needs to continue.

Yu. IZRAEL (Russian Federation): I think that mathematicians should be involved in future Chernobyl-related research, because the mortality figures that have been mentioned — 4000 and 8000–9000 radiation-induced cancer

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deaths among the 600 000 exposed persons) have no statistical value. For every person who has at least some knowledge of mathematics, it is obvious, and we should give a qualified mathematical evaluation of these figures. This is my wish for the future.

B.G. BENNETT (Chairperson): The figure of 4000 has certainly caused a lot of confusion. The point is that however many deaths you postulate, those deaths will be indiscernible from the background of total deaths occurring in the population. The figure of 4000 is a scientifically reasonable figure, and by citing it we were trying to emphasize that the final figure will not be — say — 400 000 or even 40 000. I hope that the media will make proper use of the 4000 figure.

I.P. BLOKOV (Greenpeace): I would like to make a formal proposal for a decision. In the light of the discussions which took place yesterday and today, I formally propose that the conference adopt the following statement: “The results presented in the expert groups’ report involve too much uncertainty and leave a number of gaps, and no statistical explanation of data was included in the report. Consequently, the report cannot be accepted as full, adequate and final.”

The ongoing research needs to be continued, as we do not know the full consequences of the Chernobyl accident.

B.G. BENNETT (Chairperson): I disagree with that proposal. In my view, the conclusions and recommendations of the Chernobyl Forum are very clear, well founded and objective, and I do not believe that the report is unacceptable.

I.P. BLOKOV (Greenpeace): I do not wish to engage in a discussion, but points of view expressed and research done by some very respected scientists were not reflected in the report.

B.G. BENNETT (Chairperson): This is a conference organized by eight United Nations organizations and the three affected countries, and scientists from all round the world have — I think — done a remarkable job. If Greenpeace wants to say that we still do not know what we are talking about, it can do so, but that is very counterproductive.

There are more important things Greenpeace could do than talk about a ‘radiological catastrophe’. The Chernobyl accident was simply a catastrophe, and much work remains to be done, and I believe that the results of the Chernobyl Forum’s scientific assessment can be of great practical use to governments, international organizations and NGOs.

P. KAYSER (Luxembourg): As Mr. González said, science should prevail. However, it has not always prevailed. In 1986, for instance, while prevailing in France, which is a highly centralized country, it did not prevail in Germany, which has a federal, decentralized political system. Cabbage grown just on the German side of the French–German border was destroyed

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unnecessarily, whereas cabbage grown nearby on the French side was eaten. In Germany, it was politics that prevailed.

B.G. BENNETT (Chairperson): There is something special and controversial about ionizing radiation, and that gives rise to problems which we are all continuing to learn lessons about.

CHAIRPERSON'S CLOSING COMMENTS

B.G. Bennett

Radiation Effects Research Foundation,
Hiroshima,
Japan/USA

I would like to bring this conference to a close with a few brief statements. First of all, I would like to thank those who participated in the presentations and discussions of the past two days. The assessments of the continuing environmental levels of radioactive contamination, the health consequences of radiation exposures received by workers, evacuated persons and by those who continue to live in contaminated areas, and also the social and economic issues were very clearly presented. These sound, scientific evaluations form the basis for sensible, practical recommendations that could be adopted by governments to manage the public health problems that will be faced still for some time as a legacy of the accident.

We owe a great debt of gratitude to the specialists who prepared the expert reports that formed the basis of the conclusions and the recommendations of the Chernobyl Forum. These reports incorporate the latest scientific findings on the consequences of the accident. A careful review of social and economic issues has also been prepared to serve as a basis for new national and international initiatives to help the recovery process. This material was constructed on the already solid foundation of numerous studies, international reviews and evaluations that have been conducted over the past 20 years. Together, this knowledge forms a solid basis for our present observations and recommendations.

The Chernobyl accident was a disaster that required a massive response. The former Soviet Union and the successor countries reacted with heroic efforts to limit the contamination of the environment and exposure of the public. The protective measures were extremely effective. We can truly say that except for the high exposures received by workers on the night of the accident and for many children who very unfortunately received high exposure to radioactive iodine released in the accident and who later incurred thyroid cancer, the accident was a low dose event.

The majority of workers who participated in the cleanup efforts, the many thousands of persons evacuated during the early days following the accident, and all those who continued to live in contaminated areas received radiation doses from Chernobyl released radionuclides that were relatively low and

unlikely to lead to widespread and serious health effects. The doses to these individuals are comparable to those caused by naturally occurring radionuclides that produce a background level of radiation to which everyone in the world is exposed. Some notable regions of high background radiation exist in several countries that are caused by higher concentrations of thorium or uranium radionuclides in the beach sands or in soil or water. The Chernobyl exposures are not unlike these naturally occurring areas that are not associated with discernable radiation health effects.

Many of the health effects in the population of the Chernobyl affected regions are caused by factors other than radiation. That is not to belittle the possible consequence of radiation exposures, but it is to recognize the harm done by smoking, excessive alcohol consumption, poor diet, or inadequate health care or advice. It may make sense to address these other issues at the same time or even instead of the radiation threats to achieve the best progress in improving public health and well-being in the Chernobyl countries. Let us resolve to see things in wide perspective and to accept proper priorities to improve public health in the region.

I would like to stress that our conclusions are more than just valid, objective, scientific statements. They are a consensus of all of the scientists, international organization staff and representative of governments who participated in the Chernobyl Forum and this conference. All of us agree on the basic underlying facts. We agree with the evaluations of the health and environmental effects. We accept the characterization of the social and economic problems engendered by the accident, and we acknowledge the critique of the response thus far to the existing issues by the governments and the public.

We are speaking with one voice on the various issues. Even in the complex situation that we have now and the uncertainties that we face going forward, we are starting out now with consensus views on the issues. We have reached agreement on the recommendations to guide our continuing efforts to ensure the well-being of the populations of the affected areas and contribute to the economic recovery of the region.

These consensus views cannot be taken lightly now and then disregarded sooner or later when other statements would seem to be more expedient or would perhaps attract more attention. If we do not hold to these agreements, the disputes will re-emerge. The problems of ineffective government measures to deal with public health problems will continue, and the public will continue to feel that their concerns are not being heard and dealt with. It will also be difficult for international organizations to work effectively with governments to initiate widely supported measures to improve public health and lead to economic stability and prosperity. We must speak with one voice now and with one voice as we go forward.

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The stakes are high for disregarding our consensus views and the agreements we have just concluded. We would revert to continuing disputes and ill will, waste large sums of money and be unable to attract international assistance that is still required. However, the prospects are high for going forward in a positive way, utilizing the consensus evaluations for dispelling unfounded views on the consequences of the accident, redirecting our limited resources in the most effective ways, and restoring the trust of the public that is so essential to resolve the problems that are still faced as residual features of the accident.

In the past, we have experienced a disparity in the views of the scientists, who evaluated the health and environmental issues, and the views of the politicians who felt that different conclusions would be more likely to win international sympathy and humanitarian aid. We know so well that it does not work for us to go our separate ways. We must speak with one voice if we are to overcome the problems that we still face. Let us resolve to help each other to bring clarity to all aspects of the issues related to the Chernobyl accident and to bring efficiency and success to our efforts to deal with the continuing problems.

We will certainly be challenged as we go forward. Nobody said it would be easy to transform the recommendations of the Chernobyl Forum into practical measures that can be enacted by governments to contribute to a better future of their countries. The contamination will not go away, even if we understand the transfers of radionuclides in the environment and realize the countermeasures that are most effective for dealing with this. The stress and worry of the public about radiation effects will only slowly dissipate, even with good information and clear presentation of the real risks and dangers. The economy will not respond quickly to new initiatives, even if these seem in the long term to be the most sensible and effective for fostering economic development.

We must understand these difficulties, but we must face realistically and resolutely the challenges before us. We must be patient with the long recovery, but let us be steadfast in our resolve to deal with the issues in a sincere and truthful way, so that the efforts of government, international organizations, and the public will be united and coordinated, and all will be satisfied that we are doing our utmost to recover from the serious consequences of the Chernobyl accident.

On behalf of the organizers and sponsors of this conference, I would like to express our gratitude for the many specialists from many countries who compiled the expert reports that form the basis of the conclusions and recommendations of the Chernobyl Forum. The expert reports were prepared in a remarkably short timeframe. Obviously, those involved made considerable effort to complete their work in a timely fashion. They addressed the most

important issues related to the accident and the recovery process, and they produced the most complete and useful compilation of information and results available at present. Their clarity and objective presentation have enabled not only scientists but also Government representatives and politicians to accept the conclusions. The Chernobyl Forum will be judged successful in large part from the good work of the expert groups.

The Chernobyl Forum will also be judged successful from the participation all along of Government representative of Belarus, the Russian Federation and Ukraine. Their good will and understanding have ensured that there will be wide acceptance of the Forum's recommendations and effective measures will be taken with the encouragement of international organizations. We all have great expectations for progress and continued alleviation of the consequences of the accident, for the economic development of the whole region, and for the improvement in public health that we all aspire and strive for.

Finally, I would like to thank the IAEA for organizing the Chernobyl Forum. In that regard, I should thank Dr. ElBaradei personally for the original initiative that he proposed to bring agreement from disputes, to bring concerted and coordinated efforts to measures still needed to improve public health and to bring consensus as the basis for future actions.

I thank the many other international organizations that have joined with the IAEA in sponsoring the Chernobyl Forum. The World Health Organization and UNDP made substantial, direct contributions to the work of the Forum and the presentations at this conference. I thank all those who have participated in and contributed to the success of the Chernobyl Forum.

Especially for the persons directly affected by the accident, I wish that our work of preparing informative materials and of presenting the findings at this international conference will be translated into effective actions that will benefit them directly and improve their health and well-being, and their prospects for productive and fulfilling lives. They are the ones who deserve and expect the fruits of our efforts and the good that may come from our effective actions.

I now declare closed the activities of the Chernobyl Forum. After having looked back, let us now go forward together and join in our efforts to transform discussions into actions. Let us cooperate to make concerted efforts to inform the public of the measures still needed to avoid further radiation exposures from radionuclides released by the accident, to formulate reasonable and fair measures to compensate for injuries and disruptions of lives, and utilize our limited resources most effectively for the common good. Let us turn the Chernobyl accident from a disaster unfolding into a public health issue into an economic potential expanding. The crisis that befell the region now needs

CLOSING COMMENTS

solutions that will erase the damage and disruption and bring forth better prospects for the health and prosperity of all those involved. Let our problems be solved, and let our hopes and aspirations become reality.

Thank you for your participation in this conference and your efforts hitherto to make our work successful. I will thank you in advance for your continuing willingness to contribute to a better future for the Chernobyl region.

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Opening Session		
Session 1	B.G. BENNETT	Radiation Effects Research Foundation, Japan/USA
Session 2	K. MIZSEI	UNDP
Closing Session	B.G. BENNETT	Radiation Effects Research Foundation, Japan/USA

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The objective of the international conference on the Chernobyl accident, organized in September 2005 by the IAEA on behalf of the Chernobyl Forum, was to inform governments and the general public about the Forum's findings regarding the environmental and health consequences of the 1986 Chernobyl accident, as well as its social and economic consequences, and to present the Forum's recommendations on further remediation, special health care, and R&D programmes, with the overall aim of promoting an international consensus on these issues. These proceedings contain all of the presentations, the discussions held during the conference, as well as the conference findings.

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