decision, however, was based on many people's desire to take the tablets, the psychological benefit from the consequent reduction of fears, and the negligible physical side effects.

Stable iodine was given to all of the 27 000 children evacuated from the 30-km zone and to 700 000 children living outside the evacuation zone. The children who were found to have received thyroid doses in excess of 0.3 Gy are receiving close medical follow-up.

Measurements of radioactivity in the thyroid glands of 330 000 people living close to the evacuation zone were taken within a month of the accident; 68% of those tested were children. The average amount of radioactivity in the thyroid gland was less than 0.1 MBq: 10 times less than the forecast level for the whole of the south-western economic region of the USSR. The average thyroid doses were 26 mGy for children aged less than 1 year, 2 mGy for children aged 1–10 years and 2.6 mGy for adults in this more heavily contaminated region, where the maximum levels for individual radiation doses to the thyroid were found. Ingested ^{131}I contributed 2.5% of the total dose received by the Soviet population and 1.0% of the total dose to the population of Byelorussia. Further details of the doses from radioiodine and how they relate to doses from other radioisotopes have been given in Table 3.

Of the people evacuated from Pripyat to nearby centres in the Polessky region and studied by whole-body monitoring, 97% had thyroid doses of less than 0.3 Gy, 2% had doses of 0.3–1 Gy, and 1%, 1.1–1.3 Gy. These relatively low exposures were due to the benefits of iodine prophylaxis and restrictions on milk consumption.

Other people, including most of those evacuated from Pripyat to Belaya Tsak and examined on 7 May 1986, had thyroid exposures of 0.015–0.25 Gy. A few children aged 3–8 years, however, had thyroid burdens of 0.17–0.24 MBq, giving an absorbed dose of 1.5–2.2 Gy. These thyroid exposures due to inhalation were roughly characteristic of the other evacuees.

In the most heavily contaminated areas, a number of actions to control the contamination of milk by ^{131}I resulted in doses to the thyroids of members of the public that were 5–20 times lower than expected.

Poland

In Poland, elevated levels of radioactivity in the air were first detected at 9 a.m. on 28 April 1986. Further investigation showed that 80% of the radioactivity was due to radioiodine and related compounds (^{133}I and tellurium-132 (^{132}Te)). Measurements of radioactivity in the thyroid glands in children and adults were carried out by 29 April, and levels in excess of 5700 Bq were detected in some children. Information on the likely duration of the release was not available and, since it seemed possible that some children might receive thyroid doses of more than 50 mSv, iodine prophylaxis was recommended on that day for those under 16 years of age. Prophylaxis was not recommended for pregnant women or other adults.

KI was used, at a recommended single dose of 70 mg in solution for children aged 2–16 years and 50 mg for those under 2 years of age.

The advice initially related to north-eastern Poland, but was extended to the rest of the country 24 hours later. In all, about 12 million children received iodine prophylaxis; 8 million adults took stable iodine on their own initiative. In the most highly contaminated parts of Poland, thyroid dose equivalents in people without prophylaxis were 205 mSv (25 mSv from inhalation and 180 mSv from ingestion), and 35 mSv in children who had received stable iodine. In moderately contaminated areas, the doses to the thyroid were 68 mSv to people without prophylaxis: 8 mSv from inhalation and 60 mSv from ingestion.

According to the evidence available, the prophylaxis seemed to have been well tolerated in general. For example, some pregnant women took KI, against the official advice; the preliminary follow-up data suggest no adverse effects in their offspring at birth. Among the 8 million adults who took iodine, there was some increase in thyrotoxicosis, especially in people with controlled Graves' Disease, although only preliminary data were available.

Allergic effects also appeared to be rare; only three severe adverse reactions (bronchospasm) occurred, all in adults, and all three responded to intravenous steroids. Among the 10.5 million children and teenagers followed up, there were 163 minor and 5000 moderate allergic reactions.

So far, no significant change in the incidence of neonatal hypothyroidism has been detected. Although neonates given iodine on the second or third days of life showed some evidence of transient hypothyroidism, by an elevated level of thyroid-stimulating hormone, they had normal thyroxine and tri-iodothyronine levels on days 7–10. For this reason the Polish authorities considered that it might be preferable to limit the dose for neonates to 7–10 mg KI instead of the 15–30 mg given following the Chernobyl accident.

A number of epidemiological studies are being undertaken in Poland. These include studies on the effects of exposure to radioiodine and of iodine prophylaxis, and national work on developing intervention levels, protective measures and training in the context of exposure to radioiodine in an accidental release.

In particular, the studies will address the following topics. Evaluations will assess:

— the exposure of pregnant women to radioiodine and its effect on the development and function of the thyroid in their children, immediately after delivery and during the first five years of life;

— the side effects of protective doses of KI given to pregnant women on the development and function of the thyroid in their children, immediately after delivery and during the first five years of life;

— the risk of side effects on the thyroid from a dose of KI in people with a history of thyroid disease;

— the efficacy of a single dose of KI, depending on age, dosage, time of administration and environmental factors; and

— the early and long-term effects of radioiodine isotopes and of a single dose of KI on thyroid function in people of different ages, living in different regions of the country.

In addition, the dose equivalent commitment from ^{131}I in the thyroid will be estimated for children, teenagers and adults, with and without protective measures, in different regions of Poland.

Czechoslovakia and Romania

In Czechoslovakia, the Slovak Socialist Republic recommended prophylaxis on 4 May for about 2340 people (aged 18–60 years) working on sheep farms at high altitudes. They used 130 mg calcium iodide plus 15 drops of Lugol's solution daily for a week (5–12 May). Other members of the population also took stable iodine. The rationale for the advice was the level of radioiodine in sheep's milk and cheese. No side effects were reported. Advice against the use of stable iodine was given in the Republic where air sampling suggested that the level of contamination was below that requiring intervention.

In Romania, because of rising levels of radioiodine in the air, people under 18 years of age were recommended on 2 May to take 1–5 mg KI (according to their ages); 80% of the target population received prophylaxis. No side effects were recorded.

Members of the public in other countries undoubtedly took stable iodine in various forms but it was almost impossible for national authorities to obtain accurate information on such matters.

Conclusions

In general, where large numbers of people received stable iodine, the available evidence suggests that it was well tolerated. The detailed studies being undertaken in Poland will provide valuable additional information on the risks and benefits of prophylaxis. In addition, epidemiological studies have been proposed in the USSR and are likely to produce useful additional data on side effects.

A preliminary analysis of the Polish data suggests that the two possible sensitive groups needing more detailed consideration are infants (as fetuses and neonates) and people who have or have had an overactive thyroid gland.

The criteria for the use of stable iodine need to be reassessed in the context of the additional information gained from the response to Chernobyl in Member States.

Hazards to health from cesium

In June 1987, WHO convened a meeting in the Federal Republic of Germany to discuss the health hazards from radiocesium following the Chernobyl nuclear accident *(4)*. The meeting concluded that radiocesium was the only radionuclide of significance in the assessment of the radiological impact of the accident outside the USSR, although short-lived radionuclides, particularly ^{131}I, might contribute around 25–30% (or a maximum of 50%) of the dose in the first year.

In only a few instances had the inhalation of airborne radioactive materials significantly contributed to the doses received. About half of the total dose from the ingestion of radiocesium would be delivered in the first year after the accident.

The importance of the different foods contributing to the dose absorbed via the ingestion pathway varied with the timing of the accident in relation to the growing calendar across the affected parts of Europe. Soil characteristics, plant types, and food consumption patterns for different animal species also greatly influenced the contribution from different foodstuffs.

External doses of cesium to individuals were generally smaller in urban than in rural areas, because of the shielding effect of buildings and the more rapid action of processes such as wash-off and weathering in urban areas.

For estimating doses via ingestion, a dose conversion factor of 10^{-8} Sv/Bq would be satisfactory, in general, although it should be realized that human metabolism alters with age.

On the basis of the available data, the average individual dose from radiocesium in Europe through all pathways was estimated at approximately 0.3 mSv in the first year after the accident, and 0.6 mSv over the next 50 years.

Assuming a linear no-threshold dose–response curve, and a risk factor for fatal radiation-induced cancers of 2×10^{-2} Sv, the result might be up to 7000 fatal cancers among 550×10^{6} Europeans. This was equivalent to an increase of 0.6×10^{-5} in the incidence of fatal cancers. Such an increase, if evenly distributed throughout the population, would not be likely to be detected against the background incidence of fatal cancer.

The three most effective countermeasures employed in Europe were:

— reducing the radionuclide intake of animals;

— converting contaminated milk to hard cheese;

— controlling the use of contaminated rain-water (washing vegetables contaminated by direct deposition was also useful in certain areas).

The meeting concluded that it was important for national authorities to maintain and improve their quality assurance programmes for the analysis of radionuclides. These programmes should include adequate assays of levels of background radiation, airborne contamination, environmental radioactivity and direct gamma dose rates. Standardizing sampling procedures and the methods for collating and assessing the results are also important.

In addition, scientists, the public and the mass media need education on the basis of radiological assessments and the science of risk assessment.

In the present Working Group's discussion of cesium, some members from western Europe felt that the estimated average individual dose of 0.3 mSv was rather high. This figure, however, might be due to the somewhat higher exposures in eastern European countries. Austria and Italy had estimated average individual exposures around 0.5 mSv, but many of the other western European countries had estimated lower doses of around 0.15–0.3 mSv.

It was not known how much of the advice given by governments was followed by the public or whether there were any adverse effects, for example, from reduced intakes of fresh vegetables. The OECD review *(3)*, however, gave some indication of the doses (collective doses and individual doses to critical groups) averted in member countries. More information on doses was likely to be available in due course from the work being carried out by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

Epidemiology

Soon after the Chernobyl accident, it became apparent that epidemiological investigations into the possible adverse effects of the radioactive release on the health of the exposed population would be important. This was emphasized by the representatives of the Member States at the thirty-sixth session of the Regional Committee for Europe in September 1986. As a consequence, the Regional Office implemented a series of actions to facilitate this work.

A first decisive step was a Consultation on Epidemiology Related to the Chernobyl Accident held at the Regional Office in Copenhagen in May 1987, at which a number of experts reviewed the situation throughout

Europe *(5)*. The Consultation was organized in collaboration with the International Agency for Research on Cancer (IARC), and was followed by a Joint IAEA/WHO Workshop to Discuss Appropriate Methodologies for Studying Possible Long-term Effects of Radiation to Individuals Exposed in an Accident *(5)*, held later in the same month at IAEA headquarters in Vienna.

It was recognized that the widespread contamination following the Chernobyl accident had generated considerable public concern about its possible adverse effects on the health of the exposed populations.

Outside a limited area surrounding the accident site, current dose estimates and present knowledge of radiation biology suggested that such adverse effects might be at a level too low to detect against variations in the background incidence of disease. The exposed population was sufficiently large, however, that even a small increase in incidence would be of importance to public health. Moreover, substantial uncertainties remained in the knowledge of the effects of radiation and their magnitude; these justified the monitoring of dose levels and the health of exposed populations over extended time periods.

The participants at the Consultation recommended that the people most exposed (those near the site of the accident) should therefore be monitored for both dose and adverse health effects in the greatest detail possible. The USSR had already taken considerable steps in that direction. Reliable information on dosimetry should also be compiled for areas outside the limited evacuation zone; existing sources of health registration, such as registers of cases of cancer and congenital malformation should be used to monitor any variations in risk, examine their relationship to the temporal and spatial distribution of risk and relate them to the duration of exposure to radiation following the accident.

It was suggested that urgent consideration should be given to the possibility of establishing such registers, where they did not exist. The accident had highlighted a lack of baseline information on important aspects of health in many areas of Europe, and it was hoped that the recognition of this lack would motivate national authorities to make additional efforts to introduce such procedures to collect routine data.

Birth defects, childhood cancers (especially leukaemia) and mental retardation were considered to be the most important health effects for study. In the long term, other cancers should be studied.

International coordination of such monitoring would be essential to make possible the standardization and pooling of results. It was thought that WHO should coordinate the assessment of health effects; IARC will have a special role in the evaluation of cancer risks.

The Joint IAEA/WHO Workshop in Vienna concentrated on the Soviet studies that were proposed following the Chernobyl accident and on advising on appropriate studies of the long-term effects of radiation on the exposed population. It would be necessary for such studies to continue for many years, as the Hiroshima and Nagasaki studies were still producing significant results 40 years after the exposures had occurred.

The report on the action taken in the USSR since the accident gave an impressive account, *inter alia*, of the development of plans for an organizational structure to carry out the necessary follow-up.

It was considered that international collaboration in the Soviet studies would be extremely valuable and would offer a unique opportunity to obtain further scientific knowledge on the effects of low doses of ionizing radiation. The participants at the Workshop expressed their willingness to respond actively to the information provided by collaborating, in any way that was considered appropriate, in all aspects of the proposed investigations.

The establishment of an institute in Kiev to follow up the exposed population was welcomed. It would provide a sound basis on which to build. This institute, along with others in the USSR, would be an important focus for the work. The participants hoped that links could be developed between Soviet research centres and others working in similar fields to ensure that information on new techniques and the expertise gained could be exchanged by the relevant scientists and become rapidly available throughout the international community. It would be particularly important for links to be established with those involved in the Japanese studies.

The participants at both the meetings in May 1987 agreed that WHO should set up a steering group to coordinate and advise on epidemiological studies both inside and outside the USSR *(5)*. It was considered important that this group should consider studies on cancers, prenatal and birth defects and genetic effects, as well as the consequences of iodine prophylaxis.

The present Working Group welcomed the USSR's commitment to a careful follow-up of the people exposed to radiation in the area around Chernobyl, which the USSR recognized would need to be extended well into the next century. A group of 45 000 people among the evacuees, who had received a collective dose of 1.5×10^3 man-Sv *(5)*, was particularly important; the follow-up of these people (with average individual doses of 2.5 mSv) could provide information on the effects of such relatively small doses of radiation, and might give unique information on the shape of a dose–response curve at low doses. There was no comparable population among those exposed at Hiroshima and Nagasaki, where only 2000–3000 people had received doses in this particular range. If present dose/risk estimates were correct, about 10 additional cases of leukaemia would be expected in children or juveniles within this group. A number of cases differing significantly from this prediction would suggest that present dose/risk estimates need to be reconsidered.

With regard to the activities of IARC, a meeting was held in 1987 at which a number of registers had agreed to work together to monitor health statistics in coming years, in the context of the exposures from Chernobyl. National registers (in Denmark, Finland, the German Democratic Republic, Norway, Poland and Sweden), as well as subnational registers (in Scotland, the Slovak Socialist Republic, the Socialist Republic of Slovenia and parts of Austria, France and Switzerland) and some childhood cancer registers (in England & Wales, the Federal Republic of Germany, Hungary and the Netherlands), had agreed to participate in this work.

IARC was to collect and analyse the data and, where necessary, provide assistance in improving registration. Dose estimates based on the data primarily collected through UNSCEAR would be used, along with any other nationally available data. Initially, the survey would concentrate on childhood leukaemia rates. There was considerable discussion about the value of such studies in areas at long distances from the Chernobyl accident. It was unlikely that adverse health effects would be detected if the present dose/risk estimates were correct, because the doses were low and owing to the inevitable presence of confounding factors, for which allowance could not be made.

Nevertheless, many members of the Working Group felt that such an epidemiological survey would be valuable. Even if detectable effects were not anticipated, the survey would make a coordinated assessment of the data and would ensure that standardized data of high quality were available; these would be needed to respond to the inevitable queries about possible health effects of the Chernobyl accident.

Further, although most of the Group agreed on the risk factors, there was also some scientific discussion on the possibility that risks from exposures to radiation were greater than was generally believed. The proposed IARC study would enable further information relevant to this discussion to be collected and assessed.

The importance of ensuring a long follow-up on all proposed epidemiological studies was emphasized by a recently published paper on the people exposed at Hiroshima and Nagasaki *(6)*. In these cities, the risk factors for solid tumours were now the subject of considerable scientific discussion, and the doubling dose for solid tumours could be as little as 1.6 Gy. Attention was also drawn to the probable greater sensitivity to irradiation of people exposed as children. Their risk of developing cancer appears to be increased as they enter the age at which the spontaneous incidence of solid cancers becomes notable.

The Working Group stressed the importance of well coordinated multicentre studies, such as those of IARC and EUROCAT, in rapidly refuting or substantiating suggestions about the effects of Chernobyl on health. EUROCAT is a project for the epidemiological surveillance of birth defects in the majority of countries of the European Communities. The monitoring system includes 23 regional registers (including 3 each in France, Italy and the United Kingdom, and 1 in the Netherlands) each covering a defined population and including live-born and stillborn babies and children up to the age of 1 year. The data base includes 32 000 cases of congenital anomaly registered in 1980–1986 from a reference population of about 1.6 million births.

The EUROCAT study on the frequency of Down's syndrome in its registers between January 1986 and March 1987 showed no statistically significant increase in the number of cases following the Chernobyl accident *(7)*. Other studies were proceeding, including investigations of effects on the central nervous system of the fetus. The results were likely to appear in the not-too-distant future.

Although there are some difficulties in carrying out and interpreting epidemiological studies, the continuous medical follow-up of individuals could benefit health. Long-term follow-up studies require adequate control groups. In addition, the increasing trend of cancer incidence in some European countries is a point to consider in the interpretation of the results of the studies. It was pointed out that doses due to the accident in areas distant from Chernobyl were substantially smaller than the differences between the doses due to radon in different areas, even within countries. It was also important to realize that some so-called significant results would appear by mere chance; unexplainable clusters of cases of cancer, for example, would always occur.

Because adequate epidemiological studies would involve a number of groups of people and would need to be coordinated over many years, appropriate funding would be important to ensure adequate organization and a coordinated approach. WHO, through the Regional Office for Europe, and IARC would have a prominent role to play here, but it was equally important that national authorities and scientific institutions also gave active, long-term support to the work. The Working Group strongly urged WHO to provide sufficient long-term funds to stimulate countries' interest in and support for epidemiological studies.

In its consideration of solid tumours, the Working Group agreed, in general, on the importance of studies of the frequency of thyroid cancer resulting from exposure to radioiodine, and of epidemiological studies on the possible short- and long-term side effects of iodine prophylaxis.

Great emphasis was placed on conducting studies on populations close to the accident site: both the 130 000 people evacuated and others who might have received substantial doses of radiation. The people exposed to doses of 50–500 mSv were of particular interest. As much information as possible should be collected on those exposed to relatively low doses, to test whether a no-effect level — as suggested by some — might in fact exist. For this reason, epidemiological studies showing negative results would also be of major interest.

The Working Group welcomed the proposal that the WHO Regional Office for Europe and IARC maintain contact with the USSR authorities and collaborate in the necessary epidemiological work. The suggestion that the experience gained from the studies of effects in Japan should be utilized to the full was also welcomed.

Finally, it was pointed out that epidemiological studies would not give immediate and easily interpreted results, as health administrators and the experts in the field must explain to politicians, the mass media and the public at large.

Response and subsequent actions by international organizations

Food and Agriculture Organization of the United Nations (FAO)

The major responsibility of FAO was to ensure adequate protection of the consumer, while also protecting international trade from unreasonable or unnecessary distortions. It therefore sought to establish guideline levels for radionuclides in food that took account of public health but would not result in unnecessary barriers to trade or result in undue expense.

FAO thus identified levels below which there was no need to apply constraints on international trade in food *(8)*. These levels had formed the basis of actions in many countries distant from the accident site, particularly those that were not affected by direct deposition of radionuclides from the cloud.

Further, FAO and WHO were to meet in February 1988 to develop a common approach to levels of radionuclides in food in countries far from the accident (including both those with direct deposition from the cloud and those without). Such levels were intended to be compatible with the protection of both public health and trade. A report would thereafter be submitted to the Codex Alimentarius Commission.

International Atomic Energy Agency (IAEA)

As an immediate response to the Chernobyl accident, IAEA established informal contact with radiation protection authorities in most European and a number of non-European countries, to obtain a more complete picture of the areas affected by the accident. It also transmitted daily to its member states the data on radiation levels provided by the USSR from seven monitoring stations (one close to the accident site and six along its western border).

In May 1986, IAEA convened a meeting of representatives of international organizations with responsibilities in health and environmental protection, to plan a study of the radiological consequences of the accident. In response to a joint request by IAEA and WHO, countries affected by the accident provided the Agency with data for an assessment by

UNSCEAR of the resultant radiation doses to individuals and to populations as a whole. An initial report for a limited number of countries was to be published as an addendum to the 1988 UNSCEAR report.

Following a Post-Accident Review Meeting held in August 1986, at which Soviet experts presented a report on the causes of the Chernobyl accident, its consequences and the countermeasures taken, the International Nuclear Safety Advisory Group prepared recommendations for future action, several of which were reflected in the IAEA supplementary nuclear safety programme, approved by the Board of Governors in December 1986.

An IAEA meeting of government experts from 62 of its member states, along with representatives of 10 international organizations, in July 1986 resulted in the drafting of two international conventions on responses to nuclear accidents; these were subsequently adopted by the Special Session of the IAEA General Conference on 26 September 1986.

The Convention on Early Notification of a Nuclear Accident came into force on 27 October 1986; it applies in the event of any accident from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international transboundary release that could be of radiological safety significance for another State.

The accidents covered *(9)* include those occurring in:

(*a*) any nuclear reactor wherever located;

(*b*) any nuclear fuel cycle facility;

(*c*) any radioactive waste management facility;

(*d*) the transport and storage of nuclear fuels or radioactive waste;

(*e*) the manufacture, use, storage, disposal and transport of radioisotopes for agricultural, industrial, medical and related scientific research purposes; and

(*f*) the use of radioisotopes for power generation in space objects.

Thus, any nuclear accident involving facilities or activities carried out anywhere under the jurisdiction or control of a State Party to the Convention — be it on land, at sea or in outer space — would be subject to notification. Accidents connected with nuclear weapons and nuclear weapon tests may also be reported under the Convention.

The Convention requires a State Party, in the event of an accident, to notify IAEA, and (directly or through IAEA) the countries that may be physically affected, of the nuclear accident, its nature, the time of its occurrence and its exact location, when appropriate. The State Party must also promptly provide such countries and IAEA with the available information relevant to minimizing the radiological consequences in those countries. This should include *(9)*:

(*a*) the time, exact location where appropriate, and nature of nuclear accident;

(*b*) the facility or activity involved;

(*c*) the assumed or established course and foreseeable development of the nuclear accident relevant to the transboundary release of the radioactive materials;

(*d*) the general characteristics of radioactive release, including, as far as is practicable and appropriate, the nature, probable physical and chemical form and the quantity, composition and effective height of the radioactive release;

(*e*) information on current and forecast meteorological and hydrological conditions, necessary for forecasting the transboundary release of the radioactive materials;

(*f*) the results of environmental monitoring relevant to the transboundary release of the radioactive materials;

(*g*) the off-site protective measures taken or planned;

(*h*) the predicted behaviour over time of the radioactive release.

Although the State Party in which an accident has occurred may provide information directly to the countries affected, it may also do this indirectly, through IAEA, which will also give the same kinds of information to the other States Parties, its member states and the relevant international intergovernmental organizations.

The Convention also provides for the updating of information, at appropriate intervals, on the development of the emergency situation, including its foreseeable or actual termination. All information may be used without restriction, except when it is provided in confidence by the notifying State Party.

To implement the Convention, each State Party is required to establish a continuously available point of contact responsible for issuing and receiving the notification and support information.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency came into force on 26 February 1987. It provides for cooperation between States Parties and IAEA *(9)*:

> to facilitate prompt assistance in the event of a nuclear accident or radiological emergency to minimize its consequences and to protect life, property and the environment from the effects of radioactive releases.

The Convention recognizes the usefulness of bilateral or multilateral arrangements between States Parties.

Under the Convention, a State Party must specify the scope and type of assistance needed and, when practicable, provide the Assisting Party with the information necessary to determine the extent to which it is able to meet the request. Assistance may include the provision of experts, equipment and materials, medical treatment, and the temporary relocation of populations in the territory of another State Party. States Parties are asked to inform IAEA of the assistance they might be able to provide on request, as well as of the terms, including financial arrangements, under which such assistance could be provided.

IAEA must respond to a Member State's request for assistance in the event of a nuclear accident or radiological emergency by *(9)*:

(*a*) making available appropriate resources allocated for this purpose;

(*b*) transmitting promptly the request to other States and international organizations which, according to the Agency's information, may possess the necessary resources; and

(*c*) if so requested by the requesting State, coordinating the assistance at the international level which may thus become available.

Unless otherwise agreed, the overall direction and control of the assistance given within the territory of the country requesting help is the responsibility of that country. The Convention also deals with *(9)*:

— the handling of information given in confidence

— the costs of providing assistance

— the protection of the personnel, equipment and property employed.

Since the Chernobyl accident, requests have increased sharply for IAEA-sponsored operational safety review team missions to nuclear power plants in both developing and industrialized countries; an average of one mission per month took place in 1987. The demand for IAEA radiation protection advisory team missions also increased significantly; 17 missions were completed by the end of 1986, with a further 8 missions in 1987. These missions, in which WHO has participated, indicate an urgent need in many developing countries for the strengthening of national authorities and regulations in relation to radiation protection.

The 60 documents comprising the codes of practice and supplementary safety guides that make up the IAEA nuclear safety standards are being reviewed and revised to incorporate the lessons learned from nuclear accidents.

The various measures taken in countries after the Chernobyl accident demonstrated an urgent international need for comprehensive guidance on principles and evaluation procedures. Specific values are also urgently needed for various environmental materials and foodstuffs at which controls on use or consumption may have to be introduced. In 1985, IAEA, with other relevant international organizations, provided consistent guidance on the principles for establishing intervention levels to protect the public in the event of a nuclear accident or radiological emergency *(10)*. IAEA also began to prepare guidance on the setting of derived intervention levels in foodstuffs and environmental materials. Following the Chernobyl accident, this guidance was revised for more practical application in early and intermediate accident phases, which may last for several weeks *(11)*. Additional guidance is under preparation on the recovery phase and the effects of dispersing radioactive materials over large distances and populations, and extended periods of time. In all of its work on intervention, IAEA coordinates its activities with those of the other relevant international organizations, particularly WHO and FAO.

IAEA also provides the secretariat for the Inter-Agency Committee for the Co-ordinated Planning and Implementation of Response to Accidental Releases of Radioactive Substances. The Committee is charged with: harmonizing the relevant activities of its participating organizations to avoid any unnecessary duplication of work at the international level, identifying new areas for cooperation, and planning joint action. Its programme focuses on means of strengthening national monitoring capabilities, the exchange of monitoring results, forecasting the movement of radionuclides, and supportive training. Work has begun to help developing countries — through the IAEA technical assistance programme — to develop or strengthen their monitoring capabilities; priority is given to countries that have no effective capability but border countries with nuclear power programmes.

World Health Organization (WHO)

The specific task of WHO in the field of radiation safety is to address those problems that lie within the competence of health authorities and/or are directly relevant to the medical community in Member States. Correspondingly WHO has global programmes on (*a*) the preparedness of medical services to handle radiation emergencies, including practices in the diagnosis, treatment and follow-up of overexposed persons; (*b*) the health-related monitoring of environmental radiation; and (*c*) the elaboration of internationally recommended standards and guidelines for radiation emergencies. In carrying out these activities, WHO collaborates with IAEA, the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), FAO, UNSCEAR, ICRP, the International Commission on Radiation Units and Measurements and other international bodies as well as with many national institutions.

Medical preparedness and assistance. Medical preparedness and assistance in radiation emergencies should be regarded as part of the overall system for radiation safety and prevention. For many years, WHO has been collecting and distributing information on cases of overexposure, and on techniques for its diagnosis and treatment; organizing meetings to exchange information, coordinate work in this field and elaborate recommendations for Member States; issuing publications on this subject and disseminating them in Member States; encouraging the training of personnel in the medical handling of radiation emergencies and victims; etc.

WHO has established three collaborating centres for the promotion of medical preparedness in radiation emergencies and for practical assistance to countries in case of overexposure to any source of radiation. These centres are the International Centre on Radiopathology, Paris, the Medical Health Sciences Division, Oak Ridge Associated Universities, Oak Ridge, USA, and the Central Research Institute of Roentgenology and Radiology, Leningrad.

These centres serve as focal points for advice, training and possible medical treatment of radiation injuries; assist in the establishment of medical emergency plans for large-scale radiation accidents; initiate coordinated studies on human radiopathology and radiation epidemiology; and assist in the preparation of relevant documents, guidelines and meetings.

In the case of a radiation accident, the collaborating centres could provide: a team for on-site emergency treatment; a survey team for rapid external radiation monitoring and/or contamination surveys with appropriate equipment; transport for patients; facilities and staff for medical investigation and treatment; and follow-up medical supervision and treatment. The experience and resources of the collaborating centres in France and the USA have already been used on several occasions for international help in radiation emergencies.

At present an urgent task is to increase the number of such WHO collaborating centres to about 10 and to develop them into an international network that could provide some kind of worldwide ambulance service. An important step in setting up this network was the first coordination meeting of existing and prospective WHO collaborating centres on radiation emergency medical preparedness and assistance held in 1987. The meeting was attended by representatives of the three existing centres, a representative from the Australian WHO collaborating centre for radiation protection which had expanded its functions into the field, and representatives from prospective centres in Argentina and Brazil. They drew up a plan of coordinated action and recommended that the terms of reference of the Australian collaborating centre be officially expanded and that Argentina and Brazil be invited to designate appropriate collaborating centres. The participants suggested that countries without collaborating centres could become involved in the network through liaison institutions, i.e. national points of contact with the appropriate collaborating centre and/or with WHO, including its regional offices. Contributions could also come from support institutions, i.e. national institutions that could be invited to solve particular problems, especially in an emergency.

Health-related monitoring of environmental radiation. Countries with nuclear power and/or who use radioactive materials have environmental radiation monitoring systems that are established by the authorities responsible for the maintenance of nuclear and other radiation facilities. Most countries do not rely solely on these systems, which are bound up with nuclear technology. They also use other control systems set up by governmental bodies concerned with public health, environmental protection, agriculture, forestry, etc., as well as by governmental and nongovernmental organizations specializing in radiation protection. These control systems that are independent of the nuclear authorities may cover not only general supervision of environmental radiation but also the verification of information on environmental radiation provided by the nuclear authorities. The relationship of the car driver/police inspector type between the two kinds of system seems to be gaining more and more support among decision-makers and specialists.

The WHO programme addresses those national radiation monitoring activities that are conducted by public health institutions and other bodies concerned with the environmental health of the population.

As early as in 1969, WHO launched a network of national institutions to monitor environmental radioactivity, with the aim of studying trends in levels of ^{90}Sr and ^{137}Cs originating from atmospheric nuclear tests. The network is coordinated by a WHO collaborating centre, the International Reference Centre for Radioactivity in Le Vésinet, France. The most comprehensive data on radioactivity in air, precipitation, milk and other environmental media have been provided by Australia, Canada, France, Japan, New Zealand, Sweden, the USA and the USSR. In total, countries occupying about 20% of the earth's territory have been involved. The results of the monitoring are published quarterly. Once or twice a year, the Centre organizes comparison studies for the participants in the network. About 20 countries, including developing ones, have taken part in each comparison to ensure the quality of their measurements.

The network was not designed, however, to provide a rapid response in the event of a nuclear accident. After the Chernobyl accident, therefore, WHO intensified its efforts to strengthen the ability of Member States to respond adequately and consistently to any future accidental release of radioactivity. A WHO/UNEP expert meeting held in December 1987 considered the principles on which to base a global network, both for monitoring environmental radioactivity on a routine basis and for the rapid exchange of information in the case of radioactive releases.

The new WHO/UNEP network would be part of the Global Environmental Monitoring System and would be based largely on existing national programmes for monitoring environmental radiation and for dealing with major releases of radioactivity. The network should have the ability to:

— collect, compile and disseminate information on environmental radiation;
— provide an international alert in cases of unusual increases in environmental radiation;
— collect, compile and exchange relevant information rapidly during radiation emergencies on a harmonized basis; and
— improve the quality of measurements, and the harmonization of sampling and reporting, in all participating countries.

The network would consist of:

— WHO headquarters and regional offices, and UNEP headquarters;
— a scientific advisory committee;
— a coordinating collaborating centre;
— regional collaborating centres;
— national liaison institutions; and
— national radiation monitoring stations and laboratories.

The monitoring stations and laboratories would measure environmental radiation and supply the raw data to the liaison institution in their own country. The monitoring stations and laboratories would not be called upon to communicate with other elements of the network.

The liaison institutions would coordinate work on environmental radiation monitoring and preparedness for major radioactivity releases in their own countries. Only one liaison institution would be included in the network for each country. It might be a medical research institute, a radiation protection service or a nuclear medicine laboratory. In those countries where relevant collaborating centres have been designated, it is they who would probably serve as liaison institutions. The liaison institutions would gather raw data from the environmental monitoring stations or laboratories in their own countries, process these data and pass the processed information on to the coordinating collaborating centre, either directly or through a regional collaborating centre, depending on which centre had been chosen as the most appropriate for the country. In the event of an emergency, the liaison institutions would be receivers and suppliers of information within their country.

The coordinating collaborating centre would collate the processed information and issue a regular bulletin on routine monitoring. The bulletin and other summarized information and interpretation would be sent back directly to the participating regional centres and liaison institutions, and to WHO/UNEP for distribution to other international agencies. In the event of an emergency, the liaison institutions would communicate directly with WHO/UNEP or with the coordinating centre. In collaboration with other scientific groups as arranged, the centre would then compile and analyse the data coming from the network and, in consultation with WHO and UNEP, be responsible for assessing the global radiation situation. The regional centres — like the other liaison institutions — would serve only as national points of contact for the network.

WHO and UNEP would coordinate the overall development and operation of the network; collect and store summarized information, including the bulletins, on the results of routine monitoring and disseminate it on request; advise Member States; and support programmes of technical cooperation to strengthen the ability of developing countries to monitor environmental radiation. In the event of a major release of radioactivity to the environment, WHO/UNEP would receive and transfer urgent information, as far as practicable in conformity with the format requested under the Convention on Early Notification of a Nuclear Accident; activate the emergency response of the network; promote the exchange of information between the elements of the network; and give advice to any Member State requesting it.

The scientific advisory committee would advise WHO/UNEP on the network and its developments.

The minimum requirements for participation in the network would be the ability to:

— measure the external radiation dose rate at ground level all the time;

— measure airborne radioactivity at least weekly;

— measure the radioactivity of precipitation (rain, snow, dry deposition) and milk at least quarterly;

— process the raw information at the liaison institution and report the processed information in standard form, once a quarter, to the appropriate collaborating centre, not later than one month after the end of each quarter;

— send the processed information from the regional collaborating centre, if one is involved, to the coordinating centre within two months of the end of the quarter;

— use SI units for reporting information to the collaborating centres (secondary units should be standardized and the conditions of sampling and measurement clearly indicated so that data from different liaison institutions can be compared).

Standards and guidelines for radiation emergencies. WHO follows the basic safety standards for radiation protection jointly sponsored by IAEA, the International Labour Organisation, NEA/OECD and WHO *(12)*. These standards recommend that:

> for any sources or practices ... that could lead to accidental or emergency exposures ..., an intervention plan shall be established and approved by the competent authority ... The emergency plan shall include ... the intervention levels and derived intervention levels.

WHO has always given consideration to the problem of intervention levels and the appropriate countermeasures to be taken. As to primary intervention levels, WHO supports the values already developed before the Chernobyl accident by ICRP, to provide guidance to national authorities in setting criteria for introducing protective measures at the early and intermediate phases of an accident. These values have been set out in a Regional Office publication *Nuclear power: accidental releases — practical guidance for public health action (13)*. The Chernobyl accident showed a great need for guidance on derived intervention levels as well. Hence, WHO undertook a study on derived intervention levels for food and this study is discussed in detail on pp. 59–64.

World Meteorological Organization (WMO)

WMO has 160 member countries and territories. The national meteorological services of WMO members operate a global network of observation stations. The unique WMO world weather watch system — within which member countries exchange meteorological data and forecasts — could contribute to international cooperation in case of a nuclear accident with transboundary release of radioactive material. IAEA and WMO have agreed that the WMO Global Telecommunication System will be used for the prompt transmission of information as outlined in the IAEA Convention on Early Notification of a Nuclear Accident. For this purpose, IAEA headquarters in Vienna has been linked to the system. In the event of a nuclear accident, the information received by the IAEA from the country in which the accident occurs will be transmitted to the national points of contact in the countries that may be physically affected and, on request, to other States Parties to the Convention, IAEA member states or relevant international organizations.

Commission of the European Communities (CEC)

The CEC intended to become a signatory to the two IAEA Conventions and so have access to the information they will provide. It was also developing, in collaboration with other international bodies, atmospheric dispersion models to be used to predict the path of any radioactive cloud from an accident.

The treaty that established the European Atomic Energy Community (Euratom) in 1958 required the setting of uniform safety standards. Before Chernobyl, no guidelines had been available on acceptable levels of radionuclides in the environment or, in particular, in food after an accident; thus, the response in countries had been fragmented. Building agreement, particularly on levels in food imported into the CEC, was slow and difficult. The CEC was trying to reach agreement with the member states of the European Communities on a regulation that could be brought into force immediately after a future nuclear accident and would provide agreed acceptable levels for radionuclides in food following a nuclear accident. Discussion of this regulation was underway during the meeting of the Working Group. The regulation was intended to apply to food produced and sold in member states, food exported or imported from other member states and imports and exports from other countries.

In addition to a set of permitted levels of radionuclides in food, the regulation included a mechanism for reassessing the situation as monitoring information became available and for then setting accident-specific levels. Although WHO had developed guidelines that would enable countries to set their own levels, the CEC was trying to set values acceptable to and legally binding on all the member states of the Communities.

Organisation for Economic Co-operation and Development (OECD)

The activities of the Nuclear Energy Agency (NEA) of the OECD in the field of radiation protection were directed by the Committee on Radiation Protection and Public Health (CRPPH). The Committee was composed of senior representatives from OECD member countries, which include 19 European countries. After the Chernobyl accident, the CRPPH developed a programme of activities, in addition to its regular radiation protection programme, to enable priority to be given to certain important areas.

The first priority in this new programme was to make an independent assessment of the radiological impact of the accident, and to review the emergency responses adopted in different member countries. NEA therefore prepared the report previously mentioned *(3)*, on the basis of information provided by the countries.

Another priority task for NEA was a critical review of the rationale for the establishment of intervention levels for accidents. An expert group reviewed the responses to the accident and the corresponding intervention levels adopted in member countries following Chernobyl, and examined existing international guidance on the topic. A preliminary report *(14)* identified a number of issues requiring further discussion.

Further, the CRPPH initiated a survey of changes in emergency planning practices and criteria in member countries. Information obtained through a questionnaire had been compiled, and a report was to be presented to the next CRPPH meeting.

Other OECD activities included a Workshop on Public Understanding of Radiation Protection Concepts, held in Paris late in 1987 to discuss ways of improving the public perception of radiation protection and the terminology of accident management, as part of an effort to develop a simplified and clear description of the concepts involved in radiation protection. Discussion examined issues in the communication of such radiation protection concepts as:

— dosimetry

— the effects of radiation

— the quantification of risk estimates

— the comparison of radiation risks

— a system of dose limitation

— radioactivity in the environment

— accidents and emergencies.

In addition, in the context of the NEA public information programme, another workshop was planned for February 1988, to examine the mechanisms and procedures for preparing and channelling information for the public in the event of a nuclear accident.

The CRPPH also initiated preliminary studies on:

— changes in research and development programmes in radiation protection in member countries following the Chernobyl accident;

— the national and international development of systems for reporting and handling radiological data; and

— the significance of environmental processes and parameters in influencing accident consequences.

Many OECD studies were believed to be yielding information of importance in the international harmonization of nuclear accident management.