ANALYSIS OF THE RADIOLOGICAL CONSEQUENCES OF THE CHERNOBYL ACCIDENT

FOR THE POPULATION IN THE EUROPEAN PART OF THE USSR

A. Moiseev.
WHO Consultation on Epidemiology
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As a result of the accident to the No. 4 reactor unit of the Chernobyl Nuclear Power Station (CNPS) at 01h.23 on 26 April 1986, large quantities of radioactive substances which had accumulated in the reactor during operation escaped from the station. The cloud formed at the time of the accident left a radioactive plume in the neighbourhood in westerly and northerly directions in accordance with the prevailing meteorological conditions of airstream movement. During the next 10 days intensive emission of radioactive gases and aerosols continued from the accident zone, and this led to contamination of the neighbourhood in different directions and at considerable distances from the CNPS. In the reports submitted by Soviet specialists to the IAEA in August 1986 it was stated that the total emission of radioactive substances (not including radioactive noble gases) according to calculations on 6 May 1986, was about 50 MCi, corresponding to 3.5% of the total quantity of radionuclides in the reactor at the time of the accident. The emission of the nuclides of greatest importance from the radiation aspect, such as strontium 90, iodine 131 and caesium 137 was 0.22 MCi, 7.3 MCi and 1.0 MCi respectively.

In the report of the Soviet delegation submitted to IAEA and WHO the causes of the accident at the CNPS and the first results of estimates of the radiological consequences of this accident for the population of the USSR were examined in detail. During the subsequent time Soviet specialists have obtained new facts that give evidence of a positive trend of the radiation hygiene situation as a result of the implementation of large-scale protective and preventive measures.

Firstly, it was found that doses of external irradiation of people living in the contaminated areas, actually measured by means of individual dosimeters, were less than half of the calculated dose values. Consideration of this fact showed that it was only among the rural population of Gomel' Region that the dose of external irradiation of individuals could slightly exceed 0.5 rem, i.e., the limit of the annual dose of irradiation of the population laid down by the NRB-76 Radiation Safety Regulations. Taking this into account, the collective dose of irradiation of the population in the European part of the USSR, with a population of about 75 million persons, in 1986 would be about 5×10^6 rem, and in the 50 years after the accident, less than 20×10^6 rem. For comparison we may point out that the collective dose from the natural radiation background for this population per annum is roughly 1.5 times higher than the dose received in 1986 due to emission during the accident in that year, and over the period of 50 years the dose from natural background radiation will be almost 20 times greater than the corresponding expected collective dose from the accident at the CNPS. Accordingly, the number of additional deaths from cancer, calculated on the basis of a linear dose-effect relationship, without a threshold, will be about 0.03% of the spontaneous cancer mortality (about 9.5 million cases during 70 years) among this population.

Secondly, sufficiently high levels of contamination with radioactive substances were confirmed, especially of local farm produce by caesium isotopes. The proportion of local produce with higher than acceptable levels of radioactivity at the present time is of course significantly lower than on the first days after the accident, but as a whole it still remains quite high. For example, in the case of milk, of 269 736 samples tested in 1986 in the Belorussian SSR the concentration of radioactive substances was above the permissible levels in 30 465 (about 11%), so that these batches of milk had to be withdrawn from direct consumption and sent for processing. The scale and effectiveness of these measures were such that a detailed investigation of tens of thousands of people living in the Belorussian SSR, Ukraine, and RSFSR with personal radiation dosimeters showed that the caesium 134 and caesium 137 levels were 10-20 times lower than expected from model calculations. In most of these regions the situation could arise when doses of internal irradiation of the human body were at the level of doses of external irradiation from local radioactive fallout. Meanwhile, in certain settlements in which, because of the low absolute levels of contamination of the neighbourhood with caesium isotopes, a full programme of protective and preventive measures was not carried out, the ratio of doses of internal irradiation due to consumption of local produce and doses of external irradiation of individuals reached 10, i.e., the model estimates presented in the report of the USSR Delegation to the IAEA were confirmed.

On the assumption that monitoring the level of contamination of local farm produce will remain just as effective in the future as it is today, it can be taken that the expected collective dose of human internal irradiation will be at the same level as the dose of external irradiation, i.e., about 20-30 million **rem**, i.e., the additional mortality will be reduced to 0.06-0.08% of the natural mortality from cancer.

However, a correct evaluation of the expected dose loads on the population due to consumption of local produce in the second and subsequent years after the accident will be possible only after realistic coefficients of passage of caesium and strontium isotopes along food chains for the given regions have been established. Investigations of this kind, to be undertaken by branches of the various scientific departments of the USSR, will draw up recommendations on optimal methods of farming in a zone of radioactive contamination, from the standpoint of dose loads received by the consumer, and they will thus reduce even more the radiation doses received by man.

It must be emphasized once again that the estimates given in the report of Soviet specialists (to IAEA and in this communication) are based on the concept of a nonthreshold linear dose-effect relationship, accepted in most countries of the world. This concept is based on theoretical views regarding the mechanism of carcinogenesis, data on the dose-effect relationship obtained in a region of higher radiation doses, and also the principle of decision making for the benefit of mankind, i.e., for making sure of man's safety in the region of low radiation doses. It is not by accident that in the very first publication of the ICRS on matters of radiation safety (ICRS publication 26, No. 30), it is stated that: "The use of linear extrapolation methods, based on data on the frequency of high-dosage effects, can be used to estimate the maximal risk ... However, the more cautious the assumption of linearity, the more important it is to recognize that this may lead to over-estimation of the possible radiation risk ..."

The values given in the present communication must therefore be considered as the "upper" estimate of the radiological consequences of the accidental emission of radioactivity from the Chernobyl atomic power station among the population of the European part of the USSR. However, even these "upper" estimates can raise the additional mortality from cancer among the population of the regions under scrutiny by only a small fraction of a percentage. This increase will be so small that it cannot be detected against the background of fluctuations of natural mortality from malignant neoplasms. Risk levels are even lower for the population of Kiev, where the expected annual dose in 1987 does not exceed 108 mrem, and will be virtually identical with the natural radiation background.