PREDICTED HEALTH EFFECTS IN BULGARIA FROM THE CHERNOBYL NPP ACCIDENT: OBJECTIVE ASSESSMENTS AND PUBLIC REACTIONS

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1. FIRST POST-ACCIDENT YEAR AND LIFELONG EXPOSURE OF THE BULGARIAN POPULATION (TOTAL EXPECTED EFFECTIVE DOSE)

The results of analyses are shown in Table I. More particularly, the following may be noted:

- To determine ^{131}I exposure, use was made of the tissue weighted factor 0.05 newly proposed in ICRP Publication No.60 [1].
- The total mean individual lifelong exposure is 0.95 mSv (effective dose), with contributions from the three principal factors (external exposure and internal exposure from ^{131}I and from ^{137}Cs and ^{134}Cs) nearly equal.
- The difference in total exposure between children and adults is about 35% (higher for children).
- ICRP Publication No.60 [1] proposes for the first time a limit for exposure of the whole population: a mean of 1.0 mSv/a (as averaged over every five consecutive years).
- Exposures from other sources (point 4 in Table I) concern surface contaminations, possible intake of other radionuclides besides the indicated ones, etc.

Table I
First-year (May 1986 - May 1987) and Lifelong Exposure of the Bulgarian Population

Exposure	Effective doses (mSv)			
	First year			For 50 years
	Children	Adults	Weighted mean	
1. External exposure	0.35	0.29	0.31	0.31
2. Internal exposure from ^{137}Cs and ^{134}Cs	0.13	0.17	0.16	0.30
3. Internal exposure from ^{131}I	0.50	0.17	0.28	0.28
4. Other sources	0.05	0.03	0.04	0.06
TOTAL	1.03	0.67	0.79	0.95

2. EXPOSURE OF THYROID GLANDS FROM IODINE-131 INTAKE (EQUIVALENT AND EFFECTIVE DOSES)

The results are shown in Table II. The UNSCEAR report from 1988 [2] indicates for the Bulgarian population values of 3.0 mSv for adults and 25.0 mSv for children under 1 year (equivalent doses). In our opinion, the children value given is not realistically founded, as it has been obtained on the basis of model calculations only, without in vivo measurements.

The results of effective dose estimation are also given in Table I.

Table II
Exposure of Thyroid Glands from Iodine-131

Dose (mSv)	Children	Adults	Weighted mean
Equivalent	10.0	3.3	5.5
Effective	0.50	0.17	0.28

3. TENTATIVE FIGURES FOR MEAN RADIATION DOSES IN VARYING REGIONS OF THE COUNTRY

The country's radioactive contamination was nonuniform. This is a normal phenomenon for such atmospheric transfer during the spring season in our geographic latitudes. The same phenomenon was observed over the whole of Europe. A better estimate of exposure of the population residing in different regions of the country is hardly obtainable for a number of objective reasons: nonuniform deposition, presence or absence of radiation control, individual features of behaviour, in particular eating habits, etc.

Exposures were probably greatest in regions of higher altitudes above sea level, as well as in those where fallout density was highest.

Estimates of probable mean doses by regions of the country are shown in Table III. They were obtained using two main assumptions: first, that the majority of the population stayed within a limited region (place of residence); and second, that the largest part of the consumed foodstuffs were of local origin. Clearly, such estimates are largely circumstantial; nevertheless, they are a useful guide for planning and conducting epidemiological studies.

Table III
Estimation of Mean Doses by Regions

Group	Region	Total effective dose (mSv)
I: highest	Kurdzhali, Stara-Zagora, settlements at above 0.8 km altitude	1.7
II: high	Iambol	1.3
III: medium	Sofia city and county, Pernik, Russe, Silistra, Shumen, Khaskovo, Razgrad, Pazardzhik, Vidin, Turgovishte, Gabrovo, Sliven	1.0
IV: low	Burgas, Blagoevgrad, Varna, Veliko-Turnovo, Pleven, Tolbukhin, Kyustendil, Lovech, Mikhailovgrad, Plovdiv	0.8
V: lowest	Vratsa	0.6

4. ASSESSMENT OF PROBABILITY FOR APPEARANCE OF LATE STOCHASTIC EFFECTS, IN CONFORMITY WITH THE NEW RISK COEFFICIENTS PROPOSED BY ICRP

Table IV
Late Stochastic Effects

Fatal cancer Nonfatal cancer	363 cases overall 107 cases	Severe hereditary effects
TOTAL	470 cases	80 cases

Publication No.60 [1] proposes new risk coefficients as regards stochastic effects: fatal and nonfatal cancer, and severe hereditary effects. For chronic exposure of the whole population (all age groups and sexes), the new coefficient regarding malignancies with lethal outcome (the so-called fatal cancer) is estimated at 5.0×10^{-2} Sv^{-1}. In the case of nonfatal cancer, detriment is held to be increased by 20 to 30%. As for severe hereditary effects, the radiation risk coefficient for the whole population is estimated at 1.3×10^{-2} Sv^{-1}. Accepting that the Bulgarian population numbers 8.8×10^6, estimates for stochastic effects are as shown in Table IV.

Table V
Carcinogenic Effects

Organ or tissue	Fatal cancer cases	Period of appearance
Bladder	18	Beyond year 2000
Bone marrow	31	Around year 1991
Bone surface	3	Around year 2000
Breast	12	Around year 2000
Colon	52	Beyond year 2000
Liver	9	Beyond year 2000
Lung	52	Around year 2000
Oesophagus	18	Beyond year 2000
Ovaria	6	Beyond year 2000
Skin	1 (2)	Around year 2000
Stomach	63	Beyond year 2000
Thyroid gland	44	Around year 1995
Other	30	
From prenatal exposure	20	
TOTAL	363 cases	

Table V presents a breakdown of fatal cancer cases according to a variety of sites. With regard to prenatal radiation exposure risk, the coefficient used is 25×10^{-2}, that is, five times above total; and the number of exposed population was taken to be 10^5. Tentative time periods for appearance of maxima of radiation-induced cancer cases are indicated in the last column of Table V. It should be noted that the predicted cancer cases indicated are to develop over a period equal to the lifetime of an average generation, that is, over 50 to 70 years. At the present time in Bulgaria, registered new cases of fatal cancer amount to about 23 thousand anually.

5. NONSTOCHASTIC SOMATIC EFFECTS AND EFFECTS OF PRENATAL EXPOSURE

ICRP abides by its conceptions in Publications No.26 [3] and No.41 [4]. Nonstochastic somatic effects will be avoided if the equivalent radiation dose to any organ or tissue is less than 500 mSv/a (except for the eye lens, where it is 150 mSv/a). Publication No.60 provides for the population a "provisional reduction factor" of 10, bringing these dose levels to 50, respectively 15 mSv/a (the latter for skin and eye lens). As for effects of prenatal exposure (apart from cases of cancer), a threshold of 100 mSv is indicated for congenital malformations, and likewise 100 - but under question and with a recommendation for 10 mSv - for possible CNS damage during a certain critical period of gravidity (8th to 15th week). Such damage could lead to mental retardation.

The highest probable individual doses received in Bulgaria are presented in Table VI (compared with effects of prenatal exposure and nonstochastic somatic effects).

Equivalent doses from external exposure of about 3.0 mSv may have been sustained by persons residing at peaks higher than 2.0 km (Musala, Botev Peak), i.e., by several tens of persons.

Internal exposure from caesium-137 and caesium-134 could amount to about 5.0 mSv. Experimentally, by whole-body counting, this has been ascertained in the case of a Vienna resident with maximum caesium body burden of about 10^3 Bq/kg body weight during the spring of 1987. In Bulgaria, such a body burden has not been observed.

With regard to thyroid gland exposure, the probable maximum equivalent dose of about 200 mSv could have been received by residents of some mountainous or iodine-deficiency regions.

Table VI
Probable Highest Exposure - Equivalent Doses (mSv)

Exposure	mSv	Regions	Number of population
External	3.0	Peaks higher than 2.0 km	Up to 100 persons
Internal (Cs)	5.0 (10^3 Bq/kg)	Mountainous	Several thousands
Thyroid gland (^{131}I)	200	Mountainous, iodine-deficiency	Several thousands
Effects of prenatal exposure			
Congenital malformations		Threshold, 100 mSv	
Mental retardation		Threshold, 100 mSv (?)	
Cancer		Coefficient of risk, 25 x 10^{-2} Sv^{-1}; cases, 20	
Nonstochastic somatic effects			
Dose limit for the population - 50 mSv/a (eye lens - 15 mSv/a)			

Table VII
Distribution of Overall Exposure

Source of exposure	Mean effective doses (μSv/a)	Collective doses (man-Sv/a)	Background exposure (%)	Excess over background exposure (%)
1. Background exposure	2283	19600		215.4
1.1. External	735	6300	32.1	
1.2. Internal	1548	13300	67.9	
2. Excess over background exposure	1054	9130	46.4	
2.1. Occupational exposure	116	1000		11.0
2.2. X-ray diagnosis	802	6900		75.70
2.3. Radioisotope diagnosis	81	700		7.67
2.4. Uranium mining	41	350		3.83
2.5. NPP	3	32		0.35
2.6. TPP	3	80		0.88
2.7. Global fallout	2	15		0.16
2.8. Other sources	6	51		0.56
TOTAL	3337	28700		

Experimentally determined by in vivo measurements, such a figure has not been found in Bulgaria. Iodine is not considered to be a genetically significant radionuclide.

For the Bulgarian population, the estimated collective dose due to the Chernobyl accident is as follows:

- For the first post-accident year - 7000 man-Sv;
- Dose commitment for 50 to 70 years - 8400 man-Sv.

Table VII shows for comparison the Bulgarian population's collective doses due to various sources by the beginning of 1990.

In Bulgaria, as well as in a number of other countries, public response to the danger entailed by radioactive contamination from the Chernobyl accident was hardly appropriate. The problem is of a purely psychological nature. It is not a new one because almost never has a fully realistic assessment been made of events relating to major accidents that are striking to human consciousness. In Bulgaria, over 1986 and 1987, and later also, this issue was particularly pressing as the level of public information on the actual situation and its dangers was far from adequate. There was a lack of proper co-ordination between relevant national services. In addition, a number of existing problems were of a purely political nature.

Now, 10 years after the Chernobyl accident, the situation and its actual dangers are gradually being clarified. A number of programs for epidemiologic surveys are being implemented, and it is a major objective to bring their results to a possibly wider audience. As always, the best strategy to which both scientists and politicians should adhere is to give the truth, only the truth, and the whole truth.

REFERENCES

[1] ICRP. Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Pergamon Press, Oxford (1990).

[2] UNSCEAR. Sources and Effects of Ionizing Radiation. Annex D. UNSCEAR 1988 Report, United Nations, New York (1988).

[3] ICRP Recommendations of the International Commission on Radiological Protection. ICRP Publication 26. Pergamon Press, Oxford (1977).

[4] ICRP. Nonstochastic Effects of Ionizing Radiation. ICRP Publication 41. Pergamon Press, Oxford (1984).