

One decade after Chernobyl: Summing up the consequences of the accident

Poster presentations — Volume 1

International Conference held in Vienna, 8–12 April 1996

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POSTER PRESENTATIONS — VOLUME 1

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FOREWORD

The consequences attributed to the disastrous accident that occurred at the Chernobyl nuclear power plant on 26 April 1986 have been subjected to extensive scientific examination; however, they are still viewed with widely differing perspectives. It is fitting then that, ten years after the accident, the European Commission (EC), the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) should jointly sponsor an international conference to review the consequences of the accident and to seek a common and conclusive understanding of their nature and magnitude. The International Conference on One Decade after Chernobyl: Summing up the Consequences of the Accident was held at the Austria Center, Vienna, on 8–12 April 1996.

Five other organizations of the United Nations system — the United Nations Department of Humanitarian Affairs (UNDHA), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and the Food and Agriculture Organization of the United Nations (FAO) — together with the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), co-operated in the organization of the Conference, demonstrating a community of interests internationally.

The Conference recapitulated the International Chernobyl Project of 1990 and took particular account of the findings of two related conferences. These were: the WHO International Conference on the Health Consequences of the Chernobyl and other Radiological Accidents, held in Geneva, 20–23 November 1995, and the First International Conference of the European Commission, Belarus, the Russian Federation and Ukraine on the Consequences of the Chernobyl Accident, held in Minsk, 18–22 March 1996. The Conference also considered the results of an International Forum on One Decade after Chernobyl: Nuclear Safety Aspects, jointly sponsored by the IAEA and the UNDHA. The Forum was held at the IAEA Headquarters in Vienna on 1–3 April 1996 and addressed a number of nuclear safety issues, including the measures taken since the accident to improve the safety of Chernobyl type RBMK reactors and the safety of the containment structure (the so-called sarcophagus) built around the destroyed reactor and that of the site itself.

To facilitate the discussions of the Conference, background papers were prepared for the Technical Symposium by teams of scientists from around the world, who collaborated over a period of months to ascertain, consolidate and present the current state of knowledge in six key areas: clinically observed effects; thyroid effects; long term health effects; other health related effects; consequences for the environment; and the consequences in perspective: prognosis for the future. A background paper on the social, economic, institutional and political impact of the accident was prepared by Belarus, the Russian Federation and Ukraine. The conclusions of the Forum on Nuclear Safety Aspects served as a background paper on this topic. The Joint Secretariat expresses its thanks to all those distinguished scientists who co-operated in the rigorous preparation of these papers, and also to all the officers, the Advisory Committee and the Secretariat of the Conference for their participation, guidance and assistance.

The IAEA acted as host for both the International Forum and the final International Conference which recapitulated the consequences of the Chernobyl accident. Conclusions of the meetings mentioned and those of other international and national projects were reported at the Conference and integrated into a broad international consensus. Two major objectives of the Conference were: to agree on proven scientific facts and to clarify *interpretations and prognoses in order to dispel confusion*.

The Conference, which was presided over by Germany's Federal Minister for the Environment, Nature Conservation and Nuclear Safety, Ms. A. Merkel, attracted high

level political participation, including that of the President of Belarus, the Prime Minister of Ukraine and Ministers from Russia and France. More than 800 experts, mainly in the fields of radiation protection and nuclear safety and including medical, environmental and engineering specialists, from 71 countries, participated. The Conference was also attended by 208 journalists from 31 countries — an indication of the continuing interest and concern of the international community.

An earlier publication in the IAEA Proceedings Series, issued in September 1996, contained a summary of the Conference results and the texts of oral presentations and discussions at the Conference. This IAEA-TECDOC reproduces the material from the poster presentations. It is in two volumes: Volume 1 contains the material from Sessions 1–4 and Volume 2 the material from Sessions 5–8 and the List of Participants.

The posters submitted in advance for presentation at the Conference were in many cases not consistent with established international scientific understanding of the effects of radiation and radioactive contamination. Nevertheless, in accepting posters for presentation, the Advisory Committee and the Joint Secretariat recognized that the topics under discussion were controversial. To meet the objectives of the Conference, namely to agree on proven scientific facts and to clarify interpretations and prognoses, it was considered important also to accept for presentation and discussion, so as to permit clarification, posters that showed apparent misinterpretations. For this reason, the poster papers accepted and included in these proceedings are of variable quality.

The Conference did much to fulfil the hope that it would be possible for scientists from around the world to reach a broad consensus on the major consequences of the Chernobyl accident. The results of this Conference deserve the widest possible dissemination, with the aim of consolidating knowledge and understanding of the consequences of the accident and permitting the countries most affected by those consequences to develop well informed and balanced policies for their alleviation.

EDITORIAL NOTE

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SESSION 1

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REPRODUCTIVE STATE OF HEALTH AS A CRITERION FOR DETERMINISTIC EFFECTS OF LOW RADIATION DOSES

L.A. BULDAKOV, I.Ya. VASILENKO, S.I. DEMIN, A.M. LYAGINSKAYA,
M.M. SAUROV

Russian Federation State Science Centre, Biophysics Institute,
Moscow, Russian Federation

СОСТОЯНИЕ РЕПРОДУКТИВНОГО ЗДОРОВЬЯ КАК КРИТЕРИЙ ДЕТЕРМИНИРОВАННЫХ ЭФФЕКТОВ МАЛЫХ ДОЗ ИЗЛУЧЕНИЯ

Л.А. Булдаков, И.Я. Василенко, С.И. Демин,
А.М. Лягинская, М.М. Сауров

Государственный научный центр Российской Федерации - Институт биофизики, Москва

Изменения таких показателей репродуктивного здоровья, как мертворождаемость, заболеваемость новорожденных, частота врожденных аномалий, смертность новорожденных, как в ранние сроки (после Чернобыльской аварии), так и в отдаленные сроки (Южный Урал) после радиационного воздействия, имеют положительную корреляцию с дозой. Совокупность показателей репродуктивного здоровья может служить показателем здоровья популяции, облученной в малых дозах.

Репродуктивное здоровье является одним из наиболее социально-значимых показателей здоровья индивида и популяции. По современным радиобиологическим представлениям показатели репродуктивного здоровья являются одним из наиболее рано ожидаемых детерминированных эффектов облучения людей в малых дозах.

Основными показателями репродуктивного здоровья являются показатели состояния здоровья беременной женщины, исходы беременности (самопроизвольные аборты и выкидыши, недоношенность, мертворождения, ранняя неонатальная и перинатальная гибель новорожденного), состояние здоровья потомства, включая оценку частоты и характера врожденной и наследственной патологии. По совокупности этих показателей можно судить о последствиях облучения не только сегодняшнего, но и будущих поколений.

По современным представлениям о генетических эффектах радиации, четко регистрируемые фенотипические нарушения у потомства (внутриутробная гибель, аномалии и врожденные пороки развития, ранняя постнатальная гибель и физиологическая ослабленность рожденного потомства) имеют генетическую природу.

Таким образом, показатели репродуктивного здоровья позволяют оценить и контролировать динамику не только соматического, но и генетического здоровья индивида и популяции на протяжении нескольких поколений.

Изучали показатели репродуктивного здоровья (РЗ) у лиц подвергшихся длительному радиационному воздействию во время проживания на радиационно загрязненных территориях после аварии в Чернобыле и на Южном Урале. Исследовали в динамике 8 показателей РЗ. Под наблюдением было $40 \cdot 10^3$ человек, проживающих на территориях с плотностью выпадения ^{137}Cs от 1 до $15 \text{ Ки} \cdot \text{км}^{-2}$ при дозах внешнего излучения от 7 до 68 мЗв.

Сравнение данных динамики РЗ женщин Рязанской и Брянской областей показывает, что население указанных областей различается как по исходному уровню РЗ (в доаварийный период) так и по интенсивности коэффициентов изменчивости в послеаварийные годы. В Брянской области в доаварийный период выше чем в Рязанской области была рождаемость, ниже показатели общей заболеваемости новорожденных, частоты врожденных

аномалий, преждевременных родов, но выше - заболеваемость беременных и неблагоприятных исходов беременностей, мертворождаемость. В послеаварийные годы в контрольных районах Брянской области имело место улучшение 6 анализируемых показателей (положительная динамика) и ухудшение (отрицательная динамика) по 2 показателям, тогда как в Рязанской области по 5 показателям наблюдалась отрицательная динамика и только по 3 - положительная.

Таким образом, в доаварийный период в Брянской области хуже были показатели здоровья беременных, а в Рязанской области - показатели здоровья новорожденных.

В загрязненных районах Рязанской области с плотностью ^{137}Cs в почве 1-5 $\text{Ки}\cdot\text{км}^{-2}$ наблюдали более выраженную, чем в доаварийный период и в контрольных районах отрицательную динамику по пяти показателям из восьми основных взятых для сравнительного анализа. Интенсивные показатели (коэффициент отрицательной динамики) общей заболеваемости беременных увеличился с 1.20 до 1.41 (на 17%), общей частоты неблагоприятных исходов с 1.51 до 1.93 (на 28%), общей частоты заболевания новорожденных с 0.98 до 1.20 (на 25%), преждевременных родов с 0.85 до 1.17 (на 38%).

В загрязненных районах Брянской области с плотностью загрязнения почвы ^{137}Cs 1-5 $\text{Ки}\cdot\text{км}^{-2}$ отмечено изменение положительной динамики на отрицательную в послеаварийные годы по сравнению с доаварийным по двум основным показателям: частоте врожденных аномалий (коэффициент изменился с 0.66 до 1.41, то-есть на 114%) и частоте мертворождений (коэффициент изменился с 0.66 до 1.39, то-есть на 110%).

Таким образом в Рязанской области, где исходный (доаварийный) уровень РЗ характеризовался более низкими показателями, в послеаварийные годы произошли более глубокие негативные изменения, чем в Брянской области. При этом следует отметить, что при равных уровнях загрязнения почвы ^{137}Cs (1-5 $\text{Ки}\cdot\text{км}^{-2}$), дозы общего облучения и дозы облучения щитовидной железы у жителей Брянской области были несколько выше, чем в Рязанской области (3 сГр и 30 сГр в Рязанской, 5 сГр и 75 сГр в Брянской соответственно). Эти результаты позволяют сделать вывод о том, что исходный уровень РЗ популяции, может быть ведущим в формировании последствий облучения этой популяции в малых дозах.

В табл. I приведены суммарные данные по динамике интенсивных показателей объединенной популяции Рязанской и Брянской областей. Из материалов таблицы видно, что в объединенной контрольной популяции в послеаварийный период положительная динамика (прирост негативных состояний) наблюдался по трем из восьми взятых в анализ показателей: снижение рождаемости, увеличения заболеваемости беременных и частоты, неблагоприятных исходов беременностей ($K=-12.12$, $K=7.07$ и $K=34.98$ соответственно).

В загрязненных районах с плотностью цезия 1-5 $\text{Ки}\cdot\text{км}^{-2}$ прирост негативных состояний (положительная динамика интенсивного показателя) наблюдался по 7 из 8 выбранных для анализа показателей: снижение рождаемости ($K=-12.99$), заболеваемость беременных ($K=12.27$), частота неблагоприятных исходов беременностей ($K=19.49$), частота заболеваний новорожденных ($K=12.62$), мертворождаемость ($K=17.71$), преждевременные роды ($K=3.69$) и рождения ребенка с нормальным весом ($K=6.55$).

В загрязненных районах с плотностью цезия 5-15 $\text{Ки}\cdot\text{км}^{-2}$ (только Брянская область) все восемь выбранных показателей РЗ имели положительную динамику интенсивного показателя (прирост негативных состояний) более выраженного, по сравнению с показателем динамики в районах с плотностью цезия 1-5 $\text{Ки}\cdot\text{км}^{-2}$.

Таким образом, выявляется четкая зависимость ухудшения показателей РЗ от плотности загрязнения почв цезием и доз облучения населения. Средний показатель негативной динамики РЗ по восьми выбранным показателям в контрольной популяции составил -5.09, в популяции с загрязнением территории 1-5 $\text{Ки}\cdot\text{км}^{-2}$ равен 20.96, на территориях с загрязнением 5-15 $\text{Ки}\cdot\text{км}^{-2}$ - 162.51.

Таблица 1

Коэффициенты* изменчивости показателей РЗ объединенных популяций
Рязанской и Брянской областей

Среднегодовой показатель (на 1000)	Контрольные районы			Загрязненные районы ^{137}Cs 1-5 Ки·км ⁻²			Загрязненные районы ^{137}Cs 5-15 Ки·км ⁻²		
	до аварии	после аварии	Коэфф.	до аварии	после аварии	Коэфф.	до аварии	после аварии	Коэфф.
Рождаемость	13.7	12.0	-12.12	12.9	11.2	-12.99	15.9	11.9	-25.00
Общая частота заболев. берем.	479.4	513.3	+7.07	449.1	506.3	+12.72	488.7	512.4	+4.85
Общая частота НИБ	147.5	199.1	+34.98	153.4	183.3	+19.49	138.9	164.1	+18.14
Общая частота заболев. новор.	74.2	73.4	-1.02	56.5	63.6	+12.62	52.5	74.5	+41.84
Врожденные аномалии	11.2	10.8	-3.76	13.3	8.1	-38.83	9.3	15.5	+66.67
Мертворож- даемость	10.0	7.4	-26.5	7.5	8.8	+17.71	8.3	10.7	+22.91
Преждевремен- ные роды	40.2	37.9	-5.59	37.1	38.5	+3.69	29.5	40.9	+38.64
Масса тела новор. соотв. адапт. норме	506.5	505.5	-0.19	452.2	481.8	+6.55	525.3	496.2	-5.54

$$* k = \frac{n_2 - n_1}{n_1} \cdot 100, \text{ где } n_1 - \text{показатель до аварии, а } n_2 - \text{после аварии.}$$

Среди обследованного населения Южного Урала от 40 до 85 тысяч человек средние индивидуальные дозы излучения за 1-й, 18-й, 28-й и 38-й годы после пуска атомного предприятия составили 0,71; 7,6; 0,49 и 0,53 мЗв в год.

Обнаружено, что изменение таких показателей РЗ как рождаемость, общая заболеваемость новорожденных, частота врожденных аномалий развития, мертворождаемость возрастает с увеличением дозы излучения и встречаются чаще, чем в регионах с высокой плотностью выпадения радионуклидов после Чернобыльской аварии. Такие показатели как общая частота заболеваний беременных, частота неблагоприятных исходов беременности, преждевременные роды, масса тела новорожденных не связаны с дозами и с уровнем радиоактивных выпадений.

Анализ медицинских последствий проживания в критичных зонах Южного Урала показал, что достоверно положительный коэффициент корреляции (учащение с увеличением дозы излучения) наблюдали по частоте мертворождений, смертности новорожденных и младенческой смертности. Наоборот, частота врожденных аномалий развития, смертность от них, имели отрицательную корреляцию с дозой.

Выявленные влияния минимальны и проявляются как правило в условиях неблагоприятных социальных факторов или в условиях худшего исходного уровня репродуктивного здоровья.

Таким образом, изменение таких показателей репродуктивного здоровья, как мертворождаемость, заболеваемость новорожденных, частота врожденных аномалий, смертность новорожденных, и в ранние сроки после радиационного воздействия (Чернобыльская авария) и в отдаленные сроки (население Южного Урала) имеют положительный коэффициент корреляции с дозой.

Совокупность показателей репродуктивного здоровья может служить показателем здоровья популяции, а ухудшение состояния здоровья новорожденных (суммарный показатель физиологической ослабленности) может быть критерием детерминированных эффектов низких доз хронического излучения при точном учете других отягчающих влияний.



CLINICAL PECULIARITIES OF THE BRAIN DAMAGE IN THE LIQUIDATORS OF THE CHERNOBYL ACCIDENT

Y.A. ZOZULYA, A.R. VINNITSKY, I.V. STEPANENKO

Institute of Neurosurgery, Academy of Medical Sciences,
Kiev, Ukraine

Investigation into the features of the brain damage by the liquidators of the Chernobyl accident has become an urgent issue of today due to a number of circumstances. According to the classical concept dominating radiobiology until recently, the brain being composed of highly - differentiated nerve cells, presents a radioresistant structure responsive to radiation injury induced by high and very high radiation doses (10000 rem and higher) only. It has been universally recognized that there exist the subthreshold radiation doses harmless to human organism while higher doses produce dose - dependent biological effects. Proceeding from this theoretical assumption, the condition of the nervous system exposed to radiation has been studied quite rarely while dealing with effects of small - dose radiation on the brain was considered to be the most irrational.

The results of clinical examinations given to the Chernobyl accident recovery workers at Kiev Institute of Neurosurgery, Academy of Medical Sciences of Ukraine, show that even the so - called " small - dose " radiation, when consumed continuously, produces neurological signs of the brain damage whose development was noted to be divided in certain phases :

- 1 Initial response phase which should be regarded as an acute radiation encephalopathy (headaches, asthenia, nausea, vomiting, vertigo, insomnia).
2. Temporary compensation or pseudorecovery phase which occurs after people have been removed from radioactive area .
- 3 Decompensation phase characterized by reverting to previous complaints and disorders or worsening thereof, with addition of newly acquired symptoms, this giving the clinical picture of progressive encephalopathy which impacts all the three brain levels . the cortex, subcortex and stem. The hypothalamic and stemic disorders always prevail, however (Fig 1).

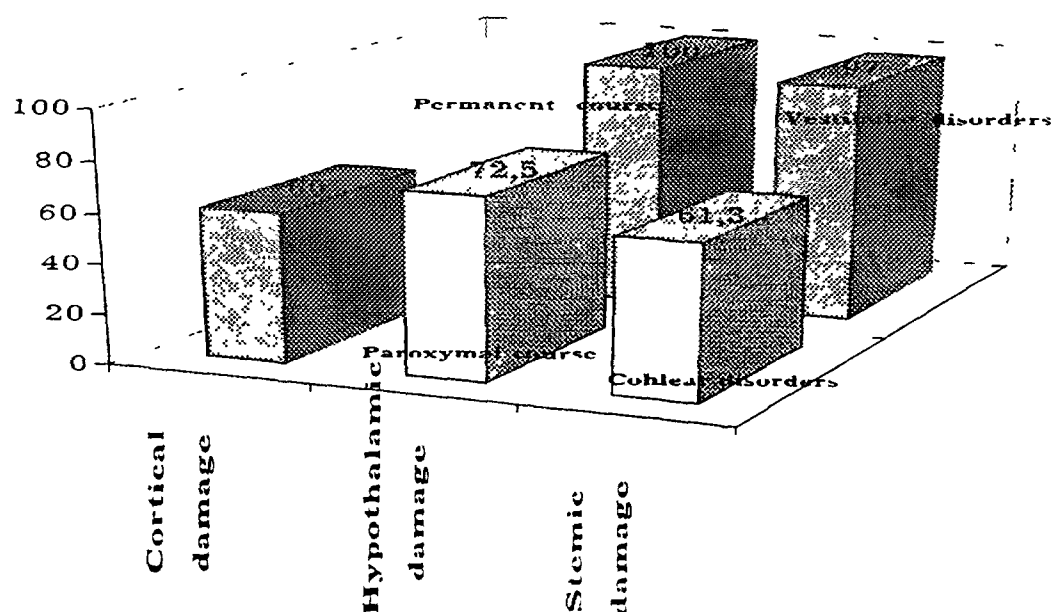


Fig.1. Damage incidence to various brain structures in the liquidators 8-9 years after the Chernobyl accident, %

Pathogenetically, this organic brain damage is a polyfactor one. Therefore, maintaining its etiological unity, it ceases to be just a radiation disease but transforms into a multi - cause postradiation encephalopathy

Retrospective analysis of case histories showed that 89 % of patients had the first phase of the brain damage. The rest 11 % have assessed their condition during the first days under radiation as normal. It should be taken into account, however, that 6 - 9 years have passed since then, and the patients could easily forget whether they had any disturbances. This assumption may be justified by the fact that in a considerable part of patients (57 %) the signs of the 1 -st phase correspond to those of a mild radiation injury. Moreover, it should be noted that, firstly, all the patients were radiation - injured and, secondly, all of them demonstrated differently manifested hemogramic shifts even feeling relatively well

Regarding the 2 -nd phase, i.e. pseudorecovery and temporary compensation, this definition should be also considered as just a conventional one. According to our data, 9 % of patients believed that this phase had not been recognized in them and reported no improvement in their health after the 1 -st acute phase. This percentage was probably higher in fact but self - assessment is usually much influenced by personality characteristics and the extent to which one is concerned about his health condition. Nonetheless, there is no doubt that after leaving radiation zone, some improvement in health, psychological relaxation in particular, took place. For all that, unfortunately, it was just a temporary improvement and pseudorecovery. In some way or other, the 3 -rd phase of the disease, i.e. progressive decompensation, occurred later on which both patients (subjectively) and doctors (objectively) have discovered in absolutely all the liquidators. Progressive nature of radiation encephalopathy is seen from our clinical records, the much time passes the fewer patients with mild symptoms are admitted to our Institute and the greater becomes the number of those diagnosed as having severe variance of the disease, i.e. the 3 -rd phase of postradiation encephalopathy as illustrated in Fig 2.

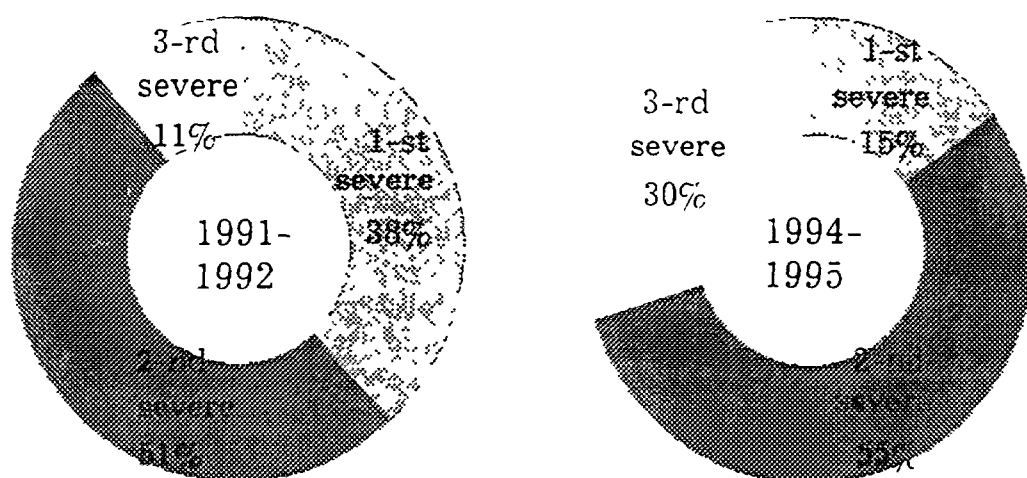


Fig.2. Incidence of differently severe postradiation encephalopathy in the liquidators as revealed 5-6 and 8-9 years after the Chernobyl accident.

Comparing the patient population of 1991 -92 with that admitted to the Institute 3 - 4 years later (1994 -95) without any special preselection , it appears that the percentage of moderate cases remained practically stable whereas severe cases (3 -rd phase) increased 3 times with simultaneous equal decrease in mild cases (1 -st phase).

The 3 -rd phase of the disease is characterized mainly by subcortical - stemic disturbances which are manifested in hypothalamic dysfunction (dyencephalic , hypertensive and symphathoadrenal crises , obesity , impotency , etc .) and vestibular ataxia . All the patients reveal the syndrome of dysadaptation to bodily and mental exercises as well as a drastic decline of recent memory . As the disease progresses in the 3 - rd phase , it becomes possible to distinguish the 2 - nd and the 3 - rd degrees of severity of postradiation encephalopathy induced by the growing endogenic intoxication and hemodyscirculation .

The cause of the disease progression is that , on the one hand , the patients develop alterations in every functional system (vascular , immune , endocrinal , gastro - intestinal , etc.,) and heavy metabolic disorders involving the entire biochemism and oxidative processes , thereby creating unfavourable general somatic background..On the other hand , the brain damage at the level of hypothalamic , i.e. higher vegetative regulators , promotes the development of dysadaptation syndrome . All the above factors diminish the resources of sanogenetic recovery processes and result in patient 's rapid decompensation and disability .

Evidently , disability in liquidators occurs during the 3 -rd phase of postradiation encephalopathy due to both somatic and neurological diseases. However , national - scale statistical data evidence that disability among the liquidators due to the brain damage increases from year to year becoming predominant. Psychoneurological deficiency in these patients is explained on the one hand by their still aggravating social dysadaptation both in

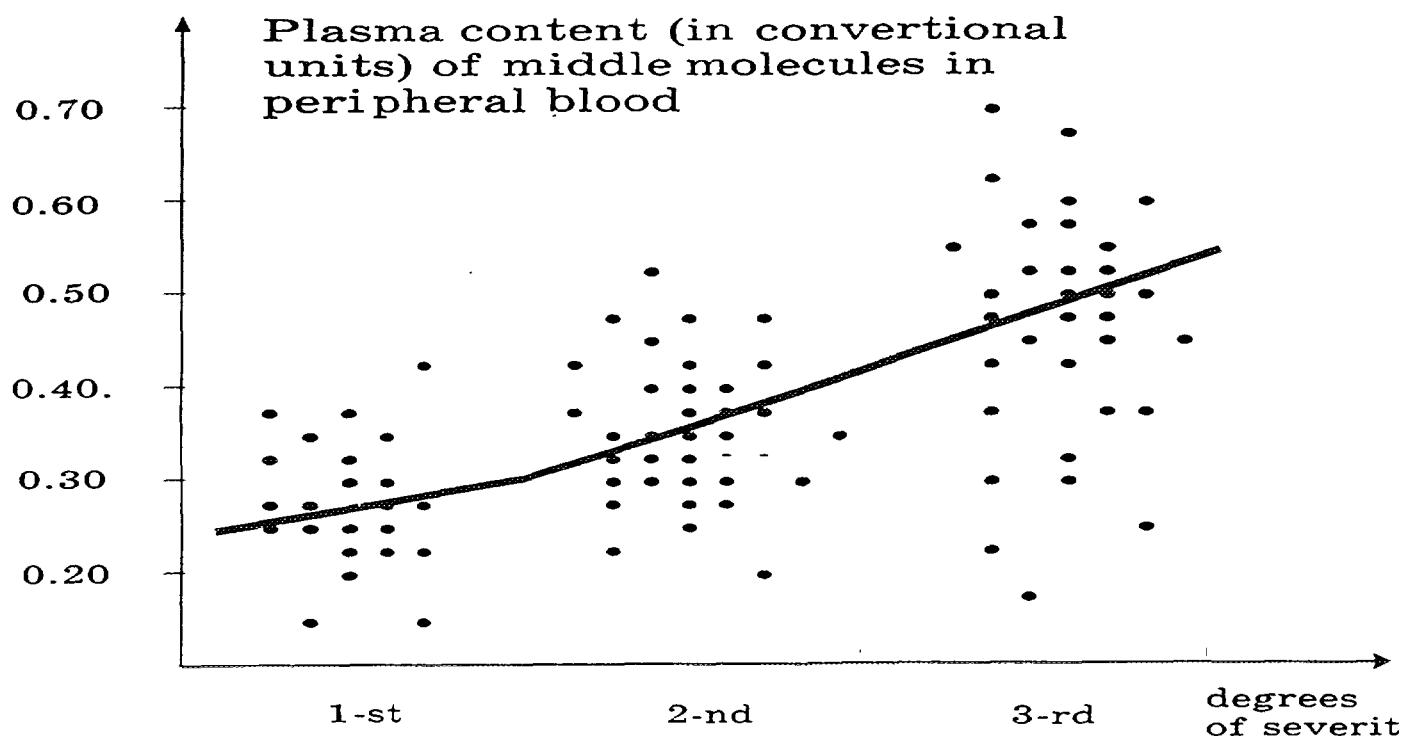


Fig.3 Correlation between the severity of postradiation encephalopathy and the expression of endogenic intoxication

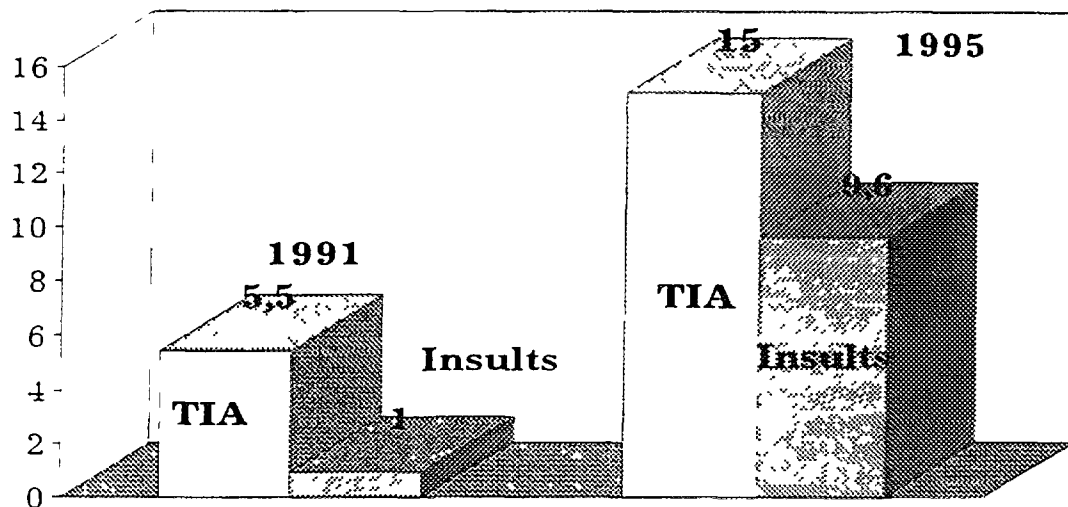


Fig.4. Cerebrovascular complications at different periods after radiation injury, % patients

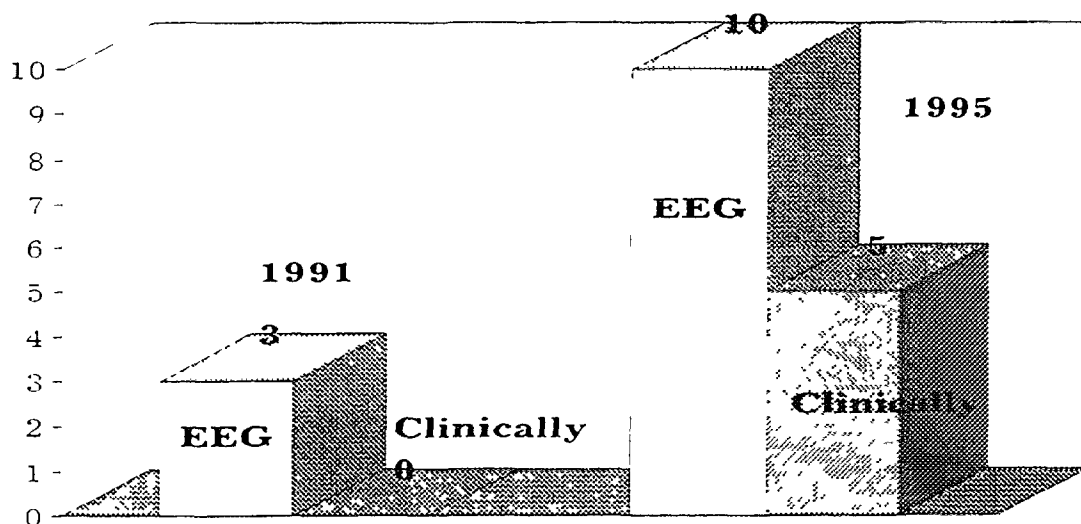


Fig.5. Epilepsyl incidence at different periods after radiation injury, % patients.

private life and business mainly because of catastrophic memory decline. On the other hand, this results from such defects as paresis and paralysis following hemodiscirculation. The latter as seen in Fig 4, was found in severe forms in about 15 % of patients.

Of significance in the etiology of disability is that 5 - 10 % of patients reveal epileptic syndrome (Fig 5)

Thus our investigations evidence that .

1. In contrast to the postulate on the CNS radioresistance, we have found the CNS to be radiosensitive. Therefore the patients exposed to the so - called " small - dose " radiation develop progressive organic brain damage .

2. The most severely damaged are hypothalamic and stemic structures, this fact being confirmed by vegeto - vascular disorders, endocrinal shifts, vestibular ataxia and memory loss .

Parallel with clinical / neurological findings concerning the regularities in the development and course of postradiation encephalopathy , we have discovered in the liquidators multiple systemic disorders .

Preliminary correlative analysis of different pathogenic factors involved in the disease shows that these factors do not progress unidirectionally. There are probably some specific disagreement and dissociation between them .

In particular , we have found that concurrently with progressive neurological deficiency whose rate indicates the severity of postradiation encephalopathy , the serum levels of autoantibodies to the brain neuroproteins tend to rise progressively , though not so rapidly as neurological deficiency does.

This fact acquires principal significance since it proves once again the presence of organic brain damage in our patients. It is also important that parallel with the progression of the two above said characteristics , pathologic alterations in biochemism grow up correlatively , though with some fluctuations . Undoubtedly , these alterations being involved in pathological process , become one of its major parts.

In view of the above , an extremely interesting and extraordinary seems to be our finding that the levels of autoantibodies to glial cells and MBP elevate only up to the 2 -nd phase of encephalopathy inclusive , and then fall down apparently. This phenomenon may be indicative of either the exhaustion of a given immunologic component or , conversely , the occurrence of adaptation.

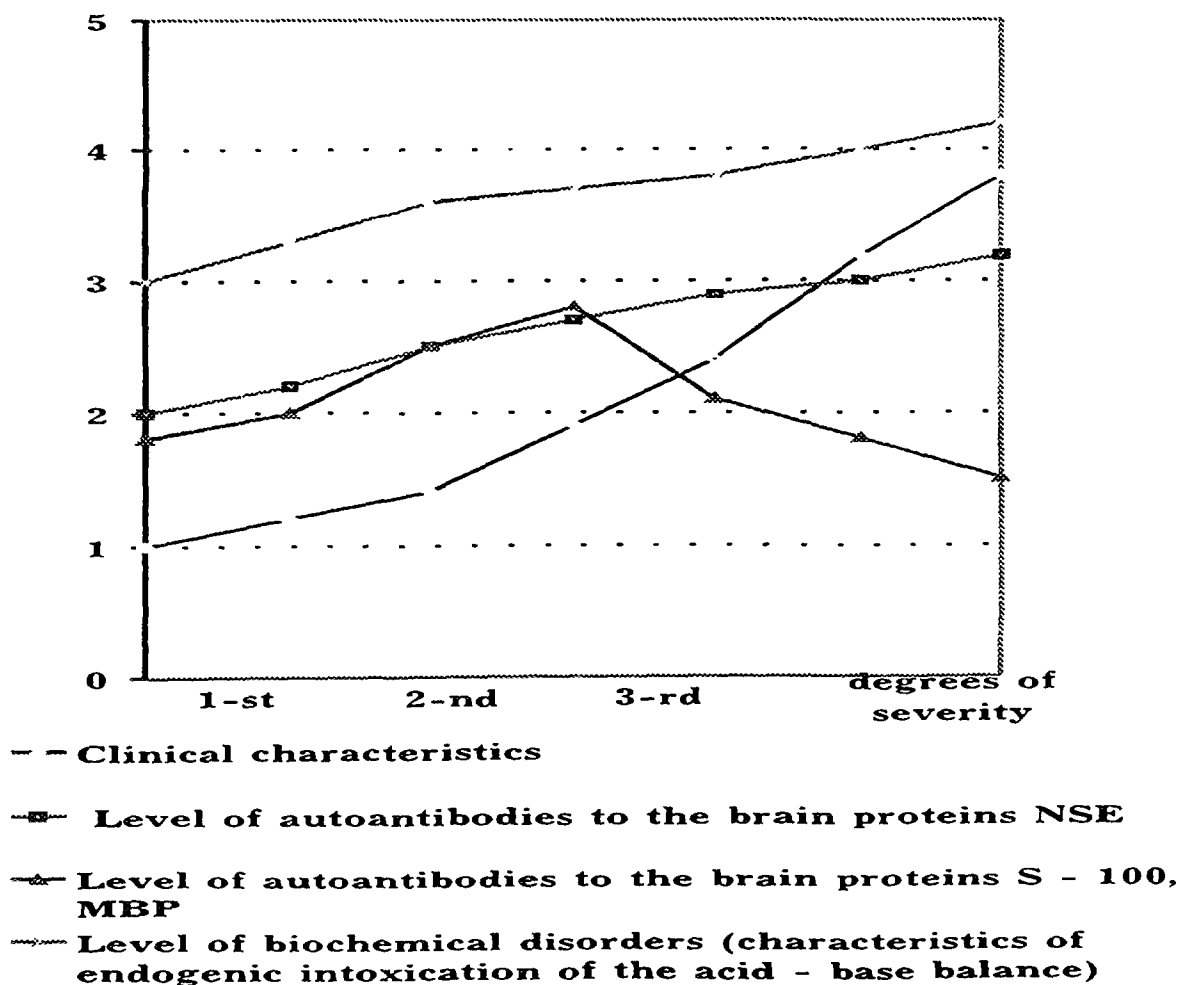


Fig.6. Levels of clinical, neuroimmunological and metabolic characteristics in patients with differently severe postradiation encephalopathy.



SPECIAL FEATURES OF RADIATION EFFECTS IN CHERNOBYL VICTIMS REVEALED BY CYTOGENETIC METHODS AT DIFFERENT STAGES AFTER THE ACCIDENT

V.E. KOMAR, S.N. KOLIUBAEVA, V.V. RAKETSKAYA, L.V. MJASNIKOVA,
N.A. ABISSOVA, L. KORYTOVA, N. ILJIN

Central Research Institute of Roentgenology and Radiology,
St. Petersburg, Russian Federation

The object of this research is to estimate a specific radiation effect in Chernobyl victims by the cytogenetic methods in different period after the accident. All the persons studied worked in 1986-1987 within the 30 km zone around the nuclear power station. The first group of patients consisted of 19 persons who were investigated in 1 month after the Chernobyl accident. The second group of liquidators was analysed in 1990-1993 and the third one was studied in 1995. The chromosome analysis included an account of a total number of chromosome aberrations, single and double fragments, chromosomal exchanges, radiation specific markers (dicentrics and rings) and micronuclei per 1000 cells in peripheral blood lymphocytes. The additional irradiation in vitro of blood samples in a dose of 1.5 Gy was used for an estimation of a genetic instability in the chromosome apparatus.

In the first group of the persons studied the rise in three times of the chromosome aberrations total number was revealed. The number of dicentrics amounted to 0.12% , no dicentrics being observed in the control group.

In the second group we observed a rise of a dicentrics rate when the total chromosome aberration number was reduced. In the third group of liquidators the further rise of dicentrics was revealed. It was found again, as in the first group, a rise of a total number of chromosome aberrations. Data concerning the frequency of micronuclei in peripheral blood lymphocytes correspond with those obtained by the chromosomal analysis. So the level of micronuclei in the second group is near to the control values, but lymphocytes containing 3.4 and more micronuclei appeared. Besides that, in the third group of liquidators we observed a rise of a total frequency of micronuclei.

The test irradiation in vitro resulted in an unexpected relative reduction of the chromosome aberrations and micronuclei rise in liquidators blood samples comparatively to those of the healthy donors.

1. Introduction

Studies on medical and biological consequences of the Chernobyl accident have been carried out since 1986. One of the guidelines of these researches was to estimate a specific radiation effect in Chernobyl victims with the cytogenetic methods.

Data obtained for the space of the past ten years are presented in the report taking notice of the peculiarities of cytogenetic manifestations in the different periods after the accident.

2. Contingents studied and methods

All the persons studied worked in 1986-1987 within the 30 km zone around the nuclear power station. The first group of patients consisted of 19 persons who were investigated in 1 month after the Chernobyl accident. The second group of liquidators (50 persons) was analysed in 1990-1993 and the third one (51 persons) was studied in 1995. 50 healthy donors served for a control group. The techniques for the analysis of chromosome aberrations in cultured peripheral blood lymphocytes was as in general uses.

The yield of radiation specific markers (dicentrics and rings) as well as of the total number of chromosome aberrations, exchanges, single and double fragments, were counted. Micronuclei identification was carried out in the blood lymphocytes cultures using cytochalasin B per 1000 cells for an each sample. The additional irradiation of the blood samples in vitro in a dose of 1.5 Gy was used for an estimation of the genetic instability in the chromosome apparatus.

Total number of chromosome aberrations and its distribution in peripheral
blood lymphocytes of liquidators, %

Table 1

Group		A total number	Dicentric	Fragments		Exchanges
Number, year				single	double	
Donors (50 persons)	Base level	3.3 ± 0.09	0	2.57±0.3	0.72±0.3	0.12±0.05
	Test irradiation, 1.5 Gy	20.50±2.70	8.3±2.00	4.5±1.21	6.66±1.72	0.19±0.04
Liquidators						
1986 (17 persons)	Base level	9.9±1.37	0.12±0.09	3.75±0.51	6.0±0.68	0.12±0.09
1990-1993 (50 persons)	Base level	3.9±0.29	0.2±0.07	3.1±0.27	0.7±0.12	0.1±0.03
	Test irradiation, 1.5 Gy	15.86±3.06	4.0±0.91	7.03±1.03	4.2±1.17	0.11±0.03
1995 (51 persons)	Base level	4.5±0.35	0.54±0.09	2.25±0.17	1.21±0.15	0.034±0.012

Micronuclei content in peripheral blood lymphocytes of liquidators, %

Table 2

		A total number of micronuclei %	Distribution of cells according to the number of micronuclei			
Number, year			1	2	3	≥4
Donors (50 persons)	Base level	26.6±4.6	21.20±4.80	1.80±0.10	0	0
	Test irradiation, 1.5 Gy	222.06±23.60	142.8±8.00	30.80±3.60	4.20±0.80	1.00±0.50
Liquidators						
1990-1993 (50 persons)	Base level	25.53±3.08	19.83±2.03	1.53±0.41	0.39±0.14	0.22±0.09
	Test irradiation, 1.5 Gy	101.75±7.62	77.25±5.16	11.38±1.91	0.75±0.49	0.38±0.18
1995 (50 persons)	Base level	50.0±3.29	43.3±2.29	5.38±0.59	0.84±0.17	0.35±0.08
	Test irradiation 1.5 Gy	148.82±11.30	111.53±7.51	14.23±2.02	2.17±0.58	0.47±0.22

3. Results and discussion

The yield of chromosome aberrations in the three groups of liquidators studied is presented in Table 1. The results of the additional test irradiation in vitro concern only the second group of liquidators in comparison with the group of healthy donors. It can be seen that in the first group of investigated persons the rise in three times of the total number of chromosome aberrations was revealed, mainly as a result of the increase of the single and double fragments frequency. The number of dicentric amounted to 0.12%, no dicentric being observed in the control group.

On the contrary, in the second group we observed a rise of the dicentric rate when the total number of chromosome aberrations was reduced in comparison with the first group.

It is interesting to note that the double fragments frequency did not exceed 0.7% in average of the total chromosome aberrations number. The additional irradiation in vitro in a dose of 1.5 Gy resulted in an increase of both the dicentric frequency and that of the total chromosome aberrations, but this effect was less pronounced than in the control group.

In the third groups of liquidators studied in 1995 the further rise of dicentric was revealed (in 2.45 times in comparison with the average data obtained in the preceding group). It was found again, as in the first group, a rise of the total number of chromosome aberrations.

Data concerning the frequency of micronuclei in peripheral blood lymphocytes counted in two-nuclei cells were obtained for the second and the third groups of liquidators (Table 2).

The main results of these studies correspond with those obtained by the chromosomal analysis. So the level of micronuclei in the second group is near to the control values. However lymphocytes containing 3, 4 and more micronuclei appeared that was not observed in the group of donors. It was shown previously in the in vitro experiments that the appearance of lymphocytes with several micronuclei was a specific radiation effect depending on the dose.

Besides that, in the third group of liquidators we observed a rise of a total frequency of micronuclei as well. The test irradiation in vitro using for an estimation of a genetic instability resulted in unexpected relative reduction of the micronuclei rise in the second group of liquidators comparatively to that of the healthy donors, that corresponds to the results presented in Table 1 concerning the data on chromosome aberrations.

The effect observed resembles to some extent an adaptive response described for fractionally irradiated cells. However the degree of this "adaptive response" is reduced in the third group of liquidators indicative of an increased radiosensitivity of their chromosome apparatus.

The principal results of these studies consisted, first of all, in the conservation of cytogenetic damages in long terms after the accident, secondly, in lowering of nonspecific damages (a total number of chromosome aberrations) and in the rise of specific radiation injuries (dicentric) during the period studied and thirdly, in changing radiosensitivity of the chromosomes to an additional irradiation.

The data obtained are difficult to interpret. The two factors might be taken into consideration: the conservation of radiation damages in stem cells and the peculiarities in radiosensitivity of different subpopulations in the lymphopoietic system. The further studies concerning an estimation of the lymphopoietic status of overexposed people are necessary to clear up the mechanisms of such a dynamics of cytogenetic indices.

4. Summary

In summary some important changes took place in cytogenetic manifestation in peripheral blood lymphocytes of liquidators during the different stages after the Chernobyl accident, having been expressed in lowering of nonspecific damages and in the rise of the specific radiation injuries as well as in the different radiosensitivity of the chromosome apparatus.



MEDICAL CONSEQUENCES OF THE CHERNOBYL ACCIDENT IN ARMENIAN EMERGENCY WORKERS - TEN YEARS OF OBSERVATIONS

I. EMERIT

Department of Genetics, Institut des Cordeliers,
Paris, France

N.M. OGANESIAN, A.S. POGOSIAN, K.V. ASRIAN

Radiation Medicine and Burns Research Centre,
Yerevan, Armenia

According to 10-year studies of state of health of more than 2000 eliminators which under regular medical check-up at the Institute are, the leading place in the sick rate structure the nervous system pathology takes. In addition, 44.7% the organic diseases of nervous system are which during last years from 7% in 1987 to 44.7% in 1995 have grown. The overwhelming majority of them the blood circulation insufficiency in different cerebral basins and dicirculatory encephalopathy are, the cerebral blood circulation momentary violations including (55%). In 50,4% of cases the diencephalon structures interest and moderately-manifested cortical-subcortical relations are discovered.

The immunological, biochemical and other blood changes are shown that they are on nervous and endocrine system depend, which the immunocompetent cells growth, maturity and differentiation regulate. The nervous system changes and peripheral blood lymphocytes cytogenetical status (2-5 times chromosome aberrations frequency increase) as well as spermatogenesis (teratospermy frequency) correlations are observed. The latter points to the possible low-dosage radiation mutagenous effect owing to which the eliminators' posterity who after Chernobyl accident were born state-of-health study (monitoring) is kept. Even 7-8 years later the clastogeneus factor level in eliminators' organs is still 2-3 times higher.

As an anticlastogeneus agent the new French antioxidant TANAKAN preparation is used now, which on eliminators-volunteers was tested. It is shown that average, the chromosome aberrations percentage in eliminators sell cultures, by tanakan treated is almost 3 times lower than in donor ones.

Thus, in Chernobyl accident eliminators the nervous system progressing changes with clastogeneus factor parallel increase, cytogenetic and other morfolological shifts are observed.

THE HEALTH OF LIQUIDATORS FROM THE CHERNOBYL ACCIDENT

G. RENNERT, S. SHAPIRO, H.S. RENNERT, M. SHEINFELD
National K.H. Cancer Control Centre, Carmel Medical Centre,
Haifa, Israel



XA9745445

Background

More than 700,000 immigrants from the former Soviet Union (FSU) have arrived in Israel since 1989. Among them an unknown number of immigrants hold a **liquidator** card. This card was provided to testify that its holder was employed within the 30 Km zone around the Chernobyl power station after the 1986 accident. The liquidators often resided outside of the exposed area and were called in to aid in the rescue and clean-up activities. The current study evaluated the health status of the liquidators in Israel.

Methods

All liquidators currently residing in Israel were requested through the media to contact the study center in Carmel Medical Center in Haifa. Recruitment was further enhanced by reports of the liquidators themselves on more members of the group.

Each liquidator identified by this mechanism was requested to provide copies of his/her liquidator certificate, and was invited for a health-status evaluation session.

The health evaluation session included the following components:

- 1) A demographic and dosimetry questionnaire, including information on time of exposure, place and length of exposure in addition to routine data on age, sex, residence in the FSU, date of immigration and family status.
- 2) A health questionnaire evaluating current health status, health perception, history of hospitalizations, use of medication and reproductive history.
- 3) Physical examination conducted by a general surgeon and by an expert endocrinologist.

Table 1: Demographic and Exposure Characteristics

Sex	
males	110
females	23
Mean age in 1995	
	48.9
Year of work	
1986	88 (65.7%)
1987	29 (21.6%)
1988 and over	17 (12.7%)
Distance from site	
On-site	39 (30%)
1-10 Km	26 (20%)
11-30 Km	67 (51%)
Occupation	
Army	39 (29%)
Driver	12 (9%)
Technical	24 (18%)
Medical	13 (10%)
Laborer	30 (23%)
Other	15 (11%)
Age at Time of Accident	
<30	28 (20.9%)
30-39	50 (37.3%)
40-49	17 (12.7%)
50+	39 (29.1%)
Length of exposure	
mean	12.4 months
median	3 months

- 4) Blood tests including biochemical routines (liver and kidney function tests, glucose, cholesterol, electrolytes and proteins), hematological routines (full blood count and differential), thyroid function tests and anti-thyroid antibodies. Blood was also drawn and DNA extracted for future genetic analysis.

Results

The current report is based on data available from 130 liquidators. Another 6 liquidators who registered with the study center but died

before they were invited for the physical examination, and for whom the cause of death and other medical history is known have also been included. Another 70 liquidators are awaiting invitation for interview and examination and are not included in this analysis. The total number of about 200 known liquidators is believed to comprise about 90% of this group in Israel. The 130 liquidators examined thus far are a random and non-selected group of the 200 identified liquidators.

Description of the study group:

The study group was composed mainly of males, mean age xx, most of whom resided in the contaminated area in the year 1986, for periods of about two months (Table 1). Many of the group members were on army duty, but others belonged to the technical and medical rescue teams.

The most common medical finding among the liquidators was that of hypertension (28 cases - 18.4 %), followed by ischemic heart disease 12 cases - 7.9 %).

Cancer of various sites was diagnosed in 10 cases (7.6 %) (table 2).

Of all cancers diagnosed in this group, 60% have been formerly reported to possibly be related to radiation.

Table 2 Characteristics of cancer cases among liquidators

Type	# of cases	Age at exposure	relation to radiation	reside	Employed in area		
					Distance	Years	Duration
a) Thyroid	2	28/58	+	Kiev	11-30km	86-94	97m
b) Lymphosarcoma	1	52	+	remote	on site	86	6m
c) Brain	1	26	+	Kiev	?		
d) Lymphoma	1	33	+/-	expos	On site	88	3m
e) Stomach	1	51	+/-	remote	On site	86	2m
f) Rectum	1	57	-	Kiev	11-30km	86	2m
g) Prostate	1	58	-	expos	11-30km	86-88	29m
h) CLL	1	56	-	expos	11-30km	86	3m
i) Skin	1	55	-	Kiev	11-30km	86	2m

Non-malignant thyroid pathology was found in 14 cases (10.6%). This figure seems high compared to data on prevalence of thyroid disease in the general Western population.

Most findings were not related to length of exposure. All cases of cancer but one were at the site of accident in 1986.

The age-adjusted prevalence rate of these diseases in the liquidators group was slightly higher than that documented among 1.5 million adults in one HMO in Israel for hypertension and asthma and significantly higher for ischemic heart disease and malignancies (Table 3).

Table 3 Disease Prevalence rate /100,000 in Liquidators and Control Population in Israel

Disease	Liquidators	Israeli HMO 1995
Hypertension	17.4	16.6
Ischemic heart disease	12.3	6.3
Malignancy	4.3	2.3
Asthma	3.6	2.3

Conclusions

Cardiovascular end-points, such as hypertension and ischemic heart disease were found to be most common. Ischemic heart disease was more prevalent in the liquidators cohort than in the Israeli comparison group. This is in line with reported difference in IHD mortality between Israel and the FSU.

A significantly increased rate of malignant tumors was identified in our study. Most of the identified cancers have formerly been described to be related to radiation. It is surprising, though, that these tumors emerged within less than 10 years since the accident. The number of events is too small to reach a definite conclusion but a closer follow-up after this group of liquidators seems warranted.

Such follow-up should probably also include a survey for non-malignant thyroid disorders which were also found to be very prevalent.

DIRECT CLINICAL EFFECTS ON VICTIMS OF THE CHERNOBYL NPP ACCIDENT



XA9745446

A.K. GUSKOVA, I.A. GUSEV

Biophysics Institute, Russian Federation State Science Centre,
Moscow, Russian Federation

The accident at Chernobyl NPP happened in April 26-27, 1986 was characterized by complex combination of a number of factors of radiation and non-radiation origin.

The staff of two accidental shifts and firemen called to eliminate fire were predominantly exposed by external beta-gamma radiations combined with possible applications of radionuclides in skin and mucosa and radioactive aerosol inhalation.

Similar combinations of radiation factors were found in our previous experience, which was the basis for urgent decision on the assessment of main damaging component importance for early health effects in individuals injured in April 26, 1986. The method of analysis of relationships between clinical pictures and dosimetry data in individuals admitted in Clinical Department of the Institute of Biophysics in April 27-28, 1986 (129 persons) represents the basic method of study.

Dosimetry assessments were done in vivo in all people surveyed (237 persons including both hospitalized patients and out-patient individuals) and these assessments were added by postmortem studies in all 27 early fatalities observed.

The scope of elaborated investigations will be described in poster illustrations.

Clinical observations included complete repeated clinical laboratory tests were also complemented by techniques of dose indications using cytogenetic data and blood indices dynamics.

Results

The determinative importance of intensive external gamma-beta exposure for clinical effects is established. Dose range of the external gamma exposure is 0.7 to 13 Gy. Skin doses caused by beta exposure were 10-20 times higher. Radionuclide body burdens were found to accumulate final dose of the same range as external dose for two patients only, which two patients had the radionuclide intake through damaged skin (vapour burn) and radionuclide inhalation (radioiodines and radiocaesiums determined the main part of internal doses in organs and body). All other patients had internal exposure of lungs of <0.8 Gy and thyroid doses were calculated to be more than 4 Gy in 8 persons including two patients with 11-13 Gy in thyroid.

Early clinical revealings were specific to the exposure of relatively uniform gamma radiation combined with beta radiation damage of skin itself (beta dermatitis).

Dose levels from indicated combination caused the development of isolated (in a few cases) and combined (in a majority of cases) manifestations of acute radiation syndrome (bone marrow syndrome, intestinal syndrome complicated by radiation dermatitis, mucositis and lung damage).

Recovering has practically taken place in all patients exposed by less than 4 Gy, two thirds of patients recovered for dose of 4-6 Gy and 2 patients from 21 individuals exposed by 6-13 Gy.

Main peculiarities of direct clinical effects of chernobyl accident consist in:

- high incidence rate of combined damage of different organs and skin, which, for instance, limited the effectiveness of treatment measures to suppress post-radiation myelodepression (allogenic bone marrow transplantations, etc.);
- significant occurrences of skin injuries, which aggravated clinical syndrome by toxic revealings and adult distress syndrome even for small depth of skin damage;
- mass character of both such severe damages and number of people involved in the accident, which caused relevant social psychological resonance; significant complications and duration of treatment of radiation damage of skin in the outcome of the disease.

SIGNIFICANCE OF SEVERITY OF ACUTE RADIATION SYNDROME IN THE DEVELOPMENT OF ENCEPHALOPATHY IN CHERNOBYL ACCIDENT RECOVERY WORKERS AND POSSIBILITIES FOR COMPUTER MODELLING OF SPECIAL FEATURES OF CLINICAL CAUSES OF ENCEPHALOPATHY

I.V. STEPANENKO, N.V. GUZHOVSKAYA

Institute of Neurosurgery,
Kiev, Ukraine



XA9745447

Clinical findings in the Chernobyl accident recovery workers evidence of a manifestative organic damage to the CNS reflected in progressive lesions at all the brain levels - the cortex, the subcortex and the stem.

Retrospective analysis of the disease showed that a part of patients exhibited clinical signs of an acute response to radiation injuries. In our opinion, these signs were due to the brain membrane and the matter stimulation resulted in nausea, vomiting, headache, vertigo, blood pressure elevation, ataxia, drowsiness, fatiguability, emotional instability. The patients responded unambiguously, this probably depending upon individual sensitivity to radiation, the dose received, the place and time of work in radiation area, premorbid condition, etc.

Further development of the disease suggests the 3 phases of the brain damage progression (A.R. Vinnitsky, 1993) 1) acute response to radiation exposure; 2) pseudorecovery, 3) decompensation

We have classified the acute radiation brain injuries as being mild, moderate and severe. A mild brain response to radiation means moderate headaches, dizziness, drowsiness and other complaints that did not reduce the liquidators' performance at the time of their being exposed to radiation. A moderate response implicates the increased complaints and more objective symptoms: nausea, ataxia, abrupt blood pressure fluctuations, heartaches, emotional instability as well as local reactions such as coughing, dermatitis. A severe response implies headaches, numerous vomitings, loss of consciousness with aggravated symptoms inherent in a moderate response. This group of patients also reveal endocrinal disorders and hemogrammic changes.

As seen from anamneses and medical records of 300 liquidators, a mild initial response to radiation injury was found in 57%, moderate in 28,9% and severe in 14,1% of patients. Later on, all of them developed encephalopathy which we classified as being of the 1 - st, 2 - nd and 3 - rd degrees of severity. The dynamics of the disease was studied in relationship with the severity of the brain response to radiation injury.

Patients' dissimilarity, different manifestation of clinical symptoms as well as diversified pathogenic links involved in the formation of patient's condition have impelled us to use mathematical methods to assess the severity of postradiation encephalopathy and prognosticate its development.

To assess patient's condition, we used clinical and paraclinical methods of investigation in order to determine the degree of endogenic intoxication, the signs of auto-sensitization to neuroantibodies, the direction of hemogram deviations and hemodynamic disorders.

To make medical evaluation of a patient's condition more objective, we have devised clinical and biochemical indices of the disease severity based on probability estimations introduced by G.I. Marchuk, I.B. Pogozev and S.M. Zuyev. The results of information analysis were used to determine the sensitivity of the indices to alterations in parameters indicating a patient's condition.

When modelling mathematically the metabolic disorders, the oxygen and carbon dioxide delivery system was isolated and analysed. Systemic model of oxygen delivery disorders was created using the system of differential equations supplemented with algebraic relations showing the parameter interactions. The feedback principle and control - on - perturbation method enabled the model for

regulating the blood flow per minute to be built up. The disease severity indices were assessed in the dynamics. The most informative signs were determined to forecast the course of the disease and identify the higher risk groups among the postradiation encephalopathy patients. These signs included acid -to - base ratio , protein fractions ratio , mnesic impairment , response to primary radiation exposure , etc.

We have found that in liquidators who had the symptoms of a mild primary brain response to radiation , the pseudorecovery phase lasted for 1.5 - 2 years. Further course of the disease (decompensation) was characterized by a gradual increase of the brain damage clinical symptoms with insignificant involvement of other systems. 8 - 9 years after the accident the 1 -st degree of encephalopathy which we classified as postradiation one, was revealed in 42.6% of patients within this group , the 2 -nd degree in 41.7 % and the 3 -rd degree in 15.7 %.

In patients with with a moderate brain response to radiation the disease was of more progressive character. The phase of pseudorecovery lasted for about a year. Progressive worsening of the patients' condition was seen 3 -4 years after the accident : considerable gastro - intestinal , vascular and other disorders . In the follow - up period , the symptoms of encephalopathy within this group of patients were found in the following percentage : 1 -st degree in 26.5% , 2 -nd in 48.5% and 3 -rd in 25%.

The most severe and progressive encephalopathy which involved the signs of other systemic damages was found in the patients with well - pronounced primary brain response to radiation. In these patients the pseudorecovery phase either lasted for several months or was absent at all. The phase of decompensation was very short and involved the lesions at all the brain levels.

A few months after the radiation exposure the patients exhibited the symptoms of hypothalamic dysfunction and endocrinal disorders (impotency , weight and trophical changes , dysmenorrea , thyroid dysfunction , etc.) pointing to dysadaptation 8 - 9 years after the accident 18% of the patients revealed the 1 - st degree of postradiation encephalopathy while the 2 -nd and 3 -rd degrees were found in 54% and 28% , respectively.

The above data show that encephalopathy of the 3 -rd degree is more frequent to develop in the liquidators with an acute primary brain response to radiation injury. Similar dependence can be traced when evaluating metabolic and autoimmune disorders revealed 8 - 9 years after the accident. Comparison of clinical and biochemical indices points to the relationship between metabolic disorders , acid - to - base ratio , endogenic intoxication level and the severity of radiation injury at the moment of the accident.

Thus clinical and laboratory correlations evidence of the existence of a complicated and polyfactor mechanism responsible for the development and progression of postradiation encephalopathy.

The above described mathematical model may be a helpful tool for giving additional tests to postradiation encephalopathy patients for assessing their condition

SESSION 2

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CLINICO-MORPHOLOGICAL COMPARISONS IN ULTRASOUND DIAGNOSIS OF CARCINOMA OF THE THYROID IN CHILDREN EXPOSED TO RADIATION

E.D. CHERSTVOJ

Minsk Medical Institute,
Minsk, Belarus

E.P. DEMIDCHIK

Republican Centre of Hygiene and Epidemiology,
Minsk, Belarus

V.M. DROZD

Scientific Research Institute for Radiation Medicine, Belarus Ministry of Health,
Minsk, Belarus

The purpose of the study was to compare morphologic and ultrasonic pictures of the thyroid. The study included 42 children with thyroid cancer exposed to ionizing radiation after the Chernobyl accident. All children were operated on during 1990-1994 yy.. This study has shown that diffuse sclerosing variant of papillary carcinoma (PC) occurred more frequently in patients with higher absorbed doses to the thyroid. This variant of PC was rarely found at pT1 stage, besides, diffuse sclerosing PC was more frequently accompanied by bilateral and median metastases ("pure" PC and follicular variant of PC).

Biometry of thyroid carcinoma showed a wider spread of neoplastic process in diffuse sclerosing PC than in pure papillary carcinoma. The patients with diffuse sclerosing PC had the second operation more frequently than those with follicular PC. It might be related to a larger volume of operation due to follicular PC. Any other ultrasonic peculiarities were not found in this study. However, the revealing of of two and more pathological sites with uneven contours and bilaterally enlarged lymphatic nodes, spreading into the both lobes, could be estimated as high risk symptoms of diffuse sclerosing PC. In these cases more extended surgery should be recommended.

ВВЕДЕНИЕ: Исследования, проводимые по выявлению параллелизма морфологической и ультразвуковой картины ЩЖ показали, что все узловые образования можно разделить на солидные и кистозные, возможны также смешанные варианты [3,4,10,11]. Практически отсутствуют сведения об особенностях ультразвуковой визуализации карциномы ЩЖ у детей в зависимости от ее морфологического варианта, что и стало предметом нашего изучения. По данным LiVolsi A. (1992) [6] кроме типичной модели папиллярной карциномы в 15-20% случаев встречаются менее обычные гистологические подвиды. Среди опухолей, появившихся в Беларуси после Чернобыльской аварии, 21% можно классифицировать как фолликулярный вариант папиллярной карциномы и 10% - как диффузносклеротический [8]. Диффузносклеротический вариант описан как детский рак и характеризуется более агрессивным течением [6,7,9]. Однако в исследованиях, проведенных в Японии, получены данные, что диффузносклеротический вариант вел себя таким же образом как и типичная папиллярная карцинома [12].

МЕТОДЫ: УЗИ ЩЖ проводилось при помощи аппаратов "Toshiba" SAL-38B и "ALOKA-500", датчиком 7.5 МГц в реальном масштабе времени с использованием авторского программного комплекса для автоматизации диагностики и контроля состояния ЩЖ. Ультразвуковое исследование ЩЖ проводилось по методике Brunn et al. (1981) [3] в собственной модификации с расчетом объема ЩЖ в относительных показателях (% превышения объема ЩЖ относительно

возрастного норматива). Нами предложено также проводить биометрию узлов и локальных изменений в ЩЖ. Измерялись передне-задний размер (а) и ширина узлового образования (в) в трансверзальном скане, длина (с) - в лонгитудинальном. Объем узлового образования вычислялся по формуле эллипсоида: $0,524 \cdot a \cdot v \cdot c$. Затем определялся процент, занимаемый узлом от доли ЩЖ и от всего объема ЩЖ.

Материалом послужили ЩЖ пациентов в возрасте от 4 до 15 лет, оперированных с 1989 по 1994 гг. в Республиканском научно-практическом центре по проблемам рака щитовидной железы (директор - профессор Е.П. Демидчик).

Морфологическую верификацию карцином проводили на кафедре патологической анатомии Минского государственного медицинского института (зав. кафедрой профессор Черствой Е.Д.) в соответствии с Международной гистологической классификацией опухолей ЩЖ [1]. Критериями определяющими папиллярный рак были наличие сосочковых структур, псамоммных телец и преобладание опухолевых клеток с овальными бледноокрашенными наслаивающимися друг на друга ядрами типа "притертого стекла". Кроме того, выделяли варианты папиллярного рака: "чистый" папиллярный (ПВ), фолликулярный вариант (ФВ) и диффузносклеротический (ДСВ).

При анализе гистологического строения опухолей визуально оценивали относительное содержание папиллярных, фолликулярных и солидных структур. Кроме того, учитывали характер роста (наличие капсулы опухоли, мультицентричность, прорастание за пределы анатомической капсулы ЩЖ), наличие лимфоидной инфильтрации, сочетанной тиреоидной патологии, распространенность метастазирования.

Распространение рака ЩЖ в организме определяли по международной системе pTNM.

Расчет дозы, поглощенной ЩЖ, проводился сотрудниками НИИ биофизики г. Москва [2].

Таблица I.

Распределение детей по дозовым характеристикам в зависимости от морфологического варианта папиллярной карциномы ЩЖ

Морфологический вариант		ПВ n = 26	ФВ n = 9	ДСВ n = 7
Мальчики	abc	12	5	4
	%	46.15	55.6	57.1
Девочки	abc	14	4	3
	%	53.85	44.4	42.9
Области :				
Гомельская	abc	16	8	6
	%	61.5	88.9	85.7
Брестская	abc	6	0	1
	%	23.1	0,0	14.3
Могилевская	abc	3	1	0
	%	11.5	11.1	0,0
Минская	abc	1	0	0
	%	3.9	0,0	0,0
Доза (сGy)		n=19	n=5	n=6
1 доз.гр. (0-30)	abc	9	3	2
	%	47.4	60	33.3
2 доз.гр. (30-100)	abc	5	1	1
	%	26.3	20	16.7
3 доз.гр. (> 100)	abc	5	1	3
	%	26.3	20	50

Таблица II.

Зависимость морфологической картины папиллярной карциномы ЩЖ от дозы, поглощенной щитовидной железой.

Дозовая группа (сGy)	Всего n = 31		0 - 30 n = 15		30 - 100 n = 7		> 100 n = 9	
	1		2		3		4	
	абс	%	абс	%	абс %		абс	%
Наличие капсулы опухоли	10	32.26	5	33.33	2	28.57	3	33.33
Склероз	13	41.94	8	53.33	2	28.57	3	33.33
Внутриорганный дис- семинация	25	80.65	1 3	86.67	5	71.43	7	77.78
Перитуморозный тиреоидит	14	46.57	7	46.67	3	42.86	4	44 (n=8)

Таблица III.

Распределение больных по стадиям pTNM в зависимости от морфологического варианта папиллярной карциномы ЩЖ.

Морфологический вариант		ПВ n = 26 (1)	ФВ n = 9 (2)	ДСВ n = 7 (3)
T1	абс	4	3	0
	%	15.4	33.3	0
T2	абс	3	0	2
	%	11.5	0	28.5
T3	абс	0	0	1
	%	0	0	14.3
T4	абс	19	6	4
	%	61.5	66.7	57.1
N 0	абс	8	4	3
	%	30.77	44.5	42.86
N 1A	абс	12	3	1
	%	46.15	33.3	14.29
N 1B	абс	6	2	3
	%	23.1	22.2	42.86
M 0	абс	26	9	7
	%	100	100	100

РЕЗУЛЬТАТЫ: Исследования проведены среди 42 детей, подвергшихся воздействию радионуклидов в результате аварии на ЧАЭС и прооперированных по поводу папиллярной карциномы ЩЖ. Среди них было 26 случаев с “чистым” вариантом папиллярной карциномы, 9 - с фолликулярным и 7 - с диффузносклеротическим. При папиллярном варианте несколько чаще встречались девочки - 53,83%, при фолликулярном и диффузносклеротическом незначительно преобладали мальчики - 55,6 и 57,1% соответственно (табл. I). Как видно из табл. I, средний возраст детей при папиллярном и фолликулярном вариантах составлял $10,34 \pm 0,52$ и $10,0 \pm 0,72$ лет и несколько меньше при диффузносклеротическом варианте - $9,4 \pm 1,5$. Абсолютное большинство детей с различными вариантами карциномы проживали в Гомельской области: с папиллярным - 61,5%, с фолликулярным - 88,9%, с диффузносклеротическим - 85,7%

При изучении распределения детей по дозовым группам в зависимости от морфологического варианта выявлена определенная тенденция: при папиллярном и фолликулярном вариантах наибольший процент детей относился к первой дозовой группе (0-30 сГр) - 47,4% и 60% соответственно. При диффузносклеротическом - отмечалась обратная зависимость: 3 дозовая группа (свыше 100 сГр) насчитывала относительно большее число детей - 50% (табл. I).

Зависимость морфологической картины (наличие капсулы опухоли, склероза, внутриорганной диссеминации, перитуморозного тиреоидита) от дозы, поглощенной ЩЖ, представлена в табл. II. Оказалось, что проявления склероза несколько чаще - 53,3% встречались в дозовой группе 0-30 сГр по сравнению с группами более высоких доз (28,6-33,3%). В большинстве случаев, практически независимо от дозы, была выражена внутриорганная диссеминация процесса (71,43-86,67%) и почти у половины детей - признаки перитуморозного тиреоидита (42,9-46,7%).

Таблица IV.

Ультразвуковая биометрия при папиллярной карциноме
ЩЖ в зависимости от морфологического варианта

Морфологический вариант		ПВ n = 26	ФВ n = 9	ДСВ n = 7
Моно-узел	абс	23	7	3
	%	92	77.8	42.8
2 узла и более	абс	3	2	4
	%	8	22.2	57.2
Диаметр узла до 1 см	абс	4	2	0
	%	16	23	0
Средний диаметр узла (см)		1.6 ± 0.19	1.92 ± 0.35	2.83 ± 0.79
Средний объем узла		2.04 ± 0.75	3.0 ± 1.28	4.06 ± 2.49
% от доли железы		24.02 ± 5.28	42.04 ± 12.3	53.01 ± 15.8
% от всей железы		14.02 ± 3.59	27.06 ± 10.2	41.80 ± 13.53
% увеличения всей железы		137.36 ± 7.5	238.9 ± 46.0	195.86 ± 37.57
% остаточной ткани после операции		72.05 ± 7.2	45.2 ± 9.3	57.0 ± 16.6
Повторные операции	абс	10	2	3
	%	38.5	22.2	43

Распределение детей по стадиям pTNM в зависимости от морфологического варианта карциномы ЩЖ представлено в табл. III.

Выявлена достоверно более высокая частота стадии T1 среди больных с папиллярным и фолликулярным вариантами карциномы (15,4%, 33,3%) в сравнении с диффузносклеротическим ($P < 0,05$). Стадия T2 чаще встречалась при диффузносклеротической форме, чем при фолликулярной (28,5%, 0, $P < 0,05$). Достоверных различий в частоте стадии T4 в зависимости от морфологического варианта не отмечено. Метастазы в лимфатические узлы встречались при различных морфологических формах в 69,23%-55,5%. Стадия N1B относительно чаще отмечалась у детей с диффузносклеротическим вариантом карциномы ЩЖ - 42,8%, в сравнении с папиллярным и фолликулярным - 23,1-22,2%.

Данные по ультразвуковой биометрии приведены в табл. IV, где видно, что в виде моноузла чаще протекал папиллярный вариант рака ЩЖ - 92%, реже диффузносклеротический - 42,8% ($P < 0,05$).

В тоже время два и более узловых образования чаще встречались при диффузносклеротическом варианте - 57,2% ($P < 0,05$). Узлы диаметром до 1 см обнаружены при папиллярном варианте в 16% случаев, при фолликулярном - в 23%, а при диффузносклеротическом - выявлены не были ($P < 0,05$). Средний диаметр узла был меньше в группе детей с папиллярным вариантом - $1,6 \pm 0,19$ см, наибольший - при диффузносклеротической форме - $2,8 \pm 0,79$ см. Аналогичные тенденции прослеживались и на других показателях: объеме узла, проценте патологических изменений в доле и во всей железе, хотя достовернозначимых различий нами выявлено не было. Общее увеличение ЩЖ в большей степени отмечено при фолликулярном варианте - в среднем до $238,9 \pm 46,0\%$, несколько меньше при диффузносклеротическом - $195,86 \pm 37,57\%$ и папиллярном - $137,36 \pm 7,5\%$.

Нами проанализирована частота повторных операций по поводу возобновления опухолевого роста в течение 2-5 лет наблюдения (табл. IV). У детей с диффузносклеротическим вариантом в 43% случаев было проведено повторное оперативное вмешательство, что в 2 раза чаще, чем при фолликулярном - 22,2%.

Подобную ситуацию мы можем объяснить как биологическими особенностями опухолей, но и тем, что при диффузносклеротическом варианте отмечается самый высокий процент поражения ткани ЩЖ - 41,8 и в тоже время через 6 месяцев после операции визуализируется в среднем до 57% объема железы. При фолликулярном варианте более расширенные оперативные вмешательства (отстаточная ткань - 45,2% объема ЩЖ) на фоне меньшего поражения (до 27%) приводят к меньшей частоте повторных операций. При папиллярном варианте карциномы отмечено возобновление опухолевого роста в 38,5% случаев на фоне операций с остаточным объемом ткани ЩЖ в среднем до 72%.

Ультразвуковая картина различных вариантов карциномы ЩЖ представлена в табл. V. Более характерным было расположение патологического процесса в правой доле для всех трех

Таблица V.

Ультразвуковая картина различных морфологических вариантов карциномы ЩЖ

Морфологический вариант		ПВ n = 26	ФВ n = 9	ДСВ n = 7
Локализация патологических изменений:				
Справа	абс	17	5	3
	%	65.4	55.6	42.9
Слева	абс	9	3	2
	%	34.6	33.3	28.55
Вся железа	абс	0	1	2
	%	0.0	11.1	28.55

		1	2	3
Расположение относительно полюсов :				
Верхний	абс	0	1	1
	%	0.0	11.1	14.2
Центральная часть	абс	20	3	2
	%	76.9	33.3	28.6
нижний	абс	6	1	2
	%	23.1	11.1	28.6
Вся доля	абс	0	4	2
	%	0.0	44.5	28.6
Подкапсульно расположено	абс	25	8	7
	%	96.1	88.9	100
Отсутствие контакта с капсулой	абс	1	1	0
	%	3.9	11.1	0.0
Контур :				
Четкий	абс	3	0	0
	%	11.5	0.0	0.0
Относительно четкий	абс	10	1	1
	%	38.5	11.1	14.3
Нечеткий	абс	13	8	6
	%	50.0	88.9	85.7
Наличие "Halo"	абс	2	1	1
	%	7.7	11.1	14.3
Наличие капсулы узла	абс	4	0	0
	%	15.4	0.0	0.0
Структура однородная	абс	5	0	1
	%	19.2	0.0	19.3
Неоднородная	абс	21	9	6
	%	80.8	100	85.7
Эхогенность :				
Изоэхогенная	абс	1	1	0
	%	3.8	11.1	0.0
Гипоэхогенная	абс	22	6	5
	%	84.6	66.7	71.4
Гиперэхогенная	абс	0	0	0
	%	0.0	0.0	0.0
Смешенная	абс	3	2	2
	%	1.15	22.2	28.6
Визуализация лимфоузлов :				
Выявлено	абс	17	6	5
	%	65.4	66.7	71.4
Единичные	абс	6	2	1
	%	23.1	22.2	14.3
Множественные	абс	11	4	4
	%	42.3	44.5	57.1

морфологических вариантов (65,4%, 55,6%, 42,9%), билатеральная локализация чаще встречалась при диффузносклеротическом варианте и не выявлена при папиллярном (28,55%, 11,1%, 0%).

Определение патологического процесса в центральной части доли ЩЖ при папиллярном варианте было в 76,9%, при фолликулярном - чаще, чем при других формах поражалась вся доля (44,5%, $P < 0,05$), при диффузносклеротическом - одинаково часто изменения визуализировались либо в центральной, либо в нижней части доли, либо охватывали всю долю целиком (28,6%).

Расположение патологических изменений внутри железы было таково, что в преобладающем большинстве случаев имелся четко визуализируемый контакт с капсулой ЩЖ. И только по одному случаю выявлено при папиллярном варианте - 3,9% и фолликулярном - 11,1% локализации патологических очагов в глубине ткани ЩЖ.

Структура узлов по данным УЗИ у большинства детей была неоднородной (80,8%-100%), причем при фолликулярном варианте чаще, чем при папиллярном ($P < 0,05$). Типичным для карциномы ЩЖ было наличие нечеткого контура узла, который достоверно чаще встречался при фолликулярном варианте (88,9%) и диффузносклеротическом (85,7%) по сравнению с папиллярным (50,0%, $P < 0,05$). Визуализируемая капсула узла отмечена только при папиллярном варианте (15,4%, $P < 0,05$), в единичных случаях при всех формах встречался феномен "halo" (7,7%-14,3%).

Эхогенность карциномы ЩЖ в большинстве наблюдений была пониженной: при папиллярном варианте - 84,6%, при фолликулярном - 66,7%, при диффузносклеротическом - 71,4% (табл. V). При фолликулярном и диффузносклеротическом вариантах несколько чаще встречался смешанный тип эхогенности (22,2%, 28,6% соответственно).

Лимфатические узлы визуализировались в 65,4%-71,4% случаев, причем несколько чаще при диффузносклеротическом варианте они были множественные (57,1%) (табл. V).

Таким образом, диффузносклеротическая форма характеризовалась тенденцией к возникновению на фоне более высоких доз поглощенных ЩЖ. Она реже диагностировалась в стадии pT1, и чаще давала билатеральное и медиастинальное метастазирование. Подобные особенности могут быть в определенной степени объяснены радиационным генезом диффузносклеротического варианта карциномы ЩЖ, однако более основательные утверждения проблематичны из-за малочисленности этой группы детей в наших наблюдениях. Биометрия карциномы ЩЖ показала, что наибольшую распространенность патологический процесс носит при диффузносклеротическом варианте, наименьшую - при папиллярном. Частота повторных операций выше также при диффузносклеротическом варианте и ниже при фолликулярном, что, возможно, связано с более расширенным характером проводимых операций при фолликулярном варианте карциномы ЩЖ. Каких-либо специфических особенностей эхоэмоиотики нами выявлено не было, из чего следует, что ультразвуковой метод исследования не может дифференцировать морфологические варианты карциномы. Однако выявление распространенного на обе доли двух и более патологических очагов с нечеткими контурами и билатерально увеличенными лимфатическими узлами можно расценивать симптомами повышенного риска диффузносклеротического варианта карциномы ЩЖ. В этих случаях должны быть даны рекомендации более расширенного хирургического вмешательства.

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HYPOPHYSIS-THYROID SYSTEM AND METABOLISM IN CHILDREN AND ADOLESCENTS RESIDING IN THE TERRITORIES OF BELARUS CONTAMINATED WITH RADIONUCLIDES

T.A. MITYUKOVA, F.N. SOLODVNIKOVA, B.F. KOBZEV, L.N. ASTAKHOVA,
O.N. POLYANSKAYA, A.M. DUBOVTSOV, S.V. MARKOVA, M.P. KAPLIEVA
Research Institute of Radiation Medicine,
Minsk, Belarus



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The results of complex investigation (1990-1995) of the functional state of the hypophysis-thyroid system and metabolism in children and adolescents residing at the territories of Belarus contaminated with radionuclides are presented.

In patients from the Gomel region, absence of TSH pre-puberty peak was revealed which is considered to be normal, as well as absence of TSH reaction to iodine deficiency. In younger children (0-2 years of age at the time of the accident) who had received maximal dose loads of I-131 to the thyroid, elevated levels of thyroglobulin and free thyroxin (FT4) were marked, as well as the reduction in binding of thyroxin with thyroxin-binding globulin (TBG).

Changes in metabolism were characterized by the intensification of lipid peroxidation processes and reduction in activity of antioxidant protection enzymes, as well as by the accumulation of lactic and pyruvic acids in blood. Expressiveness of changes depended upon the level of radioiodine to the thyroid.

Thus, in children and adolescents exposed to radionuclides of iodine and permanently residing at the territories contaminated with radionuclides of Cs-137, changes in central and peripheral mechanisms of thyroid status regulation were ascertained which are connected with the disturbances in the system of energy metabolism and lipid peroxidation.

1. Введение

За период, прошедший после аварии на ЧАЭС, в Республике Беларусь зафиксирован значительный рост тиреоидной патологии, особенно у детей и подростков [1]. Изучение экскреции йода с мочой у детей и подростков из различных регионов республики показало, что в большинстве обследованных районов йодная недостаточность соответствует легкой степени [2]. Что касается роли факторов радиационной природы в формировании патологии щитовидной железы (ЩЖ), то она требует тщательной оценки. Учитывая, что даже малые дозы радиации могут нарушать процессы нейрогуморальной - регуляции и внутриклеточного метаболизма, представляло большой интерес исследовать функциональное состояние гипофизарно-тиреоидной системы, включая центральные и периферические регуляторные механизмы, во взаимосвязи с показателями метаболизма. В задачу исследования входило сопоставить изучаемые показатели с уровнем загрязнения местности Cs-137 и его инкорпорацией, а также с радиационными нагрузками на ЩЖ, сформированными за счет поглощенного I-131.

2. Материалы и методы исследования

В 1990-1995 г.г. было проведено безвыборочное скрининговое исследование состояния щитовидной железы у детей и подростков (5-17 лет), проживающих в Хойникском (630 чел.) и в Ветковском (336 чел.) районах Гомельской области, а также у 205 школьников (6-14 лет), проживающих в Столинском районе Брестской области. В этот же период времени проведено углубленное обследование, включающее показатели метаболизма, у детей и подростков из групп риска по развитию тиреопатологии, выделенных на основании

результатов скрининговых исследований с учетом дозовых нагрузок на ЩЖ и инкорпорированной активности Cs-137. Радиационные нагрузки на щитовидную железу (ЩЖ) оценивали по данным прямой дозиметрии (Гомельская область и дети, отселенные из 30-ти км зоны ЧАЭС), выполненной сотрудниками Московского Института биофизики, и на основании расчетных доз (Брестская область), представленных теми же авторами [3]. Инкорпорацию Cs-137 оценивали по значениям СИЧ (Счетчик излучения человека WBC-101, фирма "Aloka", Япония). Кроме того учитывали данные [4]. Основные сведения о радиационных нагрузках для обследованных контингентов представлены в таблице 1. Контролем являлись дети и подростки из Браславского района Витебской области (420 чел.) и Столбцовского района Минской области (203 чел.), практически не загрязненных радионуклидами.

Обследование включало осмотр эндокринолога, ультразвуковое исследование щитовидной железы с ее биометрией по методике [5] с учетом норм объемов, разработанных для детского населения Беларуси [6]. У детей, не получавших препараты стабильного йода, определяли концентрацию йода в моче при помощи спектрофотометрического церий-арсенитного метода [7]. Тиреотропный гормон (ТТГ), общую и свободную фракции тироксина и трийодтиронина (Т4 и Т3), тироксинсвязывающий глобулин (ТСГ), тиреоглобулин (ТГ) определяли в сыворотке крови радиоиммунным методом с использованием наборов фирмы "CIS bio international" и производства Института биоорганической химии (Минск). Тироидтранспортные системы крови изучали методом электрофореза с использованием меченых I-125 Т4 и Т3 (Институт биорганической химии, Минск). Связывающую активность ТСГ, альбумина и преальбумина выражали в процентах по отношению к общему количеству внесенной метки.

Для характеристики интенсивности перекисного окисления липидов определяли содержание гидроксиперекисей липидов и малонового диальдегида в плазме крови. В

гемолизатах эритроцитов исследовали показатели антиоксидантной системы: активность каталазы, глутатионредуктазы, глутатионпероксидазы и супероксиддисмутазы. В крови определяли содержание молочной и пирувиноградной кислот. Перекисный гемолиз эритроцитов изучали в присутствии прооксидантов - ионов железа и аскорбиновой кислоты

3. Результаты

На основании безвыборочного гормонального скрининга (1990 г.) детей и подростков, проживающих в Хойникском районе Гомельской области, была изучена возрастная динамика ТТГ и гормонов тироидного статуса. Все обследованные дети находились в рамках эутиреоидного состояния. Дозовые нагрузки у детей и подростков, проживающих в Хойникском районе, были максимальными у детей 4-6 лет, которым на момент аварии было не более 2-х лет, и составляли в среднем около 2.5 Гр и минимальными у подростков 15-17 лет - в среднем 0.9 Гр. Средняя поглощенная ЩЖ доза для общей группы Хойникских детей и подростков составляла 1.57 Гр. Сопоставлялись данные обследования лиц из Хойникского и двух контрольных районов - Браславского Витебской области и Столбцовского Минской области. Медиана содержаний йода в моче в группе Хойникских детей и подростков составляла 72.2 мкг/л, Браславских - 93.0 мкг/л, а у Столбцовских была ниже, чем у Хойникских. Установлено, что у лиц, проживающих в контрольных районах, существует повышение уровня ТТГ в возрасте 7-14 лет по отношению к другим возрастным группам. У Хойникских детей препубертатный подъем ТТГ отсутствовал. Наиболее высокое среднее значение ТТГ отмечалось в возрастной группе 4-6 лет, а с увеличением возраста уровень ТТГ поступательно снижался. Следует подчеркнуть, что, как у Хойникских, так и у Браславских детей в период с 11 до 15 лет отмечены наиболее низкие, близкие по значению средние уровни свободного Т4 в интервале 15.14 - 15.45 пмоль/л. Средний уровень свободного Т4 в целом для Хойникской группы был достоверно выше, чем в Браславской (17.91±0.46 и

16.49+0.43 пмоль/л, соответственно). Особенно резкое повышение свободной фракции гормона отмечалось у детей 4-6 лет в Хойникском районе (27.96+2.59) по сравнению с проживающими в Браславском (19.54+0.75) и Столбцовском (14.68+1.05 пмоль/л). Уровень ТСГ в группе Хойникских детей 4-6 лет был наиболее высоким (25.75+1.08 нг/мл). Средний уровень ТСГ у Хойникских детей составлял 24.24+0.40, что достоверно превышало среднее значение этого показателя у Браславских детей (20.98+0.64 нг/мл). Изучение связывающей активности тироидтранспортных систем крови показало снижение связывания Т4 с ТСГ. Как видно из таблицы II, в норме около 85% Т4 и 75% Т3 транспортируется ТСГ. У детей, проживающих в наиболее загрязненных радионуклидами районах Гомельской области, наблюдается перераспределение Т4 на менее аффинные носители - альбумины и преальбумины крови. Средний уровень ТГ был несколько выше в Столбцовском районе, где йодный дефицит более выражен, чем в Браславском и Хойникском. В группе Хойникских детей 4-6 лет среднее содержание ТГ превышало нормальные значения и составляло 69.09+9.87 нг/мл. Изучение зависимости показателей тироидного статуса от поглощенной ЩЖ дозы показало, что повышение дозы до 1.0 Гр вызывает достоверный рост уровня ТГ (на 40%). При повышении дозы до 4.0 Гр отмечается тенденция к нарастанию уровня ТТГ и снижению Т4, что указывает на повышенный риск развития гипотироза у данной категории лиц.

На основании определения содержания йода в моче все обследованные из Ветковского района Гомельской области и из контрольной группы (1992-1993 г.г.) были разбиты на подгруппы: более 100 мкг/л, 50-100, 20-50 и менее 20 мкг/л. Анализ гипофизарно-тироидных взаимоотношений в зависимости от содержания йода в моче выявил ряд особенностей у лиц, проживающих на территориях радиационного загрязнения (средняя поглощенная ЩЖ доза 1.6 Гр, инкорпорация Cs-137 в среднем 11.5+0.9 по сравнению с 1.2+0.2 кБк/организм в контроле). В контрольной группе у детей с минимальным содержанием йода в моче (менее 20 мкг/л) было установлено наиболее высокое среднее значение уровня ТТГ (3.65 мМЕд/л), причем в группах с нарастающими концентрациями йода в моче наблюдалось последовательное снижение среднего уровня ТТГ до 2.00+0.09 мМЕд/л (при концентрации йода в моче более 100 мкг/л). У школьников из Ветковского района Гомельской области была отмечена противоположная картина: при самой низкой йодной обеспеченности было зарегистрировано и самое низкое значение ТТГ (1.70 мМЕд/л). С увеличением экскреции йода с мочой содержание ТТГ в крови у Ветковских детей-школьников несколько повышалось (2.27+0.28 мМЕд/л). По-видимому, у детей контрольной группы при недостатке йода эутиреоидное состояние достигается при помощи повышения уровня ТТГ (в рамках нормы), а в Ветковской группе этот механизм регуляции тиростатуса нарушен. Йодная обеспеченность Ветковских детей была в среднем значительно хуже, чем Браславских (медианы содержания йода в моче соответственно составляли 53.0 и 93.0 мкг/л), тем не менее средний уровень ТТГ у Ветковских детей был несколько ниже, чем у Браславских. В целом следует отметить, что у детей и подростков, постоянно проживающих на наиболее загрязненных территориях Гомельской области (Хойникский и Ветковский районы) отмечается сглаживание реакции ТТГ, как в возрастном аспекте, так и при дефиците йода.

Скрининговые гормональные исследования, проведенные у школьников Столинского района Брестской области (1995 г.), у которых дозовые нагрузки на ЩЖ (в среднем 0.32 Гр) были значительно ниже, чем у Гомельских детей (Табл. I), также выявили ряд отличий по сравнению с группой школьников из Минской области. Показано, что средний уровень ТТГ, общего и свободного Т3 достоверно ниже, а содержание общего и свободного Т4 - выше, чем в контроле. При этом не зафиксировано отличий в активности тироидтранспортных белков крови (Табл. II). Анализ показателей метаболизма выявил существенное повышение уровня малонового диальдегида и пировиноградной кислоты в крови у лиц из данной группы, а также резкое снижение устойчивости эритроцитов к перекисному гемолизу, более выраженное, чем у обследованных из Гомельской области.

Таблица I

**НЕКОТОРЫЕ ПОКАЗАТЕЛИ РАДИАЦИОННОГО ЗАГРЯЗНЕНИЯ НА
ТЕРРИТОРИЯХ ПРОЖИВАНИЯ ОБСЛЕДОВАННЫХ ДЕТЕЙ И ПОДРОСТКОВ.**

ПЛОТНОСТЬ ЗАГРЯЗНЕНИЯ ТЕРРИТОРИИ					
Область, районы		Cs 137, МБк /м ²		J131 на 10.05.86 МБк /м ²	Средняя поглощенная доза щж детей, Гр
		min-max	среднее	min-max	
ГОМЕЛЬСКАЯ	Хойникский	0.1-1.0	0.36	1.9-19.0	1.57
	Ветковский	0.2-1.0	0.64	1.9-19.0	1.60
БРЕСТСКАЯ	Столинский	0.02-0.4	0.10	0.4-1.9	0.32
ВИТЕБСКАЯ	Браславский	0.04	0.04	до 0.2	--
МИНСКАЯ	Минский	до 0.04		0.4	0.08

Таблица II

**СВЯЗЫВАЮЩАЯ АКТИВНОСТЬ ТИРОИДТРАНСПОРТНЫХ БЕЛКОВ КРОВИ У
ДЕТЕЙ И ПОДРОСТКОВ, ПРОЖИВАЮЩИХ В РАЗЛИЧНЫХ РАЙОНАХ БЕЛАРУСИ**

Группы обследованных		Связывание с Т4 в %			Связывание с Т3 в %		
		ТСГ	Ал	ПАл	ТСГ	Ал	ПАл
I	п	12	12	12	12	12	12
	X	84.5	10.49	4.98	75.49	22.7	1.51
	Sx	2.89	1.53	1.38	2.47	2.11	0.20
II	п	40	40	40	39	39	39
	X	80.07	11.68	8.20*	74.41	24.04	1.56
	Sx	1.26	0.70	0.62	1.02	0.98	0.36
III	п	67	67	67	35	35	35
	X	75.53*	13.66	10.80	74.85	23.89	1.26
	Sx	1.3	0.65	0.76	1.63	1.54	0.13

Примечание: I- Минская область (контроль), II- Брестская область, III- Гомельская область,
*-достоверные отличия от контроля при $p \leq 0.05$.

Сокращения: Ал- альбумин, ПАл- прсальбумин

**СВЯЗЫВАЮЩАЯ АКТИВНОСТЬ ТИРОИДТРАНСПОРТНЫХ БЕЛКОВ КРОВИ У
ДЕТЕЙ И ПОДРОСТКОВ, В ЗАВИСИМОСТИ ОТ ПОГЛОЩЕННЫХ ЩИТОВИДНОЙ
ЖЕЛЕЗОЙ ДОЗ РАДИОЙОДА**

Доза сГр		Связывание с Т4 в %		
		ТСГ	Альбумин	Преальбумин
Контроль Браслав	п	18	18	18
	X	77.80	13.20	9.50
	Sx	1.30	0.90	0.70
Дети отселенные из 30-км зоны	п	39	39	39
	X	61.10 *	30.20 *	7.40*
	Sx	1.30	1.20	0.60
0-100	п	9	9	9
	X	62.63*	28.35*	9.01
	Sx	1.45	1.29	1.45
101-200	п	6	6	6
	X	61.58*	32.05*	6.37*
	Sx	2.53	1.55	1.12
201-500	п	14	14	14
	X	60.81*	30.91*	7.62
	Sx	2.09	1.88	1.06
501-1000	п	6	6	6
	X	59.10*	34.97*	5.93*
	Sx	3.66	3.69	1.05
>1000	п	4	4	4
	X	71.05	21.95	7.00
	Sx	5.04	4.61	1.57

Примечание: *-достоверные отличия от контроля при $p \leq 0.05$

Исходя из результатов скрининговых исследований были сформированы предпосылки для концепции о существовании групп повышенного риска по развитию тиреоидной патологии у детей и подростков, имеющих наиболее высокие дозовые нагрузки на ЩЖ и повышенную активность инкорпорированного Cs-137. С этой точки зрения большой интерес представляло углубленное обследование детей и подростков, эвакуированные 4-6 мая 1986 г. из 30-километровой зоны Чернобыльской АЭС в Жлобинский и Буда-Кошелевский районы Гомельской области, а также лиц, постоянно проживающих на территориях Столинского района Брестской области. Было установлено, что спустя 7 лет после аварии, у детей и подростков, отселенных из 30-км зоны ЧАЭС (средняя поглощенная ЩЖ доза 5.1 Гр),

изменения в гипофизарно-тироидном статусе проявлялись в статистически достоверном повышении средних значений ТТГ, снижении среднего уровня свободной фракции Т4 при отсутствии значимых различий по сравнению с контрольной группой общих фракций Т3 и Т4. Выраженность указанных изменений определялась величинами дозы, поглощенной ЩЖ. Отмечено монотонное повышение уровня ТТГ по мере нарастания поглощенной ЩЖ дозы от 1.43 ± 0.16 (дозы до 2.0 Гр) до 2.96 ± 0.19 мкЕд/мл (дозы более 10.0 Гр). Средние значения общих фракций тироидных гормонов не зависели от дозовых нагрузок на ЩЖ. Содержание свободной фракции Т4 с увеличением дозы более 5.0 Гр имело тенденцию к снижению ($0.05 < p < 0.01$), а при дозе более 10.0 Гр было достоверно снижено по сравнению с контролем (8.20 ± 0.89 против 16.23 ± 0.37 пмоль/л, $p < 0.05$). Таким образом, при дозовых нагрузках на щж более 10.0 Гр наблюдается состояние скрытого гипотироза когда на фоне резко сниженного, по сравнению с нормой уровня свободного Т4, сохраняется относительно нормальный средний уровень ТТГ

У детей с дозовыми нагрузками на ЩЖ от 0 до 5.0 Гр было проведено изучение активности тироксинтранспортных белков крови (Табл. III). Сравнение средних величин выявило существенные отличия, которые проявлялись, главным образом, в достоверном снижении связывания Т4 с ТСГ и перераспределении гормона на альбуминовую фракцию крови. Анализ дозовой зависимости показал снижение связывающей активности ТСГ в интервале доз от 0-0.1 до 0.5-1.0 Гр. При более высоких дозовых нагрузках наблюдался резкий скачок в сторону увеличения связывания. Характер сдвигов связывающей активности альбумина был прямо противоположен ТСГ.

С увеличением поглощенной ЩЖ дозы радиоактивного йода регистрировалось последовательное снижение активности ферментов антиоксидантной защиты. Так, если активность супероксиддисмутазы у лиц с дозой от 2.0 до 5.0 Гр составляла в среднем 20.68 ± 1.12 мкг/мл, то в интервале доз от 5.0 до 10.0 - 18.48 ± 1.32 мкг/мл, а у детей и подростков с дозой более 10.0 Гр она снижалась до 17.38 ± 1.86 мкг/мл, что было достоверно меньше контрольных значений (42.28 ± 1.14 мкг/мл) и ее уровня у лиц с дозами до 1.0 Гр (26.31 ± 2.52 мкг/мл). Аналогичные тенденции отмечались и в активности глутатионпероксидазы.

Характер изменений в гипофизарно-тироидной системе и метаболизме у детей и подростков с высокой инкорпорацией радионуклидов цезия (715.6 ± 52.43 Бк/кг), постоянно проживающих в условиях хронического воздействия малых доз радиации (д. Ольманы Столинского района) был иным. Изменения в содержании ТТГ по сравнению с контролем не были статистически значимыми. При снижении как общей, так и свободной фракции Т4 содержание Т3 у лиц данной группы достоверно превышало таковое в контроле, что, вероятно, было обусловлено усиленной периферической конверсией тироксина. Изменения показателей, характеризующих функциональное состояние ЩЖ, зависели от уровня удельной активности радионуклидов цезия в организме. При возрастании уровня удельной активности Cs-137 от 500 Бк/кг до 1500 Бк/кг и более отмечалось последовательное, достоверное по сравнению с контролем снижение содержания свободного Т4 и повышение Т3 при практически неизменных значениях ТТГ. При уровне активности цезия в организме более 1000 Бк/кг нарастало содержание ТТГ и его наибольшие значения (35.55 ± 4.15 нг/мл) регистрировались у обследованных с активностью радиоцезия в интервале от 500 до 1500 Бк/кг.

При повышении инкорпорации радионуклидов цезия нарастала интенсивность липидной пероксидации, о чем свидетельствовал достоверно высокий по сравнению с контролем уровень малонового диальдегида во всех дозовых подгруппах. (от 100 до 1500 Бк/кг и более). Регистрировалось последовательное снижение активности глутатионпероксидазы. Вышеописанные изменения сочетались с повышением содержания молочной и пировиноградной кислот в крови. При повторном обследовании (через год) выраженность выявленных изменений метаболизма возросла.

Таким образом, у детей и подростков, подвергшихся радиационному воздействию в результате аварии на ЧАЭС, выявлены изменения функциональной активности ЩЖ, механизмов регуляции тиростатуса, как на центральном, так и на периферическом уровнях, сопряженные с изменениями окислительного метаболизма. Характер изменений определялся особенностями сочетания радиационных факторов и их интенсивностью.

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ANALYSIS OF METHODS AND RECONSTRUCTION OF IODINE DOSES FROM THE CHERNOBYL RELEASE IN BELARUS



XA9745450

A.M. LUTSKO, K.A. KRIVORUCHKO
International Sakharov College of Radioecology,
Minsk, Belarus

INTRODUCTION

The radiation induced pathology of the thyroid gland comprising specifically the cancer cases in children are currently recognized to be the only indisputable health after-effect of the Chernobyl accident [1-3]. The iodine prophylactics took place neither in Belarus nor in the Ukraine or was effected only too late. Thus with rather full case registers available there is a unique possibility to determine the radiation risk coefficients for NPP large-scale accidents at least for the pathology mentioned above. For the measuring equipment being regrettably inadequate to the scale of the radiation exposure in the early (or so called iodine) phase of the accident, the detailed information on the spreading of the iodine nuclides and the doses to thyroid gland has been irretrievably lost.

There are a number of approaches exercised to the reconstruction of iodine release and fall-outs which are mainly based on the isotopic ratio. In [4] the correlation has been established empirically between the cesium and iodine fall-outs:

$$a(^{131}\text{I}) = 3,77[a(^{137}\text{Cs}) - a_0(^{137}\text{Cs})]^{0,847},$$

where a - the surface activities expressed in $\text{Ci}\cdot\text{km}^{-2}$ ($1 \text{ Ci}\cdot\text{km}^{-2} = 37 \text{ kBq}\cdot\text{m}^{-2}$) as for May 15, 1986; $a_0 = 0,057 \text{ Ci}\cdot\text{km}^{-2}$ - a pre-accident level of ^{137}Cs global fall-outs.

In [5] the attempt has been made to build up a map of contamination across Belarus as for the 10th of May, 1986 using the above expression along with the results of the aero-gamma survey performed in the middle of May 1986, and also the milk contamination maps available for the same period.

The limitations of this particular approach, though none of them is expected to restore the maps of the iodine spatial spreading with the absolute accuracy, can be brought to the following. Fume temperatures, chemical properties as well as the natural behaviour of cesium and iodine differ to a considerable extend. Thus it is of no surprise that the expression given above describes the iodine fall-outs only for a certain part of the eastern trace, and consequently it appears to be inapplicable for most cases [4]. In this context the aero-gamma survey done three weeks later after the start-up of the release and applying its results to a short-living isotope can be treated merely as an additional information. As for the milk contamination maps they present data for the integrated activity obtained through a scarce network of radiometric sites which failed to be arranged timely.

The method of the iodine isotopic ratio seemed to be a promising one. However among 24 well known isotopes there are only three with their half-lives T longer then that of ^{131}I - ^{125}I (60.2 days), ^{126}I (12.8 days) and ^{129}I ($1.7 \cdot 10^7$ years). On commencing the reconstruction the first two had already decayed long ago. As for iodine-129 it is known [6] that by the time of the accident the $^{129}\text{I}/^{131}\text{I}$ ratio in the active core accounted to $\sim 2.5 \cdot 10^{-8}$. With the allowance made for the ratio along with the nature of radiation emitted by the isotope it offers no difficulty to arrive to a conclusion that the potentialities of the most sensitive modern analysis methods (built upon using enriched soil samples) will enable to determine only the high activity fall-outs of ^{131}I [5,7] which could hardly take place even in the vicinity of the reactor site. However major doubts arise in connection with the extreme mobility of the element: it is unlikely that a couple of years later the distribution will follow the release pattern of the early period.

METHODOLOGY

The present paper suggests a method for the dose reconstruction that differs from those mentioned above and is based on experimental dosimetric exposure measurements. The choice of the initial values of an exposure dose can be justified with the following arguments to be brought forward: in Belarus in the pre-accident time there existed the network of meteorological stations equipped with the accredited standard dosimeters ДП-5 which could start regular measurements immediately after the accident, and also the station for background monitoring, established in the National Reserve of Beryozinsk in the 60s for the purpose of registering the global fall-outs resulted from the test explosions. The early information on the exposure dose rate started to arrive at 9 a.m. April 26. Next day more frequent measurements were initiated in the South of the country; on April 28 the measurement data were being registered at all the meteorological sites available in Belarus with a three hour interval (Fig.1).

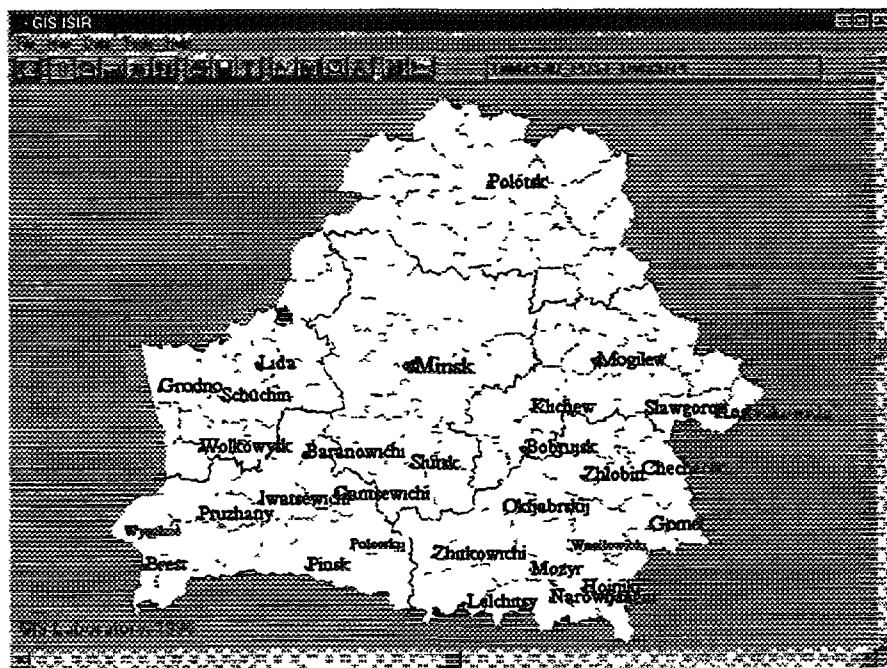


Fig.1. The Hydrometeorological Service station network in the territory of Belarus in 1986.

Hence the data base of comparable data for the whole country is available. Scarce as they are, these measuring sites nevertheless provide the most reliable data due to the simplicity of measuring equipment used and also describe the relative changes in the gamma background registered from the very rise of the accident. Daily observation data have been simulated by the following function:

$$\hat{D}(t) = B + S \times \sum_{i=0}^{\min(9, t-1)} \left[p_i \frac{\ln 2}{T_i} e^{-\frac{\ln 2}{T_i}(t-i)} + (c_i - p_i) \frac{\ln 2}{T_x} e^{-\frac{\ln 2}{T_x}(t-i)} \right],$$

where $\hat{D}(t)$ - the calculated exposure dose rate, B - a value to be calculated that corresponds to a long-living component (cesium isotopes , mainly) in the period under consideration; S - a constant to be calculated, c_i and p_i - per diem releases for all radionuclides and ^{131}I during April 26 -May 5, 1986 according to [9], respectfully, T_i and T_x - the ^{131}I half-life and the integrated component to be calculated of the isotopes with a half-life shorter that of ^{131}I ; t - the time passed from the very outset of the accident, days

The values B , S , T_x have been determined by minimizing the function, $\frac{1}{n} \sum_{t=1}^n (\hat{D}(t) - D(t))^2$,

where $D(t)$ - the data observed at the sites at the day t after the start of the accident. In so doing the model has been chosen that permits, with allowance made for the nature of release, the values for the three components of an exposure dose to be determined through short- and long-living γ -emitters and ^{131}I radiation.

In the initial phase the into-deepening of the radionuclide fall-out on the surface can be neglected, and the conversion coefficients will not be affected by the specific properties of soils. In this case the universal conversion coefficients can be applied for ^{131}I . The values for the ^{131}I surface contamination are obtained for a singled-out iodine calculated component by using the transition coefficient $k_a = 3.6 \cdot 10^{-16} \text{ (Sv/c)/(Bq/m}^2\text{)}$ [9]. Fig. 2 shows the example of calculation made for the ^{131}I surface contamination for several settlements in Belarus. As is seen from Table I there is an adequate agreement between the direct measurements and the results of this calculation for the early days of the accident.

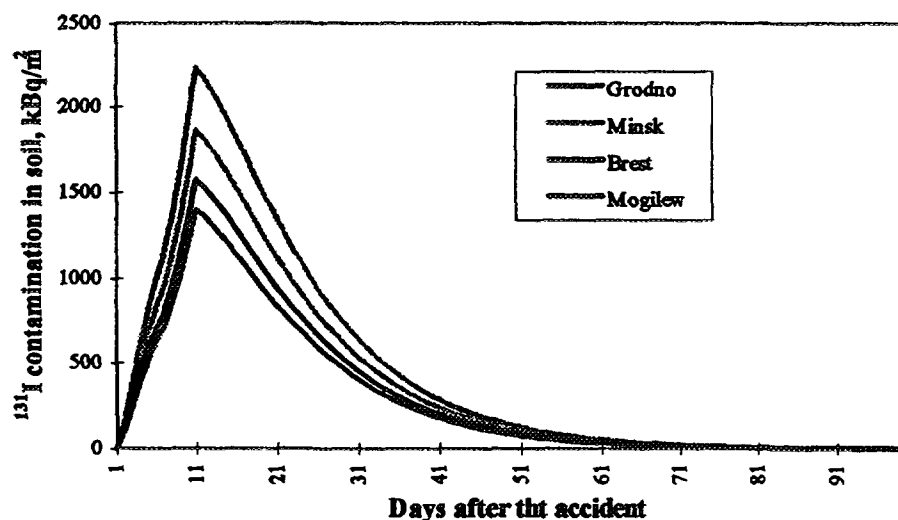


Fig.2. An example of calculation made for ^{131}I soil contamination in several cities in Belarus.

Table I. Direct measurements of ^{131}I fall-out [5] and the results of calculation during the early days after the accident

City	Date	Data, $\text{kBq}\cdot\text{m}^{-2}$	Calculation, $\text{kBq}\cdot\text{m}^{-2}$
Pinsk	27-28.04.86	740	600
Brest	27-28.04.86	110	117
Gomel	28-29.04.86	2450	2677
Baranovichi	28-29.04.86	150	141
Grodni	27.04.86	260	277

Unfortunately the experimental measurement data on the ^{131}I fall-out in succeeding days are not available and the comparison can be made only with the results on the dose reconstruction [5,6] as of May 10, 1986 (Fig.3) A fairly adequate agreement of data is observed for 14 out of 30 settlements located both in the zone adjacent to Chernobyl NPP (Mozyr, Chechersk, Pinsk) and the remote one (Lida, Mogilev). At the same time our calculations show big cities like Minsk and Brest having the iodine fall-out of an order of magnitude higher.

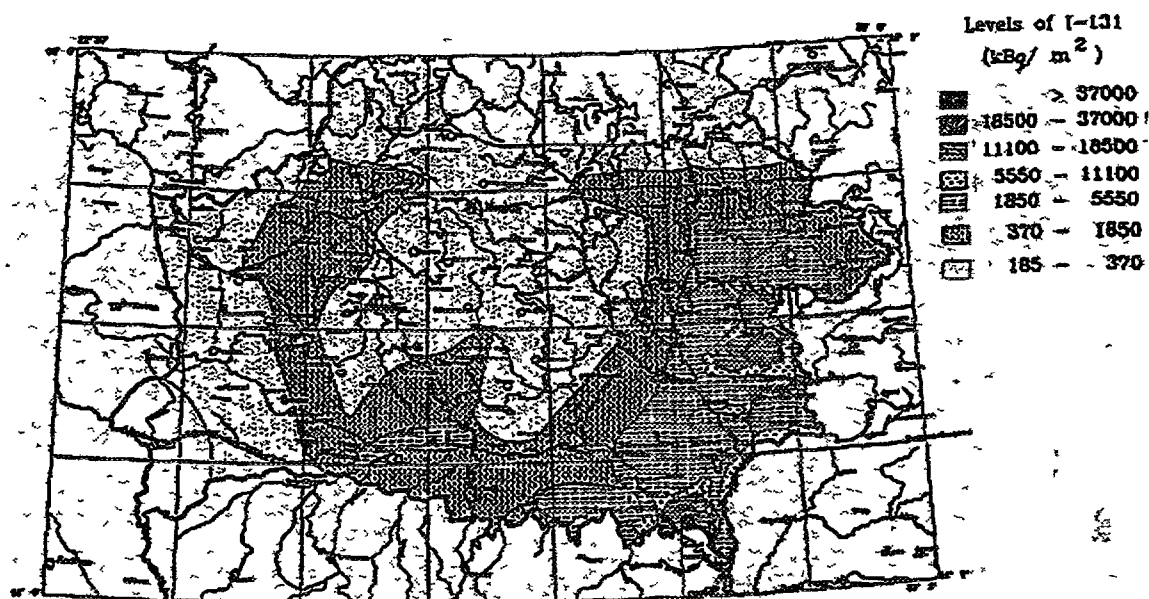


Fig.3. The ^{131}I contamination of soil in the territory of Belarus as for May 10, 1986 (Reconstruction made by the State Belgidrometeorological Service).

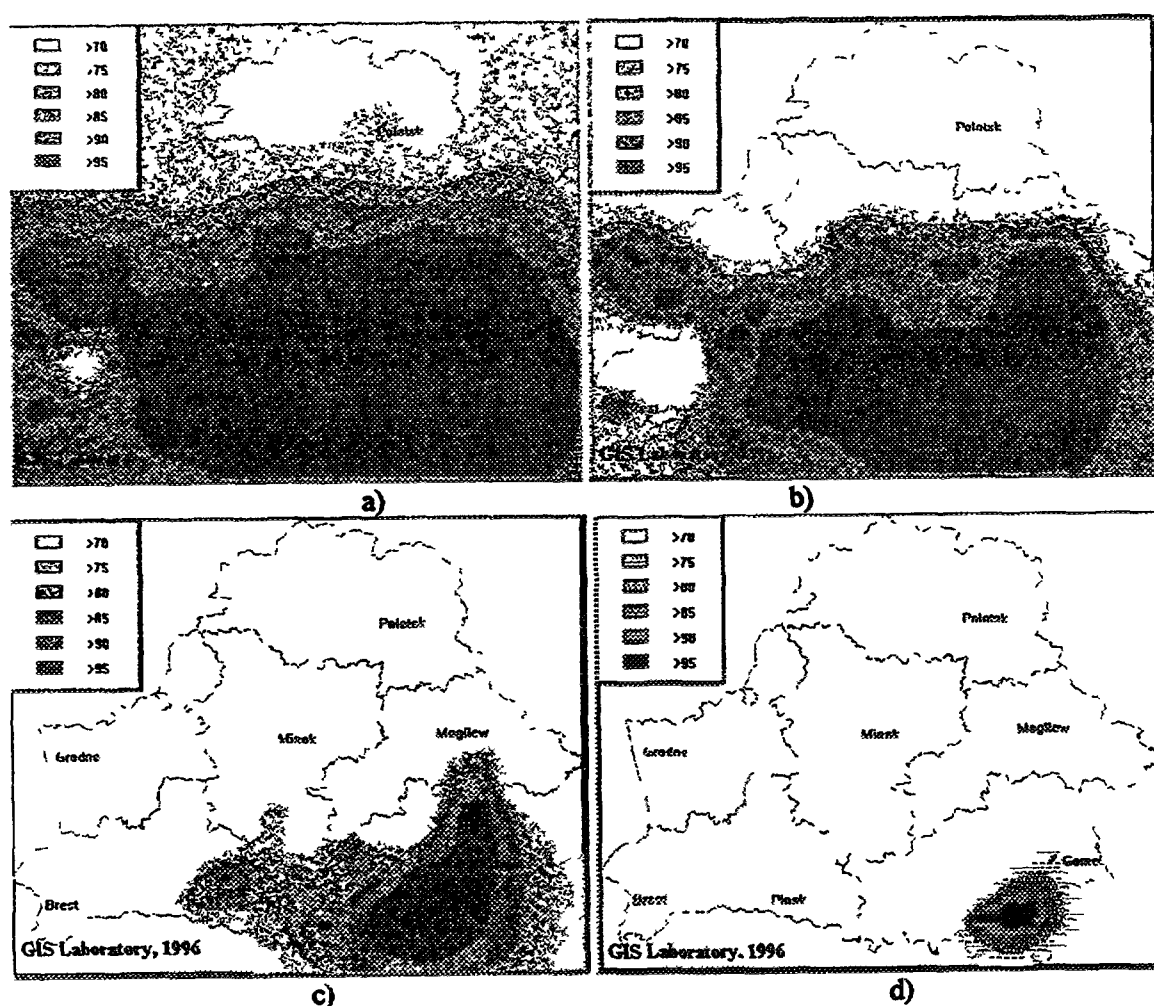


Fig.4. Probabilistic simulation of the ^{131}I soil contamination across the territory of Belarus as of May 10, 1986 - the exceeds in the surface contamination for the levels of 185(a), 370(b), 1850 (c) and 5550(d) kBq·m⁻², respectively.

RESULTS

Three different techniques of spacial data interpolation have been used for mapping the iodine fall-out in the period of May 1-31, 1986. The trend surface analysis based on the polynomial regression [10] as well as the method based on the Voronoi map, which merges geometrical problems and graph theoretical solutions [11] have not provided adequate results because of a scarce number of experimental observation sites. It was the reason of applying the analysis based on a geostatistical approach [12] with a special software developed to that end. The main idea of the predictive statistics resides in classifying any non-measured value of z as a random variable Z , the probability density of which can define the uncertainty around z . This approach enables one to obtain the interpolation maps as well as to build up the probability maps of the exceed over a given level on the base of the spacial uncertainty for the values predicted. Fig. 4 presents the results of the probabilistic simulation of the ^{131}I soil contamination across the territory of Belarus as of May 10, 1986 - the exceeds in the surface contamination for the levels of 185, 370, 1850 and 5550 $\text{kBq}\cdot\text{m}^{-2}$, respectively.

Fig.5 presents the result of simulation of the map for the ^{131}I surface contamination in soil in the territory of Belarus as for May 10, 1986 (probability evaluation - 75%).

The maps shown in Fig.4 and 5 have been built by using the exponential anisotropic model.

For the reconstructed iodine component of the exposure dose rate the external and internal exposure doses to thyroid gland have been determined. The per diem external doses D_{ext} are calculated from the equation:

$$D_{\text{ext}} (\text{mSv}) = k_1 \cdot k_2 \cdot k_3 \cdot F \cdot P,$$

where $k_1 = 0,0087$ - the conversion factor from an exposure dose to an absorbed dose in the air, $\text{Gr}\cdot\text{R}^{-1}$; $k_2 = 0,7$ - the conversion factor from the effective dose in the body of an adult individual; $\text{Sv}\cdot\text{Gr}^{-1}$; $k_3 = 24$ - twenty-four hours; $F = (0,24 - 0,41)$ - the shielding factor for various types of settlements; P - the exposure dose rate due to the iodine contribution.

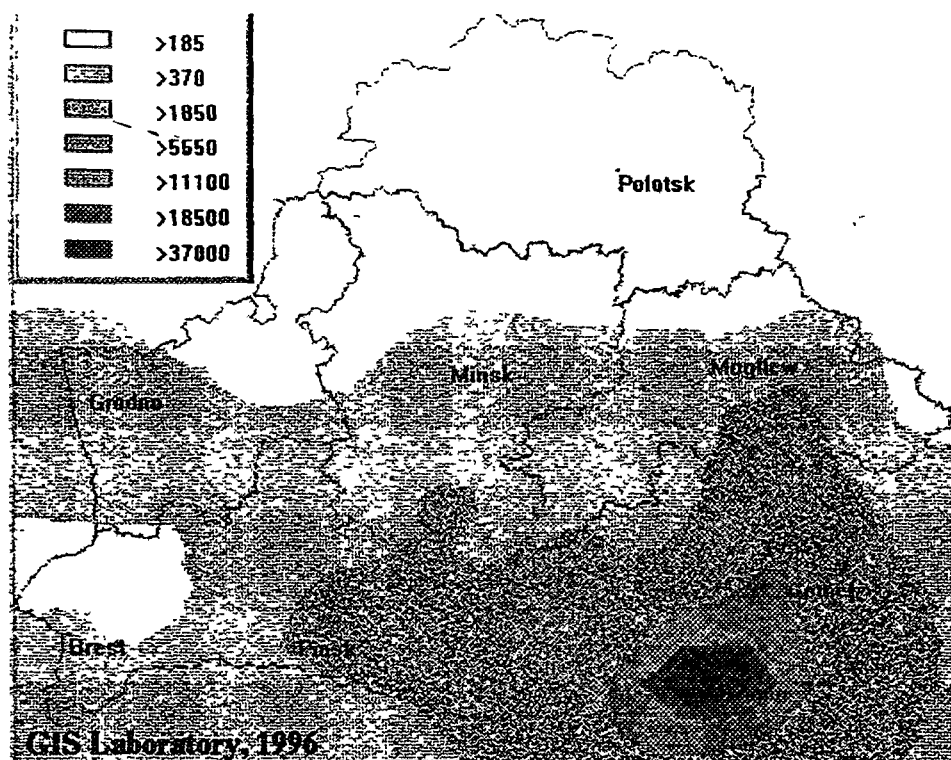


Fig.5. Simulating the map of the ^{131}I surface contamination in soil in the territory of Belarus as for May 10, 1986 (probability evaluation - 75%).

Table II. Doses to the thyroid gland for several settlements.

City	External Dose, mSv	Internal Dose, mSv	Cumulative Dose, mSv
Bragin	29.500	10727.6	10757.1
Brest	0.012	137.7	137.7
Gomel	0.611	846.6	847.2
Grodno	0.012	195.8	195.8
Khoyniki	21.901	8136.0	8157.9
Minsk	0.012	163.8	163.8
Mogilev	0.011	121.8	121.8
Pinsk	0.012	303.2	303.2
Polotsk	0.013	29.9	29.9

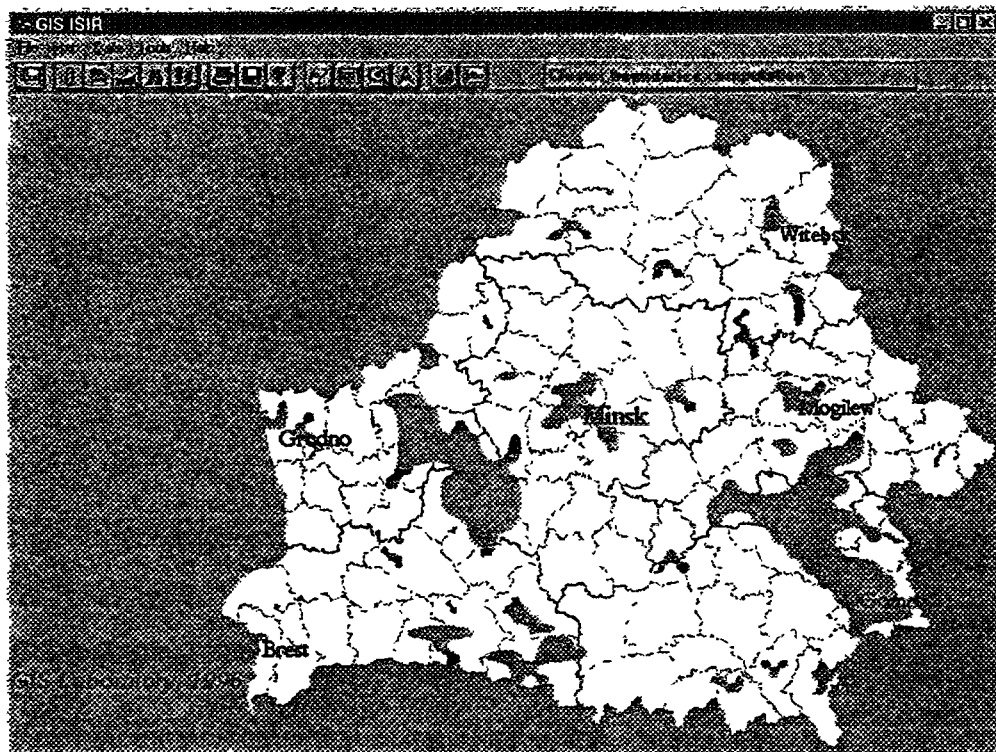


Fig.6. Increased incidence of the thyroid gland cancer among the population of Belarus after the accident.

The internal exposure doses to thyroid gland from ^{131}I , received through the surface contamination-cow-milk chain (on assuming that the population does not migrate and keeps to a local food diet) are derived from:

$$D_{\text{int}} = a_{\text{int}} k' k'',$$

where a_{int} - ^{131}I per diem fall-outs, Bq m^{-2} ; $k' = 1.3 \text{ m}^2$ - the conversion ratio in a human body through milk; $k'' = 5.1 \cdot 10^{-7} \text{ Sv Bq}^{-1}$ - the conversion ratio from the ^{131}I activity to the dose absorbed in thyroid gland. For calculating the accumulated dose to thyroid gland the consideration was made for the biological half-life of 7.6 days.

Table II presents the dose contributions and the cumulative dose commitment to the organ in the result of the iodine exposure for several settlements located at various distances from the Chernobyl NPP; the latter being integrated over a three month period after the accident.

Finally it is of importance to compare the results obtained for the dose load spacial reconstruction of the iodine phase with the distribution of the thyroid gland cancer cases. To this end maps of the increased incidence (covering the period from May 1986 to January 1994) have been built for both the adult (over 3000 cases) and the children population register (330 cases) by the method based on the minimum spanning tree [13]. Fig. 6 illustrates the mapping for the thyroid gland cancer in adults.

As is seen, the map (Fig.5) we have built includes all the clusters available on the increased thyroid gland cancer incidence.

CONCLUSION

Though this work is currently in progress we feel that the approach proposed for reconstructing the doses of the iodine phase with using the GIS-technology tools is rather promising as it can provide the results which will not contradict the observed spreading of the thyroid gland pathologies and also offer a reliable estimation of the risk coefficients for the case being considered as well as that of the cumulative dose for the initial period of the accident.

Acknowledgments

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PATHOGENIC ASPECTS OF FUNCTIONAL DISORDERS OF THE THYROID GLAND IN CHERNOBYL LIQUIDATORS

E.L. STRUKOV, L.B. DRYGINA, A.M. NIKIFOROV
All-Russian Centre of Ecological Medicine,
St. Petersburg, Russian Federation



XA9745451

360 male participants of the Chernobyl accident recovery workers (liquidators) (group 1) have been studied in 1994-95 under clinical and laboratory screening and 504 male liquidators (group 2) aged from 30 up to 55 years old have been examined in 1991-93. All patients have been staying on the territories contraminated by radionuclides within period from May 1986 up to May 1987.

Those persons had the dose of outer irradiation from 2 to 30 cGy, but some of them not examined.

The quantitative definition of thyroxine (T_4), triiodothyronine (T_3), thyroid stimulating hormone (TSH) and prolactin in blood serum of the patients was carried out by the method of enzymeassay analysis (EIA), in group 2 by radioimmunological method (RIA) without prolactin definition.

The liquidators before the medical examination did not take any pharmacological treatment and there were not any evident clinical conditions which influence the concentration of hormones under investigation.

Syndrome of "low T_3 " among liquidators included in group 2 was detected in 39 patients (i.e. 7.7%) and in group 1 - in 94 patients (i.e. 26.1%). Increased TSH level enable us to diagnose subclinical hypothyroidism in 8 (i.e. 1.6%) patients involved in group 2 and in group 1 - in 40 (i.e. 11.1%).

Functional thyroid pathology frequency growth in liquidators could be explained by the different time exposition and finishing a latent period for endocrinopathies manifestation.

Thyrotropin-releasing hormone (TRH) is known to be the stimulant of both TSH and prolactin secretion. Hyperprolactinemia (the average level 803.7 ± 37.6 mU/l) was revealed in 27 (i.e. 16.4%) of 165 liquidators. The investigation of hyperprolactinemia part in hormonal screening of thyroid pathology is important because prolactin is a mammalian mitogen, tumor promoter and immunodepressor.

Thus, the results of the investigation point out that risk (pathogenetic negative) groups with the rapid manifestation of thyroid pathology should include liquidators with "low T_3 " and hyperprolactinemic syndromes.

1. ВВЕДЕНИЕ

Несмотря на долгую историю изучения, проблема ранней и рациональной диагностики дисфункций и заболеваний щитовидной железы остается актуальной.

Известно, что процентный вклад коротко-, средне-, и долгоживущих изотопов в общем спектре загрязнения вследствие аварии на ЧАЭС составил соответственно 23 - 30; 51 - 62.1 и 6.2-19.8% и практически не зависел от расстояния от места аварии [1].

Таким образом, вклад изотопов йода - 132, - 133, - 135 (короткоживущих), йода - 131 (среднеживущего) обозначил особую значимость изучения функции щитовидной железы у пострадавших, в том числе, и у ликвидаторов последствий аварии (ЛПА) на ЧАЭС [2].

2. МАТЕРИАЛЫ И МЕТОДЫ

В условиях клинико-лабораторного эндокринологического скрининга в 1994-1995 гг обследовано 360 мужчин - участников ликвидации последствий аварии (ЛПА) (группа

1) на ЧАЭС, а в 1991-1993 гг - 504 мужчин-ликвидаторов (группа 2) в возрасте от 30 до 55 лет. Все обследованные находились на загрязненных радионуклидами территориях в период с мая 1986 г. по май 1987 г., т.е. после ЛПА к моменту обследования прошло 7-8 лет (группа 1) и 5-7 лет (группа 2).

Доза внешнего облучения у этих лиц колебалась от 2 до 30 сГр, но у части пациентов в документах не зафиксирована и им неизвестна.

В группе 1 количественное определение тироксина (T_4), трийодтиронина (T_3), тиреотропного гормона (ТТГ) и пролактина в сыворотке крови пациентов проводили методом иммуноферментного анализа, а в группе 2 - радиоиммунологическими методами (в группе 2 определение пролактина не проводили).

Обследуемые не получали фармакологических препаратов и не имели клинически выраженных состояний, влияющих на концентрации исследуемых гормонов.

Ликвидаторы, обследованные в 1994-95 гг (1 группа) были подразделены на 5 подгрупп по отношению к величинам базальных значений T_3 и ТТГ в сыворотке крови. Первые три подгруппы составили лица с нормальным содержанием ТТГ в крови (см. табл. I, II).

3. РЕЗУЛЬТАТЫ И ИХ ОБСУЖДЕНИЕ

Как видно из таблицы I, наиболее часто у ЛПА из группы 1 отмечено снижение концентрации T_3 в периферической крови.

Таблица I

Средняя концентрация ($M \pm m$) T_4 , ТТГ и пролактина у эутиреоидных ЛПА на ЧАЭС в зависимости от уровня T_3

Подгруппа 1	Исследуемый гормон, единицы измерения			
	T_3 , нг/мл ^a	T_4 , нг/мл	ТТГ, мЕД/л	Пролактин, мЕД/л ^{b,c}
1 (52)	0.61 ± 0.03	75.8 ± 6.2	1.49 ± 0.13	336.1 ± 31.6
2 (42)	0.80 ± 0.00	83.8 ± 6.2	1.44 ± 0.17	556.3 ± 102.1
3 (226)	1.16 ± 0.04	82.1 ± 2.2	1.53 ± 0.09	441.9 ± 42.0

^a различия между всеми подгруппами достоверны $p < 0.001$

^b различия между подгруппами 1-2, 1-3 достоверны $p < 0.05$

^c в скобках указано число обследованных, уровень пролактинемии в 1 подгруппе определяли у 27, в подгруппе 2 - у 26 и в подгруппе 3 - у 94 человек.

Частота выявления синдрома "низкого T_3 " среди обследованных ликвидаторов группы 1 достигла 26.1%.

Необходимо отметить, что синдром "низкого T_3 " у ЛПА может быть следствием как соматогенно- и ятрогенно- обусловленных, так и экологически (возможно и радиоиндуцированных) воздействий, так как показано присутствие энзимов, участвующих в периферической конверсии тиреоидных гормонов во многих тканях организма [3]. Вместе с тем у ликвидаторов, представленных подгруппами 1-3, изменение уровня T_3 в периферической крови не сопровождалось значимыми изменениями средних концентраций как ТТГ, так и T_4 (таблица I).

При клиническом наблюдении оказалось, что синдром "низкого T_3 ", выявленный у ЛПА при поступлении, сопутствовал осложненному течению заболеваний сердечно-сосудистой и пищеварительной систем. Известно, что многие болезни сопровождаются отклонениями от нормальных величин в сторону преимущественного снижения уровня тиреоидных гормонов.

Как видно из таблицы II, у 40 (11.1%) обследованных ЛПА 1 группы по величинам ТТГ был выявлен субклинический гипотиреоз.

Таблица II

Средние концентрации $M \pm m$ T_4 и пролактина у гипотиреоидных по уровню ТТГ ЛПА на ЧАЭС в зависимости от уровня T_3

Подгруппа	Исследуемый гормон, единицы измерения			
	T_3 , нг/мл ^a	T_4 , нг/мл	ТТГ, мЕД/л	Пролактин мЕД/л ^b
4 (11)	0.67 ± 0.05	68.0 ± 8.1	6.06 ± 1.32	352.3 ± 47.3
5 (29)	1.21 ± 0.07	77.9 ± 6.9	5.11 ± 0.67	387.5 ± 31.5

^a различия между подгруппами 4-5 достоверны $p < 0.05$

^b в скобках указано число обследованных лиц, уровень пролактина исследован у 8 мужчин подгруппы 4 и у 10 - подгруппы 5.

Синдром "низкого T_3 " среди ЛПА группы 2 был выявлен у 39 человек (7.7%), а латентный гипотиреоз - у 8 человек (1.6%).

Нарастание частоты выявления функциональной патологии щитовидной железы у ликвидаторов может объясняться различной временной экспозицией после аварии, истощением латентного периода для проявления эндокринопатий.

Несмотря на достоверные различия в концентрации T_3 в подгруппах 4 и 5, средние концентрации ТТГ в этих подгруппах не различались. Если в подгруппе 4 снижение уровня T_3 вызвало адекватную ответную реакцию ТТГ и у пациентов наблюдался первичный латентный гипотиреоз, то в подгруппе 5 наблюдалось нарушение механизма отрицательной обратной связи T_3 - ТТГ, что может приводить к возникновению автономных тенденций в системе гипофиз-щитовидная железа. Повышенный уровень ТТГ создает условия для пролиферации клеток фолликулярного эпителия.

При анализе уровня пролактинемии в зависимости от концентрации T_3 (таблица I и II) выявлено, что при эутиреоидном синдроме "низкого T_3 " концентрация пролактина была существенно ниже, чем при нормальных концентрациях T_3 в крови.

Согласно большинству исследований, снижение уровня периферических тиреоидных гормонов может быть причиной гиперпролактинемии по принципу отрицательной обратной связи, учитывая, что стимулятором секреции как ТТГ, так и пролактина является тиреотропинрилизинг- гормон. Исходя из вышеизложенного, можно считать, что выявленная тенденция "более низкий T_3 - более низкий пролактин" у части ЛПА является парадоксальной.

Необходимо отметить, что средние базальные уровни пролактинемии, выявленные нами у ЛПА, достоверно более высокие, чем средние концентрации пролактина, полученные при популяционном гормональном исследовании здоровых мужчин Ленинграда 1986-1987 гг.

Нами установлено, что среди ликвидаторов, страдающих сердечно-сосудистыми заболеваниями, наблюдается достоверная тенденция к относительному гипоинсулинизму и гиперпролактинемии по сравнению с аналогичным по нозологии и возрасту, а также здоровым контролем [4].

Известно, что инсулин является стимулятором гипофизарной секреции и, возможно, редкая частота повышения ТТГ у мужчин-ликвидаторов может быть связана как с относительным гипоинсулинизмом, так и с особенностями гипоталамо-гипофизарной регуляции, приводящей только к стимуляции лактотропной, а не тиреотропной функции гипофиза.

Изучение роли гиперпролактинемии при гормональном скрининге патологии щитовидной железы важно не только вследствие общих регуляторных гипоталамических механизмов для ТТГ и пролактина. Высказывается также мнение о том, что пролактин у млекопитающих является митогеном и опухолевым промотором [5], а также обладает иммуносупрессивным действием [6].

4. ЗАКЛЮЧЕНИЕ

Проведенные исследования показывают, что гормональный скрининг позволяет выявить некоторые патологические синдромы дисфункций щитовидной железы, которые могут предрасполагать к развитию гиперплазии или гипертрофии ткани щитовидной железы, то есть тех состояний, на раннее выявление которых и должен быть направлен, по нашему мнению, скрининг тиреоидной патологии у ЛПА.

Выявление синдрома "низкого Т₃" и гиперпролактинемии у ЛПА являются, с нашей точки зрения, патогенетически неблагоприятными и эти состояния способствуют быстрому клиническому манифестированию тиреоидной патологии.

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DOSIMETRIC ESTIMATION OF CHILDHOOD THYROID CANCER CASES IN RUSSIA AFTER THE CHERNOBYL ACCIDENT



XA9745452

A.F. TSYB

Medical Radiological Research Center (RAMS),
Obninsk, Russian Federation

E.M. PARSHKOV, V.F. STEPANENKO

Medical Radiological Research Centre, Academy of Medical Sciences,
Obninsk, Russian Federation

The results of direct measurement of radioactive iodine contents in thyroid gland were used for development of a method for reconstruction of doses of radiation to thyroid gland in cases when the measurements were not performed in 1986. With this purpose, published results on absorbed dose evaluations based upon direct measurement of iodine-131 in thyroid gland in 31,000 inhabitants of Kaluga, Bryansk and Tula Regions in Russia, and in 130,000 inhabitants of Gomel and Mogilev Regions in Belarus were analyzed.

A model was developed allowing to obtain a retrospective evaluation of doses of radiation to thyroid gland, both individual and mean values for a settlement. Mean dose values to exposed population of each Russian settlement where the density of soil contamination with cesium-137 exceeded $0,1 \text{ Ci/km}^2$ ($3,7 \times 10^9 \text{ Bq/km}^2$) using the model were evaluated. The collective dose from internal exposure of thyroid gland to iodine radionuclides equals to 234 thousand person-Grays for the population (3,674,000 persons) of contaminated territories of 7 Russian regions (Bryansk, Tula, Kaluga, Orel, Ryazan', Kursk and Leningrad). It may result in about 700 cases of radiation induced thyroid gland cancers during the period of entire life after the irradiation. Maximum values of collective doses are found to be in Bryansk and Tula Regions, where about 280 and 270 cases (respectively) of radiation induced thyroid gland cancers should be expected. The main part of the predicted cases of the thyroid gland cancers should be expected in those persons who were children or adolescents in April and May 1986.

The linear dependence was found between the dose of radiation to thyroid gland and the frequency of thyroid gland cancers revealed up to the end of 1994 in children and adolescents in Bryansk Region.

The retrospective evaluations of individual doses of radiation to thyroid gland were made in 30 out of 56 children

and adolescents (the age at the moment of exposure) with the established diagnosis of thyroid gland cancer, who had resided in the contaminated territories of Bryansk Region in May and June 1986. In 14 cases out of 30 (47 %) the most

probable values of individual doses were found to be between 200 mGy and 2,700 mGy, while in the rest 53 % cases the most probable individual dose values were of 50 mGy or less. It is worthy to note that typical distribution of individual doses in total population of children residing in the contaminated territories, but without cancer of thyroid gland, is different in character: in the majority of children doses of radiation (below 200 mGy) are relatively low and only in the minor part of them the doses exceeded 200 mGy.

At present, the work is being performed to further retrospectively evaluate doses of radiation to thyroid gland in persons with established abnormalities of the gland.



PRINCIPLES OF THE STRUCTURE-METABOLISM MODEL FOR CALCULATING THE INTERNAL EXPOSURE OF THYROID IRRADIATED BY IODINE RADIOISOTOPES

K.I. GORDEEV, A.V. GORDEEV, L.A. ILYIN, A.N. LEBEDEV, M.N. SAVKIN
Biophysics Institute (Russian Federation State Science Centre),
Moscow, Russian Federation

Modification to the traditional model for calculation of internal doses of human thyroid exposure is suggested. The modification is based on using autoradiographic data on spatial distribution of some iodine radioisotopes incorporated into thyroid cellular structures of test animals, the data having been obtained by Dr. Yuri A. Classovsky.

It's supposed, that during thyroid irradiation the radiological effect is defined not by "average dose for organ" but by "dose for parenchyma".

In new dose model it's suggested to consider two periods of iodine radioisotope metabolism in thyroid:

- (1) iodine transportation into follicular colloid;
- (2) iodine concentration in follicular colloid.

Duration of iodine radioisotopes transportation through parenchyma till maximum accumulation in colloid may be evaluated by 24 hours. At this period the main share of energy emission in thyroid (more then 85%) occurs for short-lived iodine radioisotopes - ^{132}I , ^{134}I , ^{135}I , about half of energy emission for ^{133}I and only ~ 10% for ^{131}I . The distribution of iodine radioisotopes in thyroid structure (colloid, parenchyma) may be considered uniform as average for this period. The uniform distribution causes uniform structure irradiation and, consequently, dose for parenchyma may be characterized by average dose for organ.

Second period is characterized by nonuniform distribution of iodine radioisotopes. This causes microgradients of dose field in thyroid structure. Doses are higher in colloid, where iodine radioisotopes concentrate, then in parenchyma. I.e., average dose for parenchyma is less then average dose for organ in second period. Nonuniformity of dose field and dose reduction for parenchyma as comparison with average dose for organ are depended on iodine radioisotope physics characters and on thyroid structure-anatomical parameters determined particularly by age.

Numeric values of dose coefficients for relative effectiveness of iodine radioisotopes with mass numbers of 132, 133, 134 and 135 as compared to iodine-131 incorporated into human thyroid have been determined.

Based on the obtained dose coefficients of relative effectiveness of some iodine radioisotopes as well as on the data obtained after a real nuclear explosion a comparative spatial-and-temporal investigation of probable thyroid irradiation doses for children and

adults under conditions of inhalation and ingestion activity intake by human body has been carried out, the exposure dose rates being calculated using both the traditional model and the improved model.

A similar analysis of anticipated thyroid exposure at different periods for a hypothetical large-scale radiation accident when the population can be affected by the radioactive fallout during a relatively long period of time has been provided.

STUDY OF THYROID DISORDERS IN TWO LITHUANIAN REGIONS WITH DIFFERENT DEGREES OF EXPOSURE TO RADIOIODINE FALLOUT AFTER THE CHERNOBYL ACCIDENT

V. SIDLAUSKAS, A. KRASAUSKIENE
Institute of Endocrinology, Kaunas Medical Academy,
Kaunas, Lithuania



XA9745454

A. AUKSTUOLYTE, D. MASANAUSKAITE, T. NEDVECKAITE
Institute of Physics,
Vilnius, Lithuania

Introduction

The released radionuclides after the Chernobyl accident were transported by moving air masses over Lithuania. Of particular importance were radioiodines. Measurements of radioactive iodine on the first day after the accident showed that J^{131} concentration in the air was 10 times higher above the normal range. The weather resulted different exposure of Lithuanian regions to the fallout (Fig 1).

Measurements of J^{131} in cows' milk at that time showed that its concentration didn't increase above standard ranges (370 Bq/l) in Central and Northern regions in contrast to 3700 ± 660 Bq/l in Southern and Western regions. In result, mean adults equivalent thyroid doses estimated by determinant method, were 1,2 mSv in Northern regions, 9,1 mSv in Western and Southern regions. They were correspondingly 10 mSv and 77 mSv for children [1].



Fig.1 Lithuanian regions affected by J^{131} after the Chernobyl accident

A - J^{131} concentration in cows' milk in normal ranges (<370 Bq/l)

B - J^{131} concentration 370 - 1000 Bq/l

C - J^{131} concentration more than 1000 Bq/l

There is no investigations giving objective data about the Chernobyl accident impact on thyroid disorders in Lithuania. It is of great importance when 9 years passed since the Chernobyl accident and it is known that the latent period between thyroid irradiation and discovery of thyroid cancer has been as long as 5 yrs, thyroid nodules (adenomas) - 10 yrs [2]

The aim of study was to investigate the prevalence of adult thyroid disorders in 2 Lithuanian regions - Varena and Kupiškis, taking into consideration different degree of radioiodine pollution after Chernobyl accident in these regions

Subjects and methods

Randomly selected Varena and Kupiškis residents aged 25 - 26 yrs were examined. They were divided into equal groups according to age and sex. Totally 415 subjects in Varena and 320 subjects in Kupiškis were investigated. Questionary, clinical examination, thyroid palpation, ultrasonography was performed and thyroid volume was measured. Blood was taken for radioimmunoassay of plasma fT₄, TSH and thyroid microsomal antibodies. Urine was collected for measurement of iodine excretion. Fine-needle aspiration biopsy was performed when needed.

Thyroid size was estimated by inspection and palpation according to WHO [3]

0 - no goiter

IA - goiter palpable but not visible

IB - visible at reclined head only

II - goiter visible

III - very large goiter, visible from a distance

The ultrasonography was performed using real-time "Toshiba" SAL - 328 with 5MHz transducer. The thyroid volume was calculated as described by Brunn et al [4]. Thyroid palpation and ultrasonography were performed by 2 same physicians in both regions.

Thyroid microsomal antibodies were detected by passive haemagglutination method. 1:80 and higher titres were considered to be positive.

Urine iodine concentration was measured by Ceric-arsenite method in casual urine sample. The samples were collected in tubes with screw tops and were refrigerated. The measurements were performed in the Institute of Radiation Medicine in Minsk (Belarus).

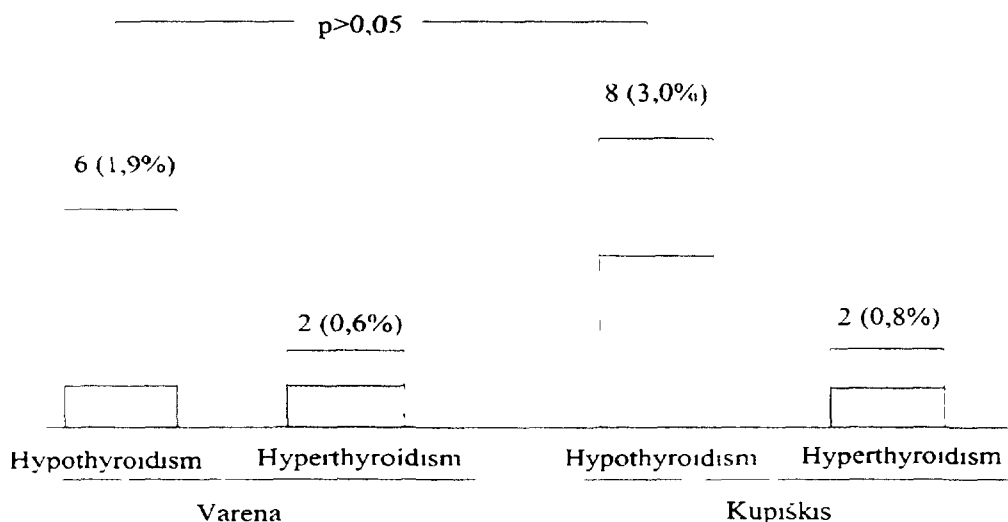


Fig.2. Prevalence of thyroid function disorders in Varena (n=415) and Kupiškis (n=320) residents

- subclinical thyroid disorder

Results and Discussion

95(22,9%) of 415 subjects in Varena had thyroid enlargement according to palpation and ultrasonography data. Thyroid nodules were diagnosed in 17 cases (4,1%). In 10 cases of nodular thyroid abnormalities more than 1 cm in diameter fine-needle aspiration biopsy was carried out and in 1 case thyroid carcinoma was diagnosed.

In Kupiškis 77(24,1%) of 320 subjects showed to have thyroid enlargement. Thyroid nodules were diagnosed in 17 cases (5,9%). After fine-needle aspiration biopsy 2 out of 11 subjects with nodular thyroid abnormalities showed to have thyroid carcinoma. There is no significant difference in the prevalence of goiter and nodules in subjects from these two regions.

Prevalence of thyroid function disorders is shown in the Fig 2.

According to ultrasensitive TSH and fT4 measurements hypothyroidism was diagnosed in 6 cases in Varena region (1,9%). Hyperthyroidism was diagnosed in 2 cases (0,6%). Prevalence of hypothyroidism in Kupiškis region was 3%, hyperthyroidism was diagnosed in 0,8% of the cases. There is no significant difference in the prevalence of thyroid function disorders in the two regions.

Measurements of the thyroid microsomal antibodies showed the increased titres ($\geq 1:80$) in 14,7% of subjects in Varena and 13,2% in Kupiškis region.

Iodine excretion in urine was measured in 40 urine samples from Varena region and in 85 samples from Kupiškis region. Mean iodine excretion in urine was $65,5 \pm 8,2 \mu\text{g/l}$ in Varena and $69,4 \pm 12,3 \mu\text{g/l}$ in Kupiškis. In non-iodine deficiency areas normal urinary iodine concentration is $>100 \mu\text{g/l}$, 50-100 $\mu\text{g/l}$ urinary iodine concentration is modest iodine deficiency, 20-50 $\mu\text{g/l}$ - moderate and $<20 \mu\text{g/l}$ - severe iodine deficiency [5]. Thus, the results indicate the problem of iodine deficiency in Lithuania [6]. It is known that the thyroid absorbs larger doses of radioactive iodine in iodine deficiency areas during atomic power accident. Establishment of iodine deficiency in Varena enabled to correct thyroid equivalent doses in this region after the Chernobyl accident [1]. Thyroid doses estimated by stochastic method are presented in Table I.

Children	Doses (mSv)	<100	100 - 200	200 - 300	300 - 400	>400
	Distribution (%)	22	59	16	2,3	0,7
Adults	Doses (mSv)	<10	10 - 20	20 - 30	30 - 40	>40
	Distribution (%)	28	55	14	2,4	0,6

Table I Distribution of thyroid equivalent doses for children and adults after the Chernobyl accident in Varena region

Table I summarises that only in 28% of the cases thyroid dose for adults were less than 10 mSv and in greater part of Varena population (55%) it was 10-20 mSv. Until the study was performed it was supposed that thyroid dose for children had been $73 \pm 10 \text{ mSv}$ in Varena. Our study proved thyroid dose for children to be a lot higher 100-200 mSv in 59% of the cases and there might be some cases of thyroid dose higher than 500 mSv. Literature reports that prevalence of thyroid nodules increases with an increase of thyroid equivalent dose above 400 mSv. In the study of Belarus children, exposed to

radioactive fallout (thyroid dose 2-5 Sv), occurrence of thyroid nodule according to ultrasonographic findings was 12-16%. In 50% of them thyroid cancer was detected. In a control group, selected from Breslau region, that was presumed to have received little or no fallout from the Chernobyl accident, thyroid nodules were diagnosed in 1,6-2% of the examined children. There were no cases of thyroid carcinoma.

For comparison, in Varena region we have examined 362 children, born in 1985-86 yrs. Thyroid palpation and ultrasonography were performed. Thyroid nodules were found in 4 of 362 children (1,1%). The results of fine-needle aspiration biopsy of nodules didn't show any signs of malignisation. According to our results there is no increase in prevalence of childhood thyroid disorders.

The aim of the study was to compare prevalence of thyroid disorders in 2 Lithuanian regions with high and low levels of radioiodine pollution after the Chernobyl accident. Thus, Kupiškis (J^{131} concentration in cow's milk < 370 Bq/l) and Varena (J^{131} concentration > 1000 Bq/l) were chosen. The results proved that there is no significant difference in the prevalence of thyroid disorders in this two regions at the time.

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THYROID NODULARITY AMONG CHERNOBYL CLEAN-UP WORKERS FROM LITHUANIA

A.Z. KESMINIENE, J. RIMDEIKA, Z. VILKELIENE
Lithuanian Chernobyl Medical Centre,
Vilnius, Lithuania

J. KURTINAITIS
Lithuanian Oncology Centre,
Vilnius, Lithuania



XA9745455

1. Introduction

The accident at the Chernobyl NPP on 26 April 1986 was the worst in the history of nuclear power. This catastrophe resulted in massive contamination of the area necessitating evacuation of the population, an extensive clean-up and construction of sarcophagus. This clean-up and construction activity was accomplished by approximately 600000 workers from former Soviet Union. Exposures were from rapidly-decaying radioactive iodines, as well as from ^{137}Cs and other long-lived radioisotopes [1].

Because the thyroid gland is highly susceptible to the carcinogenic actions of radiation, especially when exposure occurs at a young age, a clinical examination survey was conducted to determine the prevalence of thyroid abnormalities among former clean-up workers [2]. Nodules are considered a sensitive for evidence of low-dose radiation effects [3]. Presence of benign tumors has been linked with development of thyroid cancer [4]. A remarkable increase in thyroid cancer has been reported among children living in contaminated areas around Chernobyl [5].

The objective of this study is to evaluate the dose effects of chronic radiation exposure (mainly from external gamma radiation, but residual I^{131} might also have been contributed to the thyroid dose among those sent to Chernobyl within one month after the accident), prolongation of time in zone and length of time after exposure role in developing thyroid tumors within a study population.

2. Materials and methods

2.1 Cohort construction

A study of the health effects from the Chernobyl reactor accident of 1986 on Lithuanians sent to contaminated area for clean-up activity was conducted by Lithuanian Chernobyl Medical Centre (LCMC). Since 1991, subjects have been invited to participate in annual health examinations. Lithuanian Chernobyl clean-up workers cohort was constructed using data from Lithuanian National Chernobyl Registry. National Registry was established in 1991 and was based on different sources:

1. Registration card established in 1987 by directive No 640-TN of the former Soviet Union Ministry of Health. These cards are in possession of the LCMC and, up to 1991, were used by local medical services for purposes of registration and follow-up.

2. Lists of the local military commissions of former Soviet Union Ministry of Defence. They became available to LCMC starting from September 1991.

3. Lists and records of Lithuanian Movement "Chernobyl". Since 1989, it has been in the Chernobyl clean-up workers' interests to give their data to the Movement in order to facilitate the Movement's work directed towards getting health care benefits for the registered Chernobyl clean-up workers. It is important to note that to be registered as a Chernobyl

clean-up worker, there must be an official document, such as a military passport, service record. These people include those employed in the military, but the majority were specifically drafted for the clean-up under the pretence of repetition military training activity.

4. Lists and certificates of the staff of Ignalina Nuclear Power Plant (NPP) sent to Chernobyl. These documents are certified by authorities of Ignalina NPP.

5. Lists of the technical workers sent to Chernobyl by the Ministry of Construction. They are certified by authorities of the Ministry.

6. Lists of the Ministry of Internal Affairs. They include persons sent to Chernobyl area to maintain order in 30 kilometres area and also certified by authorities of the Ministry.

This information from each of the sources is to be compiled into one data file. The total estimate of 5446 is the best available at this time.

2.2 Physical examination

Thyroid examinations have been conducted by staff of LCMC for 3208 persons in the period between February 1991 and June 1995 as an item of annual health check-up and included palpation and sonographic examination. Each subject underwent a physical examination of the thyroid by at least two physicians: doctor of internal diseases and endocrinologist. The thyroid was palpated while motionless, as well as during swallowing.

All subjects underwent sonographic examinations using two ultrasound machines: both Hitachi Medical Corporation model EUB-310. A thyroid nodule was defined as an abnormality in echogenicity measuring more than 5 mm in diameter. Longitudinal images of all thyroid glands were obtained whether or not a nodule was identified. Nodules were classified as predominantly solid or cystic, single or multiple, isoechoic, hyperechoic, or hypoechoic. Their diameters were measured.

This study excludes the subjects whose health check-up has been provided by local medical staff in regional hospitals (data from these examinations are available to the LCMC).

2.3 Dosimetry

Doses based on individual thermo luminescent dosimetry (TLD) assessment and also by group assessment wherein one member of the group had a dosimeter were collected by former Soviet military authorities. This information was obtained from military records. Dose levels received by individuals and recorded in the military passports are shown in table I. Recorded dose was missing for 30,9%.

Table I. Distribution of dose among all clean-up workers and workers with thyroid nodularities.

Dose, cGy	All clean-up workers, %	Workers with thyroid nodularities, %
0 - 5	21.49	21.84
5 - 10	38.13	29.89
10 - 15	12.75	14.94
15 - 20	8.76	16.09
20 - 25	15.39	14.94
> 25	3.49	2.30

3. Results

Ultrasound examination revealed thyroid nodules in 117 (3,7%) of 3208 examined subjects. Analyses in this study are based on ultrasound findings, as these are considered to be more reliable [6]. Table II shows the sonographic characteristics of nodules.

Table II Ultrasonic characteristics of thyroid nodules		
Ultrasonic characteristic	No of cases	%
Solid		
<i>Hypoechoic</i>	23	19.66
<i>Isoechoic</i>	6	5.13
<i>Hyperechoic</i>	65	55.56
Cystic	14	11.97
Mixed	9	7.69
Total	117	

Most of the nodules (80,3 %) were solid 94 had a solitary nodule, 19 had two nodules and four had more than two nodules 14 patients with nodules were operated, two cases of papillary carcinoma and one mixed papillary-follicular tumour was identified Three patients had recurrences of nodules after have been operated 5-7 years before

The presence of nodules was not associated with the dose from known external exposure The mean dose was 11,07 cGy among men with nodules and 11,42cGy in whole population One of the patients with thyroid cancer had recorded dose of 20,47cGy, the second - 9,6cGy and in the third case dose was missing

The probability of the development of the disease is estimated to be 11 - 14 % and has slightly increasing dose dependent trend

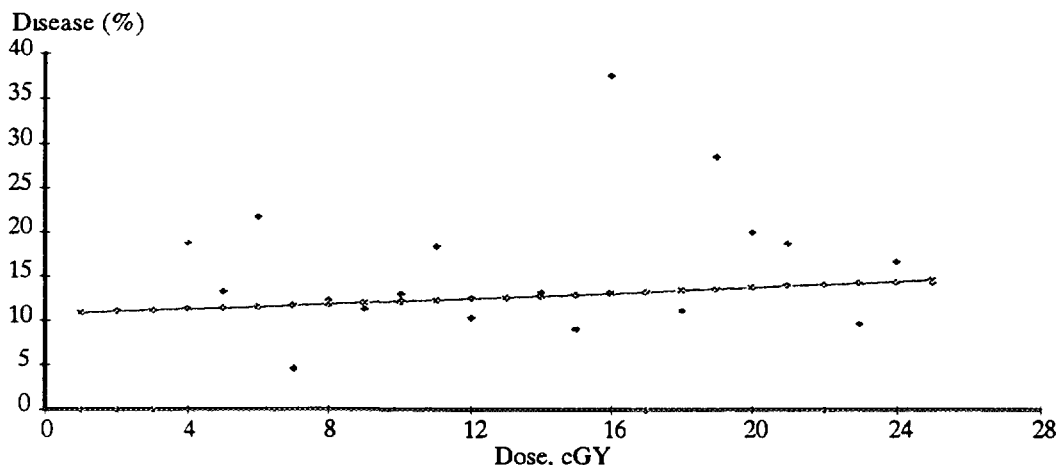


Figure 1. Development of the thyroid nodularity by dose.

Exposure to radiation does not initiate more frequent thyroid nodularity in comparison with nonexposed Lithuanian men's population where the frequency of thyroid nodularity is 1,6 - 16,3 %

Because of incompleteness and uncertain accuracy of recorded doses, the probability of nodularity also was estimated in terms of time spent in Chernobyl area The prolongation of stay in contaminated area does not effected the frequency of thyroid nodularity (figure2)

The active follow-up of Chernobyl clean-up workers revealed an appearance of the thyroid nodules at the end of 4 years period after exposure (figure 3)

More high risk (above 15%) to develop thyroid nodularities is expected after 10-12 years after exposure

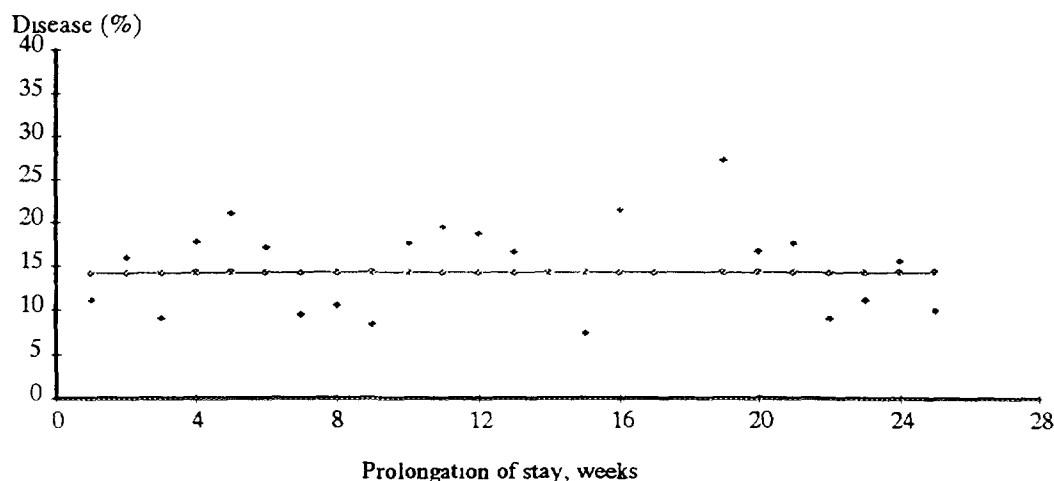


Figure 2. Development of thyroid nodularity by prolongation of stay

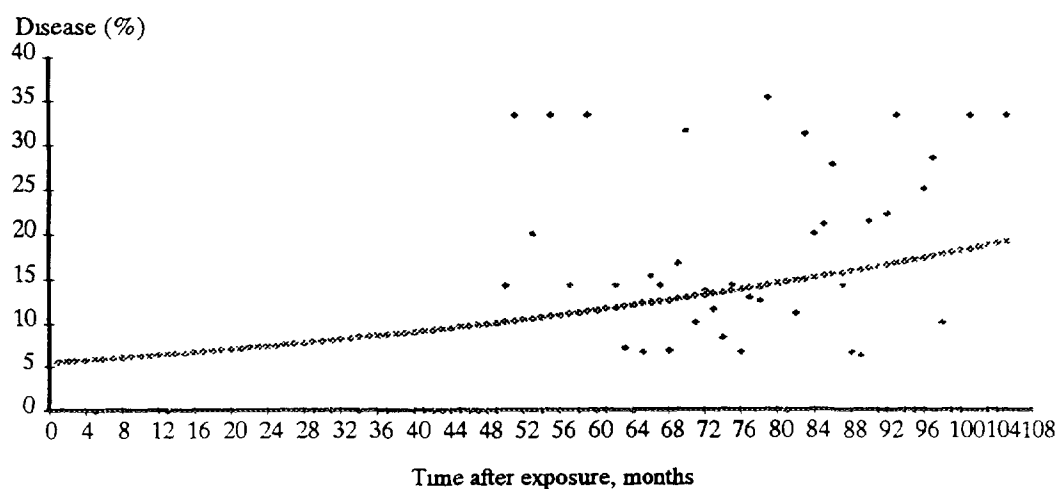


Figure 3 Development of thyroid nodularity by time after exposure

4. Discussion and conclusions

It appears that from five to nine years since participating in the clean-up activity after Chernobyl accident was not enough long time to occur radiation related both benign and malignant thyroid tumors. Routine medical check-up of 3208 clean-up workers revealed 117 (3,7%) having thyroid nodules. The similar results were in Estonia, where short term intensive screening of thyroid revealed 199 (10 0%) patients with thyroid nodules among 1976 clean-up workers [7]. All Estonian clean-up workers were screened in 1995 (nine years after exposure). The smallest acceptable size of nodules was here 0,3 cm. This might be an explanation of more high prevalence of nodules in Estonian cohort.

Exposure to radiation does not initiated more frequent thyroid nodularity in comparison with nonexposed Lithuanian men's population where the frequency of thyroid nodularity is 1,6 - 16,3 %.

The presence of nodules was not associated with the dose from external exposure which was estimated as 11,07 cGy. Radiation doses may simply have been too low to produce demonstrable effects or accumulated over variable time periods.

The probability of nodularity also was not associated with prolongation of stay in Chernobyl area

We were able to identify three thyroid cancers among 117 patients (2,6%) with thyroid nodules which is similar to the value of 5 thyroid cancers among 199 clean-up workers (2,5%) reported in Estonian study.

The absence of evident radiation effects now does not preclude the possibility that an excess of thyroid nodularity or thyroid cancer will appear in the future

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IODINE PROPHYLAXIS IN CASES OF RADIATION ACCIDENTS: PREPAREDNESS IN BULGARIA



XA9745456

A. BAYRAKOVA, G. KIRADJIEV
National Center of Radiobiology and Radiation Protection,
Sofia, Bulgaria

1. DECISION TAKING FOR STABLE IODINE PROPHYLAXIS

The decision for carrying out of iodine prophylaxis is based on the so-called Decision Criteria for Population Protection Measures in Cases of Nuclear Accident (1). The main principle here is to ensure that the predicted thyroid doses should not exceed the predetermined intervention levels. Iodine prophylaxis is obligatory when the predicted thyroid dose levels are above 500 mSv for adults and above 50 mSv for children and pregnant women. These doses refer to the initial stage of the accident or to a one-week period after the accident.

The estimation of predicted doses is carried out by the respective bodies of the Permanent Commission of Population Protection in Cases of Disasters and Accidents at the Council of Ministers. It is based on data on the radioactive fallout from the NPP accident and on the direct measurements of iodine isotopes radioactivity in atmosphere (Table I).

Table I

Values of Predicted Effective Thyroid Doses for an Adult Person when a Unit of Activity is Inhaled (Sv/Bq)

Iodine isotopes	Thyroid doses (Sv/Bq)
Iodine -129	1.6 x E-6
Iodine-131	3.0 x E-7
Iodine-132	1.8 x E-9
Iodine-133	5.0 x E-8
Iodine-134	3.0 x E-10
Iodine-135	9.0 x E-9

The iodine prophylaxis decision depends on the population residence - in the areas of emergency planning and in distant areas. The possibility for other protection measures should also be taken into account, as well as the fact that the risk of the radioactive iodine is far higher to younger individuals than to adults; and vice versa, the risk of iodine prophylaxis itself is higher to the adults.

In order to achieve a higher effectiveness of iodine prophylaxis it is necessary to start its application after the accident as soon as possible. The benefits of iodine prophylaxis are undoubted even when we have a reasonable delay of hours or days after the accident, as well as when there are conditions for permanent incorporation of radioactive iodine.

2. STABLE IODINE COMPOUNDS AND DOSAGE

Iodine prophylaxis can be exercised through all patent medicines containing stable iodine strictly following the dosage (Table II).

The iodine stocks are kept in dark and dry places and should be substituted at regular intervals. The population in the near field is provided for with potassium iodide or iodate as tablets, and the population in the far field - with potassium iodide or iodate in crystal forms.

Table II
Single Doses Stable Iodine Compounds

Age groups	Potassium iodide (mg)	Potassium iodate (mg)	5% tincture of iodine (drops)	Equivalent iodine content (mg)
Neonates	15	20	10	12.5
1 month - 3 years	31 - 35	40 - 45	20	25
3 - 16 years	65	85	40	50
Adults, including pregnant and lactating women	130	170	80	100

3. MEDICAL CONTRAINDICATIONS FOR STABLE IODINE PROPHYLAXIS

The Iodine Prophylaxis Instruction addressed to the medical personnel treats the following medical contraindications:

- increased individual sensitivity to iodine;
- thyroid diseases (thyrotoxicosis, multinodular goiter);
- some skin diseases (herpetiformis dermatitis, pemphigus, psoriasis);
- previous taking of iodine patent medicines for the treatment of some diseases (relative contraindication);

Iodine prophylaxis is applied to large population groups without a direct medical supervision. Thus, it is necessary to find out in advance the persons to whom there is some risk of iodine prophylaxis. This is important especially for the population from the regions near NPP.

4. SIDE EFFECTS FROM IODINE PROPHYLAXIS

Considered are side effects from patent medicines containing stable iodine (Table III).

Table III
Possible Side Effects from Stable Iodine Medicines

<p>A. Effects affecting the thyroid gland and its function</p> <ul style="list-style-type: none"> - thyroiditis; - hypo or euthyroid goiter; - thyrotoxicosis; - hypothyroidism.
<p>B. Effects affecting other organs</p> <ul style="list-style-type: none"> - skin and mucosa (conjunctiva, respiratory tract): irritation, eruptions, edema; - sialoadenitis (painful and transitory swelling of the parotid and the submaxillary salivary glands); - gastrointestinal complaints with general status disturbances; - allergic reactions including iodine fever (with high temperature, face and glottical edema, eruptions and other symptoms of the serum sickness).

It should be noted that the given side effects are registered after a long-lasting daily taking of iodine medicines in doses considerably exceeding the doses used in iodine prophylaxis.

5. MEDICAL CONSIDERATIONS FOR DIFFERENTIATED APPROACH TO PARTICULAR POPULATION GROUPS

Morphological and functional patterns of the thyroid gland during prenatal and postnatal development are the basis of a differentiated approach to pregnant (1st, 2nd and 3rd trimester), lactating mothers, and children.

During the 1st trimester of pregnancy the embryo has no thyroid gland and hypothalamus-hypophysis-thyroid system of full-value, thus it cannot incorporate radioactive iodine. Iodine prophylaxis is not needed. The rule that future mothers must avoid all medicines during the 1st trimester should be obeyed.

Table IV

General Recommendations for the Carrying out of Iodine Prophylaxis in Case of Radiation Accident

Age groups	Regions					
	Near NPP			Far from NPP		
	Appli- cation ^a	Dosage ^b	Other measures ^c	Appli- cation ^a	Dosage ^b	Other measures ^c
Pregnant women	XXX	0 (2) (except the 1st trimester)	PP	XXX	0 (1)	P
Neonates under 1 month	XXX	0 (1)	PP	X	0 (1)	P
Lactating mothers	XXX	0 (2)	PP	X	0 (1)	P
Children under 16	XXX	00	PP	X	0 (1)	P
Adults under 45	XXX	00	PP	-	-	P
Adults over 45	XX	00	PP	-	-	P
NPP personnel	XXX	00	PP	-	-	-

^a

XXX - obligatory;

XX - obligatory when taking into consideration the contraindications;

X - at special conditions.

^b

0 - minimally effective dose, not more than (-) times;

00 - minimally effective dose in accordance with the radiation situation.

^c

PP - sheltering and evacuation;

P - control of foodstuffs.

Remark Iodine prophylaxis during the 1st trimester of pregnancy gives no reason for abortion

The thyroid gland is functioning during the 2nd and 3rd trimester of pregnancy as well as in neonates Hypothyroidism could be developed as a result of immaturity of the hypothalamus-hypophysis-thyroid system Although transitory, such a hypothyroidism can cause serious disturbances in the mental development after birth

The differentiated approach to adults (under and over 45 years) is based on the ratio between the benefit (decreasing of thyroid doses) and the risk from side effects

For population from iodine deficiency regions a balance is sought between higher radiation risk and higher side effects risk Decreasing of stable iodine doses can be considered as an alternative The decision for each case is taken by the Ministry of Health Measures for iodine deficiency removal are important also for population protection in case of a nuclear accident

A generalization is shown on Table IV

6 INSTRUCTIONS FOR THE POPULATION

6.1. Population residing near NPP

1 The iodine prophylaxis is a contemporary, relatively safety method that ensures almost entire protection against radioactive iodine isotopes when applied properly

2 It is carried out with tablets containing stable iodine, the tablets being delivered beforehand to each household (1 tablet - 250 mg potassium iodide)

3 The tablets should be kept in dry and dark places not accessible for children

4 The tablets are to be taken right after the announcement of radiation accident

5 The iodine prophylaxis is carried out for the whole population - neonates, children, lactating mothers, pregnant women and adults

6 Dosage adults take 1/2 tablet, and children under 16 - 1/4 tablet The tablets are taken with water, milk, tea, etc

7 This dosage guarantees an effective 24 hours protection After this period another dose is taken, etc, about the duration of the tablets taking, we shall let you know later on

8 To neonates (under 1 month) the medicine is given only once, and to pregnant and lactating mothers - not more than two times

9 The medicine is not given to infants on natural feeding They receive stable iodine through the mother's lactation

10 The medical contraindications for medicine taking are sensitivity to iodine, thyroid diseases (Basedow's disease, large goiter), some grave skin diseases In such cases you should turn to the local health service

11 The medicine rarely has side effects If there are such (irritation of skin and mucous membrane, eruptions, nausea, emesis, fever, headache, palpitation, asthma, etc), please turn to the local health service

12 The tablets ensure protection only against iodine isotopes They have no effectiveness against external exposure and the other radioactive isotopes

13 The taking of tablets does not exclude the application of the other protection measures

14 Higher doses, as well as more frequent taking of the medicine does not increase the protective qualities of stable iodine

6.2. Population residing in regions far from NPP

The instruction is the same as the one for the population residing near NPP The difference is that the prophylaxis is carried out with stable iodine solution (prepared and supplied by the bodies of the Ministry of Health and the Civil Defence Administration) Iodine prophylaxis is applied only at special conditions for adults (over and under 45)

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ELEVATED TSH IN CHILDREN WHO EMIGRATED TO ISRAEL FROM BELARUS AND THE UKRAINE NEAR CHERNOBYL

J.R. GOLDSMITH, E. KORDYSH

Department of Epidemiology,
Soroka Medical Center-Faculty of Health Sciences,
Ben Gurion University of the Negev,
Beer-Sheva, Israel



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M.R. QUASTEL, L. MERKIN, S. POLJAK

Department of Nuclear Medicine,
Soroka Medical Center-Faculty of Health Sciences,
Ben Gurion University of the Negev,
Beer-Sheva, Israel

Y. LEVY, R. GORODISHER

Department of Pediatrics,
Soroka Medical Center-Faculty of Health Sciences,
Ben Gurion University of the Negev,
Beer-Sheva, Israel

Y. BARKI

Department of Ultrasound,
Soroka Medical Center-Faculty of Health Sciences,
Ben Gurion University of the Negev,
Beer-Sheva, Israel

J. WYNBERG

Faculty of Medicine, University of Toronto,
Toronto, Canada

INTRODUCTION

The degree of radiation exposure to the thyroids of children who originally lived in Chernobyl contaminated areas is of concern in Israel, because of the many immigrants who arrived from such areas in a wave of immigration from the CIS countries since 1990. Of the 650,000 people who emigrated to Israel since that time, our estimate is that about 20% came from regions of the Ukraine, Russia and Belarus that were contaminated with various amounts of radionuclides.

Children from these areas are a population that could be at higher risk because of their high past consumption of radioiodine-containing dairy products, the relatively high prevalence of goiter in these iodine deficiency region, the higher sensitivity of children to ionizing radiation and recent reports of elevated rates of childhood thyroid cancer which were described initially in Belarus, followed by the Ukraine and the southern Russian republic (1-3).

METHODS AND POPULATION STUDIED

Examination of 383 immigrant children from these areas was initiated in self referred volunteer families by face to face interviews, physical examinations (particularly of the thyroid), blood sampling and ultrasound examinations. Measurements were made of total

serum tri- and tetra-iodothyronine, thyroid stimulating hormone (TSH), thyroglobulin, antithyroid and antimicrosomal antibodies. The results of measurements of TSH levels in these children are reported in this preliminary study.

Of 383 subjects, 291 were examined for TSH levels by the chemiluminescent third generation assay (4). The group included 123 boys and 168 girls ranging in age from 5 to 24 (who were 0-16 at time of the Chernobyl accident). A natural comparative experiment was suggested by the identification of subjects coming from "more contaminated" and "less contaminated" areas, as defined by the 1991 IAEA soil radiocontamination maps (5). The group was therefore divided into those who had originally resided in regions of higher and lower Cs-137 exposures, and on the assumption that I-131 dispersal and deposition would be expected to have a similar distribution. High and low exposure areas are defined as those areas with Cs-137 concentrations greater or less than 37 GBq (1 Ci) per sq. km.

RESULTS

The distribution of TSH levels in girls was higher in the children who came from high exposure areas, although almost all results lay within the normal range (0.4-4.0 μ IU/ml). For TSH levels less than 0.8 μ IU/ml, there were half as many children from high compared to low exposure regions (24% compared to 42%), but for TSH values between 1.2 and 2.0 μ IU/ml, there were more than twice as many children from the high exposure regions (35% compared to 15%). There was no difference at TSH levels higher than 2.0 μ IU/ml. The shift to higher TSH levels was statistically significant at $p=0.023$ by the χ^2 test. Boys showed a similar trend, but their results did not reach statistical significance.

The other parameters examined - total serum T3 and T4, thyroglobulin, antithyroid and antimicrosomal antibodies - did not show noticeable differences between the groups coming from high and low exposure regions. Three of 199 children had high antithyroid microsomal antibody levels but no evidence was found for differences in autoimmune status for either group.

The prevalence of palpated enlarged thyroids in both groups of children was about 40%, presumably due to the goiterogenic areas of their original communities, but no difference in prevalence of thyroid enlargement was observed for children coming from low or high exposure areas (measurements both by palpation and by ultrasound). In a parallel study which compared the measurement of thyroid size by palpation and by ultrasound, it was found that there was a significant correlation ($p < 0.01$), but that the two methods evaluated the thyroid differently. Thyroid seemingly normal by palpation was sometimes found to be enlarged by ultrasound measurement, but ultrasound may not always detect a palpably enlarged thyroid.

In the entire group examined only one nodule was found. Fine needle aspiration revealed a malignant papillary carcinoma in a 12 year old Gomel girl. She was treated by thyroidectomy followed by ablation of remaining thyroid tissue with I-131 and appears to have good health 4 years later. Approximately 11 % of the children had palpable irregularities of the thyroid, that is to say, a tactile sensation of variable volume or densities within the thyroid that are not discrete nodules. There was no difference in the incidence of these thyroid irregularities between subjects coming from high or low exposure areas.

DISCUSSION

The assumption that the radioiodine thyroid dose (in 1986) can be correlated with recent measurements of Cs-137 distribution in the soil is probably inaccurate. The short lived radioiodines (such as I-132, I-133, I-135) have been estimated to be 4 to 10 times more destructive per rad than I-131 (6). These isotopes may well have caused radiation exposures in excess of that due to I-131 to a degree related to the distance from Chernobyl in the direction of the atmospheric dispersion, due to their physical decay by the time the radioactive cloud had passed some distance from its origin. Hence, there is reason to expect that children living nearer the reactor accident and in the path of the dispersion had relatively higher exposures to short-

lived radio-iodines, which may have been involved in the reported increase of the incidence of childhood thyroid cancer. Retrospective dosimetry has been carried out based on the initial monitoring of radioiodine levels in thyroid glands (7,8). It would be useful to be able to correlate the results of dose reconstruction with actual evidence of past radiation exposure.

The present results demonstrate a shift in the distribution of serum TSH to higher values for girls who emigrated from areas with relatively increased levels of Cs-137 contamination.

Possible explanations for this include (a) radiation damage to the thyroid with resultant homeostatic increase of TSH, (b) greater iodine deficiency in the more exposed areas, or (c) an artifactual apparent increase, because we have found that healthy teenage girls from the regions tested have lower levels of TSH than do boys (9). However, since the proportion of teenage girls in both series was the same in both groups, this explanation seems unlikely.

In order to test for the second possibility, we examined the incidence of enlarged thyroids by direct palpation and ultrasound. There was no change in the incidence of enlarged and/or palpable thyroids. These results therefore do not support the possibility of greater iodine deficiency in the higher exposure areas as an explanation for the elevated TSH levels.

Our working hypothesis is therefore that children who came from these areas had subclinical radiation damage to the thyroid leading to compensatory homeostatic increase in TSH. We are not aware that has been reported and therefore present these preliminary results, bearing in mind that large scale studies in CIS countries might be able to test the hypothesis with larger numbers of subjects from areas that were radio-contaminated. Such a test would desirably involve the correlation of TSH values with reconstructed thyroid doses.

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THYROID CANCER IN BELARUS

E.P. DEMIDCHIK

Belarus Centre for Thyroid Tumours,
Minsk, Belarus

A.E. OKEANOV

Centre for Data Processing and Medical Technology,
Minsk, Belarus

T.V. VORONTSOVA

Institute for Radiation Medicine,
Minsk, Belarus

V.Ya. REBEKO

Minsk Medical Institute,
Minsk, Belarus

Yu.E. DEMIDCHIK

Minsk State Medical Institute,
Minsk, Belarus

РАК ЩИТОВИДНОЙ ЖЕЛЕЗЫ В БЕЛАРУСИ

Е.П.Демидчик¹, А.Е.Океанов², Т.В.Воронцова³,
Ю.Е.Демидчик¹, В.Я.Ребеко¹

¹ Республиканский Центр опухолей щитовидной железы. 220600 Минск, пр.Ф.Скорины, 6 Беларусь

² Центр информатики и медицинской технологии. 220600 Минск, П.Бровки, 7а. Беларусь

³ Институт радиационной медицины. 223032 Минск, Аксаковщина. Беларусь

В исследование включены материалы Республиканского канцеррегистра и Центра опухолей щитовидной железы.

За период с 1977 по 1994 гг. рак щитовидной железы в Беларуси выявлен у 4379 больных, в т.ч. у 1139 (25%) до и у 3240

(74%) после аварии на Чернобыльской АЭС. За указанный 18 летний период в 90% наблюдений первичное лечение проводилось в Республиканском Центре.

В доаварийном периоде рак данной локализации встречался редко во всех шести областях Республики – средний показатель заболеваемости составлял всего $1.3 \div 100000$ населения. Пик частоты рака щитовидной железы наблюдался в возрастном интервале от 50 до 64 лет. У детей эта опухоль обнаружена только в 7 случаях, что составило 0.6% по отношению ко всей популяции больных за девятилетний период.

В большинстве наблюдений (88.7%) встречались дифференцированные папиллярные и фолликулярные карциномы. Анапластический рак составлял всего 8.2%, а медуллярный – только 3.1%. Характерной особенностью дифференцированных карцином у больных старше 50 лет был медленный рост опухоли. Так, продолжительность узлового или диффузного увеличения щитовидной железы до выявления первичной карциномы нередко превышала 10 лет.

В молодом возрасте чаще развивались метастазы в регионарных лимфатических узлах

шей и переднего средостения, а в случаях анапластического рака отмечался интенсивный рост опухоли и ранние лимфо- и гематогенные метастазы. При папиллярном и фолликулярном раке после хирургического лечения десятилетняя безрецидивная выживаемость составила 80.1%, а средний показатель смертности для всех больных раком щитовидной железы за девятилетний период составил $11.6 \div 100000$ населения.

После аварии на Чернобыльской атомной станции заболеваемость раком щитовидной железы возрасла до $6.1 \div 100000$, причем количество больных увеличилось во всех возрастных группах, но особенно - у детей. Так, в 1994 г. показатель заболеваемости достиг $3.5 \div 100000$ детского населения, а в целом детский рак составил 10.2% по отношению ко всем больным с первичными злокачественными новообразованиями щитовидной железы. Всего за 9.5 лет рак выявлен у 397 детей, из них у 387 первичное лечение было проведено в Центре.

Важно подчеркнуть, что в послеаварийном периоде частота различных морфологических форм рака и показатель смертности больных

существенно не изменились. Наиболее высокий уровень заболеваемости у детей отмечен в южных и юго-западных районах Гомельской и Брестской областей.

Клинические наблюдения показали, что детский тиреоидный рак обладал более выраженными агрессивными свойствами, чем у взрослых.

Так, для рака щитовидной железы у детей характерно частое и множественное поражение метастазами лимфатических узлов шеи. Во многих случаях рост метастатических опухолей был более быстрым, чем первичной карциномы. По нашим данным, на частоту метастазирования существенно влияло экстракапсулярное распространение опухоли.

Иммунологические исследования показали, что у детей больных раком щитовидной железы отмечалось угнетение Т-звена иммунитета (снижение относительного и абсолютного числа Т-лимфоцитов), подавление функциональной активности лимфоцитов в реакции бласттрансформации на фоне стимуляции В-звена иммунитета. При оценке цитокинов наблюдалась гиперпродукция интерлейкина-1. Повышенные

уровни аутоантител (к тиреоглобулину, микросомальному антигену, пероксидазе), растворимых рецепторов к интерлейкину-2 и интерферона отмечались достоверно чаще у больных раком, чем у здоровых детей. Все это свидетельствует о значительной роли аутоиммунных реакций в развитии карциномы в детском возрасте.

В первые 5 лет, после Чернобыльской аварии при выполнении хирургических операций мы стремились удалить у детей всю опухоль и, если возможно, сохранить участок здоровой тиреоидной ткани, чтобы избежать тяжелой формы гипотиреоза. Нами производилась не только тотальная, но также субтотальная и гемитиреоидэктомия. При наличии регионарных метастазов эти операции всегда выполнялись с одновременной одно- или двусторонней лимфаденэктомией.

Учитывая высокую потенциальную злокачественность рака щитовидной железы у детей, в последующие годы гемитиреоидэктомия выполнялась только при солитарной опухоли менее 1 см (T1aN0M0). После тотальной тиреоидэктомии обычно производилась

сцинтиграфия. При обнаружении метастазов в легких проводились курсы радиойодтерапии (55 наблюдений).

Результаты хирургического лечения изучены у 292 детей, оперированных 2-8 лет тому назад. Возобновление роста опухоли отмечено в 56 наблюдениях, в том числе:

- -у 8 больных - в остатках тиреоидной ткани;
- -у 48 - метастазы в регионарных лимфоузлах.

Всем 56 детям произведены повторные операции.

Окончательно оценить отдаленные результаты лечения будет возможно только через 5-10 лет. В настоящее время можно лишь отметить, что после тотальной тиреоидэктомии в 25% случаев наблюдалась паращитовидная недостаточность, которая трудно поддается медикаментозной коррекции. Дети, перенесшие удаление всей железы, в большинстве случаев отстают от сверстников в умственном и физическом развитии.

MALIGNANT NEOPLASM OF THE THYROID IN CHILDREN AND IN ADULTS ON THE TERRITORIES AFFECTED BY THE CHERNOBYL ACCIDENT

L.V. REMENNIK, V.V. STARINSKY, V.D. MOKINA, V.I. CHISSOV,
M.M. RUBTSOVA

Moscow A. Herzen Cancer Research Institute,
Moscow, Russian Federation



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1. Purpose and methods

Growth of the malignant neoplasm incidence is one of the most probable consequences of influence of ionizing radiation on the population of the territories suffered from the Chernobyl accident.

Thyroid is an organ of rather high risk for realization of cancerogenic effects of radiation [1]. The Chernobyl accident was associated with a significant discharge of several kinds of iodine radionuclides with different half-life to the environment, which were selectively accumulated by thyroid within the first two months after the accident. Hence, the necessity of an estimation of dynamics of the thyroid cancer (TC) incidence in various groups of the population living on these territories in view of background tendencies is obvious

This work was aimed to analyse the TC incidence in the population of the territories of Russia - the Bryansk (BR), Kaluga (KR), and Orel (OR) regions, which were most polluted owing to the Chernobyl accident, for the 1981-1995 period. The study of the TC incidence was carried out on the basis of analysis of databases the nosological population cancer-registers generated specially for this purpose. The information, necessary for filling the databases of the registers, resulted from the special epidemiological screening and processing of primary medical documentation on TC patients in special-purpose oncological establishments of the federal, regional levels, in general medical establishments that issue death certificates and certificates of inability of work as well as in prosectoriums. The body of information on a patient answers to the standard of cancer registers which was developed by the World Health Organisation. Using the world standard of age and sexual distribution of the population [2], there were calculated the extensive, age-specific, and intensive crude and standardized incidence rates

2. General features of dynamics of thyroid cancer incidence in the population of the territories suffered from the Chernobyl accident

Analysis of the data of the cancer registers and official statistics evidences that the highest rates of the TC incidence were in the BR and the OR (table I)

The contribution of TC to the general oncological incidence both in males and in females of the BR and the OR is twice as much as that in all Russia. On the data of the registers, from 1981 to 1995 there had been exposed 1108 cases of TC in the BR 809 of which were exposed in the post-accident period (1987-1995). In the KR were exposed 235 and 171 cases, respectively. As for the register of the OR, it is on the way to form

There has been growth of TC incidence in males and females of the BR since 1986, which, probably, is the result of both meticulous attention to the pathology of thyroid and improving the TC registration after the accident. The rates of increment of the TC incidence in males and females of the BR and the OR are much higher than in all Russia and in the KR as well. The data concerning the age and sex rates of the incidence are in table II.

In the BR and in the OR, an increment of the incidence rate higher in the junior 0-29 age group and in females of the 40-49 age group. In the KR, dynamics and incidence rate are identical with those of all Russia. Incidence rates of adults in the polluted, slightly polluted, and pure regions of the BR do not correlate with the pollution levels

Table I.

The TC incidence in the population of the BR, the KR, the OR, and Russia for the 1981-1995 period (standardized rates per 100000 of the population of a corresponding sex)

Territories	Sex	Years							Average annual rate of increment, %
		1981	1982	1983	1984	1985	1986	1987	
Bryansk region	M	1.2	1.7	0.4	0.5	0.5	1.4	1.3	-7.3
	F	3.2	2.3	2.2	2.0	1.6	2.9	6.6	-4.5
Kaluga region	M	0.6	0.2	0.3	0.2	0.0	0.2	0.6	-33.6
	F	0.9	1.8	1.4	1.0	1.5	0.9	1.9	-2.9
Territories	Sex	Years							Average annual rate of increment, %
		1988	1989	1990	1991	1992	1993	1994	
Bryansk region	M	1.4	1.0	0.8	2.3	1.8	2.1	2.6	21.1
	F	5.5	7.2	6.7	5.6	8.9	10.0	11.4	12.6
Orel region	M	*	1.1	1.4	2.5	1.9	1.5	2.1	10.1
	F	*	4.1	4.2	5.5	7.2	11.0	10.7	32.2
Kaluga region	M	0.8	0.7	0.6	0.3	1.0	0.6	1.3	13.2
	F	0.6	2.4	1.5	1.8	1.5	3.0	2.4	3.7
Russia	M	*	1.0	1.0	1.0	0.9	1.0	1.1	1.1**
	F	*	3.1	3.0	3.0	3.4	3.6	4.0	5.9**

* no data

** 1989-1994

3. Incidence of persons irradiated in childhood and in adolescence

The risk group of thyroid tumours induced with radiation includes persons who were irradiated at the age under 20 (4.5). In the KR it is in this age group that unit cases of TC were exposed. In the BR, for the 1986-1995 period, in the same age group were registered 81 morphologically verified case of TC. The data for incidence of the cohort of persons from the BR who were irradiated in childhood and in adolescence are in table III and in Fig. 1.

Table II.

Thyroid cancer incidence of various age groups of the population of the Bryansk, Kaluga, Orel regions and of the Russian Federation in 1981-1995 (rates per 100000 of the population of a corresponding sex)

Territory	Age	Males			Females		
		1981-1986	1987-1989	1990-1995	1981-1986	1987-1989	1990-1995
Bryansk region	under 29	0.2	0.6	1.2	1.0	2.0	3.8
	30-39	0.8	1.6	1.6	4.4	11.7	14.9
	40-49	1.2	0.9	2.8	3.1	14.1	21.3
	50-59	2.0	3.0	4.2	5.1	13.1	16.6
	60-69	3.6	4.6	4.6	4.4	10.7	12.7
	70 & over	2.9	3.6	4.2	3.7	8.0	8.1
	Total	1.0	1.5	2.3	2.9	7.9	10.5

Continuation of table II.

Territory	Age	Males			Females		
		1981-1986	1987-1989	1990-1995	1981-1986	1987-1989	1990-1995
Kaluga region	under 29	0.0	0.3	0.2	0.1	0.2	0.3
	30-39	0.2	0.4	0.7	1.0	2.4	2.0
	40-49	0.0	0.6	2.1	1.2	2.7	5.3
	50-59	0.5	1.5	1.1	1.4	3.4	4.8
	60-69	0.7	3.9	2.1	1.5	3.3	3.6
	70 & over	0.0	0.0	1.9	2.1	3.8	6.8
	Total	0.1	0.7	0.9	0.9	2.2	2.8
Orel region	under 29	*	0.6**	0.7	*	1.1*	4.1
	30-39		0.0	2.2		11.3	13.7
	40-49		2.2	2.9		8.3	17.8
	50-59		1.8	4.9		7.4	19.2
	60-69		5.7	4.8		4.6	11.3
	70 & over		0.0	5.1		5.3	10.8
	Total		1.2	2.4		5.2	10.7
Russia	under 29	*	0.2**	0.2***	*	0.8	0.9***
	30-39		1.0	0.7		4.3	4.3
	40-49		1.4	1.4		6.3	7.4
	50-59		2.2	2.2		6.9	7.4
	60-69		3.0	3.2		7.6	7.8
	70 & over		4.6	4.2		6.6	7.1
	Total		1.0	1.0		3.9	4.3

* no data for Orel 1995

** 1989

*** 1989-1994

Table III.

Incidence of thyroid malignant neoplasm in the cohort of persons living in the BR who were irradiated in childhood and in adolescence (rates per 100000 of the population of corresponding sex)

Sex	Years								
	1987	1988	1989	1990	1991	1992	1993	1994	1995
Males	0.9	0.0	0.0	0.5	0.5	0.9	1.9	2.3	2.0
Females	0.5	0.5	1.0	2.0	1.0	3.0	3.5	6.5	6.2
Both sexes	0.7	0.2	0.5	1.2	0.7	1.9	2.7	5.6	4.1

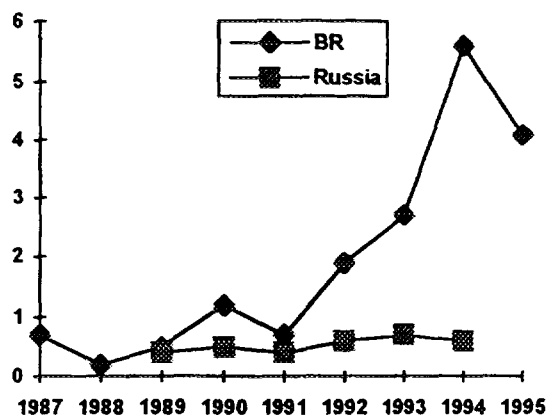


Fig.1. Incidence of thyroid malignant neoplasm in the cohort of persons living in the BR, who were irradiated in childhood and in adolescence, and the corresponding age group of the population of Russia (rates per 100000 of the population of corresponding age)

In the cohort to be studied, TC contribute significantly more (22.0%) to the general oncological incidence than in the corresponding age group of the population of Russia (5%). Besides, it is significant that 21.9% cases of TC registered in the BR in 1994 were exposed in person of this age group, whereas in OR - 15.7% and in the Russian Federation - 8.3%. Hence, it is clear that the TC incidence in this age group of the BR has a greater tendency to grow than that of the corresponding age group of the population of Russia.

4. Incidence of TC malignant neoplasm in children of the BR

In 1994 in the Russian Federation there were registered 60 cases of TC in children at the age of 0-14, including 22 cases in persons living on one of 19 territories suffered from the Chernobyl accident. Incidence rate of TC in children of the Russian Federation has been stable within last 5 years and comprises 0.2 per 100000 of child population. The contribution of TC to all solid tumours exposed in children of the Russian Federation in 1994 comprised 4.0%, whereas in the BR and in the OR those were 20.5% and 11.8%, respectively. As this takes place, in 1994 children contributed to all patients with first diagnosed TC 7.0% in the BR, 2% in the OR, 1.3% in the Russian Federation. In the period before the accident the TC incidence rates in the BR did not exceed the average ones for all Russia (table IV). In 1994-1995, they had exceeded the later more than 10 times.

Table IV.

Thyroid cancer incidence in children of the BR (dynamics of cruel rates per 100000 of child population)

Sex	Years									
	1981-1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Boys	0.0	0.6	0.0	0.0	0.6	0.0	0.0	0.6	2.5	2.5
Girls	0.2	0.0	0.6	0.0	0.6	0.0	1.4	0.0	2.6	2.6
Both sexes	0.1	0.3	0.3	0.0	0.6	0.0	0.6	0.3	2.5	2.5

From 1981 to 1995 in the BR, which is most polluted with radionuclides, there were exposed 25 cases of TC in children, including 23 after the accident. Fifteen patients live in the most polluted areas of the region, 4 — in the less polluted areas, 4 — in the pure areas. Incidence rates in children from the polluted areas are excessively high (table V).

Table V.

Thyroid cancer incidence in children from the areas of the BR with various levels of pollution (rates per 100000 of child population)

Areas	Years								
	1987	1988	1989	1990	1991	1992	1993	1994	1995
Polluted	0.0	0.0	0.0	1.9	0.0	1.9	0.0	9.4	13.2
Slightly polluted	2.1	2.1	0.0	0.0	0.0	2.1	0.0	2.1	0.0
Pure	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.3	0.2

5. Morphological types of malignant neoplasm of thyroid in BR

In children, 80% cases were papillary cancer. However, the ratio between follicular and papillary forms did not change compared to 1981 and complied 0.7. Thus, in the Bryansk and Kaluga regions, suffered from the Chernobyl accident, growth of the TC incidence is obvious, particularly in young people. So, it is necessary to further monitor TC and to carry on epidemiological investigations that correlation between this phenomenon and the Chernobyl accident be confirmed.

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THE CHERNOBYL ACCIDENT: THYROID EXPOSURE AMONG THE POPULATION DUE TO RADIOIODINE

Yu.I. GAVRILIN

Biophysics Institute (Russian Federation State Science Centre),
Moscow, Russian Federation

V.F. STEPANENKO

Medical Radiological Research Centre, Academy of Medical Sciences,
Obninsk, Russian Federation

S.M. SHINKAREV

Russian Federation State Science Centre, Biophysics Institute,
Moscow, Russian Federation

V.P. DOMARATSKIY, G.L. MOROZ

Scientific Research Institute for Industrial and Marine Medicine,
St. Petersburg, Russian Federation

V.T. HRUSHTCH

State Scientific Centre,
Moscow, Russian Federation

Different aspects of internal and external exposure to thyroid of inhabitants from the contaminated areas of Belarus, Russia, and Ukraine are discussed in the paper. In the case of consumption of contaminated foods contribution to total absorbed dose from internal radioiodine exposure was more than 90%, otherwise (in the case of only inhalation radioiodine intake) - not lesser than 85%. ^{131}I exposure to thyroid was the main contribution to internal exposure, and exposure to thyroid from short-lived radioiodines was significant only for the inhabitants who didn't consume contaminated foods (as high as 50% and sometimes 70% of internal exposure from ^{131}I). Peculiarities of formation of "measured" doses are considered. Semiempirical model of relationships between the average internal thyroid dose received by people in the rural settlements and the ground-deposition density of radionuclides in these settlements is presented. Consistency of the results calculated due to the model for different areas of Belarus, Russia, and Ukraine has been shown. It has been indicated the necessity of intensification of ^{129}I measurements in soil. Practical efficiency of used countermeasures for majority people to reduce radioiodine intake is estimated as high as approximately 2 times and caused mainly removing people from contaminated areas.

ВВЕДЕНИЕ

При рассмотрении роста заболеваемости щитовидной железы (ЩЖ) как одного из явных следствий Чернобыльской аварии естественно ставить вопрос об их радиационной обусловленности, о роли разных источников облучения ЩЖ (внешнее излучение, внутреннее облучение ^{131}I и др. радионуклидами). Такие задачи можно решать лишь на основе достаточно качественных дозовых оценок всех компонент облучения ЩЖ. Осуществление таких оценок применительно к населению загрязненных регионов Белоруссии, России и Украины стало возможным благодаря тому, что в мае и начале июня 1986 г. были проведены массовые измерения содержания ^{131}I в ЩЖ, по результатам которых реконструированы индивидуальные дозы внутреннего облучения ЩЖ для

большого числа детей и взрослых: около 130 тыс. жителей Белоруссии, 30 тыс. — России (в основном, Калужская область) и 150 тыс. — Украины. Эти данные, "измеренные индивидуальные дозы", относятся к Классу 1 достоверности. При достаточно большом числе таких данных для жителей некоторого населенного пункта можно получить коллективные характеристики облучения ЩЖ, сохраняющие объективность данных Класса 1 и позволяющие выполнять индивидуализированные оценки для необследованных жителей этого пункта (данные Класса 2 достоверности — "паспортные дозы"). Для жителей всех прочих населенных пунктов остается единственная возможность: оценивать индивидуальные дозы облучения ЩЖ по расчетной модели на основе данных о радиоактивном загрязнении территорий (Класс 3 достоверности оценок). Необходимо, чтобы модель содержала только такие параметры, которые уже определены или поддаются определению на основе измеряемых величин.

В докладе обсуждаются: соотношение между внутренним и внешним облучениями ЩЖ, вклад основных радионуклидов в дозу внутреннего облучения ЩЖ, особенности дозиметрических оценок Классов 1 и 2 достоверности, полуэмпирическая модель для оценок Класса 3 достоверности, а также эффективность реализованных защитных мероприятий применительно к ЩЖ.

1. ДВА ОСНОВНЫХ ВИДА ОБЛУЧЕНИЯ ЩИТОВИДНОЙ ЖЕЛЕЗЫ

1.1. Внутреннее облучение щитовидной железы

Внутреннее облучение ЩЖ реализуется при поступлении радионуклидов в организм человека через органы дыхания (ингаляционное поступление) и (или) органы пищеварения (пероральное поступление). При поступлении в организм предшественников радиоизотопов йода доза внутреннего облучения ЩЖ оценивается с учетом соответствующих изобарических цепочек радиоактивных превращений радионуклидов внутри организма. В анализе учтены цепочки йода и теллура с атомными массами от 129 по 135, а также изотопы $^{103,106}\text{Ru}$ и $^{134,137}\text{Cs}$.

1.1.1. Ингаляционное поступление

Результаты оценки вклада изобарических цепочек изотопов теллура и йода во внутреннее облучение ЩЖ представлены в таблице I применительно к

Таблица I. Относительный вклад теллуру-йодных изобарических семейств в суммарную дозу внутреннего облучения ЩЖ при однократном ингаляционном поступлении смеси радионуклидов ($\text{Te}, \text{I}, ^{103,106}\text{Ru}, ^{134,137}\text{Cs}$) в "реакторном" соотношении, исправленном на радиоактивный распад

Время после взрыва, сут.	Относительный вклад (%) теллуру-йодных цепочек с атомной массой A, для лиц указанного возраста							
	A = 131		A = 132		A = 133		A = 130, 134, 135	
	Змес	Взрос.	Змес	Взрос.	Змес	Взрос.	Змес	Взрос.
0	59	67	22	17	16	13	2.9	1.7
0.5	65	72	22	17	12	9.9	1.1	0.6
1.0	68	75	22	16	9.0	7.3	0.4	0.1
2	74	80	20	15	4.8	3.8	0.0	0.0
3	79	83	17	14	2.5	1.9	0.0	0.0
5	83	86	16	12	0.6	0.5	0.0	0.0
8	87	90	11	8.2	0.1	0.1	0.0	0.0
15	92	93	5.0	3.5	0.0	0.0	0.0	0.0
20	94	92	2.7	1.8	0.0	0.0	0.0	0.0
30	91	87	0.7	0.5	0.0	0.0	0.0	0.0

"мгновенному" ингаляционному поступлению смеси радионуклидов. Соотношение между активностями радионуклидов рассчитаны в соответствии с законом радиоактивного распада и режимом работы реактора в последние сутки перед аварией [1], на основе данных [2,3]. Используемые численные значения дозовых коэффициентов соответствуют Публикации 56 МКРЗ [4] для лиц разного возраста. В табл. I приведены данные для самой младшей возрастной группы (3 мес.) и взрослых. Для лиц других возрастов численные значения относительного вклада находятся между указанными значениями. Исходное реакторное отношение активности ^{132}Te к активности ^{131}I было принято равным 1.3. Для большинства случаев ингаляционного поступления радионуклидов можно принять, что указанное отношение находилось в пределах 0.4–1.2 [5]. Таким образом, данные из табл. I можно характеризовать как близкую к максимальной оценку относительного вклада радиоизотопов теллура по сравнению с ^{131}I . Следует подчеркнуть, что в любом населенном пункте абсолютные значения дозы облучения ЩЖ у жителей, потреблявших загрязненные пищевые продукты, намного (в 10–20 раз) превышали "ингаляционные" дозы. Для сельских жителей вариант преимущественно перорального поступления радионуклидов в организм является основным и обуславливает фактический вклад короткоживущих изотопов.

1.1.2. Пероральное поступление

Были рассмотрены три источника перорального поступления радионуклидов в организм: коровье молоко местного производства, листовые овощи местного производства и поступление радионуклидов с загрязненных ладоней. Воздействие на ЩЖ излучения ^{132}Te , ^{133}I , ^{134}I , ^{135}I может быть более эффективно по сравнению с ^{131}I . Результаты оценки относительного вклада короткоживущих радионуклидов (практически ^{132}Te (^{132}I) и ^{133}I) в облучение ЩЖ за счет перорального поступления представлены в таблице II.

Таблица II. Вклад короткоживущих радионуклидов в поглощенную дозу облучения ЩЖ при поступлении с молоком, листовыми овощами и с загрязненных рук в течение T сут.

Начальное отношение активности $^{132}\text{Te}/^{131}\text{I}$	Доля (% от вклада ^{131}I)		
	T = 1 сут.	T = 8 сут.	T не ограничено
1.3	20–24	8–10	4.1–5.4
2.6	28–33	15–18	7.8–10.

1.2. Внешнее облучение щитовидной железы

Проведенные защитные мероприятия в целом обеспечили реализацию решения о том, чтобы доза внешнего облучения лиц из населения за первый год после аварии не превышала 5 сЗв [1]. В то же время средние "измеренные" дозы внутреннего облучения ЩЖ у лиц, внешнее облучение которых могло приближаться к установленному пределу, составляли 1 Гр и более. Таким образом, без строгих вычислений ясно, что вклад внешнего гамма-излучения в суммарную поглощенную дозу облучения ЩЖ в типовых случаях составил существенно меньше 10%. В случаях чисто ингаляционного поступления радионуклидов верхнюю границу для доли внешнего излучения необходимо поднять максимально до 15%. Редкие случаи, когда практически было исключено поступление радионуклидов в организм, следует оценивать персонально.

2.ОСОБЕННОСТИ ОПРЕДЕЛЕНИЯ ИНДИВИДУАЛЬНЫХ "ИЗМЕРЕННЫХ" ДОЗ ОБЛУЧЕНИЯ ЩИТОВИДНОЙ ЖЕЛЕЗЫ (КЛАСС 1 ДАННЫХ)

Численное значение индивидуальной "измеренной" поглощенной дозы облучения ЩЖ ($D_{ik}, \text{Гр}$) определяли на основе результата измерения содержания ^{131}I в ЩЖ у индивида i из возрастной группы k по формуле:

$$D_{ik} = F_k(t-t_0) * G_i(t), \quad (1)$$

где F_k – возрастозависимый коэффициент пересчета от измеренного содержания радиойода в ЩЖ к поглощенной дозе, $\text{Гр} \cdot \text{Бк}^{-1}$;
 t, t_0 – время после взрыва реактора до измерения содержания радиойода в ЩЖ и до начала выпадений, соответственно, сут.;
 G_i – измеренное содержание ^{131}I в ЩЖ, Бк.

При наличии нескольких результатов измерений индивидуальную дозу находили как среднеарифметическое от результатов расчета по формуле (1).

2.1. Выбор дозовых коэффициентов F_k

Расчет по формуле (1) применительно к жителям Белоруссии в первой итерации был выполнен с численными значениями возрастозависимых коэффициентов F_k , приведенных в Руководстве [6] для случая поступления ^{131}I с молоком в модели однократного загрязнения пастбища (применительно к большинству населенных пунктов) или для однократного (ингаляционного) поступления ^{131}I в ЩЖ. В последующем значения коэффициентов были откорректированы с учетом Публикации 56 МКРЗ [4]. Такой же подход был принят для жителей Украины [7] и Калужской области России. В дальнейшем, для территорий со значимой пролонгацией выпадений, коррекцию коэффициентов F_k предполагается выполнить по схеме, описанной в Руководстве [6].

2.2. Измерения содержания ^{131}I в щитовидной железе

Особенности определения содержания ^{131}I в ЩЖ по результатам измерений, проведенных в "момент" времени t , применительно к условиям Чернобыльской аварии учтены расчетной формулой [6]:

$$G_i(t) = K_i * (P_{\text{thy}} - P_b) : r(t), \quad (2)$$

Таблица III. Расчетные значения поправки r для СРП–68–01 с неколлимированным датчиком для случая ингаляции смеси радионуклидов в "момент" взрыва реактора и для поступления $^{131}\text{I}, ^{134}, ^{137}\text{Cs}$ с молоком. Однократное загрязнение пастбища 26 апреля 1986 г. (R_x – отношение активности ^{131}I к активности ^{137}Cs в выпадениях на момент выпадений)

Условия поступления	Значения поправки r на указанную дату, отн.ед.							
	Май					Июнь		
	01	05	10	20	30	05	10	15
Ингаляция	2.4	1.9	1.3	1.0	1.0	1.0	1.0	1.0
С молоком								
$R_x = 24$	1.0	1.0	1.0	1.0	1.1	1.2	1.3	1.4
$R_x = 8$	1.0	1.0	1.1	1.1	1.3	1.6	1.9	2.4

где K_1 — в общем случае индивидуальный коэффициент пересчета к содержанию ^{131}I в ЩЖ, $\text{Бк} \cdot \text{с} \cdot \text{имп}^{-1}$, $\text{Бк} \cdot \text{ч} \cdot \text{мкР}^{-1}$ и др.;

$P_{\text{thyг}}$ — показание прибора при размещении детектора вблизи ЩЖ об —
следуемого, $\text{имп} \cdot \text{с}^{-1}$, $\text{мкР} \cdot \text{ч}^{-1}$ и др.;

$P_{\text{б}}$ — показание прибора, принятое за фон метода определения содержания ^{131}I в ЩЖ, $\text{имп} \cdot \text{с}^{-1}$, $\text{мкР} \cdot \text{ч}^{-1}$ и др.;

$r(t)$ — поправка на излучение радионуклидов, содержание которых в организме пропорционально содержанию ^{131}I в ЩЖ.

В табл. III приведены результаты расчетной оценки поправки r на γ — излучение изотопов ^{132}I , ^{133}I , ^{135}I , содержащихся в ЩЖ вследствие ингаляции смеси радионуклидов сразу после взрыва реактора, а также на γ — излучение изотопов ^{134}Cs , ^{137}Cs , поступавших в организм с молоком. Относительное содержание ^{131}I и ^{134}Cs , ^{137}Cs в организме вычисляли, следуя модели ECOSYS — 87 [8] и Публикации 56 МКРЗ [4], а подсветку датчика радиоцезием оценивали по результатам измерений, проведенных в НИИ ПММ на фантомах для трех возрастных групп: 2 г., 10 лет и введенных в табл. III не более чем на 10%. Из табл. III видно, что оптимальным временем проведения измерений был период с 10 по 30 мая, когда значения r не превышают 1.3. Важно подчеркнуть, что главное искажение в результаты измерений в любое время могло вносить наружное радиоактивное загрязнение тела (одежды) человека, если этому не уделялось должного внимания.

3. ПАСПОРТИЗАЦИЯ НАСЕЛЕННЫХ ПУНКТОВ ПО ВНУТРЕННЕМУ ОБЛУЧЕНИЮ ЩИТОВИДНОЙ ЖЕЛЕЗЫ НА ОСНОВЕ ИМЕЮЩИХСЯ ВЫБОРОК "ИЗМЕРЕННЫХ ИНДИВИДУАЛЬНЫХ ДОЗ" (ОЦЕНКИ КЛАССА 2 ДОСТОВЕРНОСТИ)

Наличие большого числа "измеренных доз" позволило найти параметры эмпирических распределений индивидуальных доз для различных возрастных групп жителей многих сельских населенных пунктов Гомельской и Могилевской областей Белоруссии (около 800 пунктов), Калужской области России (около 140 пунктов) и Украины (238 пунктов только в Черниговской области [7]). Эти данные отражают конкретную специфику каждого населенного пункта и на основе дополнительной персональной информации позволяют делать уточненные оценки Класса 2 достоверности — индивидуализированных "паспортных" доз. Важнейшие характеристики эмпирических распределений индивидуальных доз — средние значения и стандартные геометрические отклонения — являются хорошей основой для построения и проверки работоспособности расчетной модели, позволяющей приписать конкретные численные значения указанных величин для остальных населенных пунктов Белоруссии, России и Украины.

4. ПОЛУЭМПИРИЧЕСКАЯ МОДЕЛЬ СВЯЗИ ДОЗ ВНУТРЕННЕГО ОБЛУЧЕНИЯ ЩИТОВИДНОЙ ЖЕЛЕЗЫ С ПАРАМЕТРАМИ РАДИОАКТИВНЫХ ВЫПАДЕНИЙ

Для каждого пункта (j), расположенного на территории (x), рассматривались средние значения D_{jx} доз облучения ЩЖ у взрослых жителей в зависимости от плотности выпадений ^{137}Cs , $q_{jx}(\text{Cs})$. Территория (x) выделяется из соображений приблизительно одинакового интеграла концентрации радионуклидов в воздухе за время формирования основного загрязнения местности. На рис. 1 показаны отношения $(D_{jx} : q_{jx})$ этих величин в зависимости от значений плотности выпадений $q_{jx}(\text{Cs})$ для территорий, расположенных в Белоруссии, России и на Украине. Из рис. 1 видно сильное уменьшение отношения $(D_{jx} : q_{jx})$ при увеличении плотности выпадений $q_{jx}(\text{Cs})$ в пределах каждой территории, и такая закономерность прослеживается для всех проанализированных территорий. Эту общую

закономерность можно описать простой полуэмпирической формулой в следующих модификациях [9,10]:

$$D_{jx} = [C_0 \cdot L_x \cdot q_x(^{131}\text{I}) + B_0 \cdot L_{jx} \cdot q_{jx}(^{131}\text{I})] / \mu = \\ [C_0 \cdot L_x \cdot R_x \cdot q_x(^{137}\text{Cs}) + B_0 \cdot L_{jx} \cdot R_{jx} \cdot q_{jx}(^{137}\text{Cs})] / \mu = \quad (3) \\ [C_0 \cdot L_x \cdot q_x(^{129}\text{I}) + B_0 \cdot L_{jx} \cdot q_{jx}(^{129}\text{I})] \cdot s \cdot \exp(-0.086 \cdot t_{\text{eff}}) / \mu,$$

где C_0, B_0 — основные параметры модели, численные значения которых одинаковы для всех выделенных территорий, $\text{Гр} \cdot \text{м}^2 \cdot \text{Бк}^{-1}$;
 L_x, L_{jx} — произведения модифицирующих множителей, соответственно, для территории (x) и населенного пункта j на этой территории, учитывающих особенности пастбищ, вклад топливных частиц и др., отн.ед.;
 q_x, q_{jx} — плотность выпадений указанного в скобках радионуклида, соответственно, по территории (x) и пункту j, $\text{Бк} \cdot \text{м}^{-2}$;
 μ — общая для территории (x) и пункта j поправка на защитные мероприятия и особенности пастбищного сезона, отн.ед.;
 R_x, R_{jx} — отношение активности ^{131}I к активности ^{137}Cs в выпадениях в среднем для территории (x) и пункта j, соответственно;
 s — отношение активности ^{131}I к активности ^{129}I в активной зоне реактора в момент взрыва, $s = (5.0 \pm 1.5) \cdot 10^7$ [10];
 t_{eff} — эффективный момент времени выпадений ^{129}I , учитывающий радиоактивный распад ^{131}I , сут.

Уточненные за последнее время численные значения основных параметров модели составляют: $B_0 = 1.3 \cdot 10^{-8} \text{ Гр} \cdot \text{м}^2 \cdot \text{Бк}^{-1}$, $C_0 = 3.3 \cdot 10^{-8} \text{ Гр} \cdot \text{м}^2 \cdot \text{Бк}^{-1}$.

Для оценки средних доз облучения ЩЖ у детей вводятся необходимые поправки. В типовом варианте полная информация, необходимая для расчетов по формуле (1), отсутствует и приходится идти на упрощения, принимая $\mu = L_x = L_{jx} = 1$ и $R_{jx} = R_x$. В таком случае неопределенность оценки средней дозы D_{jx}

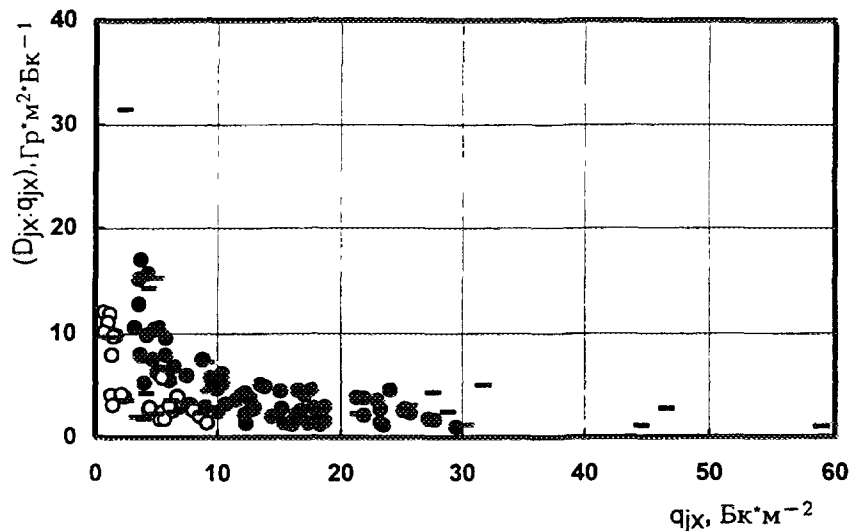


Рис.1. Отношение средней поглощенной дозы внутреннего облучения ЩЖ (D_{jx}) у взрослых жителей населенного пункта (j), расположенного на территории (x), к плотности выпадений ^{137}Cs (q_{jx}) в этом пункте в зависимости от q_{jx} . В качестве территорий (x) представлены: части Хойникского и Брагинского районов Гомельской области Белоруссии вне 30 — километровой зоны (●); часть Народичского района Житомирской области Украины (■) и Хвастовичский район Калужской области России (○).

характеризуется значениями стандартного геометрического отклонения в пределах 1.5–1.8, что отражает в целом слабую корреляцию между средними дозами облучения ЩЖ и плотностью выпадений радиоцезия в населенных пунктах (в пределах выделенной территории). В таблице IV приведены результаты оценок средних доз внутреннего облучения ЩЖ у взрослых жителей типового сельского населенного пункта, полученные по формуле (1) с изложенными выше упрощениями. Принято: $R_x = 24$. При других значениях R_x данные табл. IV следует изменить по пропорции ($R_x:24$).

Средние дозы облучения ЩЖ у детей младшего возраста в 5–10 раз больше, чем у взрослых. Кроме того, индивидуальные дозы у отдельных лиц существенно превышают средние значения (с кратностью до 6–8 раз). Таким образом, из табл. IV видно, что даже при меньших значениях R_x , характерных для наиболее загрязненных территорий (30–километровая зона), дозы внутреннего облучения ЩЖ у некоторых детей могли превысить уровни острого поражения органа. Практически поголовное дозиметрическое обследование детей, проживавших на таких территориях, не обнаружило случаев, когда бы "измеренные" индивидуальные дозы превысили 50–60 Гр, и это можно отнести на счет реализованных защитных мероприятий.

Таблица IV. Средние дозы внутреннего облучения ЩЖ у взрослых жителей типового сельского населенного пункта (j) с плотностью выпадений ^{137}Cs (q_{jx}), расположенного на территории (x) со средней плотностью выпадений ^{137}Cs (q_x), при отсутствии любых защитных мероприятий

q_x , МБк*м ⁻²	Средняя доза (Гр) при указанном значении q_{jx} , МБк*м ⁻²						
	0.01	0.03	0.1	0.3	1.0	3.0	10
0.03	0.027	0.033	0.055	0.12	0.34	*	*
0.10	0.082	0.089	0.11	0.17	0.40	1.0	*
0.30	0.24	0.25	0.27	0.33	0.55	1.2	3.4
1.0	*	0.80	0.82	0.89	1.1	1.7	4.0
3.0	*	*	2.4	2.5	2.7	3.3	5.5

**При указанном среднем значении q_x соответствующие значения q_{jx} для населенных пунктов на территории (x) практически невозможны.*

6. ПРАКТИЧЕСКАЯ ЭФФЕКТИВНОСТЬ РЕАЛИЗОВАННЫХ ЗАЩИТНЫХ МЕРОПРИЯТИЙ

Эффективность первоочередных защитных мероприятий в период прохождения радиоактивного облака можно оценить на основе результатов обследования небольшого числа лиц, находившихся в момент аварии в г. Припять [11]: закрытие окон в городских квартирах снизило возможную "ингаляционную" дозу облучения ЩЖ в 3–5 раз, а прием препаратов стабильного йода — еще приблизительно в 10 раз. Столь высокую практическую эффективность защитных мероприятий следует отнести к разряду максимальных, достигнутых лишь весьма небольшим числом лиц из городского населения. Ввиду отсутствия необходимых указаний, сельское население не было защищено от ингаляционного поступления радионуклидов. Если бы после прохождения основного радиоактивного облака сельский житель не потреблял загрязненных пищевых продуктов (молока), доза облучения ЩЖ у него была бы, в среднем, в 10–20 раз меньше, чем у жителя, не прекращавшего потребления загрязненных продуктов. Расчетная кратность снижения дозы облучения ЩЖ за счет прекращения потребления загрязненных продуктов спустя некоторое время после однократного загрязнения местности представлена в таблице V (эффективная очистка травы от ^{131}I принята равной 0.15 сут^{-1} [6], доля ингаляционной составляющей в отсутствие мероприятий — 0.05). Очевидно, что при большей доле ингаляционного поступления эффект был

меньше, чем показано в табл V, а в случае более медленной очистки пастбищной травы — несколько выше. Во всех случаях из табл V видно, что даже при абсолютно полной блокировке ЩЖ препаратами стабильного йода, это мероприятие не могло дать значимого эффекта, если было начато позже, чем 10–12 сут после загрязнения местности (6–8 мая для местности, загрязненной 26 апреля)

Таблица V Расчетная кратность (μ) уменьшения возможной дозы внутреннего облучения ЩЖ за счет прекращения поступления ^{131}I с молоком спустя время (t_0) после однократных радиоактивных выпадений

t_0 , сут	1	2	3*	4*	5	6	7**	8**	10	12	15
μ , отн ед	12	6	4	2.9	2.4	2.0	1.8	1.6	1.4	1.3	1.2

* — эвакуация из зоны 10 км; ** — эвакуация из зоны 30 км

7 ЗАДАЧИ НА БУДУЩЕЕ

Физическое и компьютерное моделирование процедуры измерений содержания ^{131}I в ЩЖ, уточнение кинетики радиоактивных выпадений и сопутствующих им метеоусловий, уточнение особенностей пастбищного сезона в апреле–мае 1986 г, реконструкция схем централизованного снабжения молоком жителей городов и крупных сел — все эти будущие работы безусловно необходимы как для возможной коррекции некоторых из имеющихся подмассивов "измеренных" доз и разработанной полуэмпирической модели, так и для уточнения количественных расчетов по формуле (1) для многих территорий Белоруссии, России и Украины. Для многих таких территорий отсутствуют эмпирические данные по фактическим соотношениям ^{131}I ^{137}Cs , и единственным путем для объективной оценки этих отношений является проведение измерений содержания долгоживущего ^{129}I в объектах окружающей среды. Объем необходимых измерений диктуется требованием определения средних значений R_x для каждой интересующей территории (х). Решение столь масштабной задачи нельзя откладывать на отдаленное будущее, поскольку из-за природной миграции радионуклида возможность получения экспериментальных данных в конечном счете будет безвозвратно потеряна.

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SESSION 3

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CURRENT PROBLEMS WITH RECONSTRUCTING THE RADIATION DOSES TO THE "LIQUIDATORS" OF THE CHERNOBYL ACCIDENT

L.A. IL'IN

Biophysics Institute (Russian Federation State Science Centre),
Moscow, Russian Federation



XA9745461

1. The paper gives a classification and numerical breakdown of the liquidators in 1986 and 1987 - who came from various ministries and authorities of the former USSR. It distinguishes three areas of emergency operations (the nuclear power plant industrial site, the 10 km zone and the zone up to 30 km), which were characterized by substantial differences in the levels of radiation affecting people.
2. Starting with the first days after the accident, the paper reviews problems of dosimetric surveillance of those operations using personnel dosimetry and area monitoring. It is shown that the most serious inadequacies in the organization of dosimetric surveillance and in the estimates of radiation burdens occurred in the military liquidator groups.
3. The data on the exposure of liquidators which were officially recorded in the State register are based on entries in military passes and other documents regarding the external gamma ray doses received. According to the analysis carried out, up to 70% of these values - especially for persons serving in the military - do not correspond to the actual radiation doses.
4. By simulation modelling using their own data on individually measured radiation doses, D.P. Osanov and V.P. Kryuchkov obtained histograms of the distribution of the average gamma ray doses which differ by factors of 1.5-2 from the values officially recorded in the State register.
5. The collective doses for various groups of liquidators in 1986 and 1987 and the expected stochastic effects of this radiation are evaluated.
6. A group of high-risk liquidators irradiated to doses exceeding 25 cGy is identified.
7. Problems of reconstructing the individual effective radiation doses taking into account the incorporation of radionuclides, data on the radiological situation on the site, and the routes taken during their work by persons engaged in operations on the industrial site of the damaged plant are discussed.

RISK ASSESSMENT AFTER THE CHERNOBYL ACCIDENT IN ROMANIA

C. MILU
Institute of Hygiene and Public Health,
Bucharest, Romania



XA9745462

1. INTRODUCTION

Few days after the Chernobyl accident from 1986, Romania's territory was crossed by a radiation cloud, consisting of a mixture of artificial radionuclides of different radiological risk. Intensive radioactivity measurements were performed by the Radiation Hygiene Laboratories Network (21 Labs) of the Ministry of Health. The results obtained by all laboratories throughout the country were reported to the Institute of Hygiene, Public Health, Health Services and Management in Bucharest and processed using an independent computer system. Data available on radioactive content of aerosols, drinking water and foodstuff (milk and dairy products, meat, bread, vegetables and fruits) allowed several dose and risk assessment calculations.

2. METHOD

Based on radioactive content of aerosols, drinking water and foodstuffs and using their consumption rate (Table I and Reference [1]), the committed equivalent dose in thyroid (by inhalation and ingestion) due by radioactive iodine and the effective dose due by caesium (by ingestion pathway) were calculated by age groups, applying appropriate dose conversation factors per unit intake [2].

Knowing the population distribution by age groups in Romania, the collective doses (collective organ dose in thyroid and collective effective dose) were calculated. To these values the risk factors expressed in probability of number of deaths per man.Sv: 5-15 per 10^4 man.Sv (for thyroid cancer) and 195 - 215 per 10^4 man.Sv (for all cancers) were applied. The obtained additional number of deaths was compared with the mean annual "normal" (natural) mortality by cancer in Romania: 130 deaths (by thyroid cancer) and about 30,000 deaths (by all other cancers), reported for the whole population in 1986 [3].

Table I. The average annual consumption per inhabitant in Romania (1986 - 1987).

	Age group (years)			
	0 - 1	1 - 10	11 - 17	over 17
Drinking water (l)	500	550	730	900
Milk (l)	90	180	180	180
Diary products (kg)	-	11	18	29
Meat (kg)	-	22	43	46
Meat derivates (kg)	-	7	15	37
Vegetables or equivalent (kg)	36	127	180	180
Fruits or equivalent (kg)	36	44	55	55

3. RESULTS

In Table II are presented the population distribution in Romania in 1986, and the calculated doses: mean (thyroid) equivalent dose (in mSv) and collective effective dose (man.Sv), by age groups. The expected total additional number of deaths by thyroid cancer for the rest of the life of the exposed persons and expected annual additional number of death by cancer of all localisations are given in Table III. The risk estimates were compared with the "normal" annual mortality in Romania by cancer, integrated for the next 50 years. The results are presented for three situations: medium, minimum and maximum value of collective doses, corresponding to medium, minimum, and maximum radioactive contents determined in Romania after Chernobyl accident.

Table II. Population distribution, mean equivalent dose (in thyroid) and collective effective dose, by age groups in Romania, in the first year after Chernobyl accident.

Age group (years)				
	0 - 1	1 - 10	11 - 17	over 17
Population (x10 ³)	325	3810	2857	15633
Mean thyroid equivalent dose (mSv)	22.70	23.74	12.23	10.41
Collective effective dose (man.Sv)	712	8739	3369	15727

Table III. Risk estimates.

	Minimum	Maximum	Medium
Expected total additional number of deaths by thyroid cancer for the rest of the life of the exposed persons	32 - 97	270 - 811	- 116 - 346
Relative increase (%)	0.5 - 1.4	5.0 - 11.8	1.7 - 5.1
Expected annual additional number of deaths by cancer of all localisations (minus thyroid)	21 - 26	125 - 156	71 - 88
Relative increase (%)	0.07 - 0.09	0.43 - 0.54	0.24 - 0.30

4. CONCLUSIONS

The risk assessment in this work is based on estimation of total detriment to the entire population using the concept of collective dose ([4]) and the assumptions of general population exposed to very small individual doses and linear dose - response relation. There was not considered the way in which cancer risk may vary with age, with sex and with time after exposure.

Only a very small increase for the thyroid cancer, and only for young population could be estimated. Although the induction rate for fatal thyroid cancer is higher relative to natural mortality rate than for all cancers, this advantage is offset by the smaller absolute numbers induced, so that detectability of an excess mortality by common human epidemiological studies is no easier than for all cancers together. Moreover, the uncertainty in the expected numbers makes the estimates of excess relative risk unreliable, more than the estimates of absolute risk.

The theoretical risk estimates of this work are confirmed by the recent results of the epidemiological studies performed in Romania and in surrounding countries after Chernobyl accident ([5]); no any specific increase of mortality by cancer was reported.

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LONG TERM FOLLOW-UP OF THE CONSEQUENCES OF THE CHERNOBYL ACCIDENT IN SLOVENIA

M. KANDUC, P. JOVANOVIĆ, B. KUCHAR
Institute of Occupational Safety,
Ljubljana, Slovenia

1. Introduction

Systematic monitoring and surveillance of the radioactivity of the elements of the biosphere is performed in Slovenia since 1961 as a part of the national network. In later time after the operation of the nuclear power plant Krško and uranium mine Žirovski vrh, which is closed now, the measurement programs become more sophisticated.

2. Results

Within the scope of the systematic radioactivity monitoring and surveillance program the activity concentration measurements of radionuclides in samples of air, fallout, soil, drinking water, food and fodder are performed in the Republic of Slovenia since 1961. The paper concentrates on the long term follow up of the activity concentration of ^{90}Sr , $^{134}\text{Cs}/^{137}\text{Cs}$ in the samples of milk, meat, vegetables, fruit and bread, what is considered to be in the critical pathway for the longterm ingestion dose from the Chernobyl accident. The results of the measurements of external gamma dose are given for the capital Ljubljana.

Results of the measurements of concentration of shortlived radionuclides and other radionuclides important in the first year after the accident were already presented and are not discussed here [1,2,3].

In the program there are four permanent locations for collecting of milk samples, Kobarid (NW region), Bohinjska Bistrica (NW region), Murska Sobota (NE region) and Ljubljana (central part). Other food samples are collected in Nova Gorica (W region), Novo Mesto (SE region), Celje, (E region), Koper (W region) and also in Ljubljana.

The highest activity concentrations of $^{134}\text{Cs}/^{137}\text{Cs}$ and $^{89}\text{Sr}/^{90}\text{Sr}$ in milk were measured in Kobarid. Maximal concentrations of $^{134}\text{Cs}/^{137}\text{Cs}$ in Kobarid were in may 1986, 2.7 Bq/l and 100 Bq/l, respectively. Activity concentrations on other three locations were approximately ten times lower. These results are in good correlation with higher activity concentration of soil samples in Kobarid area. Table I shows a follow up of the activity concentration of ^{90}Sr in milk sample of Ljubljana, where there is a milk dairy which produces and distributes the most of milk in Slovenia. Recent results show that concentration of ^{90}Sr is in the same range as before the Chernobyl accident (approximately 0.2 - 0.7 Bq/l of ^{90}Sr and 0.05 to 0.5 Bq/l of ^{137}Cs).

Table I. Specific activities of ^{90}Sr in milk in Ljubljana (Bq/l)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Sr-90	0.19	0.28	0.40	0.22	0.17	0.19	0.16	0.22	0.15	0.14

Table II. Mean values of specific activities in different foodstuffs (Bq/kg)

	milk			beef			fruits			vegetables			cereals		
Year	¹³⁴ Cs	¹³⁷ Cs	⁹⁰ Sr	¹³⁴ Cs	¹³⁷ Cs	⁹⁰ Sr	¹³⁴ Cs	¹³⁷ Cs	⁹⁰ Sr	¹³⁴ Cs	¹³⁷ Cs	⁹⁰ Sr	¹³⁴ Cs	¹³⁷ Cs	⁹⁰ Sr
1986	22.7	49.7	0.45	26	157	0.1	17.2	41.4	0.3	2.47	5.6	0.52	5	12.5	0.56
1987	10	36	0.5	6.2	13.8	0.1	1	2.9	0.5	0.68	1.8	0.62	1.34	4.64	0.3
1988	1.2	4.47	0.34	0.77	3.37	0.12	0.29	1.47	0.53	0.2	0.57	0.37	0.19	0.64	0.33
1989	0.58	3.22	0.26	0.27	1.97	0.1	0.11	0.5	0.16	0.03	0.13	0.27	0.06	0.28	0.4
1990	0.33	2.7	0.27	0.13	1.07	0.12	0.05	0.4	0.37	0.02	0.2	0.39	0.05	0.28	0.4
1991	0.31	3.3	0.24	0.1	2.4	0.06	0.1	0.27	0.06	0.05	0.22	0.36	0.11	0.33	0.31
1992	0.18	2.6	0.24	0.14	1.5	0.1	0.13	0.3	0.2	0.09	0.38	0.98	0.09	0.71	0.62
1993	0.06	1.8	0.15	0.07	0.53	0.1	0.09	0.25	0.28	0.02	0.17	0.33	0.06	0.37	0.22
1994	0.07	2.03	0.17	0.05	1.07	0.44	0.09	0.13	0.25	0.04	0.12	0.34	0.07	0.23	0.27

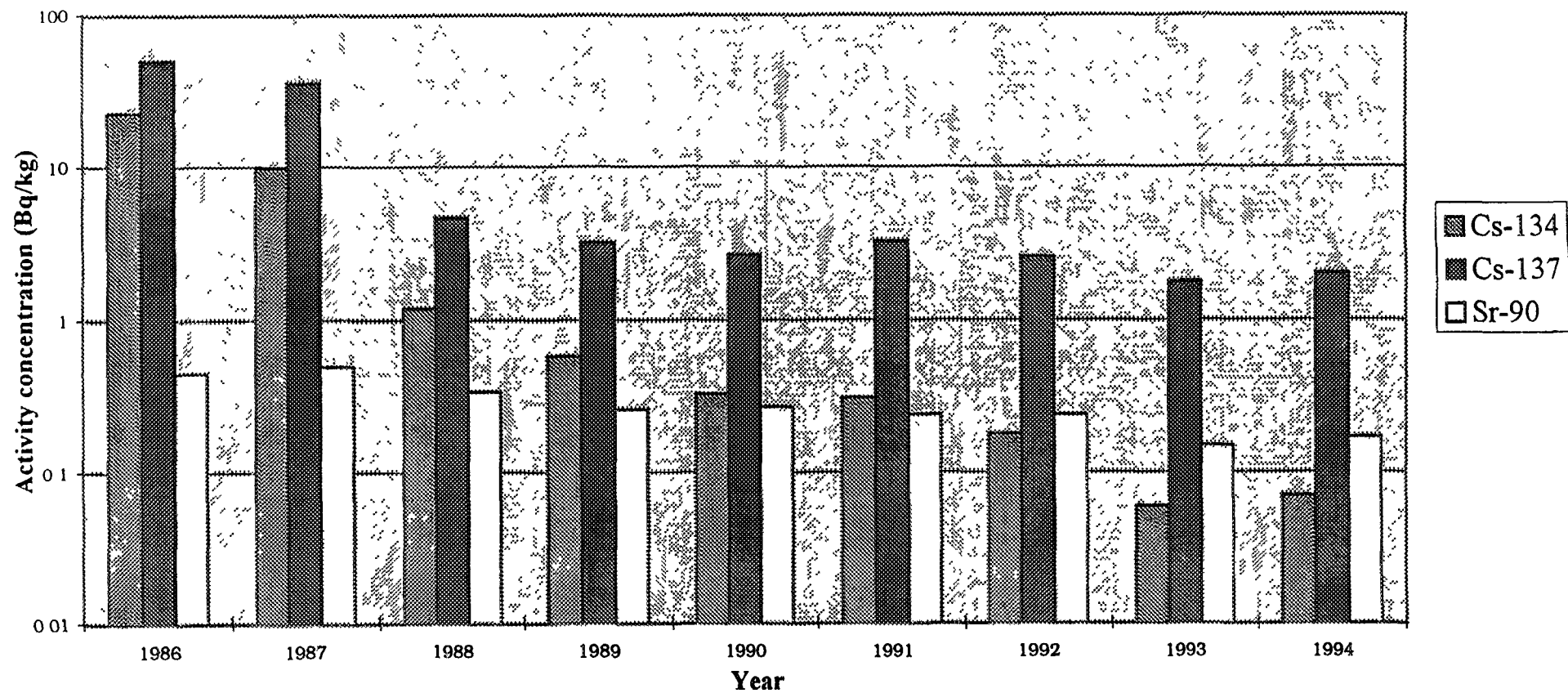


Figure 1: Average activity concentration of Cs-134 / 137 and Sr-90 in milk samples in Slovenia in years from 1986 to 1994

In the scope of measurements of activity concentrations of $^{89}\text{Sr}/^{90}\text{Sr}$ and $^{134}\text{Cs}/^{137}\text{Cs}$ in food which is in critical pathway for received dose, measurements were performed in samples of beef meat, fruits, vegetables and cereals. The highest activity concentration of $^{134}\text{Cs}/^{137}\text{Cs}$ was in 1986 measured in the sample of spinach, 39 Bq/kg and 81 Bq/kg, respectively. In same sample, activity concentration of $^{89}\text{Sr}/^{90}\text{Sr}$ was 4 Bq/kg and 1.2 Bq/kg respectively. In the same period concentration of $^{134}\text{Cs}/^{137}\text{Cs}$ in fruits (apples) varied from 8 Bq/kg to 30 Bq/kg for ^{134}Cs and from 20 Bq/kg to 75 Bq/kg for ^{137}Cs . The highest values were strictly from the mountain region from the NW part of Slovenia. Maximum activity concentration of $^{134}\text{Cs}/^{137}\text{Cs}$ in beef were measured in May 1986, 30 Bq/kg and 600 Bq/kg, respectively. Activity concentrations of $^{89}\text{Sr}/^{90}\text{Sr}$ in same sample was 0.15 Bq/kg and 0.09 Bq/kg, respectively. Concentration of these nuclides decreased by end of year to values of 2 Bq/kg for ^{134}Cs and 4 Bq/kg for ^{137}Cs , while $^{89}\text{Sr}/^{90}\text{Sr}$ was only in trace quantities. The activity concentration of $^{134}\text{Cs}/^{137}\text{Cs}$ increased in 1987 to values of 1 - 6 Bq/kg and 4 - 20 Bq/kg respectively. Similar increase was observed in ^{90}Sr concentration in beef up to 1.2 Bq/kg, while ^{89}Sr was below detection limit.

In Table II average values of activity concentration of ^{134}Cs , ^{137}Cs and ^{90}Sr are presented for milk, beef, fruit, vegetables and cereals for the period of 1986 till 1994 (see also Figure 1). On the basis of these values and estimated intake values of specific food yearly effective doses were calculated for the children of 5 years of age and adults according to dose models in ICRP 67.

In Table III external gamma and ingestion doses are presented for the capital Ljubljana. External doses were measured with thermoluminescent dosimeters and corrected with appropriate conversion factor Gy/Sv.

Cummulative doses for the whole period of follow up are 3 mSv for the children 5 years old and 3.2 mSv for adults.

Table III. External gamma and ingestion doses for Ljubljana

Year	External dose (μSv)		Ingestion (μSv)	
	External	External Chernobyl	Children	Adults
1986	1320	590	270	377
1987	1129	399	120	146
1988	1080	360	23	25
1989	1131	280	14	15
1990	994	220	14	14
1991	966	190	13	15
1992	975	190	16	18
1993	904	180	9	9
1994	876	146	10	10
Sum	9375	2555	489	629

3. Conclusions

Calculated doses show that the impact of the Chernobyl accident in Slovenia after one decade is of same dose range as longterm impact of the atomic explosions in the past. Yearly doses due to ingestion of food, contaminated with $^{134}\text{Cs}/^{137}\text{Cs}$ and ^{90}Sr are practically of same magnitude as before the accident. Aproximately 15 - 20 % of external gamma dose is still attributed to the Chernobyl surface contamination.

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CANCER RISK DUE TO Cs-137 AND Sr-90 DIETARY INTAKE AFTER THE CHERNOBYL ACCIDENT

M. TOADER, R.A. VASILACHE
Institute of Hygiene and Public Health,
Bucharest, Romania



XA9745464

1. INTRODUCTION

On the 26th of April, 1986, a major accident occurred at the fourth reactor of the Chernobyl nuclear power plant, in Ukraine. Soon after the accident, on May 1st, the radioactive cloud reached Romania. The meteorological conditions (rainy weather) lead to important fallout over our country. The most important radionuclides carried by the radioactive plume over Romania were I^{131} , Cs^{134} , Cs^{137} and Sr^{90} . As in many other countries, in the first days, I^{131} had the main contribution to the irradiation dose released to the population. After its decay, and the decay of the other short-lived radionuclides, Cs^{137} and Sr^{90} remained the most important contaminants.

The principal route of intake for these two radionuclides is considered to be the ingestion of contaminated foods. Assessments of radiation doses to people living in the Bucharest area (south-east of Romania - the area studied in this paper) have utilized data obtained from measurement of Cs^{137} and Sr^{90} content in dietary intake samples for a number of subjects of different ages and sexes.

This paper summarizes the results of some of our measurements performed in the Bucharest area, since April 1986 until March 1995.

2. MATERIALS AND METHODS

All the samples were prelevated since April 1986 until March 1995, during nine years after the Chernobyl accident, in the Bucharest area.

The first population group, selected for this study, was a group of adult men, aged between 25 and 40 years, without any health problems, hard laborers. The food samples were prelevated from the cafeteria of the factory, where they were all taking their meals.

A second group of study consisted in children, separated in three age subgroups: 4-6 years old, 7-9 years old and 10-12 years old. These children were living in the kindergartens and schools hostels. The data were then compared with similar data from the adult women working as teachers and educators at the same schools, and taking their meals together with the children. The food samples were prelevated from cafeterias of the schools.

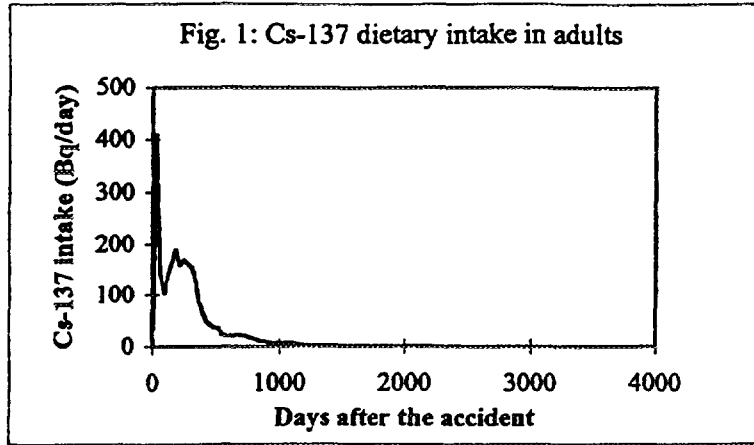
In all samples, radiocesium (Cs^{137} and Cs^{134}) was radiochemically separated using the hexachloroplatinic acid method [1] and Sr^{90} was separated using the fuming nitric acid method [2]. Eventually, Sr^{90} content was measured by his daughter product, Y^{90} . In both cases (Cs^{137} and Sr^{90}), the radiometric measurements were performed with a low-level anticoincidence beta counting system, with high efficiency.

3. RESULTS AND DISCUSSION

3.1. Cs^{137} dietary intake

3.1.1. Cs^{137} dietary intake data for adults

During the nine years of our study, the quantity of Cs^{137} ingested by the population from Bucharest varied a lot from one year to another. As expected, the Cs^{137} intake had the highest value in the first year after the accident. The peak of the Cs^{137} intake was reached in May 1986, when the average daily ingested quantity was 408.5 Bq. Beyond this date, the ingested quantity of Cs^{137} is continuously decreasing, until October 1986, when a new peak occurs in the intake plot (Fig. 1). This new increase was an artificial fact, due to some local conditions, and was presented in previous papers [3, 4]. Beginning with October 1986, the



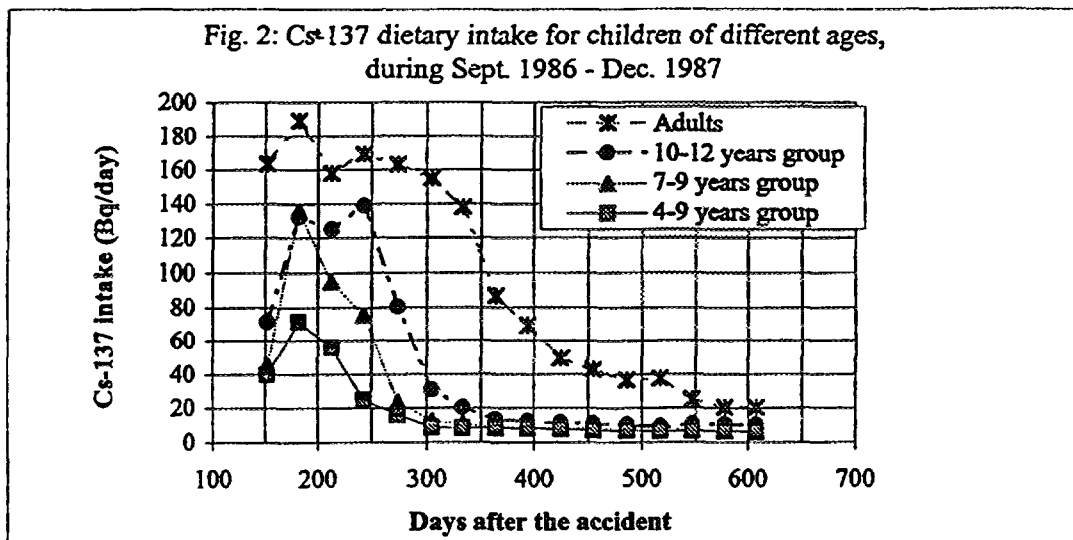
quantity of Cs^{137} intake by diet was continuously decreasing. However, a very small peak occurs again, at about 700 days after the accident (Fig. 1). This is possible to be due to Cs^{137} migration in soil [3]. The continuous (and fast) decrease of Cs^{137} intake lead to an average daily value of 0.102 Bq in March 1995.

3.1.2. Cesium-137 dietary intake data for children

During 1986 - 1995, we have selected four time periods in which we have studied the dietary intake of Cs^{137} at children, for three age groups: 4-6 years, 7-9 years and 10-12 years. In order to make a comparison, we have also studied a group of women, with ages between 24 and 49 years.

The first period was September 1986 - December 1987. From the point of view of the ingestion and excretion processes, this was the most complex period. During this period, an intake peak occurred in October 1986 at all the age groups, including the women (Fig. 2). This is probably due to the same reasons presented as for adults. After this date, Cs^{137} dietary intake is continuously decreasing, but the slope of the decrease is age-dependent.

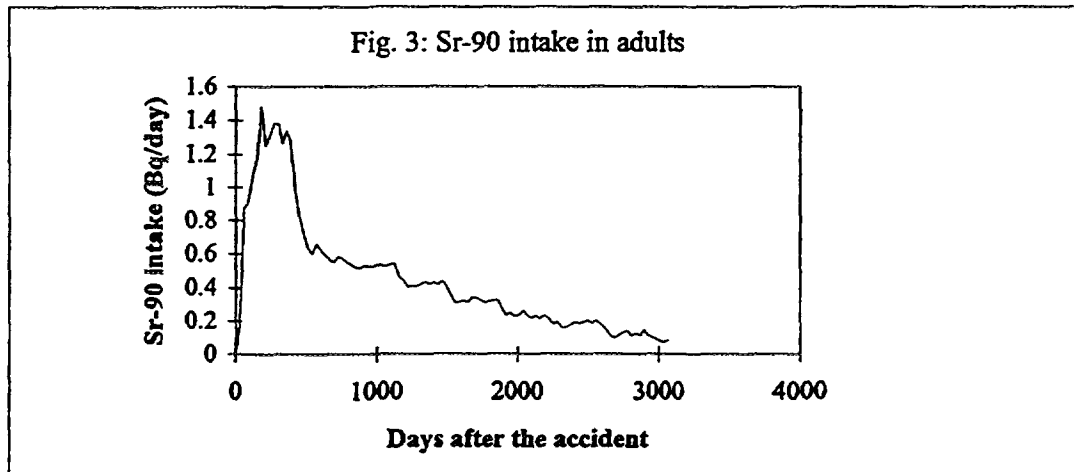
During the next three periods (May 1988 - August 1989, January 1991 - December 1991 and April 1994 - March 1995), Cs^{137} intake decreased at all age groups. In the ninth year after the accident, the average Cs^{137} intake by children was 0.046 Bq/(gK.day).



3.2. Sr^{90} dietary intake

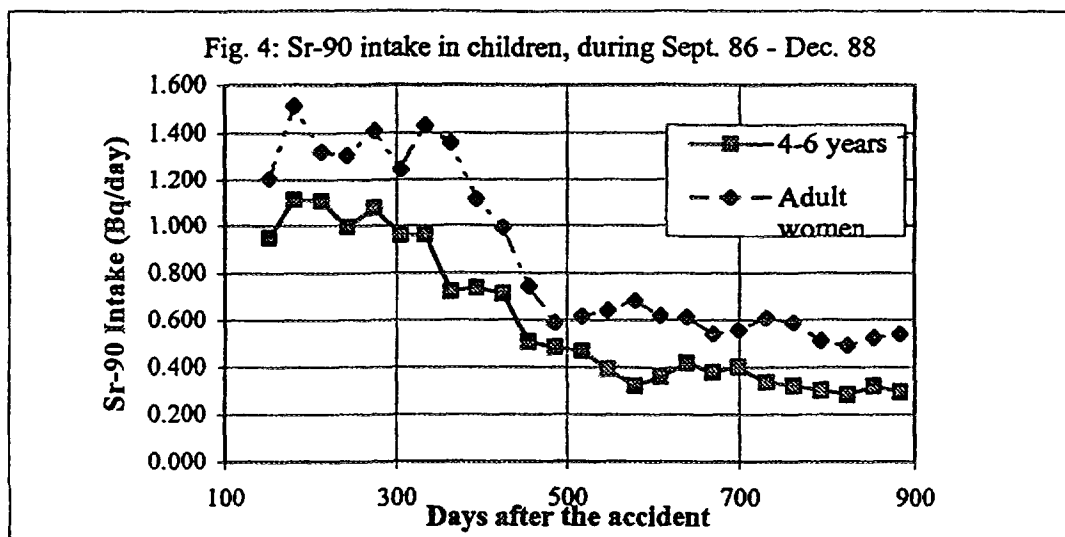
3.2.1. Sr^{90} dietary intake data for adults

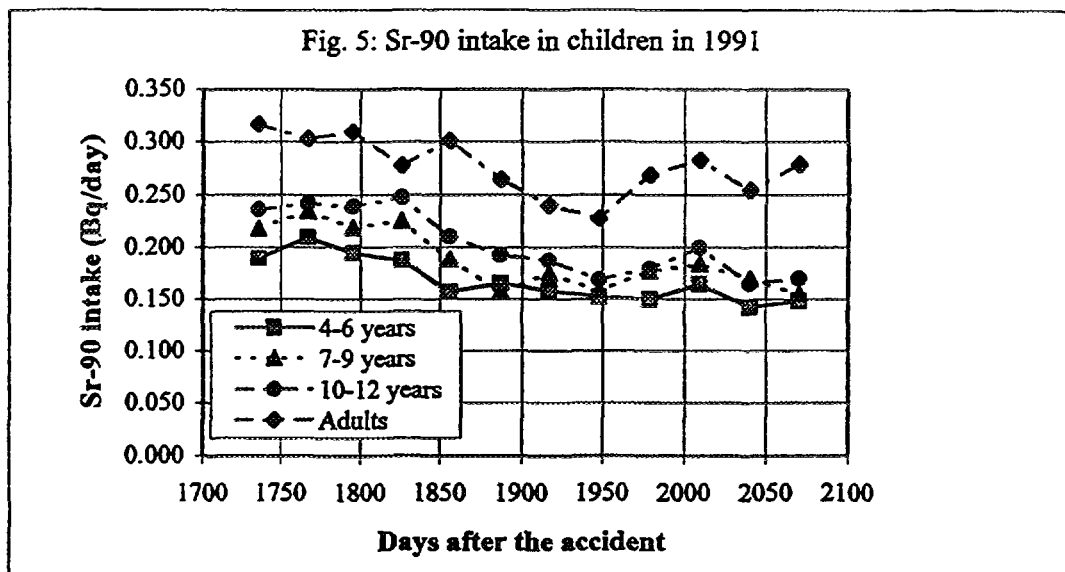
The study effectuated after the Chernobyl accident lead to the conclusions that there was a continuous Sr^{90} dietary intake, in different amounts. As it can be seen from Fig. 3, there is a strong variation of Sr^{90} intake during April 1986 - March 1995. To begin with May 1986, Sr^{90} dietary intake increased continuously, until it reached 1.48 Bq/(gCa.day) in October 1986 (Fig. 3). Sr^{90} intake remains at high values until April 1987, then it decreases continuously. The highest value of Sr^{90} intake occurred in the first year after the accident, when an average daily value of 1.07 Bq/gCa was reached. That value decreased to an average daily value of 0.36 Bq/gCa in the fifth year, then to 0.086 Bq/gCa in the ninth year after the accident.



3.2.2. Sr^{90} dietary intake data for children

During 1986 - 1994, we have selected three time periods in which we have studied Sr^{90} dietary intake for three groups of children: 4-6 years children, 7-9 years children and 10-12 years children. In order to have a comparison with the adults, we have performed the same measurements for a group of adult women.





The first interval of study was September 1986 - September 1988. During this time, Sr^{90} dietary intake was studied for a group of 4-6 years children and for the group of adult women (Fig. 4). The maximum Sr^{90} intake in children was $1.198 \text{ Bq}/(\text{gCa}\cdot\text{day})$, reached in October 1986 (Fig. 4). Sr^{90} dietary intake in 4-6 years children remained at values higher than $1 \text{ Bq}/(\text{gCa}\cdot\text{day})$ until March 1987, then decreased quite fast, and reached $0.326 \text{ Bq}/(\text{gCa}\cdot\text{day})$ in September 1988. During the same interval, Sr^{90} intake in adult women had constantly higher values than the values measured for children. Therefore, the average Sr^{90} intake during this period was $0.927 \text{ Bq}/(\text{gCa}\cdot\text{day})$ for adult women, while the average for children was $0.614 \text{ Bq}/(\text{gCa}\cdot\text{day})$.

The second period of study was January 1991 - December 1991. During this interval we have determined Sr^{90} intake for 3 groups of children (4-6 years, 7-9 years, and 10-12 years), and a group of adult women (Fig. 5). The amount of ingested Sr^{90} decreased a lot, compared to the first period of study. The average amount of ingested Sr^{90} , in this period, by the children, has values between $0.182 \text{ Bq}/(\text{gCa}\cdot\text{day})$ and $0.218 \text{ Bq}/(\text{gCa}\cdot\text{day})$ - depending of the age of the children - while the average Sr^{90} daily intake in women was $0.269 \text{ Bq}/(\text{gCa}\cdot\text{day})$.

The last period of study - since January 1993 until December 1994 - included measurements of Sr^{90} dietary intake for two children groups - 4-6 years and 10-12 years - and a group of adult women. This period is characterized by low values of Sr^{90} dietary intake. The average amount of ingested Sr^{90} for this period was $0.073 \text{ Bq}/(\text{gCa}\cdot\text{day})$ for 4-6 years children and $0.102 \text{ Bq}/(\text{gCa}\cdot\text{day})$ for 10-12 years children.

4. EFFECTIVE DOSES COMMITTED DUE TO Cs^{137} AND Sr^{90} DIETARY INTAKE

To assess the effective doses committed by the population of Bucharest, we used the data from our measurements and of the dose factors recommended by ICRP 30 Part 1 [5], and ICRP 67 [6].

The effective doses committed annually due to internally deposited Cs^{137} , by the adult population of Bucharest, are presented in Fig. 6, compared to the doses committed due to Sr^{90} internally deposited. As it can be seen, in the first year after the accident, Cs^{137} dietary intake lead to an effective dose commitment of $801.9 \mu\text{Sv}$. This value decreased quite fast, as the amount of Cs^{137} intake decreased, and reached $7.3 \mu\text{Sv}$ five years after the accident, then $0.8 \mu\text{Sv}$ in the ninth year after the accident. The effective dose committed by adults in all these nine years after the accident had a value of $1079.6 \mu\text{Sv}$.

Fig. 6: Effective doses committed by adults due to Cs-137 and Sr-90 intake

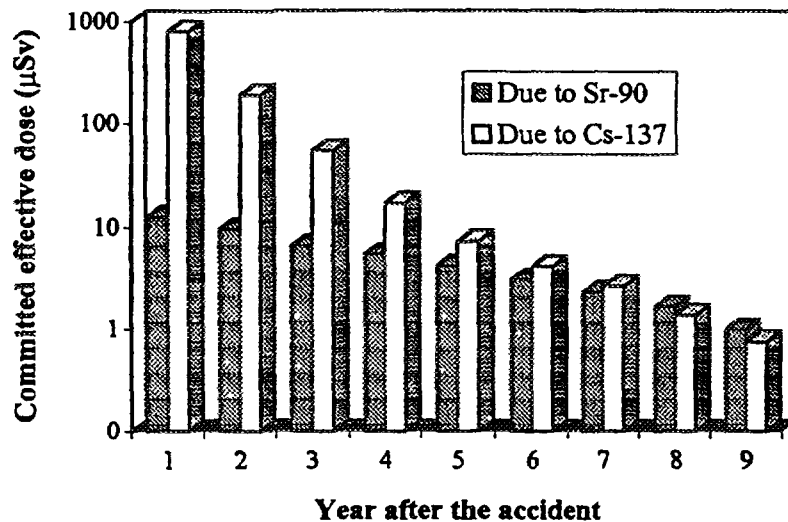
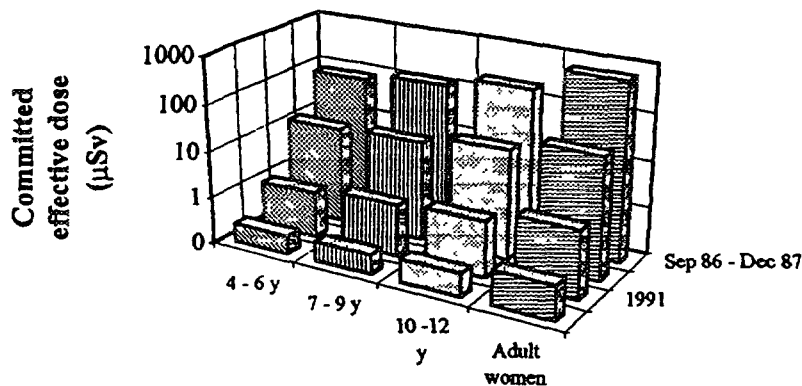


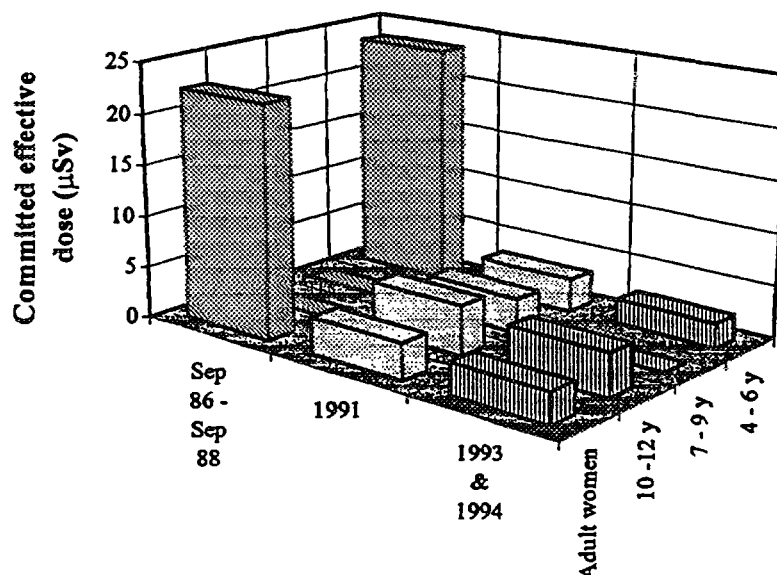
Fig. 7: Effective doses committed by children, due to Cs-137 intake



Although the trend of the doses committed by children due to Cs^{137} intake is the same as the trend of the doses committed by the adults, the values are quite different (Fig. 7). As it can be seen, the value of the committed effective dose increases as the age increases. For example, during September 1986 - December 1987, the effective doses committed due to internally deposited Cs^{137} were 75.4 μSv at 4-6 years children, 115 μSv at 7-9 years children and 192.4 μSv at 10-12 years children, while the effective dose committed during the same time by adult women was 601.9 μSv . This is due both to different Cs^{137} dietary intake, as to different dose factors. The doses are decreasing fast, for all age groups, as the time goes by.

Whereas the doses committed by children due to Cs^{137} intake are lower than the doses committed by adults, the effective doses committed by children due to Sr^{90} intake are comparable to the doses delivered to adults (Fig. 8). The effective doses committed annually are decreasing as the time from the accident elapses, for all age groups. For example, the effective doses committed by 4-6 years children decreased from 14.713 μSv (to red marrow, respectively 8.719 μSv to bone surface), during September 1986 - September 1988, to 8.719 μSv (to red marrow, respectively 0.871 μSv to bone surface), during 1994 and 1995, while the effective doses committed by adult women decreased from 14.295 μSv (to red marrow, respectively 8.140 μSv to bone surface), during September 1986 - September 1988, to 1.935 μSv (to red marrow, respectively 1.102 μSv to bone surface), during 1993 and 1994.

Fig. 8: Effective doses committed by children,
due to Sr-90 intake



5. CANCER RISK DUE TO INTERNALLY DEPOSITED Cs^{137} AND Sr^{90}

The assessment of excedentary cancer risk was made using WHO risk factors, as well as prediction models presented in NCRP Report 110 [7]. It should be stated that, in all cases, the risk estimate must be taken with great caution, as the models and the risk used are not based on a very well fundamented theory, and experimental data (especially for Sr^{90}) are not available to a very large extent. It must also be stated that we have made some approximations when we have computed the collective doses. These approximations refer to the data we used. As we had not enough data concerning the age distribution of the inhabitants of Bucharest, we have calculated the collective doses making use of the doses delivered to adults. This leads to very low errors when we estimate the risk due to Sr^{90} (because the doses delivered to children and adults are comparable), but it also leads to an over-estimate of the risk due to Cs^{137} (as the doses delivered to children are smaller than the doses delivered to adults). Another assumption have also been made: we have considered that the dietary habits are the same all over Bucharest, this assumption allowing us to extend the data compiled for the group we have studied to the entire population of Bucharest. We have considered the number of Bucharest inhabitants as 2,500,000.

5.1. Assessment of excedentary cancer risk due to Cs^{137}

For fatal cancers induced by radiation doses due to internally deposited Cs^{137} , WHO recommends a risk factor of 2×10^{-2} Sv (e.g. if 100 persons received 1 Sv of dose, a lifetime expectation of 2 fatal cancers is predicted).

In our case, the collective effective dose committed for the next 50 years by the entire population of Bucharest is 2699 person Sv. As we have already said, this is a rough value which overestimates the collective dose delivered to the population of Bucharest. This value leads us to a prediction of maximum 54 excedentary cancers in the next 50 years to follow. However, as the doses delivered to children were much smaller than the doses delivered to adults (the dose delivered to 4-6 years children is almost 7 times smaller than the dose delivered to adult women), we believe that an estimate of maximum 20 excedentary cancers in the next 50 years would be a much more reasonable estimate (from the incomplete data we have, it seems that there is a parity among the number of children and the number of adults in Bucharest).

5.2. Assessment of excedentary cancer risk due to Sr^{90}

5.2.1. Bone sarcoma

The model we used is the linear model given in NCRP 110 [7]. This leads us to an maximum excedentary number of bone sarcomas, for the next 50 years, of 3 cases, while the best estimate is 0 excedentary cases.

Therefore, we should not expect an increased number of bone sarcomas due to internally deposited strontium.

5.2.2. Leukaemiae

Using the linear model from NCRP 110 [7], we can predict 0 excedentary leukaemiae, which means we should not expect an increased number of leukemiae due to internally deposited strontium.

It is worth telling that the quadratic exponential model would lead to estimates 1000 times less than the linear models used.

6. CONCLUSIONS

In the first years after the accident, Cs^{137} contribution to the effective dose committed that year was much larger than Sr^{90} contribution (802 μSv due to Cs^{137} , in the first year after the accident, compared to 12.7 μSv - bone surface and red marrow - due to Sr^{90}). This situation changed in time, as the decrease of Cs^{137} intake was much faster then the decrease of Sr^{90} intake. Therefore, in the seventh year after the accident, their contributions to the effective dose committed that year were roughly equal (2.6 μSv due to Cs^{137} and 2.3 μSv due to Sr^{90}), and in the ninth year Sr^{90} contribution is larger.

The values obtained for the doses committed during all these years were used to asses the excedentary cancer risk due to internally deposited Cs^{137} and Sr^{90} . The evaluation indicates that we should not fear an increased number of leukemiae and bone sarcomas in the next 50 years. However, an excedentary number of maximum 20 excedentary cancers due to internally deposited cesium, in the next 50 years, resulted from the risk factors recommended by WHO. We must emphasize again that this does not mean that these cancers will actually occur. Furthermore, this number does not exceed the statistical variation of naturally occurring cancers, therefore such a number of excedentary cancers probably cannot be detected.

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BLOOD DISORDERS IN CHILDREN AND ADULTS IN BELARUS AFTER THE CHERNOBYL NUCLEAR POWER PLANT ACCIDENT

E.P. IVANOV, V.E. IVANOV, U. SHUVAEVA, G. TOLOCKO
Institute of Haematology and Blood Transfusion,
Minsk, Belarus



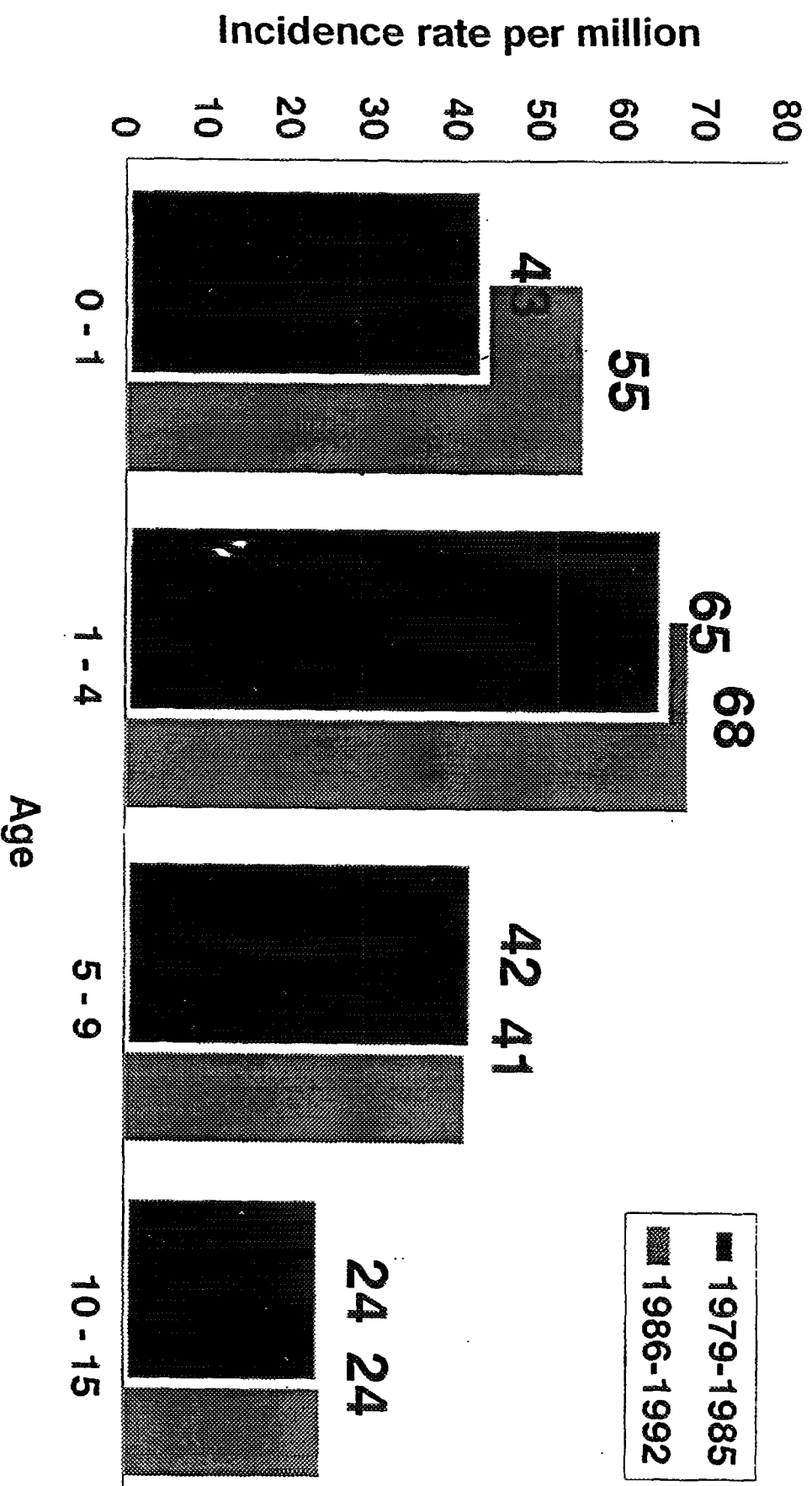
S. BECKER, A.M. KELLERER, E. NEKOLLA
Institute of Radiobiology, University of Munich,
Munich, Germany

Introduction

Epidemiological investigations of radiation - induced tumours, and, particularly, of leukaemia and lymphoma incidence rates before and after the Chernobyl disaster facilitate to enhancing our knowledge of the role of chronic effects of the low doses of ionising radiation in the genesis of malignancies of hematopoietic and immune systems. That is why in the Republic of Belarus within the framework of the National Register of Blood Disorders Programme, the WHO Pilot Project "Haematology", IPHECA programme and the European Childhood Leukaemia/Lymphoma Incidence Study (ECLIS) the data on blood malignancies were collected retrospectively by means of the epidemiological retrieval and screening of medical documentation, records in the Registers General etc. for the seven years preceding (1979-85) and seven years after the Chernobyl accident (1986-1992) and in 1993-1994.

Our results are presented in following figures and tables.

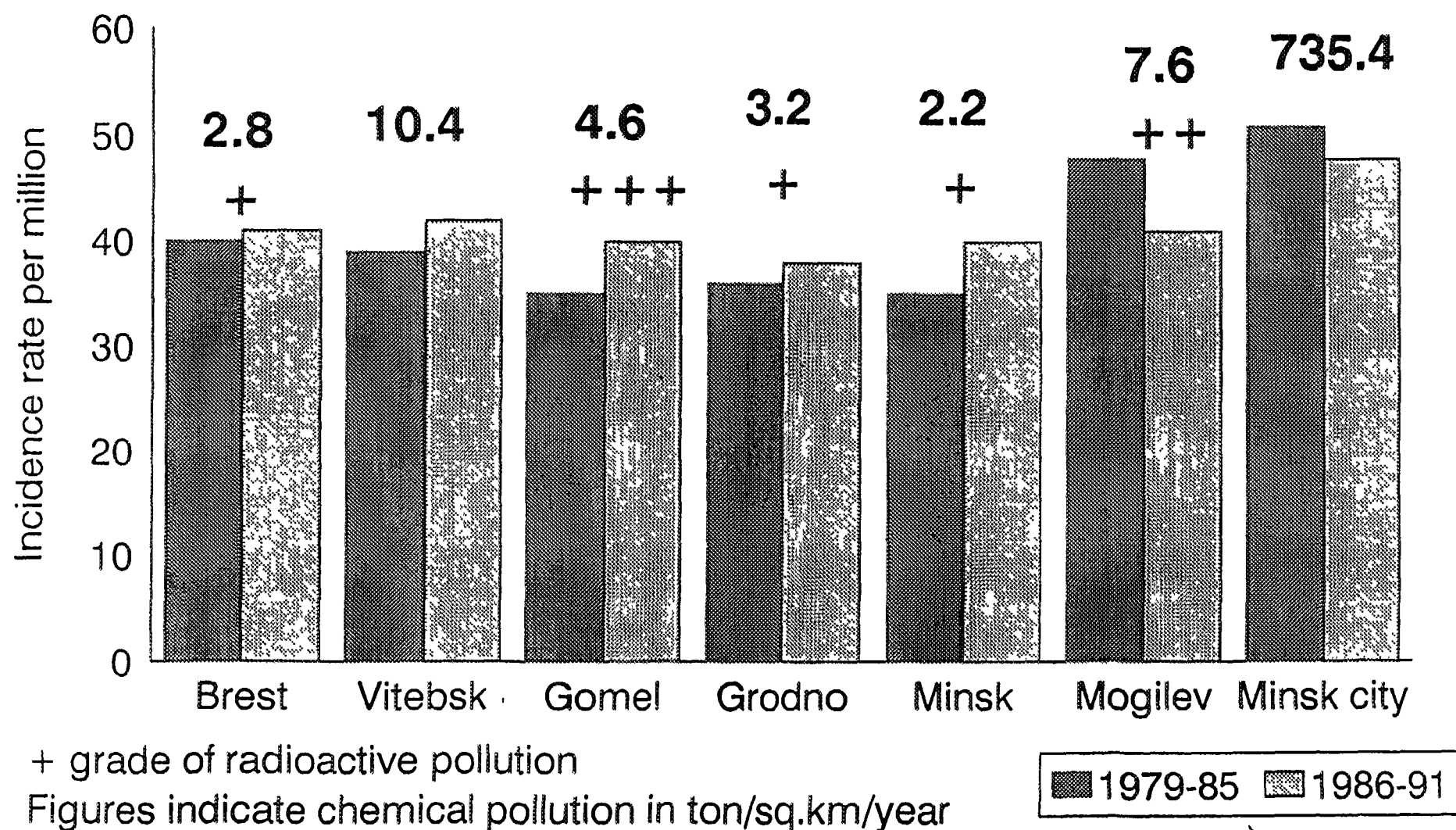
Childhood Leukaemia in Belarus



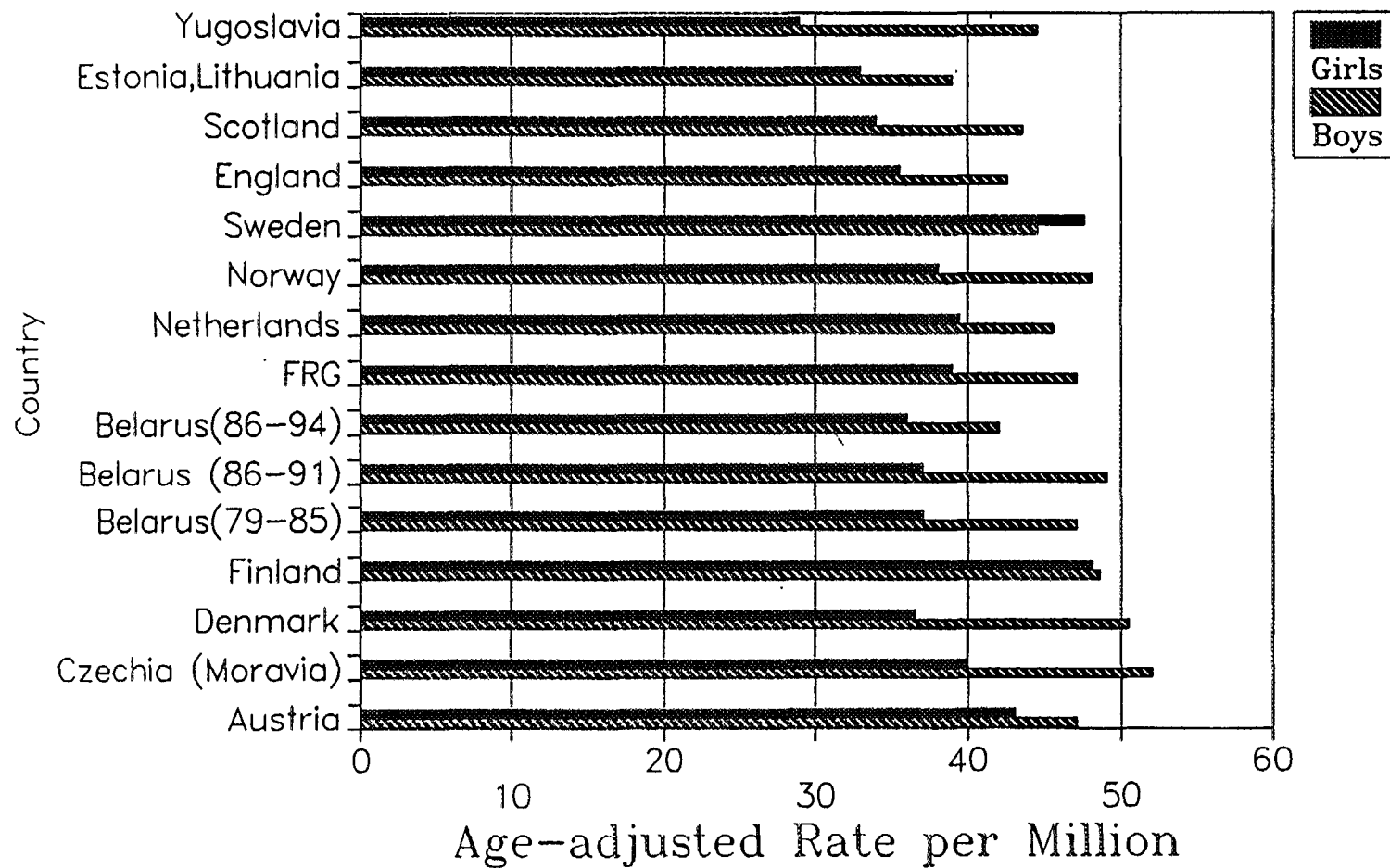
LEUKEMIA AND LYMPHOMA IN BELARUS CHILDREN IN 1979-1985 AND 1986-1992 yy

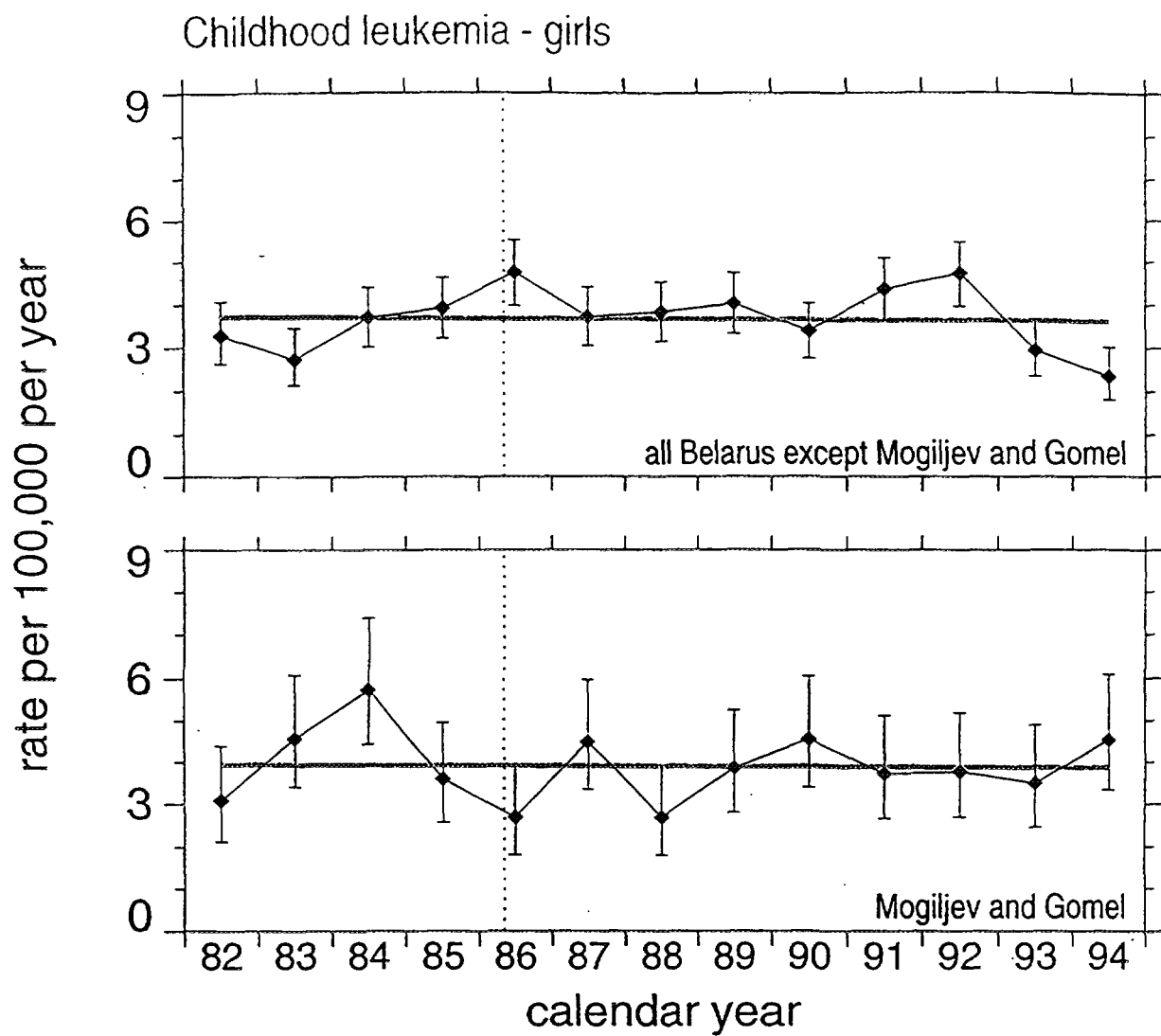
DISEASE	PERIOD 1979-1985		PERIOD 1986-1992		P
	NUMBER OF CASES	INCIDENCE	NUMBER OF CASES	INCIDENCE	
AL	655	4.2	708	4.33	>0.1
CML	22	0.14	15	0.09	>0.1
HD	161	1.03	173	1.06	>0.1
NH LYMPH	189	1.21	204	1.25	>0.1

Childhood Leukaemia Incidence, Radioactive and Chemical Pollution in Belarus Oblasts

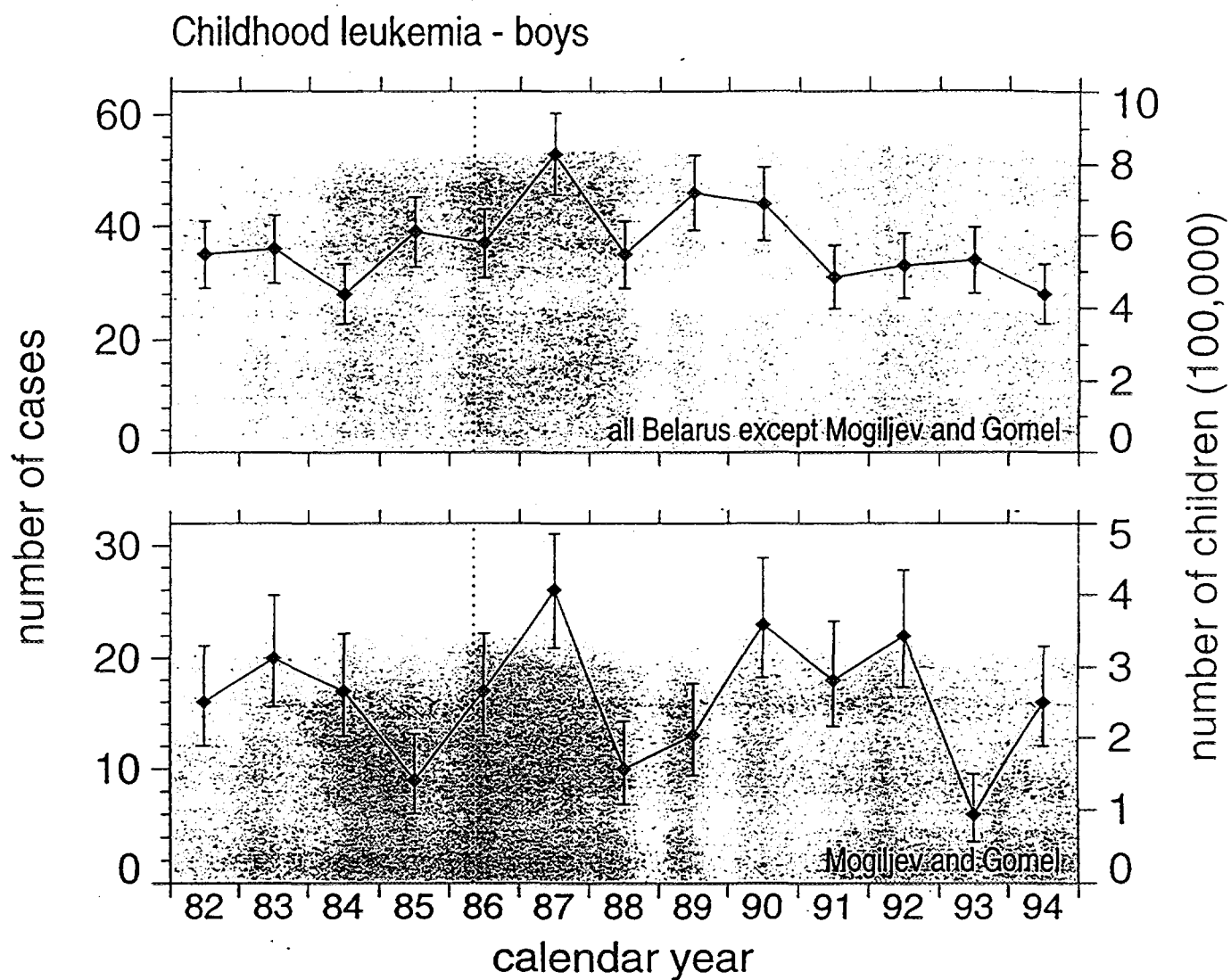


Child Leukaemia (0-14 years old) in Europe(80-85) and Belarus(79-94)

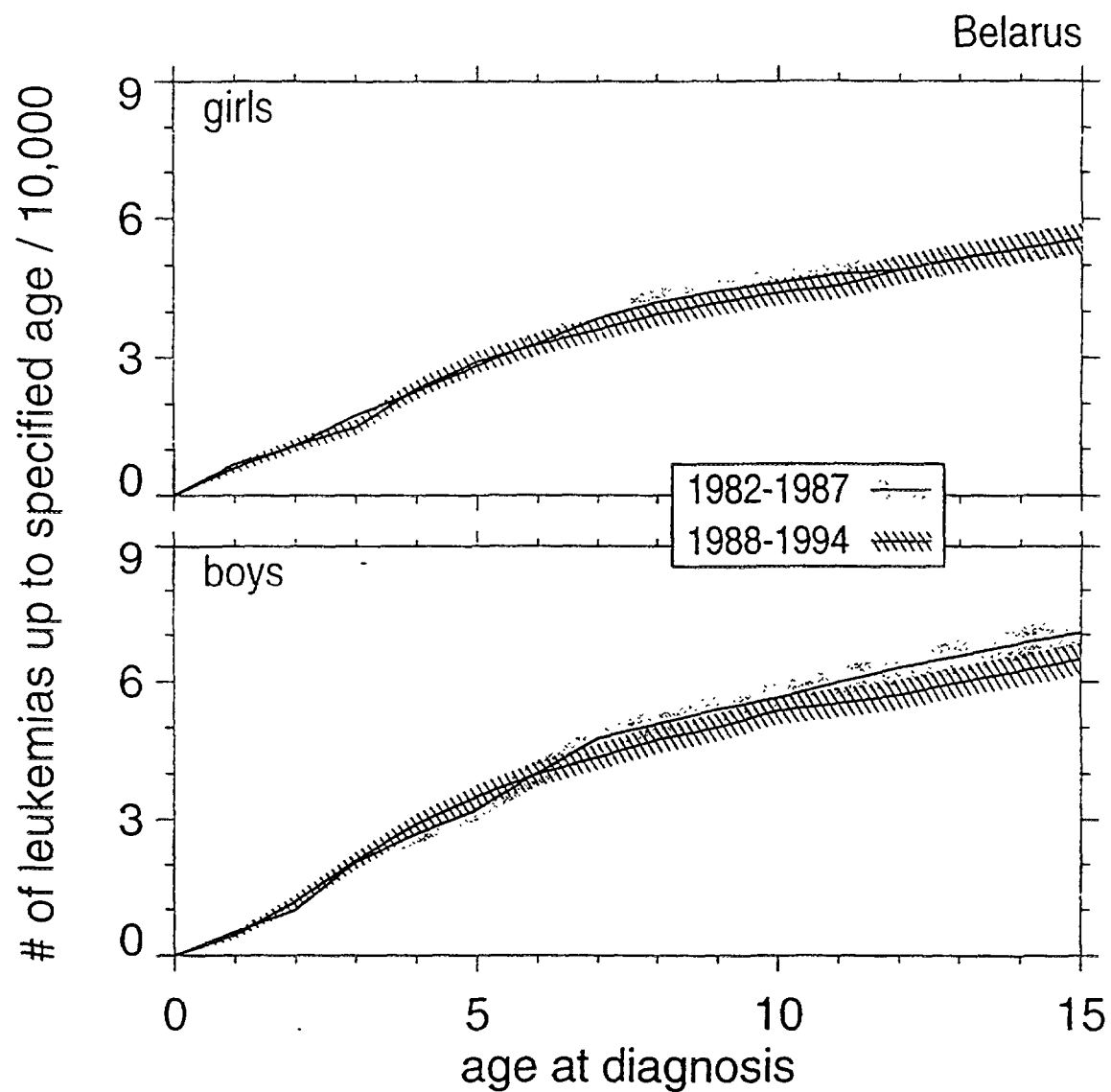


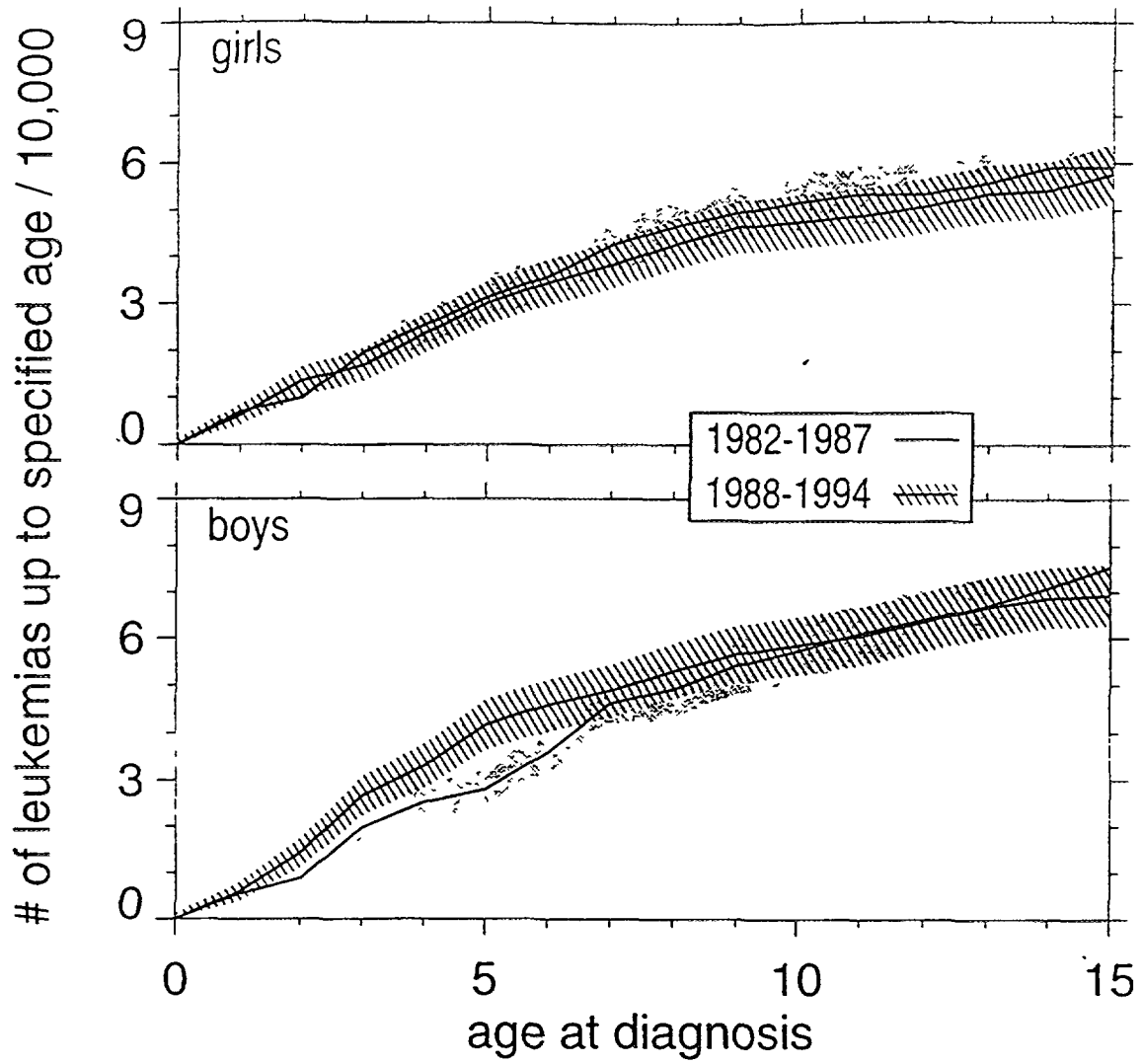


Absolute Annual Numbers of Leukaemia for Children of Age < 15



Age Specific Cumulative Childhood Leukaemia Rates for the Period of 1982-1987 and 1988-1994

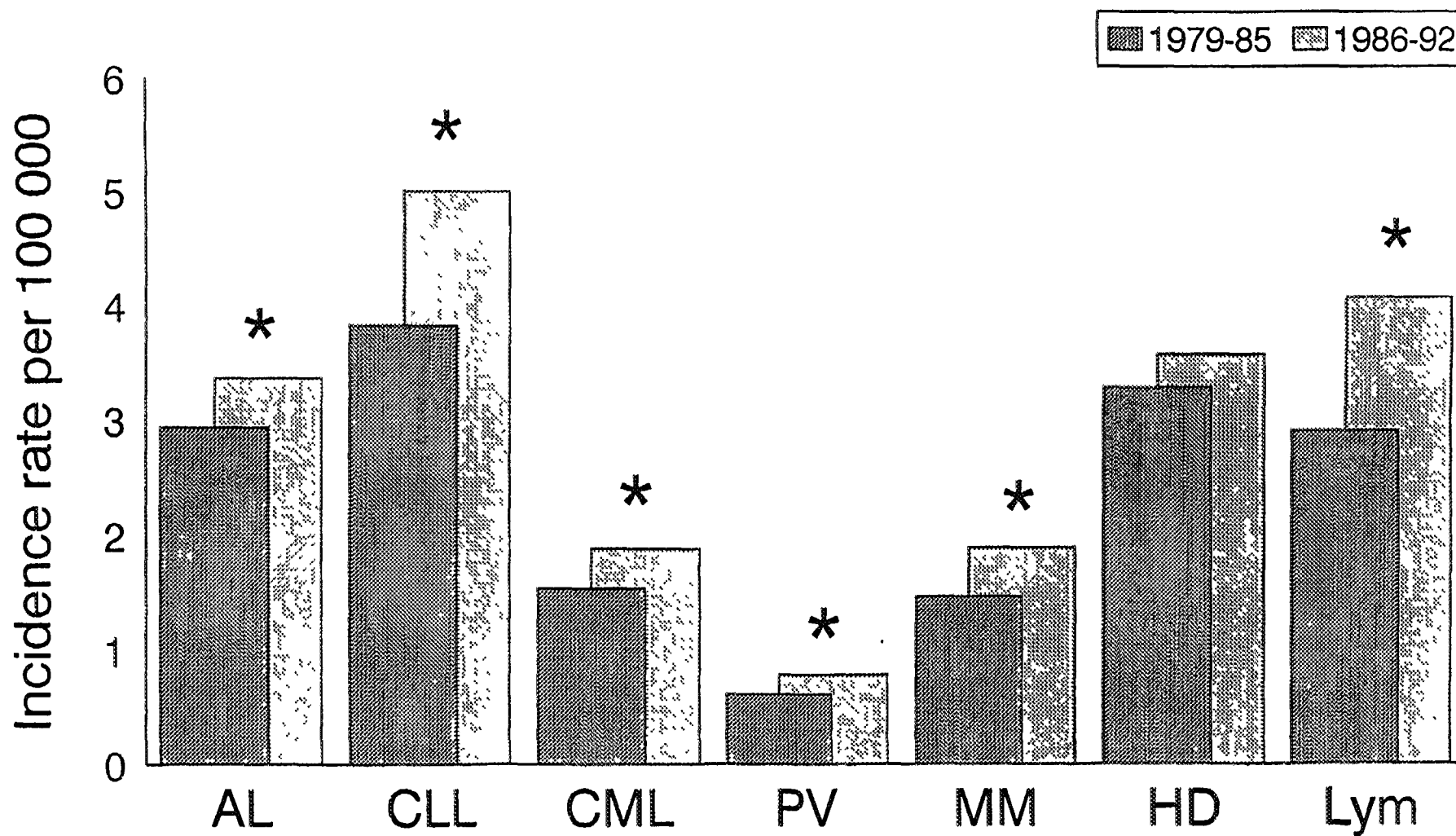




**INCIDENCE RATES OF HAEMOBLASTOSES AMONG ADULT POPULATION OF
BELARUS IN 1979-85 and 1986-92**
(per 100.000 inhabitants)

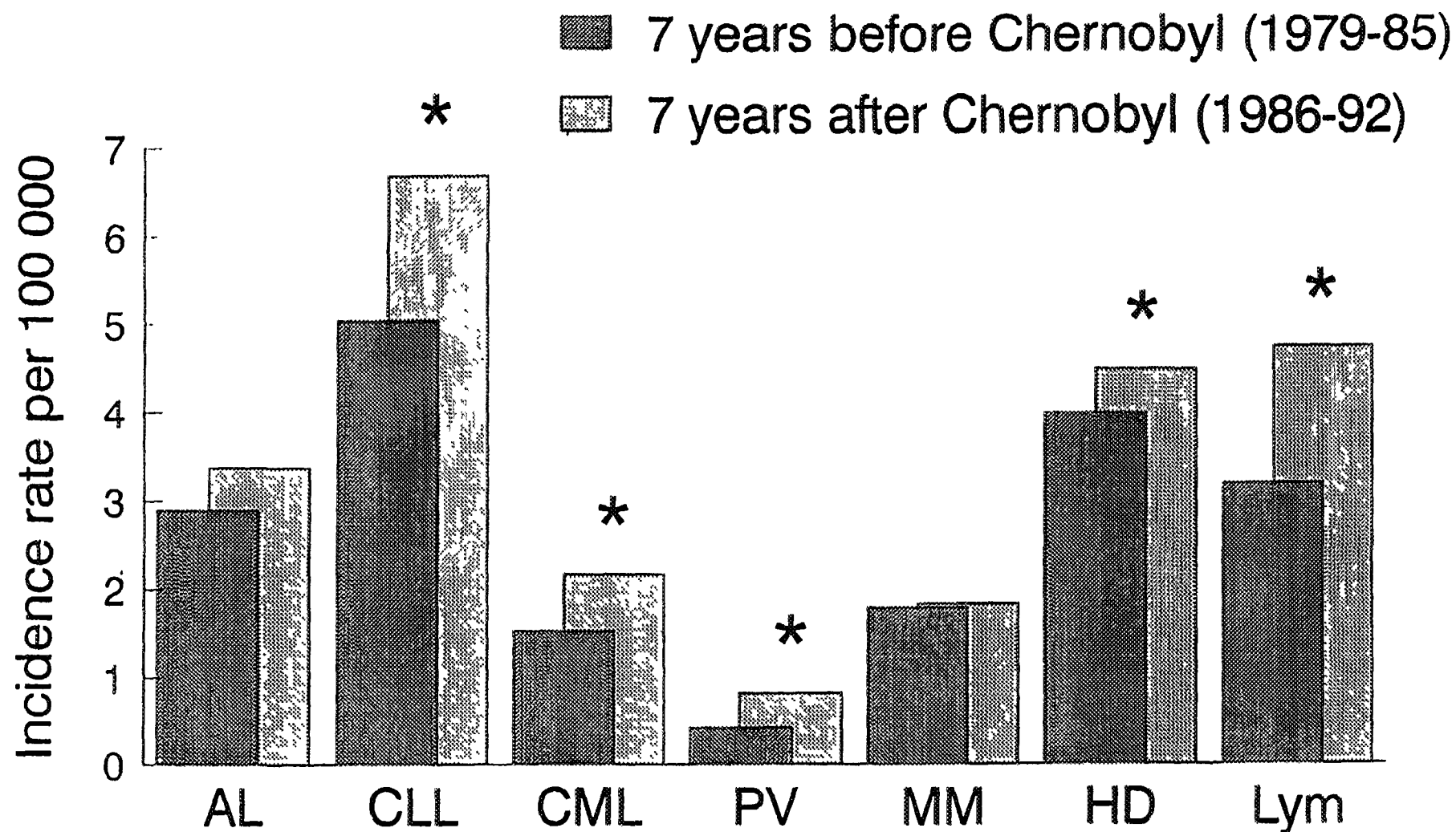
NOSOLOGIES	1979-1985 M \pm sem	1986-1992 M \pm sem	Significance (p)
Acute Leukaemia (AL)	3.22 \pm 0.07	3.58 \pm 0.11	<0.02
Chronic Myelogenous Leukaemia (CML)	1.21 \pm 0.03	1.53 \pm 0.01	<0.01
Chronic Lymphoid Leukaemia (CLL)	2.98 \pm 0.12	3.97 \pm 0.19	<0.001
Polycythaemia vera (PV)	0.48 \pm 0.04	0.62 \pm 0.04	<0.05
Multiple Myeloma (MM)	1.15 \pm 0.05	1.48 \pm 0.06	<0.01
Hodgkin Disease (HD)	2.81 \pm 0.09	3.11 \pm 0.11	>0.05
Non Hodgkin Lymphoma (Lym)	2.55 \pm 0.05	3.51 \pm 0.11	<0.001

Adults' Hemoblastoses in Belarus



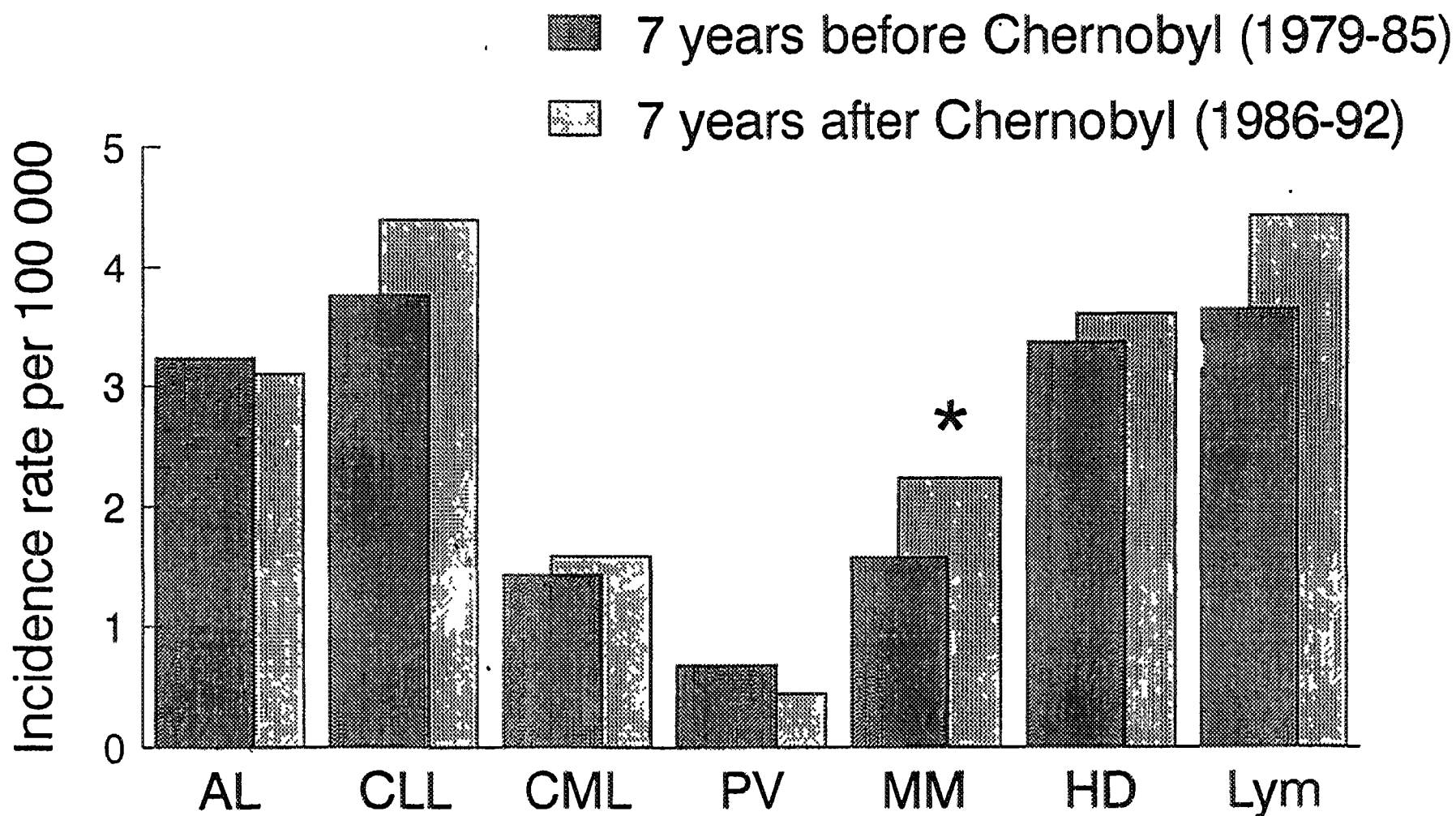
* $p < 0.05$

Adults' Hemoblastoses in Mogilev Oblast

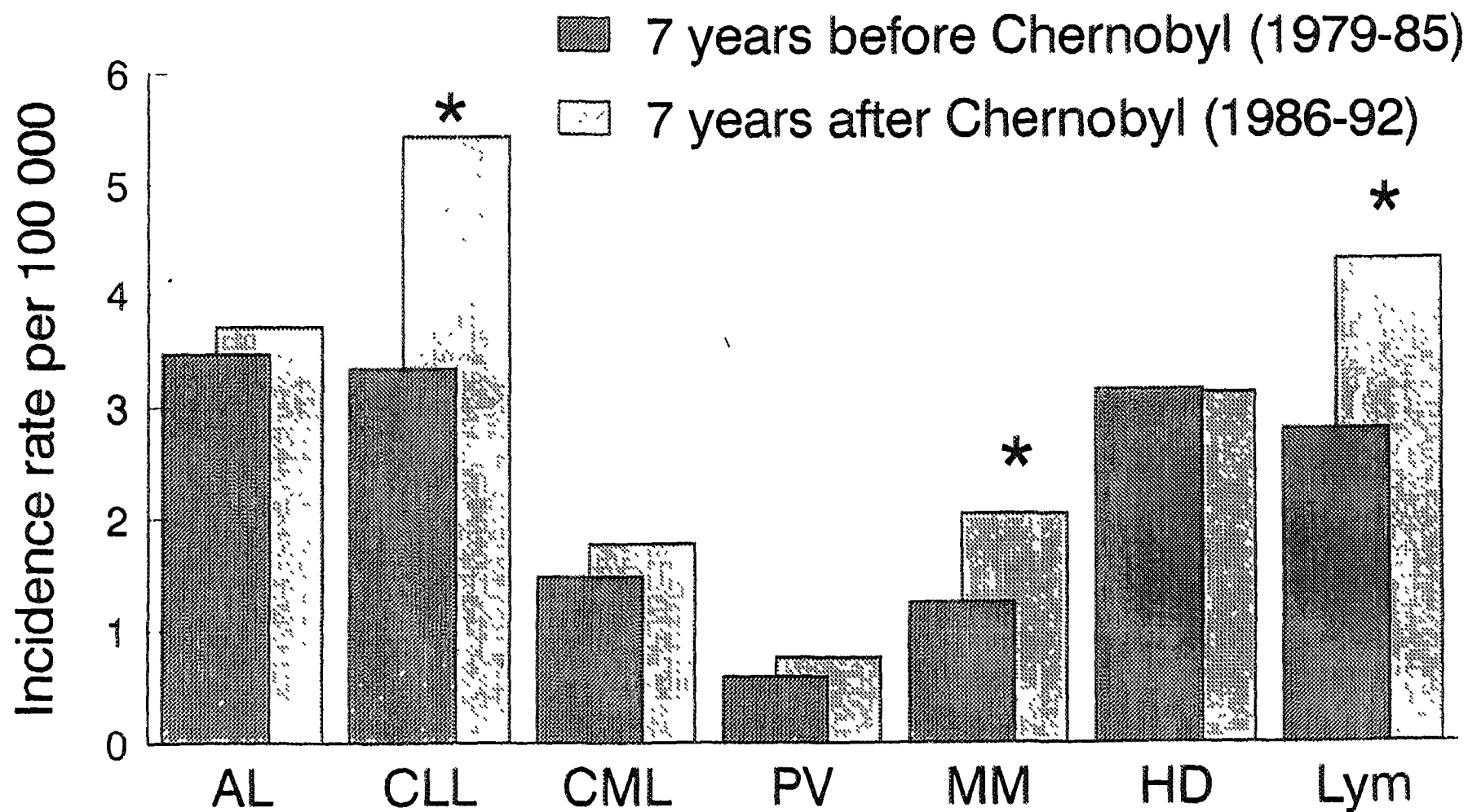


* $p < 0.05$

Adults' Hemoblastoses in Brest Oblast



Adults' Hemoblastoses in Gomel Oblast



* $p < 0.05$

Conclusion

The chronic exposure to low doses of ionizing radiation of the hematopoietic system of Belarussian children aged 0-14 in 1986-1992, 1993 and 1994 has not resulted in the increase of the leukaemia incidence rates. Close correlation is found between the environment chemical pollution and the incidence rates of childhood leukaemia, whereas the analysis of the morbidity of the inhabitants of radioactive cesium contaminated and non-contaminated territories has not as yet demonstrated the association between the incidence rates and radiation factor.

Adult morbidity of acute and chronic myeloid leukaemia is statistically significantly higher 9 years following Chernobyl disaster, but as a marker of radiation induced leukaemogenesis does not correlate with the grade of radioactive contamination and it is more closely dependent on the chemical and other leukaemogenic factors.

In postChernobyl period a tendency to an increase of the lymphoid system pathologies among adults irrespective of the place of inhabitancy is noted. It is preliminary noted that low doses of ionizing radiation potentiate the effect of chemical mutagenes precipitating the leukaemogenesis and carcinogenesis.

The study of leukaemia and lymphoma incidence rates in postChernobyl Belarus is ongoing. More detailed prospective analysis of the data on radionuclide as well as on chemical contamination has to be performed to confirm our preliminary results.

EPIDEMIOLOGICAL ASSESSMENT OF INDUCED MALIGNANT NEOPLASMS IN BELARUS FOLLOWING THE CHERNOBYL ACCIDENT

A.E. OKEANOV, G.V. YAKIMOVICH

**Belarus Centre for Medical Technology, Data Processing, Management and
the Economics of Public Health,
Belarus Ministry of Health,
Minsk, Belarus**



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ЭПИДЕМИОЛОГИЧЕСКАЯ ОЦЕНКА ИНДУЦИРОВАННЫХ ЗЛОКАЧЕСТВЕННЫХ НОВООБРАЗОВАНИЙ В БЕЛАРУСИ ПОСЛЕ КАТАСТРОФЫ НА ЧАЭС

Океанов А.Е., Якимович Г.В.

**(Белорусский центр медицинских технологий, информатики, управления и
экономики здравоохранения МЗ РБ)**

Чернобыльская катастрофа по масштабам и последствиям загрязнения окружающей среды является самой крупной в истории ядерной энергетики. В связи с чем изучение ее последствий на здоровье человека является чрезвычайно важным.

В результате аварии на Чернобыльской атомной станции из реактора, содержащего 190.2 т. ядерного горючего, в окружающую среду было выброшено около 4 т. топлива (более 10^{13} Бк радионуклидов йода, цезия, церия, бария, стронция, плутония и др.).

По данным опубликованным Государственным комитетом Республики Беларусь по проблемам последствий катастрофы на Чернобыльской АЭС, 23 % детей из районов жесткого контроля Гомельской области получили дозы, превышающие 100 сГр. Из них у 8% они составили 200-500 сГр, у 2% - 500-1000 сГр, у 1% - 1000 сГр. В Могилевской области 5% детей имели дозу свыше 100 сГр.

Около 70% радиактивных веществ, поступивших в атмосферу европейской части СССР в результате катастрофы, выпало на территорию Беларуси, при этом 23% ее территории (46.5 тыс. кв. км) оказались загрязнены цезием-137.

Особенностью формирования доз облучения населения, проживающего на загрязненных радионуклидами территориях, является пролонгированное внешнее и внутреннее облучение за счет долгоживущих радионуклидов цезия, стронция, плутония и других элементов в дополнение к сформированным дозам раннего этапа, включающего облучение короткоживущими радионуклидами.

У жителей, проживающих на территориях с плотностью загрязнения 555-1480 кБк/м², с момента катастрофы сформированы дозы общего облучения в среднем 50-60 мЗв, с плотностью загрязнения менее 555 кБк/м² - 20-40 мЗв.

В настоящее время в республике на загрязненных территориях 1.8 млн. человек, из которых 433 6 тыс. составляют дети, подвергаются постоянному воздействию малых доз ионизирующей радиации

Исходным материалом для проводимого исследования служили статистические данные о заболеваемости злокачественными новообразованиями населения Гомельской, Могилевской областей и в целом республики на основе данных Белорусского канцер-регистра.

В Беларуси, как и в других странах мира, отмечается неуклонный рост заболеваемости злокачественными опухолями. За последние 15 лет интенсивные показатели увеличились на 53.8%, стандартизованные - на 42.1%, в том числе в Гомельской области - на 63.0% и 52.0%, в Могилевской - на 31.5% и 24.5% соответственно.

До аварии на Чернобыльской АЭС в республике прослеживалась четкая географическая закономерность : наиболее высокая заболеваемость злокачественными новообразованиями наблюдалась на северо-востоке и востоке республики (в Витебской и Могилевской областях), а более низкая - на западе и юго-востоке (в Гродненской и Гомельской областях). В последние годы заболеваемость в Гродненской (в 1988-1989 годах) и Гомельской области (в 1992 году) достигла уровня Витебской области.

Анализ заболеваемости отдельными локализациями злокачественных новообразований показал, что лишь по некоторым из них наблюдается достоверное увеличение коэффициентов линейной регрессии, т.е. в Гомельской области - это увеличение темпов прироста заболеваний раком щитовидной железы, легких, мочевого пузыря, почки, молочной железы, опухолями костей , в Могилевской области - раком щитовидной железы и мочевого пузыря, в Минской области - опухолями щитовидной железы, почки, поджелудочной и молочной железы .

Рост заболеваемости злокачественными опухолями в Гомельской и Могилевской областях произошел в основном за счет увеличения частоты заболевания среди лиц среднего и преклонного возраста. Вместе с тем обращает на себя внимание факт достаточно высокого роста заболеваемости в группах лиц 40-50 лет

Заметные различия в соотношении заболеваемости городского и сельского населения в 1991-1994 гг. по сравнению с доаварийным пятилетием в Гомельской области характерны для опухолей легких, молочной железы (чаще стали заболевать жители сельской местности). В Могилевской области, кроме того, изменилось соотношение заболеваемости опухолями мочевого пузыря и почки за счет более

интенсивного увеличения ее в сельской местности. Учитывая, что дозовая нагрузка, в т.ч. за счет инкорпорации радионуклидов, более выражена среди сельских жителей, можно предполагать, что в определенной мере эта тенденция обусловлена радиационной компонентой .

В Гомельской области среди детей отмечен достоверный рост заболеваемости раком щитовидной железы и почки, в Могилевской области - только опухолями щитовидной железы.

В отношении рака щитовидной железы имеется достаточно много публикаций, показывающих рост заболеваемости среди детей. Вместе с тем практически не отражено, что рост заболеваемости имеется и среди взрослого населения республики .

С целью оценки дополнительного риска возникновения злокачественных новообразований, вероятно связанного с воздействием радиационной компоненты, были сопоставлены прогнозируемые (на основе трендов заболеваемости доаварийного периода) и фактические коэффициенты заболеваемости. Данный анализ позволил выявить увеличение относительного риска возникновения опухолей легких, мочевого пузыря, почки, щитовидной и молочной железы в Гомельской области.

В Могилевской области значимое превышение наблюдаемых показателей над ожидаемыми отмечено для опухолей почки и щитовидной железы, а также опухолей легких среди женщин. Дополнительный риск заболевания указанными опухолями произошел на фоне общего (суммарно для всех опухолей) снижения темпов прироста показателей заболеваемости в 1986-1994 гг.

Сравнительный анализ по районам Гомельской области по отдельным формам злокачественных новообразований показал достоверно выраженную тенденцию увеличения скорости роста заболеваемости и ее средней величины в районах жесткого контроля - более 15 Ки/км^2 (555 кБк/м^2) по сравнению с территориями загрязнения радионуклидами менее 5 Ки/км^2 (185 кБк/м^2), особенно выражена эта тенденция для опухолей мочевого пузыря, где в 5 из 11 районов жесткого контроля произошло достоверное увеличение скорости роста (коэффициента линейной регрессии).

Также следует отметить ускорение темпов роста заболеваемости раком почки в 6 районах с загрязнением выше 15 Ки/км^2 (555 кБк/м^2) .

Заболеваемость раком легкого в районах с радиоактивным загрязнением больше 15 Ки/км^2 (555 кБк/м^2) увеличилась более быстрыми темпами, чем в зонах с загрязнением менее 5 Ки/км^2 (185 кБк/м^2).

До аварии на Чернобыльской АЭС средние показатели в группе районов жесткого контроля (555 кБк/м^2) и менее 185 кБк/м^2 не отличались, в послеаварийном периоде достоверно более высокие показатели в зоне жесткого контроля по сравнению с территориями с загрязнением менее 185 кБк/м^2 составляли соответственно 42.7 и 34.7.

Анализ онкологической заболеваемости в Гомельской и Могилевской областях в зависимости от степени загрязнения радионуклидами показал, что в Гомельской области наблюдается выраженная закономерность к увеличению онкологической заболеваемости в районах с большей степенью загрязнения радионуклидами. В Могилевской области такой закономерности не отмечено, и рост заболеваемости на территориях с загрязнением меньше 5 Ки/км^2 (185 кБк/м^2) и больше 15 Ки/км^2 (555 кБк/м^2) достоверно не отличается.

Следует отметить, что, судя по каталогу доз облучения жителей отдельных населенных пунктов Беларуси, степень инкорпорации радионуклидов часто выше в зоне $5\text{-}15 \text{ Ки/км}^2$ ($185\text{-}555 \text{ кБк/м}^2$), чем в зоне $15\text{-}40 \text{ Ки/км}^2$ ($555\text{-}1480 \text{ кБк/м}^2$). Это объясняется тем обстоятельством, что в зонах выше 40 Ки/км^2 (1480 кБк/м^2) осуществляется более жесткий контроль продуктов питания и лучше организована доставка чистых продуктов.

RISK OF ONCOLOGICAL DISEASE AMONG THE LIQUIDATORS

A.E. OKEANOV

Belarus Centre for Medical Technology, Data Processing, Management and
the Economics of Public Health,
Belarus Ministry of Health,
Minsk, Belarus



S.M. POLYAKOV

Belarussian Centre for Medical Technology,
Minsk, Belarus

РИСК ОНКОЛОГИЧЕСКИХ ЗАБОЛЕВАНИЙ СРЕДИ ЛИКВИДАТОРОВ

Океанов А.Е. , Поляков С.М.

(Белорусский центр медицинских технологий, информатики, управления
и экономики здравоохранения МЗ РБ)

Имеющиеся в литературе данные об уровнях облучения участников ликвидации последствий Чернобыльской катастрофы свидетельствуют о том, что дозы их облучения достаточно высоки. Соответственно риск возникновения опухолей в этой когорте выше, чем среди других контингентов соответствующих возрастных групп, в том числе населения, проживающего на загрязненных территориях и в районах, не подвергшихся загрязнению радионуклидами. Так, по данным [1] дозы облучения всего тела, полученные ликвидаторами, составили от 250 до 500 мЗв для 7 % из них, 100-250 мЗв - 48% и от 50-100 мЗв - 30%.

К сожалению, до настоящего времени индивидуальные дозы облучения окончательно не уточнены. В Белорусском Чернобыльском регистре зарегистрировано 68 тыс. ликвидаторов. Из них с уточненным местом и продолжительностью пребывания в зоне воздействия радиации - 45674, в том числе 31201 человек, работавших непосредственно в зоне эвакуации (30-километровой зоне), 14473 человека работавших в это время в зоне первоочередного и последующего отселения ($>15 \text{ Ки/км}^2$ или $>550 \text{ кБк/м}^2$). Среди ликвидаторов - 10284 женщины (15% от общего количества ликвидаторов).

Благоприятным фактором для изучения заболеваемости злокачественными опухолями среди ликвидаторов является наличие в

Беларуси канцер-регистра. Это обстоятельство позволило получить и проанализировать онкологическую заболеваемость в когорте ликвидаторов и среди всего населения аналогичных возрастных групп, а также рассчитать стандартизованные коэффициенты за 1993-1994 годы.

Изучаемая когорта ликвидаторов условно разделена на две подгруппы: работавшие в 30-километровой зоне и работавшие в зоне первоочередного и последующего отселения ($>15 \text{ Ки/км}^2$ или более 555 кБк/м^2), каждая из которых разделена на субкогорты в зависимости от времени пребывания в зоне радиоактивного загрязнения.

Численность когорт ликвидаторов включенных в исследования

Группа наблюдения	Длительность пребывания в зоне (дней)	Мужчины	Женщины
01. Работа в 30-км зоне	до 30	15541	2117
	более 30	12424	1119
	Всего:	27965	3236
03. Работа в зонах $> 555 \text{ кБк/кв.м}$	до 30	3953	1182
	более 30	8110	1228
	Всего:	12063	2410

Возрастная градация ликвидаторов, включенных в исследование, - от 20 до 69 лет. Изучалась заболеваемость в целом в когорте ликвидаторов по сравнению с заболеваемостью населения от 20 до 69 лет.

Учитывая, что возрастное распределение в отдельных возрастных группах различается (среди ликвидаторов больше лиц молодого возраста), - рассчитывались стандартизованные показатели. Стандартизация показателей заболеваемости среди ликвидаторов и всего населения Беларуси выполнялась по возрастной структуре населения согласно переписи 1989 года. Вместе с тем число заболевших некоторыми формами рака было незначительным, что не всегда позволяло рассчитать стандартизованный показатель.

Сопоставление данных по структуре заболеваемости в 1993-1994 годах показало, что существенным отличием когорты ликвидаторов является более высокий процент заболевания мужчин раком ободочной кишки, мочевого пузыря, почки, щитовидной железы и лейкозов.

У женщин несколько чаще в структуре заболеваемости можно видеть рак молочной железы, рак почки, рак щитовидной железы.

Сопоставление стандартизованных показателей заболеваемости всеми формами рака показало парадоксальную картину превышения заболеваемости населения Беларуси над когортой ликвидаторов. Вместе с тем рассмотрение показателей заболеваемости по отдельным группам новообразований показывает превышение показателей заболеваемости ликвидаторов раком ободочной кишки - 18.7 и 12.0 на 100 000 жителей, раком мочевого пузыря - 31.1 и 13.6, раком щитовидной железы - 6.8 и 2.0, а также всеми формами лейкозов - 23.3 и 10.7.

Женщины-ликвидаторы также несколько реже заболевают всеми формами рака суммарно. Но вместе с тем рак кожи (47.6 и 23.2), опухоли почки (11.6 и 8.2), а также новообразования щитовидной железы (42.9 и 10.4) отмечены у них чаще, чем среди всего населения.

Заболеваемость раком среди ликвидаторов в сравнении с населением Беларуси в 1993-1994 гг.

МКБ9	Локализа- ция	Мужчины		Женщины	
		Ликвидаторы Стандартиз.по- каз. на 100000	Беларусь Стандартиз.по- каз. на 100000	Ликвидаторы Стандартиз.по- каз. на 100000	Беларусь Стандартиз.по- каз. на 100000
151	Желудок	29.5	49.4	5.7	26.3
153	Обод. кишка	18.7	12.0	5.7	12.4
162	Легкое	69.3	96.0	0.0	7.7
173	Кожа	8.5	18.3	47.6	23.2
174	Мол. жел.			56.3	57.9
188	Мочевой пузырь	31.1	13.6	0.0	2.0
189	Почка	10.5	12.7	11.6	8.2
193	Щитовид. железа	6.8	2.0	42.9	10.4
204- 208	Лейкозы	23.3	10.7	7.0	7.7
140- 208	Все локали- заци	281.2	347.8	260.4	271.0

Анализ стандартизованных показателей в группах ликвидаторов (мужчин), работавших в зоне эвакуации менее 30 дней и более 1 месяца (1-6 месяцев), показал значительные различия в уровнях заболеваемости по некоторым формам опухолей и в целом для всех новообразований. В частности, среди ликвидаторов, проработавших в 30-километровой зоне более 1 месяца, чаще отмечается заболеваемость раком мочевого пузыря, почки, щитовидной железы и лейкемией.

Суммарная заболеваемость ликвидаторов всеми формами злокачественных опухолей в группе работавших в 30-километровой зоне менее 1 месяца составила 258.1, а в группе работавших более 1 месяца - 304.4 на 100000.

Заболеваемость раком в 1993-1994 гг. среди ликвидаторов (мужчин), в сравнении с работавшими в 30-км зоне

МКБ9	Локализация	Беларусь Стандартизован- ный показатель на 100000	Все ликви- даторы Стандартизован- ный показатель на 100000	Работавшие в 30-км-зоне	
				Срок до 30 дней Стандартизован- ный показатель на 100000	Срок более 30 дней Стандартизован- ный показатель на 100000
151	Желудок	49.4	29.5	30.6	16.4
153	Обод. кишка	12.0	18.7	29.0	3.8
162	Легкое	96.0	69.3	67.5	87.6
173	Кожа	18.3	8.5	5.3	0.0
188	Мочевой пузырь	13.6	31.1	27.3	43.6
189	Почка	12.7	10.5	9.8	20.1
193	Щитовид. железа	2.0	6.8	3.6	24.2
204- 208	Лейкозы	10.7	23.3	15.8	43.2
140- 208	Все локали- заци	347.8	281.2	258.1	304.4

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INCREASED MUTATION RESPONSE TO ENVIRONMENTAL FACTORS IN LIQUIDATORS OF THE CHERNOBYL ACCIDENT

N.M. SLOZINA, A.M. NIKIFOROV, T.V. KHARCENKO, Y.G. NTRONOVA
All-Russian Centre of Ecological Medicine,
St. Petersburg, Russian Federation

ПОВЫШЕННЫЙ УРОВЕНЬ МУТАЦИОННОГО ОТВЕТА НА ДЕЙСТВИЕ ФАКТОРОВ ОКРУЖАЮЩЕЙ СРЕДЫ У ЛИКВИДАТОРОВ АВАРИИ НА ЧАЭС

Слозина Н.М., Никифоров А.М., Харченко Т.В., Неронова Е.Г.
Всероссийский центр экологической медицины, Санкт-Петербург, Россия

Cytogenetical investigations of 202 liquidators of Chernobyl accident were performed in remote period after the accident. We have examined the effect of additional hazard environmental actions in post-Chernobyl period on types and frequency of chromosomal aberrations. Statistical analysis of cytogenetical results taking into consideration the data of questionnaires (part "environmental hazard factors") was carried out. In accordance to the data of questionnaire two groups were chosen. The first one was formed from 31 liquidators without any additional contact with hazard factors (L1 group). The second one consisted of 51 liquidators having contacts with unfavourable external factors after the accident (L2 group). Control persons without occupational radiation exposure and with no more than average diagnostic exposure were subdivided into two groups with (C2 group) or without (C1 group) any contacts with hazard factors.

Between the L1 and C1 groups (without the action of environmental hazard factors) the only difference was revealed: the frequency of dicentrics and rings have been higher in liquidators than in control persons ($0.13 \pm 0.05\%$ and $0.02 \pm 0.02\%$, $p < 0.05$). But if the action of environmental hazard factors took place, the group of liquidators (L2) significantly differed from the control (C2) not only by dicentrics and rings ($0.25 \pm 0.09\%$ and $0.04 \pm 0.04\%$, $p < 0.05$) but by another types of chromosomal aberrations (chromatid exchanges $0.21 \pm 0.09\%$ and $0.00 \pm 0.04\%$, $p < 0.05$; translocated chromosomes $0.19 \pm 0.07\%$ and $0.04 \pm 0.04\%$, $p < 0.05$).

Thus, the reported results show that the cytogenetical response on hazard environmental factors significantly differ in liquidators.

ВВЕДЕНИЕ

Анализ хромосомных aberrаций в лимфоцитах периферической крови является общепризнанным методом выявления мутагенных воздействий на организм человека. При этом, на чувствительность организма к действию мутагенов влияет целый комплекс факторов различной природы - генетически детерминированных, связанных с действием антимутагенов и др. В наших предыдущих исследованиях было показано, что в отдаленном периоде после аварии у ликвидаторов повышена частота дицентрических, кольцевых хромосом, межхромосомных хроматида-хроматидных обменов и атипичных хромосом [1,2].

Настоящая работа была проведена с тем, чтобы выявить возможное влияние на геном ликвидаторов дополнительных мутагенных воздействий факторов окружающей среды, с которыми ликвидаторы контактировали после выхода из зоны аварии.

МАТЕРИАЛ И МЕТОДЫ ИССЛЕДОВАНИЯ

Обследовали ликвидаторов, находившихся на лечении во Всероссийском центре экологической медицины. Цитогенетический анализ проводили общепринятыми методами. Все обследуемые подвергались анкетированию. При составлении анкеты за основу взят образец, предложенный Интернациональной комиссией по защите от мутагенов и канцерогенов окружающей среды [3]. Опросный лист содержал более 60 позиций. Особое внимание уделяли регистрации контактов с вредными факторами после выхода из зоны аварии.

Из 202 цитогенетически обследованных ликвидаторов на основании анализа данных опросных листов отобрано две группы, различающиеся по степени контакта с вредными факторами. В первую группу из 31 человека (Л1) вошли ликвидаторы, отрицавшие какой-либо контакт с вредностями в быту и/или на производстве. Вторая группа (Л2) была составлена из 53 лиц, указывавших на контакты с вредностями. Следует подчеркнуть, что в последнюю группу не включали ликвидаторов, занятых в условиях официально признанного вредного производства. Ликвидаторы, относительно которых не было составлено точного представления о возможности контакта с вредными факторами, не включены в данное исследование.

Сформированы две группы сравнения из лиц сходного возраста, никогда не подвергавшихся действию радиации (за исключением диагностических обследований). Одна группа составлена из 31 человека, отрицавшего какие-либо контакты с вредными факторами (С1), другая - из 20 человек (С2), подвергавшихся вредным воздействиям. Спектр вредных веществ и воздействий, на которые указывали обследуемые из групп Л2 и С2, весьма широк и охватывает почти все разделы, представленные в анкете-опроснике.

Статистическая обработка данных проводилась в Математической лаборатории Всероссийского центра экологической медицины. При статистической обработке данных применяли дисперсионный анализ и другие математические методы.

РЕЗУЛЬТАТЫ И ИХ ОБСУЖДЕНИЕ

Проведен анализ частот и типов хромосомных аномалий у ликвидаторов в сравнении с контрольной группой с учетом наличия или отсутствия дополнительных мутагенных воздействий факторов окружающей среды.

В таблице I представлены данные, полученные при обследовании ликвидаторов и группы сравнения при отсутствии вредных воздействий на производстве и/или в быту.

Таблица I

Частоты и типы хромосомных aberrаций у ликвидаторов и в группе сравнения при отсутствии воздействия вредных факторов окружающей среды

	ликвидаторы (Л1)	группа сравнения (С1)
Число обследованных	31	31
Частота aberrантных метафаз	2.13 ± 0.37	1.15 ± 0.30
Одиночные фрагменты	1.58 ± 0.27	1.15 ± 0.30
Обменные хроматидные aberrации	0.06 ± 0.04	0.00 ± 0.03
Парные фрагменты	0.32 ± 0.11	0.20 ± 0.10
Дицентрики, кольца	0.13 ± 0.05	0.02 ± 0.02^a
Атипичные хромосомы	0.03 ± 0.03	0.02 ± 0.02

^a $p < 0.05$

Как следует из данных, представленных в Таблице I, ликвидаторы, не имевшие после аварии контактов с дополнительными вредными факторами, отличаются от соответствующей группы сравнения только по частоте маркеров радиационного воздействия - дицентрических и кольцевых хромосом.

Выявление радиационных маркеров в группе Л1 еще раз раз подтверждает имеющиеся данные о том, что в отдаленном периоде после аварии у ликвидаторов наблюдается повышенная частота встречаемости нестабильных хромосомных aberrаций [1,2,4,5].

В Таблице II представлены данные, полученные при обследовании ликвидаторов и группы сравнения в условиях вредных воздействий на производстве и/или в быту.

**Частоты и типы хромосомных aberrаций у ликвидаторов и в группе сравнения при
воздействии вредных факторов окружающей среды**

	ликвидаторы (Л1)	группа сравнения (С1)
Число обследованных	53	20
Частота aberrантных метафаз	3.08 ± 0.30	2.23 ± 0.46
Одиночные фрагменты	1.60 ± 0.23	1.59 ± 0.36
Обменные хроматидные aberrации	0.21 ± 0.09	0.00 ± 0.04^a
Парные фрагменты	0.83 ± 0.15	0.64 ± 0.23
Дицентрики, кольца	0.25 ± 0.09	0.04 ± 0.04^a
Атипичные хромосомы	0.19 ± 0.07	0.00 ± 0.04^a

^a $p < 0.05$

В группе ликвидаторов, имевших дополнительные контакты с вредными факторами (Л2), наряду с повышенной частотой дицентрических и кольцевых хромосом (0.25 ± 0.09 в Л2 и 0.04 ± 0.04 в С2, $p < 0.05$), наблюдаются обменные aberrации хроматидного типа (0.21 ± 0.09 в Л2 и 0.00 ± 0.04 в С2, $p < 0.05$), а также атипичные хромосомы (0.19 ± 0.07 в Л2 и 0.00 ± 0.04 в С2, $p < 0.05$).

Полученные нами данные свидетельствуют о том, что контакт со сходными внешними факторами по-разному воспринимается ликвидаторами и лицами, не принимавшими участия в ликвидации последствий аварии на ЧАЭС. Существующая специфика реакции организма ликвидаторов на окружающую среду может являться следствием действия комплекса факторов аварии, в том числе длительного состояния стресса у ликвидаторов.

Для окончательного решения вопроса о причинах и механизмах повышенного уровня мутационного ответа у ликвидаторов, а также для изучения последствий для состояния здоровья требуется дальнейшее наблюдение за ликвидаторами аварии на ЧАЭС.

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EXPOSURE DOSE FOR PERSONS INVOLVED IN MITIGATING THE CONSEQUENCES OF THE CHERNOBYL ACCIDENT

A.M. NIKIFOROV, I.I. SHANTYR, I.K. ROMANOVITCH, N.V. MAKAROVA
All-Russian Centre of Ecological Medicine,
St. Petersburg, Russian Federation



XA9745469

Introduction

The detection of different health risk groups among the persons who took part in liquidation of the Chernobyl accident consequences is the basis for conducting the scientific research, medical observation and rendering social and medical assistance.

The persons participated in liquidation of the Chernobyl accident consequences were influenced by a complex of harmful factors. The majority of researchers consider a radiation factor to be decisive. It is exactly the exposure level that will govern the risk of developing the malignant diseases, genetic hereditary pathology in the future, and, as recent publications show, of increasing in the somatic disease incidence. From this it follows that the radiation dose value can serve as a main risk criterion for persons who participated in liquidation of the Chernobyl accident. However in more than 20% of direct liquidators the individual radiation doses were not recorded.

Materials & methods

We analysed information of special Departmental Medical Dosimetry Register. The data base of the Departmental Register includes data on 37 thousand liquidators and contains information concerning the official recorded external radiation dose absorbed, type of work and conditions while being in a radiation zone. In addition there are following data points on each liquidator there: the date for starting salvage work, duration of exposure, maximum radiation power at recovery work site, type of work (decontamination, building, cordoning or staff), site of work (inside, outside, with machinery), use of individual protective equipments (respirators, specialized or changeable clothes). All these factors determined a level of exposure or radiation effect.

Analysis of officially registered external radiation doses absorbed has been carried out. Dose values in the great part of cases have been determined by a calculation immediately in the work period and in the other part - using an individual dosimeter. However in more than 20% of direct liquidators the individual radiation doses were not recorded.

We used traditional and original methods for the evaluation of influence of different factors on the dose values. Traditional methods included correlation analysis, regression analysis and frequency tables analysis. Original method suggested is the variance analysis analogue adapted to information available in the Departmental Medical Dosimetry Register.

Results

It is determined that the mean external radiation dose absorbed for liquidators was $0,062 \pm 0,001$ Gy including 1986 - $0,121 \pm 0,003$ Gy, 1987 - $0,084 \pm 0,001$ Gy. This value corresponds with a term "low dose". Radiation dose more than 0,25 Gy is registered only in 1,8% of liquidators. Sample distribution by dose and year of arrival at the zone is presented in Tab. I.

Tab. I. Distribution of liquidators on dose and year of arrival at the zone, %

Dose, Gy	1986	1987	1988	1989	1990
0 - 0.05	34.3	29.5	87.0	97.5	96.1
0.051-0.1	16.6	49.0	11.8	0.8	2.4
0.101-0.15	12.1	9.8	0.5	0.8	0.7
0.151-0.2	10.7	5.7	0.4	0.4	0.3
0.201-0.25	18.7	5.6	0.2	0.3	0.1
> 0.25	7.6	0.4	0.1	0.2	0.4

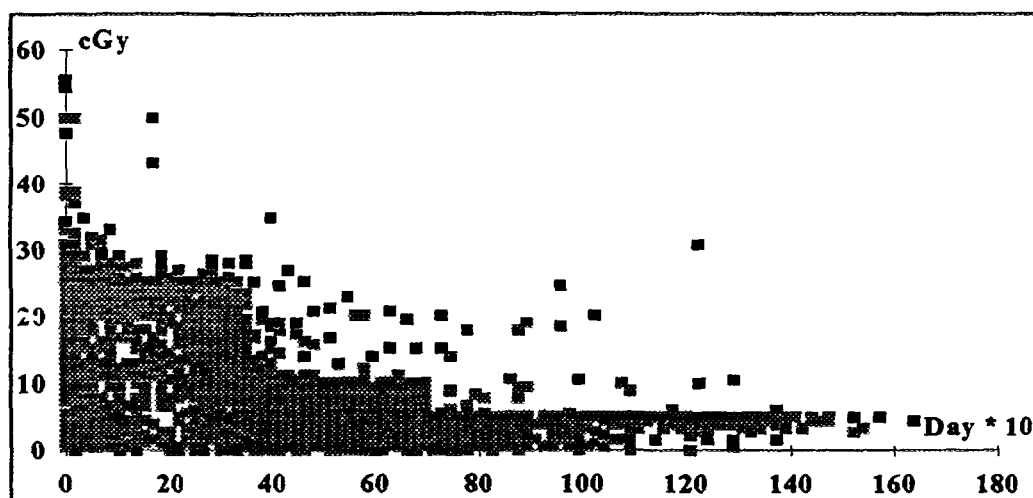


Fig. 1. Radiation dose distribution for liquidators depending on the date of work beginning after the moment of accident.

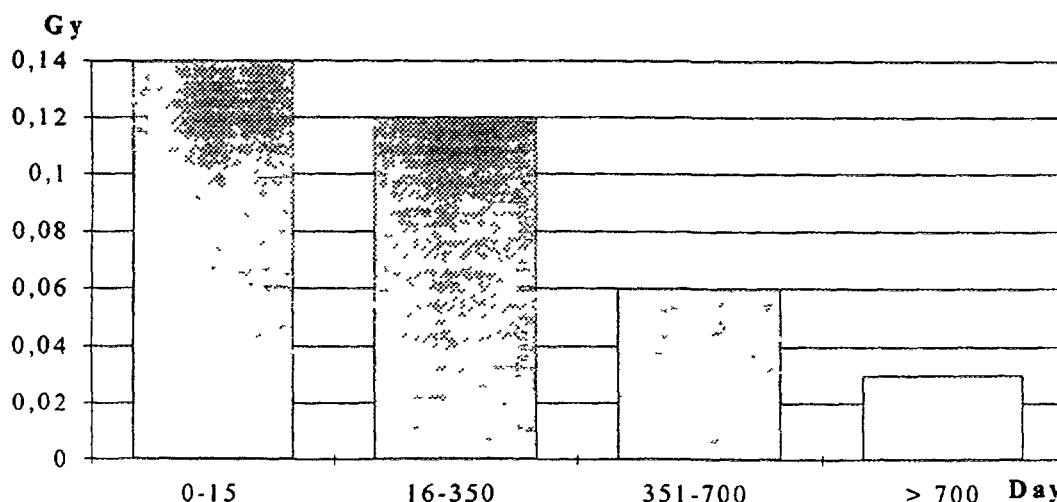


Fig. 2. Average radiation doses for the Chernobyl accident liquidators according to time intervals from the moment of the accident.

Tab. II. Distribution of liquidators on types of work in four time intervals, %

Type of work	1-15 days	16-350 days	351-700 days	> 700 days
Decontamination	26.8	47.7	69.9	51.6
Bulding	5.4	7.3	7.4	5.1
Cordoning	2.0	1.7	1.0	2.3
Administration	17.6	13.0	7.2	14.2
Others	48.2	30.3	14.5	26.8

Tab. III. Distribution of liquidators on sites of work in four time intervals, %

Sites of work	1-15 days	16-350 days	351-700 days	> 700 days
Outside	41.8	50.5	56.6	57.4
With machineri	36.7	13.1	6.8	9.7
Inside	13.3	25.0	27.9	19.7
others	8.2	11.5	8.7	12.9

Tab. IV. Distribution of liquidators on individual protective means used in four time intervals, %

Individual protective	1-15 days	16-350 days	351-700 days	> 700 days
Not used	1.1	2.1	2.4	6.4
Respirator	18.6	16.7	21.2	39.8
Gloves+ changeable clothes	29.4	27.0	22.5	12.1
Respirator+ changeable clothes	4.8	14.8	23.6	25.1
Special clothes	40.7	29.7	26.5	10.1
Others	5.4	9.7	3.8	6.5

Tab. V. Distribution of liquidators on maximum radiation power in places where the work was performed in four time intervals, %

Radiation power, R/h	1-15 days	16-350 days	351-700 days	> 700 days
< 1	40.9	48.2	68.3	82.4
1.1- 10	18.0	30.2	18.0	9.8
> 10	41.1	21.6	13.7	7.8

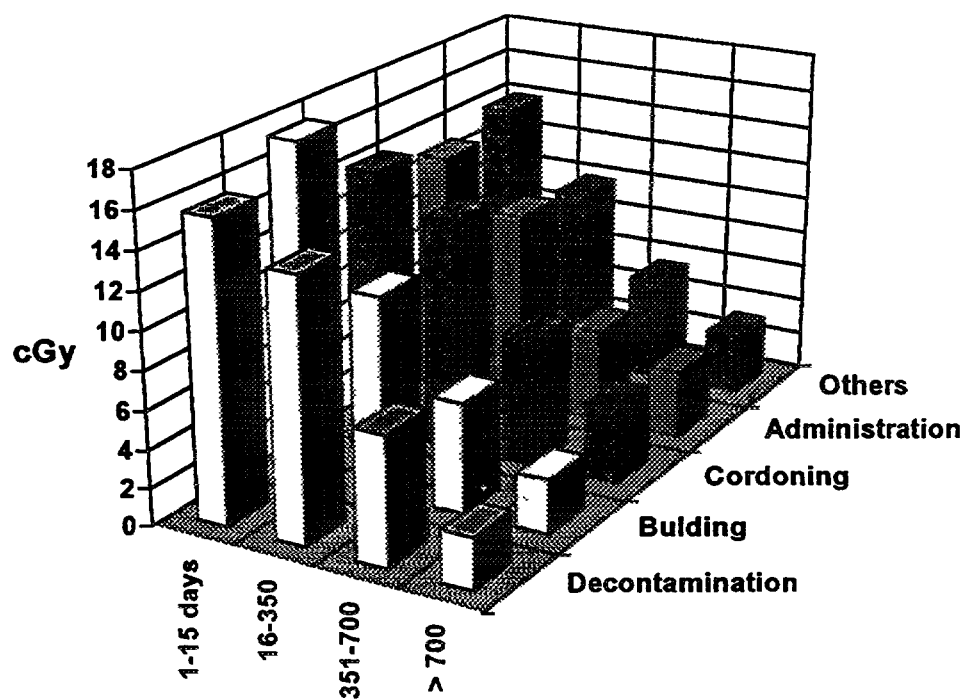


Fig.3. Average radiation exposure doses depending on the type of work .

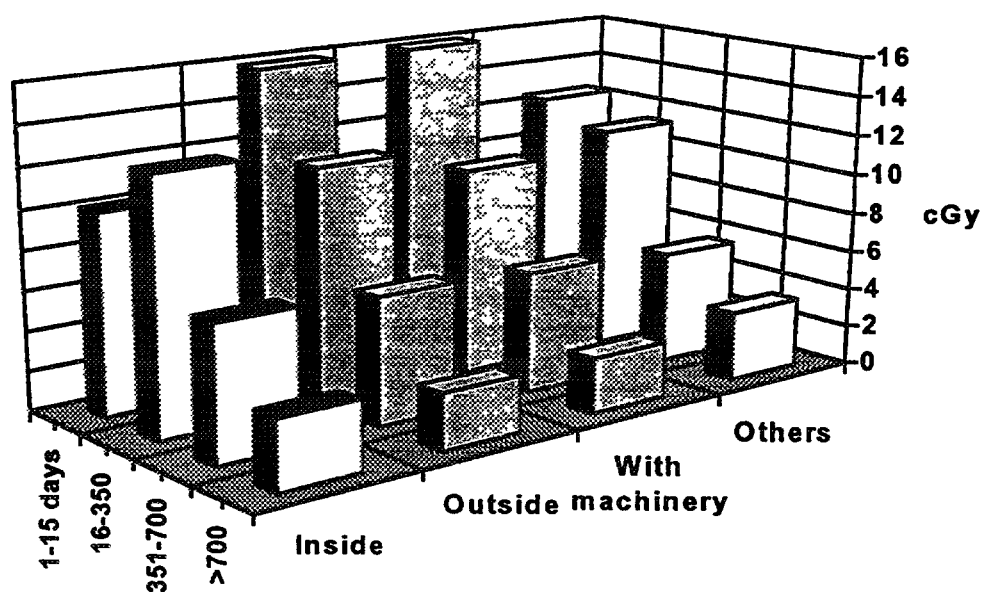


Fig. 4. Average radiation exposure doses depending on the site of work.

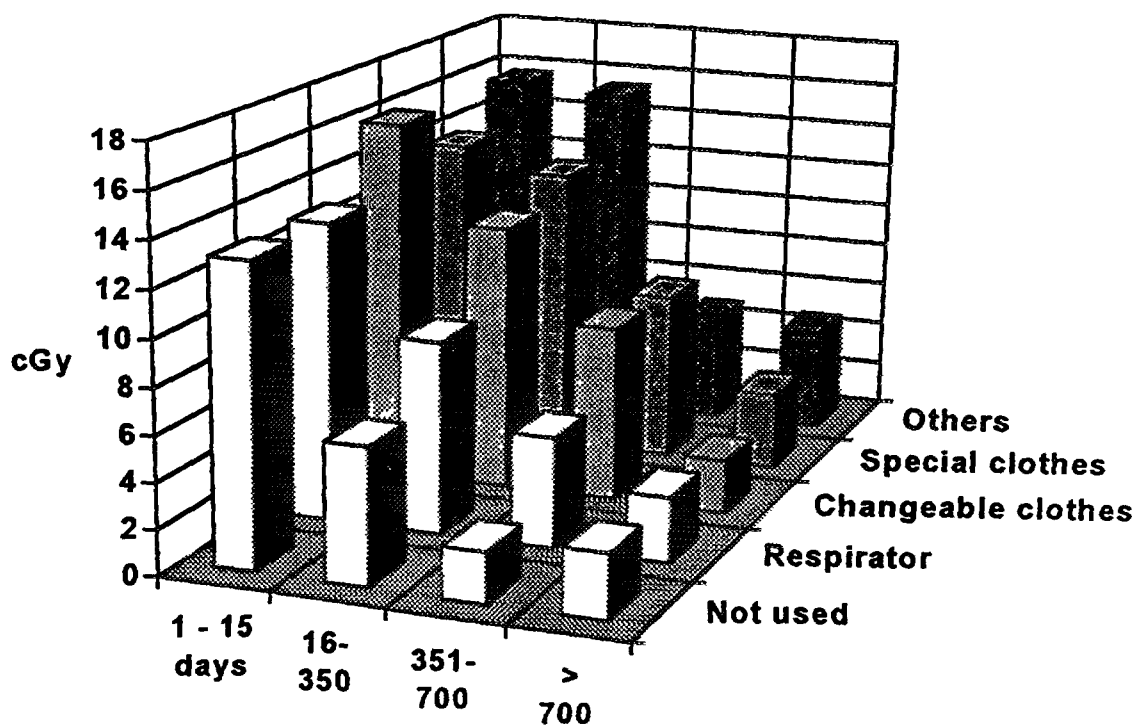


Fig. 5. Average radiation exposure doses depending on individual protective means used.

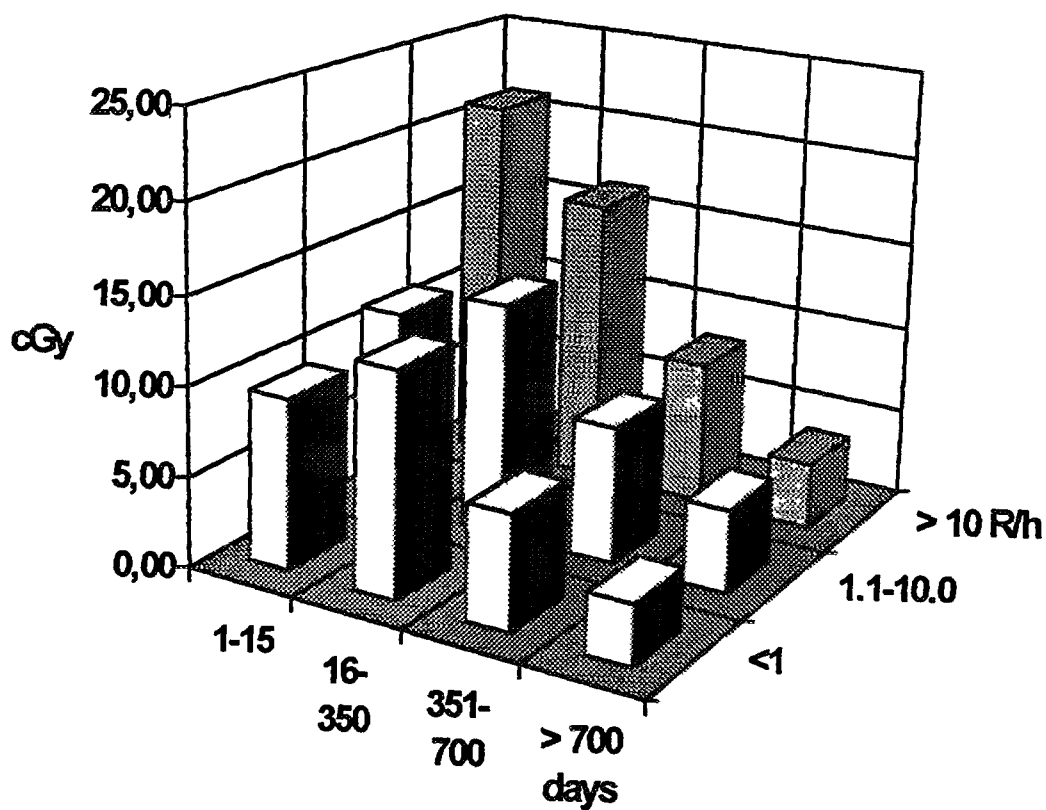


Fig. 6. Average radiation exposure doses depending on maximal intensity of radiation at work site.

It is established that such factor as "the date of work beginning in the recovery operations zone" is the most significant(Fig.1). The correlation coefficient (r) amounts to -0.487. The radiation doses significantly differ in four time intervals: the first interval ranges from 0 to 15 days from the moment of accident; the second -from 16 to 350 days; the third -from 351 to 700 days; the fourth -over 700 days. Average radiation doses are presented on Fig. 2 against time intervals. These time intervals should be the basis of forming the risk groups of liquidators of the Chernobyl accident.

Tables II-V demonstrate distributions of liquidators according to the indexes to be analysed and Fig. 3-6 show distributions of radiation doses received.

The analysis of dependences has shown that in all time intervals such factor as "type of work" is second in significance as regards to forming the exposure dose. Contingency coefficient (C) based on Pearson's chi-square statistic between the exposure dose and the type of work averages 0,223 in all time intervals.

A relationship with the significance level 0,01 is revealed as well between the exposure dose and such factors as preventive means ($C= 0,350$), maximum dose rate at the place of work ($r=0,236$), length of staying in this dangerous zone ($r=-0,172$). However the value of this relationship differs in the abovementioned time intervals and is found to be small.

Conclusion

Officially registered external radiation doses in the absolute majority of individuals involved in the mitigating the Chernobyl accident consequences are placed within a diapason of " low level".

As a result of the study the most significant factors determining the high exposure doses for liquidators of the Chernobyl accident are detected. It makes possible to reproduce individual radiation doses for those liquidators for whom they were not recorded but the rest data on their work at the Chernobyl nuclear power station are known and to divide the whole cohorta of liquidators into groups depending on radiation dose, and thereby to identify high and low risk groups according to the most significant factor.

NATIONAL CHERNOBYL REGISTRY OF RUSSIA: RADIATION RISKS ANALYSIS



XA9745470

V.K. IVANOV, A.F. TSYB
Medical Radiological Research Center (RAMS),
Obninsk, Russian Federation

1 CURRENT STATUS OF THE RUSSIAN NATIONAL MEDICAL AND DOSIMETRIC REGISTRY

Fig 1 presents the information on the dynamics of the RNMDR registrant number growth in 1986-1995. As the fig 1 shows during all these years of its existence the data base of the Federal level of the RNMDR kept accumulating medical dosimetric information and as of 1 09 95 comprises data on 435276 people from throughout the Russian Federation.

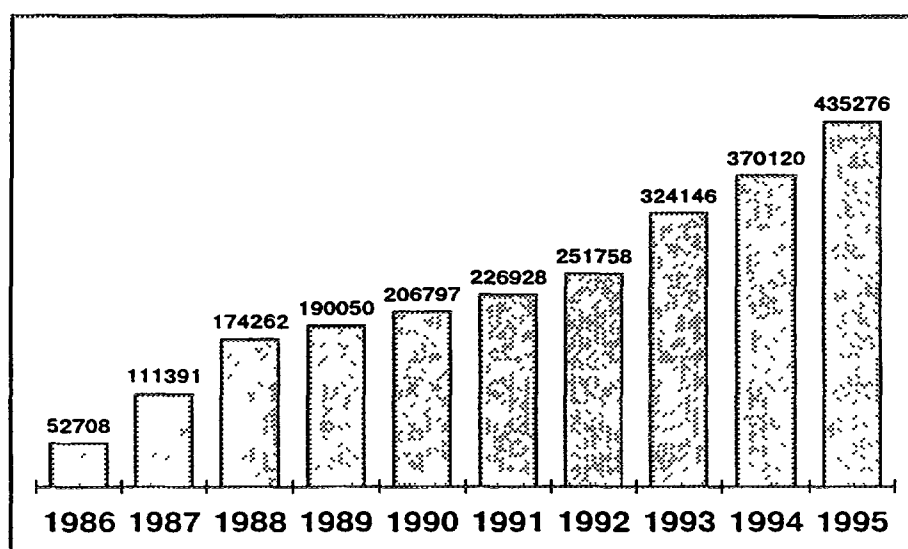


Fig 1 Dynamics of RNMDR registrant number growth in 1986-1995

All the RNMDR registrants are divided into five primary registration groups (PRG)

PRG 1 - emergency workers - 152325 (35,0 %);

PRG 2 - evacuated and resettlers - 12889 (3,0 %),

PRG 3 - residents (persons living or lived in monitoring territories) - 251246 (57,7 %),

PRG 4 - children born of emergency workers of 1986-1987 - 18816 (4,3 %)

Fig 2 demonstrates the distribution of persons registered in the RNMDR on their representation in regional centers (the registry of the Central Region does not include 4 contaminated oblasts - Bryansk, Kaluga, Orel and Tula as each of them has its own regional center)

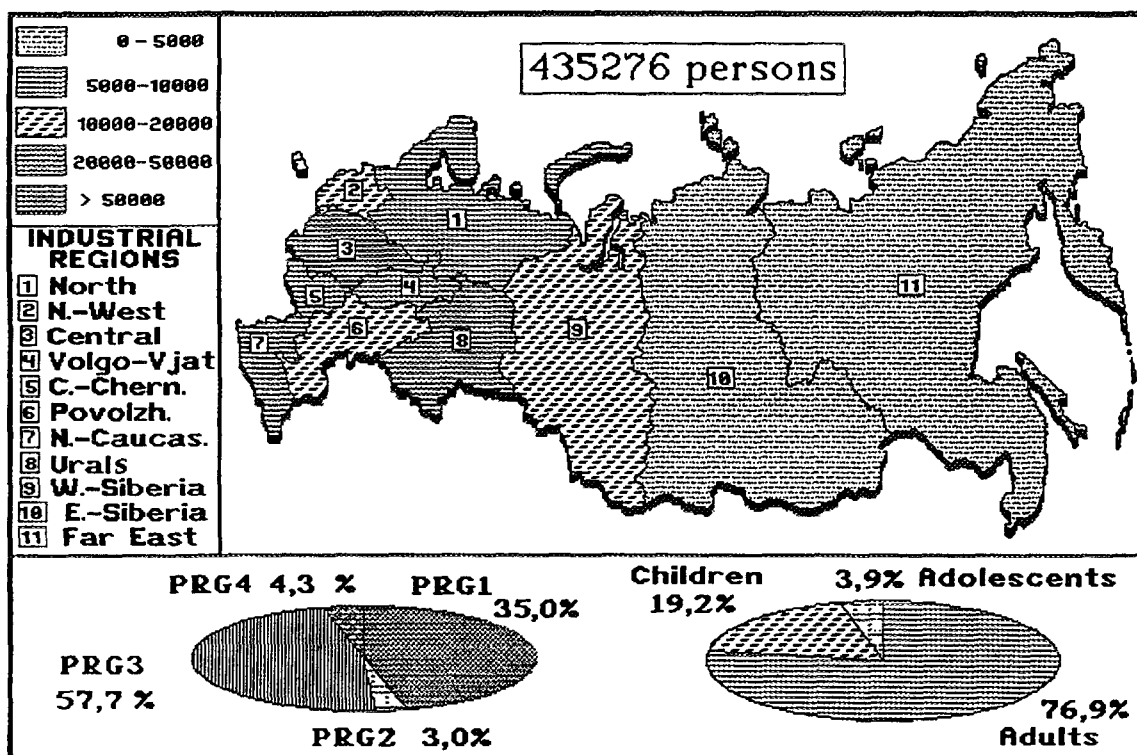


Fig. 2. Number of persons recorded in the RNMDR.

Sex-age composition of the contingent registered in the RNMDR is the following:

men	281775	64,7 %;
women	153501	35,3 %.
children	83598	19,2 %;
adolescents	16906	3,9 %;
adults	334772	76,9 %.

2. MORTALITY, MORBIDITY AND DISABILITY OF EMERGENCY WORKERS: FACTUAL DATA AND PROGNOSTICATION

Fig. 3 illustrates the distribution density $f(D)$ of external exposure doses for EWs included into the RNMDR system. As it is seen from fig. 3 the distribution of doses is of complicated character which is characterized by presence of several peaks (1, 5, 10 and 20-25 cGy). This distribution is obtained using superposition of distributions differing in dates of beginning the works by each emergency worker in the zone of radioactive contamination.

With regard to the age distribution of EWs (the average age at the moment of the accident - 33 years) and dosimetric data, in Table I the prognostication of additional mortality of EWs from malignant neoplasms 20 years after the exposure is given. In particular, the excess radiation-induced mortality (attributive risk) from all malignant neoplasms was found to account for 2,8 %. On leukemia cases the analogous parameter will be equal to 23,6 % [1, 2].

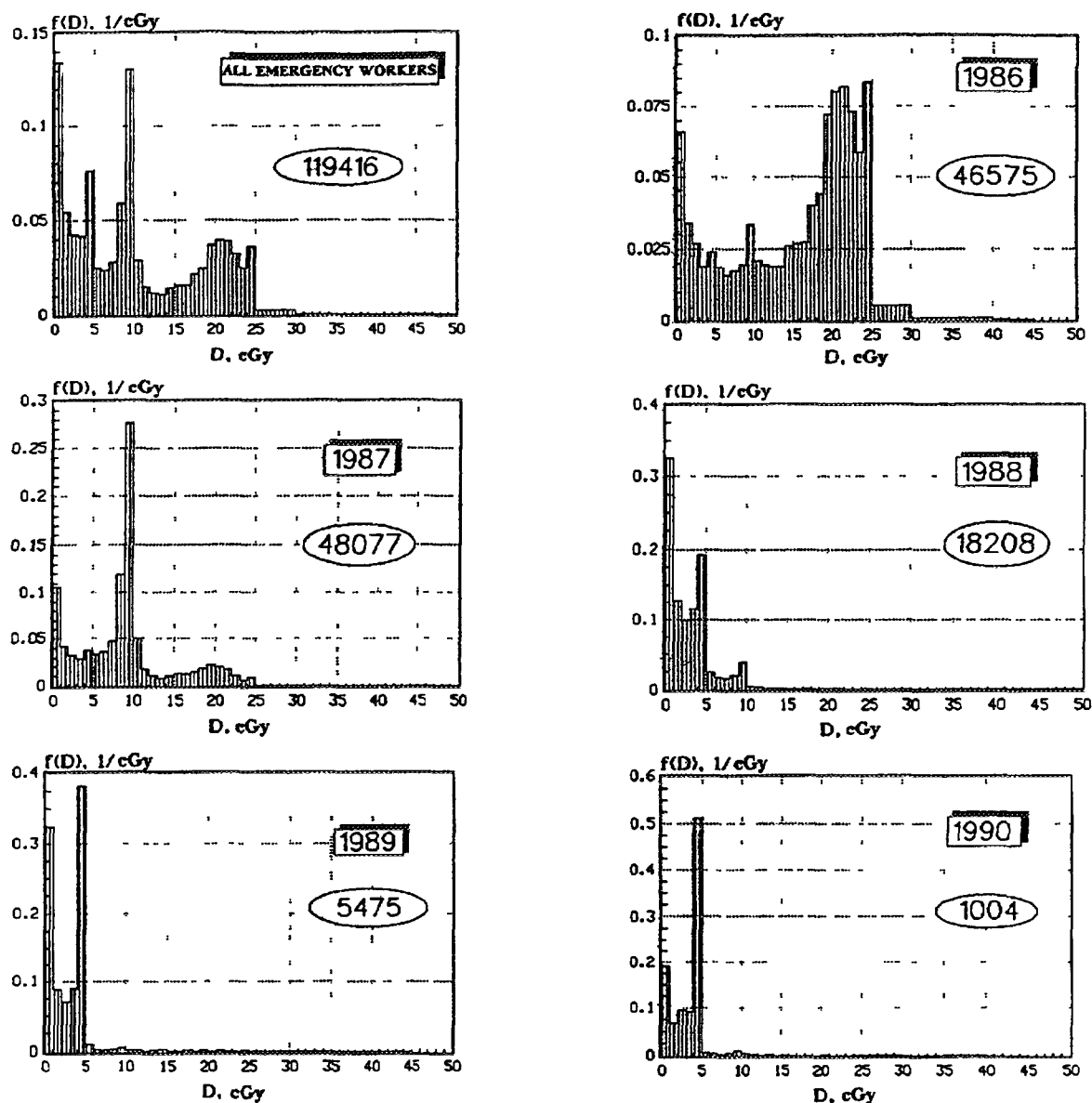


Fig 3 Distributions $f(D)$ of external exposure doses D for emergency workers registered in the RNMDR

Distributions $f(D)$ for different dates of arrival in the contaminated territories (1986, 1987, 1988, 1989, 1990) are demonstrated separately. Inside the oval the number of EWs (sample size) is indicated on each picture.

TABLE I PREDICTING LATE EFFECTS OF RADIATION ON MORTALITY FROM MALIGNANT NEOPLASMS AMONG EMERGENCY WORKERS 20 YEARS AFTER THE EXPOSURE

Year of employment in the zone	Number of emergency workers	Mean absorbed dose (cGy)	Collective dose (men*Gy)	Excess cancer death due to the exposure		Natural cancer death		Attributive risk (%)	
				leukemia	all types	leukemia	all types	leukemia	all types
1986	46575	15,9	7405,4	22	84	45	1945	32,8	4,1
1987	48077	8,95	4302,9	11	47	45	1952	19,6	2,4
1988	18208	3,3	600,9	2	7	17	768	10,5	<0,1
1989	5475	3,2	175,2	-	2	6	234	7,4	<0,1
1986-1989	118335	10,5	12483,1	35	140	113	4899	23,6	2,8

The data of prognostication on mortality from malignant neoplasms are in a good agreement with the rates of mortality (observed in the RNMDR) from these causes for EWs (Fig. 4). Mortality of EWs from malignant neoplasms does not exceed the control rate. Dose dependence of mortality from malignant neoplasms is not revealed by us as well. So, the relative risk of mortality from malignant neoplasms among EWs received the doses higher than 25 cGy amounts to 1,4. However, 95% confidence interval of this estimate is within the range of 0,61-2,16 (i.e. it includes the value of 1,0) and does not allow one to make the conclusion about dose dependence. It should be noted that in spite of significant growth of the rate of mortality among EWs from all causes in 1990-1994 this index does not exceed the control values (Fig. 5). Thus, on mortality rates (from all causes and malignant neoplasms) the health effects actually observed during 9 years after the ChNPP accident are in a good agreement with prognostication estimates.

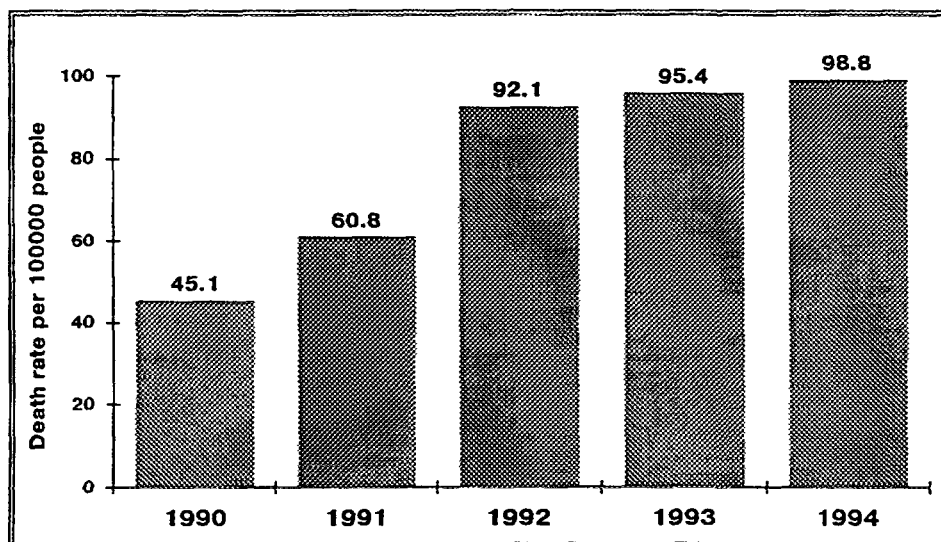


Fig. 4. Death rate of emergency workers from malignant neoplasms in 1990-1994.

It is the more complicated problem related to prediction and interpretation of actual data by morbidity and disability rates for EWs [3].

Table II demonstrates the comparison of morbidity rates per 100 thousand people on general classes of diseases both for population of Russia as a whole and for EWs. It is clear from the Table II that morbidity rates of EWs in a series of cases do repeatedly exceed the analogous ones for population of Russia. Undeniably, level, completeness and quality of prophylactic medical examination of EWs differ much from the All-Russian practice. Really, peculiarities and quality of prophylactic medical examination of EWs are that for their examination the most currently available methods of diagnosis of diseases are applied, in so doing, the works listed are carried out by trained and competent specialists. In such a manner, according to the data of the MRRC of RAMS the establishment of primary registered diseases by specialists of this institution is several times higher than by local physicians. In this situation it is very difficult to choose an adequate review control group of comparison.

Thus, on the cohort of EWs registered in the RNMDR two main conclusions may be done:

- factual evidence for the period just ended and prognostication of total mortality rate as well as that from malignant neoplasms made on the basis of radiation risk coefficients by ICRP are in a good agreement with observed rates which do not exceed corresponding control values on the Russian Federation;

- on morbidity and disability rates the EWs of 1986 and 1987 comprise the group of higher risk.

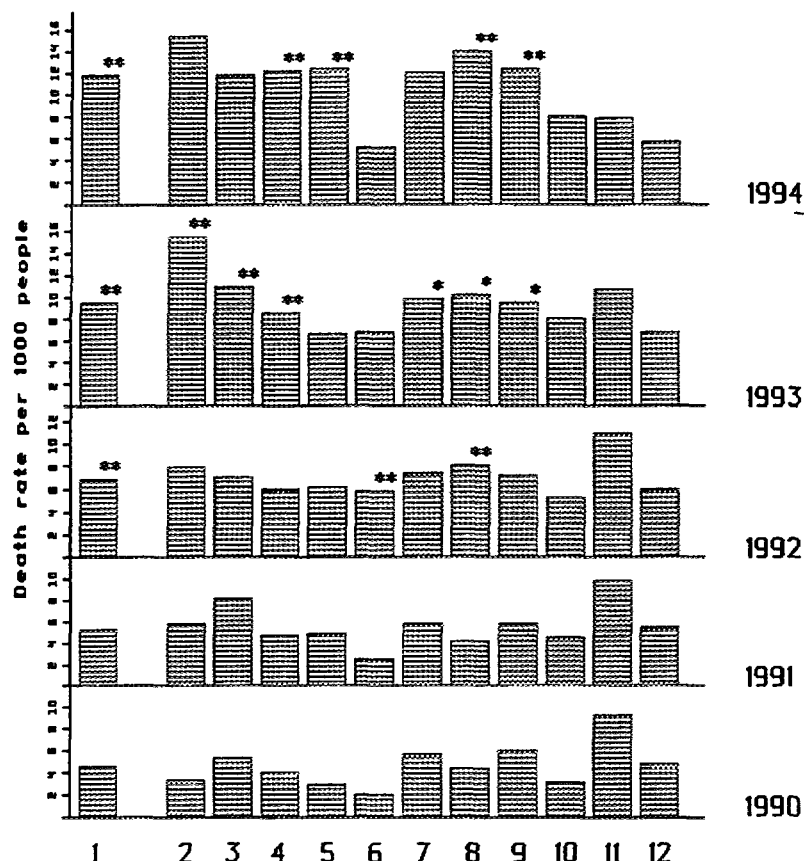


Fig. 5. Death rate from all causes for EWs in economical regions of Russian Federation in 1990-1994. 1 - Russian Federation, 2 - North region, 3 - North-West region, 4 - Central region, 5 - Volgo-Vyatsky region, 6 - Central-Chernozem region, 7 - Povolzhsky region, 8 - North-Caucasus region, 9 - Urals region, 10 - West-Siberia region, 11 - East-Siberia region, 12 - Far East region; * $p < 0,05$; ** $p < 0,01$.

TABLE II. COMPARISON OF MORBIDITY RATES PER 100000 PERSONS ON GENERAL CLASSES OF DISEASES FOR POPULATION OF RUSSIA AS A WHOLE AND EMERGENCY WORKERS ON 1993

Classes of diseases	Population of Russia	Emergency workers	Relationship among the indices
Neoplasms	788	747	0,9
Malignant neoplasms ^a	140	233	1,6
Diseases of the endocrine system	327	6036	18,4
Diseases of the blood and blood-forming organs	94	339	3,6
Mental disorders	599	5743	9,6
Diseases of the circulatory system	1472	6306	4,3
Diseases of the digestive system	2635	9739	3,7
All classes of diseases	50785	75606	1,5

a - For malignant neoplasms the standardized index on age distribution of emergency workers as of 1993 is given.

3. RADIOLOGICAL CONSEQUENCES DUE TO THE CHERNOBYL ACCIDENT AMONG POPULATION OF BRYANSK AND KALUGA OBLASTS, RADIATION RISKS IN INDUCTION OF THYROID CANCER

It is known that among radiological consequences due to the ChNPP accident the thyroid tumours will play a decisive role within the framework of somatic stochastic radiation effects.

Despite the fact that malignant thyroid tumours especially among children are of infrequent occurrence as compared with tumours of other localizations, nevertheless, an increasing level in induction of radiation thyroid cancers over spontaneous one would be expected.

At the same time it is of importance to estimate the whole spectrum of malignant tumours of different localizations and, in particular, that of tumours being the most radiosensitive malignant neoplasms of hemopoietic system which are characterized by short latent period. According to the data of the RNMDR as of 1994 no excess tumours and other malignant tumours, induced by the Chernobyl radiation, among population of the oblasts mentioned above were established. Factual data of the RNMDR evidence prognostication in this field.

Prognostication on excessive thyroid cancer cases for residents of contaminated districts of Kaluga (105300 persons) and Bryansk (466900 persons) oblasts is given in Table III. The parameter "expected" includes spontaneous and excessive (radiation-induced) morbidity.

TABLE III. ABSOLUTE NUMBER OF EXCESSIVE AND EXPECTED THYROID CANCER CASES AMONG RESIDENTS OF CONTAMINATED RAYONS OF BRYANSK AND KALUGA OBLASTS

Region (oblast)	Age groups	Time after exposure (years)						Attributive risk % (lifetime)
		10	20	lifetime	10	20	lifetime	
		Morbidity						
		Excessive			Expected			
Bryansk	adults	20	42	87	160	250	470	18
	children	20	53	185	20	68	350	53
Kaluga	adults	1	2	4	20	37	70	6
	children	2	5	18	4	8	56	32

As it is seen from the Table III the attributive lifetime risk for children living in these areas of Bryansk oblast will amount to 53% (i.e. every second cancer will be radiation-induced one), for children of Kaluga oblast - to 32%.

In the cohort of children and adolescents of Kaluga oblast (5694 people) with individual doses of radiation to thyroid estimated on the basis of direct radiometry carried out in 1986 the estimates of radiation risk of non-cancer thyroid diseases are obtained. In particular, the estimate of excess relative risk coefficient at the dose of 1 Gy which is equal to 0,2 (0,06; 0,34) is in a good agreement with the data published based on AHS cohort (Japan). Table IV presents risk coefficients.

TABLE IV. COMPARISON OF RADIATION RISK COEFFICIENTS OF NON-CANCER THYROID DISEASES IN KALUGA COHORT OF CHILDREN AND ADOLESCENTS AS WELL AS IN AHS COHORT

Cohort	Excess relative risk (ERR)	Attributive risk (AR)
AHS	0,3	16,4
(Japanese cohort)	(0,16; 0,47)	(9,1; 24,2)
Kaluga cohort	0,2	12,1
	(0,06; 0,34)	(4,1; 18,7)

At present time 48 thyroid cancer cases in those been children and adolescents at the time of the Chernobyl accident have been registered in Bryansk oblast [4, 5]. The "case-control" technology for determinating the radiation risks of cancer thyroid diseases in children and adolescents, living in Bryansk oblast is first realised (Fig. 6). Relative risk coefficient (Fig. 7) of cancer thyroid diseases in contaminated western districts of Bryansk oblast was demonstrated to be equal to 7,15 (1,52; 33,8) at the dose of 1 Gy.

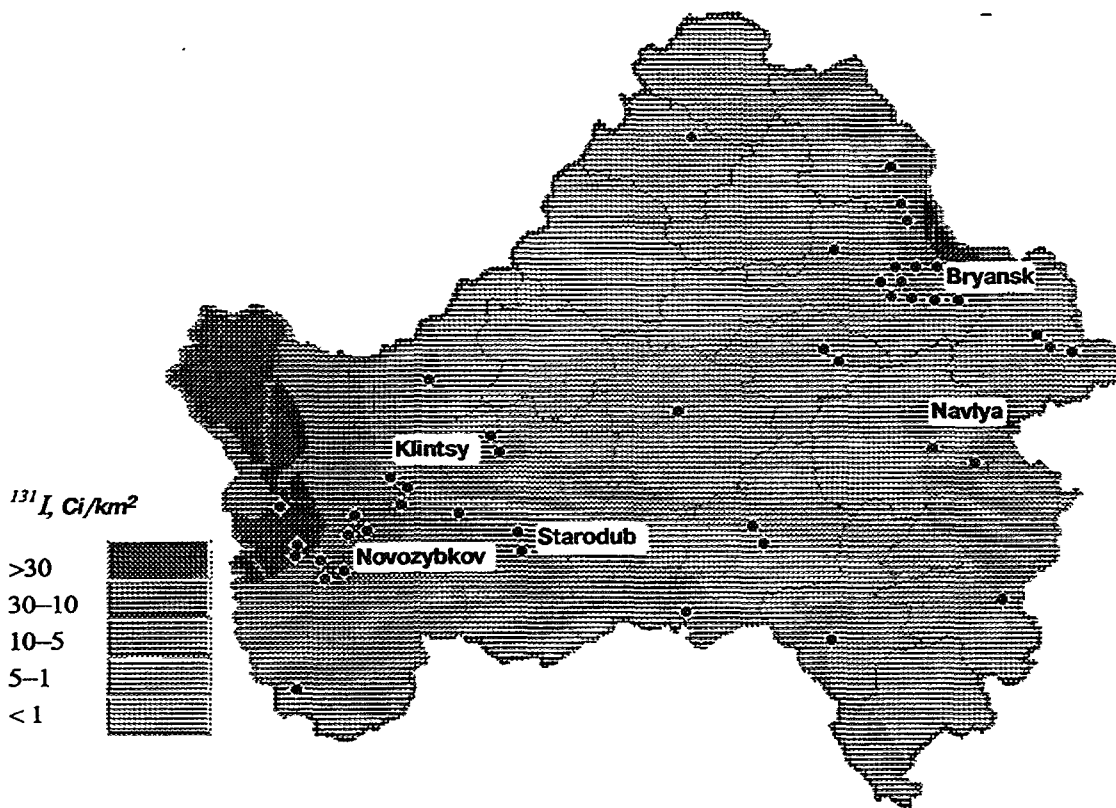


Fig. 6. Reconstruction (20 May, 1986) of ^{131}I ground contamination and cases of thyroid cancer in children and adolescents living in Bryansk oblast after the accident.

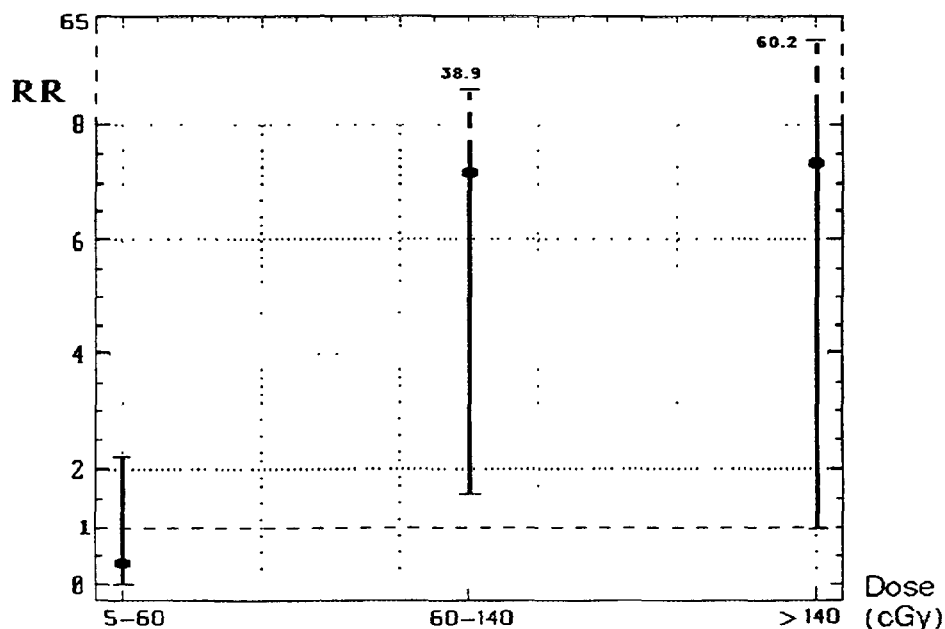


Fig. 7 Radiation risks of cancer in children and adolescents of Bryansk oblast (case-control study)

4. CONCLUSION

10 years have elapsed after the Chernobyl accident. The gravest technogenic accident throughout the human history has attracted considerable attention of the whole world community. At the same time, the problem concerning the estimation of the total integral damage to life and health of people exposed to radiation remains very complicate [4, 5]. A negative influence of the Chernobyl included a spectrum of factors which may reinforce each other. In particular, to date there are no theoretical models or practical recommendations on integral estimating the contribution of social and psycho-emotional factors to the risks of diseases due to radiological accidents. On the other hand, for maximum effective rehabilitation of suffered people the ranging and impartial determination of contribution both of proper radiation and non-radiation components of influence are needed. Therefore, continuation of long-standing investigations within the frame of the National Radiation and Epidemiological Registry along with obtaining new scientific data in the field of radiation epidemiology is of great practical importance to diminish health consequences of the accident.

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IMMUNE SYSTEM OF CHERNOBYL CHILDREN: DEVELOPMENTS IN UNDERSTANDING

K. STRAUSS

Medical Department, Becton Dickinson, France, Belgian Branch N.V.,
Erembodegem-Aalst, Belgium

V.P. CHERNYSHOV, E.V. VYCHOVANETS, Y.G. ANTIPKIN, E.P. KLIMENKO,
A.N. VASYUK, I.I. SLUKVIN

Institute of Pediatrics, Obstetrics and Gynecology, Kiev

1. INTRODUCTION

It is generally accepted that undisposible nuclear waste is real hazardous for future generations [1]. 1.5 million person, including about 160,000 children were exposed to significant amounts of radioiodine fallout from Chernobyl in April 1986 [2,3]. At present time increased amount of Cs-137(134) and Sr-90 in the soil and food attributed to radiation exposure of people who are living on radionuclides contaminated territories [4]. It has been shown that approximately 1/3 children with different doses of radiation exposure from radionuclide contaminated territories had strong functional disorders of respiratory system [5] and one recent study has found that Ukrainian children population living around Chernobyl had sick rate higher than before Chernobyl nuclear accident, and the respiratory tract diseases were prevailed among them [6]. Therefore, we studied children who were exposed long time to small doses of radionuclides.

Now, it is generally recognized that explosive increase thyroid malignancy rate among individuals who were children at the time of Chernobyl accident can be directly linked to the released radiation, especially to iodine isotopes [7,8]. Radioactive iodine comprise a major component of total body radiation received following exposure to fallout from nuclear plant accident. In addition to thyroid cancer, ionizing radiation and radioactive isotopes of iodine is known to cause thyroid dysfunction. It was demonstrated that exposure to radioactive isotopes of iodine following treatment of hyperthyroidism or after exposure to fallout from hydrogen bomb explosion can induce hypothyroidism in human [9,10,11]. Therefore, to investigate potential thyroid abnormalities and involvement of autoimmune reactions in their development, we also studied children who were exposed to radioactive iodine as a result of Chernobyl fallout.

2. PATIENTS AND METHODS

2.1. Study groups

Based on history, we divided all children into two groups: recurrent respiratory tract diseases children (RRDC) and non RRDC. RRDC from radionuclide contaminated territories had 6-12 and more cases of respiratory tract diseases (laryngo-tracheitis, bronchitis, pneumonia) in a year. Non RRDC had no history of chronic respiratory tract diseases.

2.1.1. Patients with ASD of Cs-137(134) and Sr-90

To investigate effect of long time exposure to small doses of radiation to immune system of Chernobyl children, we measured the main lymphocyte subsets (MLS) in peripheral blood (PB) of 120 recurrent respiratory diseases children (RRDC) and non RRDC 6-12 years old from fifteen radionuclide contaminated settlement using Immune Monitoring Kit (Becton Dickinson) and two color flow cytometric analysis by FACScan (Becton Dickinson). During 1991-1993 the average summary (internal and external) doses (ASD) of Cs-137(134) and Sr-90 in populations from these settlements were estimated by Ukrainian Ministry of Health to range from 0.57 to 3.09 mSv. The number, ASD of Cs-137(134) and Sr-90 in children from settlements around Chernobyl power plant and doses Cs-137(134) of soil from radionuclide contaminated territories are summarized in Table I.

Table I. CHILDREN POPULATIONS LIVING AROUND CHERNOBYL

Range of ASD of Cs-137(134) Sr-90 ^a	Group	No patients	ASD of Cs-137(134) and Sr-90 Mean±SD ^a	Dose of Cs-137 of soil Mean±SD ^b
< 1.0 (0.57-0.72)	non RRDC	17	0.7±0.03 ^{##}	26±7.4 ^{##}
	RRDC	34	0.7±0.03 ^{**}	22±3.7 [*]
> 1.0 (1.02-3.22)	non RRDC	32	2.0±0.8	52±25.7
	RRDC	37	2.1±0.7	55±22.2

^aExpressed as mSv.

^bExpressed as kBq/m².

^{##} - P < 0.005 compared with non RRDC which had ASD > 1.0 mSv.

^{*} - P < 0.01 compared with RRDC which had ASD > 1.0 mSv.

^{**} - P < 0.005 compared with RRDC which had ASD > 1.0 mSv.

2.1.2. Patients with PAD of I-131 to thyroid

To investigate effect of radioiodine to immune system and thyroid function, we obtained PB of 65 RRDC and non RRDC 6-14 years old from fifteen radionuclide contaminated settlements who had personal absorption dose (PAD) of I-131 to thyroid as a result of Chernobyl fallout in May 1986. These children had identical ASD of Cs-137(134) and Sr-90. We measured the MLS in PB and serum thyroid hormone, TSH and serum antibodies to thyroglobulin (AbTG) by ELISA. In order to determine a AbTG positive sera for the local children population the serum of twenty healthy children 6-12 years old living on non-radionuclide contaminated territories were used. These children had normal serum T3, T4, TSH concentrations, size and echogenicity of thyroid gland and had no history of thyroid diseases. Sera were defined as AbTG positive if the levels of AbTG were greater than mean + two standard deviations (1.6 mg/L and more) from levels of AbTG in these normal children. All controls sera and sera of children with PAD of I-131 to thyroid were positive by this criterium. The number, PAD of I-131 to thyroid, ASD of Cs-137(134) and Sr-90 of children living around Chernobyl are summarized in Table II.

Table II. CHILDREN POPULATIONS FROM CHERNOBYL REGION

PAD of I-131 to thyroid ^a	Group	No. patients	PAD of I-131 to thyroid Mean±SD ^a	ASD of Cs-137 and Sr-90 Mean±SD ^a
< 0.6	Non RRDC	17	0.2±14 [#]	1.2±0.7
	RRDC	7	0.3±13 [*]	1.1±0.4
1.0-2.0	Non RRDC	17	1.3±19 [@]	1.6±0.9
	RRDC	9	1.3±22 [!]	1.2±0.0
> 2.0	Non RRDC	6	2.9±33	1.5±0.9
	RRDC	9	2.9±30	1.4±0.9

^aExpressed as Gy.

- $P < 0.005$ compared with non RRDC which had PAD of I-131 within 1.0-2.0 Gy and more 2.0 Gy.

* - $P < 0.005$ compared with RRDC which had PAD of I-131 within 1.0-2.0 Gy and more 2.0 Gy.

@ - $P < 0.005$ compared with non RRDC which had PAD of I-131 more 2.0 Gy.

! - $P < 0.005$ compared with RRDC which had PAD of I-131 more 2.0 Gy.

2.1.3. Controls

The results obtained from blood samples analysis from Chernobyl children were compared with corresponded values obtained from children living on territory non-contaminated by radionuclides.

2.1.4. Setting

The study was conducted 8 years after the Chernobyl accident. Settlements chosen for the study had populations between 2000 and 50000 persons, were rural and were located from 40 to 100 km from the reactor. The control settlements were chosen to be rural, of similar population size to contaminated villages. During investigations all RRDC had no fever and cough. The protocol was approved by the medical ethical committees of the medical centers and conducted according to the declaration of Helsinki.

2.1.5. Statistic analysis

All patients data were entered into a computer database and analyzed using Stat View 512+ program. The nonparametric Mann-Whitney U test and Student's paired t test were performed for each set of variables. P values less than to 0.05 were considered significant. Regression analysis and correlations were also performed using the same program.

3. RESULTS

3.1. Analysis of main lymphocyte subsets in Chernobyl children with ASD of Cs-137(134) and Sr-90

We observed that levels of main lymphocyte subsets did not differ in non RRDC with ASD of Cs-137(134) and Sr-90 living around

Table III. PERCENTAGE OF LYMPHOCYTE SUBSETS IN CHILDREN LIVING AROUND CHERNOBYL AND CONTROL CHILDREN LIVING ON RADIONUCLIDE NON-CONTAMINATED TERRITORIES

Lymphocyte subsets	Control		Chernobyl region ASD of Cs-137(134) and Sr-90			
	non RRDC	RRDC	< 1.0 mSv		> 1.0 mSv	
	Mean±SD ^a	Mean±SD ^a	non RRDC	RRDC	non RRDC	RRDC
CD3+ T cells	67±5.4	67±5.7	68±5.4	63±7.0*	66±7.5	63±5.5 [#]
CD4+ helper/ inducer T cells	36±4.8	36±6.1	37±6.5	33±4.8*	36±7.3	31±5.5 ^{##}
CD8+ suppressor cytotoxic T cells	25±5.7	25±4.8	24±4.7	24±4.9	24±5.4	27±5.7
CD3+CD4+/CD3+CD8+ cell ratio	1.4±0.3	1.5±0.5	1.6±0.6	1.4±0.3	1.6±0.6	1.3±0.4 ^c
CD19+ B cells	16±4.9	16±4.9	15±4.2	17±3.3	14±5.1	16±4.6
CD3-CD16+, CD56+ NK cells	11±4.7	11±4.8	10±4.7	13±6.9	13±6.0	14±6.0

^aExpressed as a percentage of total lymphocytes.

- P < 0.05 compared with control RRDC.

- P < 0.005 compared with control RRDC.

* - P < 0.05 compared with non RRDC which had ASD < 1.0 mSv.

c - P < 0.05 compared with non RRDC which had ASD > 1.0 mSv.

ooo - P < 0.005 compared with non RRDC which had ASD > 1.0 mSv.

Chernobyl and control RRDC. However, RRDC living on contaminated territory had significantly lower percentages of CD3+ and CD3+CD4+ lymphocytes as compared with control RRDC. Moreover, the percentage of CD3+CD4+ cells and CD3+CD4+/CD3+CD8+ cell ratio in RRDC living around Chernobyl decrease in parallel with increase of ASD of Cs-137(134) and Sr-90 (Table III).

3.2. Analysis of quantity of children with ASD of Cs-137(134) and Sr-90 who had high and low levels of CD3+ and CD3+CD4+ cells

To evaluate the quantity of children with low or high levels of lymphocyte subsets living around Chernobyl, we studied samples from 45 control non RRDC. The normal range of percentage of CD3+ T cells and CD3+CD4+ cells calculated from these samples (95% interval) were found to be 57%-77% for the CD3+ cells and 27%-45% for the CD3+CD4+ cells. We observed that 11/71 (16%) RRDC living around Chernobyl had the levels of CD3+ T cells lower than 57%. In contrast, in all control RRDC the levels of CD3+ T cells were higher than 57%. We also observed that there was significant difference in the sum of children with percentage levels of CD3+CD4+ cells lower 27% or higher 45% between non RRDC living around Chernobyl and control non RRDC (Data not shown).

3.3. Analysis of serum thyroid hormones and TSH in children with PAD of I-131 to thyroid

As shown in Table IV and V, children with PAD of I-131 had six to ten fold increase in the TSH levels compared with controls. However, we did not find that increase in the TSH levels was dependent on PAD of I-131. The T3 levels in non RRDC with PAD of I-131 more 1.0 Gy were significantly lower than did control non RRDC. In contrast, the T3 levels had normal distributions in all RRDC with PAD of I-131 (Table V).

Table IV. SERUM THYROID HORMONE IN NON RRDC WITH PAD OF I-131 TO THYROID FROM CHERNOBYL REGION AND CONTROL CHILDREN

Thyroid hormones	Controls ^a	PAD of I-131 to thyroid		
	Mean±SD ^c	< 0.6 ^b Mean±SD ^c	1.0--2.0 ^b Mean±SD ^c	> 2.0 ^b Mean±SD ^c
T3	2.6±0.2	2.5±0.2	2.1±0.8 [#]	2.2±0.4 [#]
T4	104±28	100.6±35	113.2±32	146.1±66
T3/T4 ratio (x10 ⁻³)	27±9	26±7	20±10	17±10
TSH	1.6±1.3	6.7±6.7 ^{##}	7.9±11.6 ^{##}	15.3±7.2 [#]

^an=20. Number of children with PAD of I-131: non RRDC with PAD of I-131 < 0.6 Gy n=10, with PAD of I-131 within 1.0-2.0 Gy n=17, with PAD of I-131 > 2.0 Gy n=2.

^bExpressed as Gy.

^cSerum T3 and T4 levels are expressed as nMol/L, serum TSH levels expressed as mIU/L.

- P < 0.05 compared with controls.

- P < 0.01 compared with controls.

Table V. SERUM THYROID HORMONE IN RRDC WITH PAD OF I-131 TO THYROID FROM CHERNOBYL REGION AND CONTROL CHILDREN

Thyroid hormones	Controls ^a	PAD of I-131 to thyroid		
	Mean±SD ^c	< 0.6 ^b Mean±SD ^c	1.0--2.0 ^b Mean±SD ^c	> 2.0 ^b Mean±SD ^c
T3	2.5±0.3	2.6±0.4	3.0±1.8	2.5±0.5
T4	129±41	94.6±22	131.6±3	99.3±6
T3/T4 ratio (x10 ⁻³)	21±4	28±6	23±4	29±5
TSH	1.4±1.1	8.9±7.1 [#]	5.6±3.8 ^{##}	4.3±0.9 ^{##}

^an=18. Number of children with PAD of I-131: with PAD of I-131 < 0.6 Gy n=3, with PAD of I-131 within 1.0-2.0 Gy n=8, with PAD of I-131 > 2.0 Gy n=5.

^bExpressed as Gy.

^cSerum T3 and T4 levels are expressed as nMol/L, serum TSH levels expressed as mIU/L.

- P < 0.05 compared with controls.

- P < 0.01 compared with controls.

3.4. Analysis of serum AbTG in children with PAD of I-131 to thyroid

As shown in Table VI, the AbTG were found in approximately 80% of children with PAD of I-131. The percentage of positive sera for AbTG from controls was significantly lower.

3.5. I-131 dose-dependent changes of AbTG levels and lymphocyte subsets in children with PAD of I-131 to thyroid

As shown in Table VII, the I-131 dose-dependent increase of AbTG levels, percentage of CD3+CD4+ cells, CD3+CD4+/CD3+CD8+ cell ratio and I-131 dose-dependent decrease of percentage of CD3+CD8+ cells in non RRDC, but not RRDC were found. However, we observed the I-131 dependent decrease of CD19+ B cells in RRDC.

Table VI. FREQUENCY OF SERUM ABTG IN CHILDREN WITH PAD OF I-131 FROM CHERNOBYL REGION AND CONTROL CHILDREN

Group	Number positive ^a /total tested	% Positive
RRDC with PAD of I-131	17/21	81*
non RRDC with PAD of I-131	24/29	83#
Control RRDC	3/31	10
Control non RRDC	7/42	17

^aAnalysis were performed on all sera. Those sera showing levels of AbTG more than 1.6 mg/L or greater were scored as positive. See Patients and Methods for details of assay.

* - $P < 0.0001$ compared with control RRDC.

- $P < 0.0001$ compared with control non RRDC.

Table VII. RELATIONSHIPS BETWEEN ABTG, LYMPHOCYTE SUBSETS AND PAD OF I-131 TO THYROID

Group		PAD I-131 to thyroid	
		r^a	P
AbTG	non RRDC	0.58	0.003
CD3+CD4+ cells	non RRDC	0.49	0.018
CD3+CD8+ cells	non RRDC	-0.44	0.035
CD3+CD4+/CD3+CD8+ cell ratio	non RRDC	0.49	0.017
CD19+ cells	RRDC	-0.56	0.016

^aCorrelation coefficient.

3.6. Relationships between serum T3 levels and lymphocyte subsets in children with PAD I-131 to thyroid

The percentage of CD3+CD4+ cells and CD3+CD4+/CD3+CD8+ cell ratio correlated strongly negative with T3 levels in non RRDC, but not RRDC with PAD of I-131 ($r = -0.63$, $P = 0.0002$; $r = -0.48$, $P = 0.004$) respectively.

4. DISCUSSION

Previous studies have shown that liquidators of Chernobyl accident who received a high level of radioactivity after break down of nuclear reactor had decreased levels of CD3+ lymphocytes [12]. The most little is known, however, about effects of long time of low doses of radiation on the immune systems in children constantly living on radionuclide contaminated territories. The most significant and important finding here is that a marked decrease of levels of CD3+CD4+ T-helper/inducer cells and CD3+CD4+/CD3+CD8+ cell ratio in RRDC living on radionuclide contaminated territories around Chernobyl was in parallel to the increase of ASD Cs-137(134) and Sr-90 (Table III). Although these results for CD3+CD4+/CD3+CD8+ cell ratio are not statistically significant compared with control RRDC, this is true for RRDC from radionuclide contaminated territories. This finding is a strong evidence that observed differences in lymphocyte subsets in RRDC are due to effect of radiation but not other factors such as different etiology or rate of infection.

It has been shown, that frequency of hypothyroidism was considerably higher in population that received direct atomic bomb radiation in 1945 with doses within 0.01-0.49 Gy [13]. The results

clearly demonstrated that in non RRDC with PAD I-131 to thyroid 1.0-2.0 or > 2.0 Gy increase in TSH was accompanied by decrease of the T3 levels and slight increase of T4 levels. This observation is consistent with clinical diagnosis of modest thyroid dysfunction. Elevated levels of TSH without substantial changes of T4 concentration were noted also in some Marshall Islands exposed to isotopes of iodine from fallout [10]. Thyroid dysfunction observed in non RRDC with PAD of I-131 was accompanied by autoimmune disorders. Significant increase positive AbTG sera were found in total Children with PAD of I-131 to thyroid living around Chernobyl. It seems likely that radiation induced damage of thyroid cells and release of thyroid antigenic material that initiate autoimmune response. Indeed, a strong correlation between levels of AbTG, percentage CD3+CD4+, CD3+CD8+, CD3+CD4+/CD3+CD8+ cell ratio and PAD of I-131 to thyroid were found in non RRDC. This data suggest that I-131 dose-dependent autoimmune disorders are present in non RRDC living around Chernobyl. However, the significantly higher levels of AbTG without correlation with PAD of I-131 to thyroid in RRDC were found. It was likely due to a significant decrease of levels CD19+ B cells in these children with PAD more 2.0 Gy compared to controls (data not shown) and significant negative correlation between percentage of CD19+ cells and PAD of I-131 in them. It is generally accepted that increase in thyroid cancer in childhood reported in Belorus, Ukrainian and Russia is a direct consequence of the accident at Chernobyl [7,8,14]. Observed changes in thyroid hormones and immune disorders in non RRDC with PAD of I-131 might have significance in the development of thyroid cancer. Constant high serum TSH levels induce long activity of thyroid gland parenchyma and can promote development of neoplasia in children with high PAD of I-131 to thyroid [15]. In general, it seems likely that children with PAD of I-131 to thyroid living around Chernobyl had two versions of immune response and function of thyroid gland. These differences in immune responses might have importance in the development of thyroid disorders in children living on contaminated territories.

In conclusion, our data clearly demonstrated:

1. Long time exposure to small doses of radiation could affect immune system. However, this effect of small doses of radiation might be developed only in presence of another factors that affect immune system, including recurrent infections;
2. Autoimmune reactions appear to be involved in development of thyroid dysfunction in non RRDC;
3. Children with PAD of I-131 had two versions of immune response and function of thyroid;
4. Children who are capable to maintain strong immune response more susceptible to radiation-induced thyroid disorders than children with weak immune system.

Because link between autoimmune thyroiditis and- thyroid carcinoma have been suggested, careful investigation of autoimmune reactions against thyroid gland will be required for the possible development of thyroid cancer.

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RADIATION CONTAMINATION AFTER THE CHERNOBYL NUCLEAR ACCIDENT AND ASSESSMENT OF THE RISK TO THE POPULATION OF CROATIA

N. LOKOBAUER, A. BAUMAN, D. CESAR, M. MARACIC, M. BAJLO
Institute for Medical Research and Occupational Health,
Zagreb, Croatia



XA9745472

Summary

Because of the Chernobyl nuclear accident which led to enhanced deposition of all fission products the contamination of human environment in the Republic of Croatia has been much higher than ever in the past two decades.

This paper deals with the investigation of deposition and translocation of fission products - ^{131}I , ^{137}Cs , ^{90}Sr and ^{134}Cs , particularly in the human food chain. Its aim was to determine those radionuclides which can, by characteristic pathways, endanger a particular population.

Radiation doses received from external and internal exposure were estimated for one-year-old infants, children at the age of ten and for adults. The corresponding annual effective doses were 1.49 mSv, 0.93 mSv, 0.86 mSv, respectively.

The critical radionuclide was ^{131}I , the critical pathway direct deposition of fission products on leafy vegetables and pastures, and the critical population one-year-old infants. The paper gives also data on ^{137}Cs and ^{90}Sr intake by the most significant food components and corresponding effective doses (E) for the population of Croatia received from 1985 to 1994.

LONG TERM HEALTH EFFECTS IN SWEDEN FROM THE CHERNOBYL ACCIDENT

R. FALK, H. MELLANDER, L. MOBERG, K. EDVARDSON, L. NYBLOM
 Swedish Radiation Protection Institute,
 Stockholm, Sweden

1. INTRODUCTION

The morning of 28 April 1986 was the beginning of an intensive period of radiation protection work in Sweden. During that morning the Chernobyl accident became known in the western world through the detection of radioactive contamination in Sweden and at the Forsmark nuclear power plant in particular [1]. The accident had occurred more than two days earlier and the existing weather had brought a first radioactive cloud to the Nordic countries.

Numerous measurements were performed during the months following the accident in order to clarify the distribution of the fallout and its nuclide composition as well as the potential health effects and the need for countermeasures. The measurements included aerial gamma measurements, *in situ* gamma spectrometry and measurements of both biological and non-biological samples. A large number of whole-body measurements were performed on various groups and on adults as well as on children.

The environmental consequences of the fallout have been studied in various research projects [2]. The effects on agriculture in Sweden was mainly limited to the first year after the accident. The long term effects are instead seen in products from the semi-natural ecosystems: in moose, roedeer, reindeer, mushrooms and fish from lakes in areas with a high deposition of radioactive caesium. High concentrations of ^{137}Cs in reindeer meat in combination with an estimated effective ecological half-life of about 4 years [3], will cause problems for reindeer husbandry in the most contaminated parts for many years to come. Various countermeasures are still used to decrease the concentration of ^{137}Cs in reindeer meat. In moose, roedeer and mushrooms, the ecological half-lives are very long and in some compartments seem to approach the physical half-life of ^{137}Cs .

In the long time perspective, the two dominating exposure pathways in Sweden are external irradiation from the radioactive elements, mainly caesium, deposited on the ground and the internal irradiation through intake of contaminated foodstuffs. Two other pathways, inhalation and irradiation from the the radioactive cloud, were of minor importance. In this paper we summarize some of the work that has been performed in Sweden in order to estimate the dose consequences and we draw some conclusions about the health effects of the Chernobyl accident.

2. EXTERNAL RADIATION

The doses due to external irradiation from the Chernobyl fallout have been estimated from nuclide specific radioactive measurements made by the Swedish Geological Company (SGAB), the Geological Survey of Sweden (SGU) and the Swedish Defence Research Establishment (FOA) [4,5,6 and references therein]. SGAB made a country-wide survey in 1986 using an air-borne NaI(Tl) gamma spectrometer and SGAB-SGU supplemented this survey with measurements over a part of the wet-deposition area along the Gulf of Bothnia in 1987 to 1992. The results have been given as deposition density of ^{134}Cs and ^{137}Cs (Fig. 1) assuming a surface distribution (the surface equivalent deposition density). The FOA measurements consisted of high resolution *in situ* gamma spectrometry and gamma spectrometric analysis of soil samples taken in connection with the *in situ* measurements.

It was found from the *in situ*-measurements that the Chernobyl debris contained detectable amounts of more than twenty gamma-emitting nuclides. Some of the short-lived nuclides such as ^{131}I , ^{132}Te and ^{140}Ba were the main contributors to the gamma dose rate during the first months after the

Cesium - 137

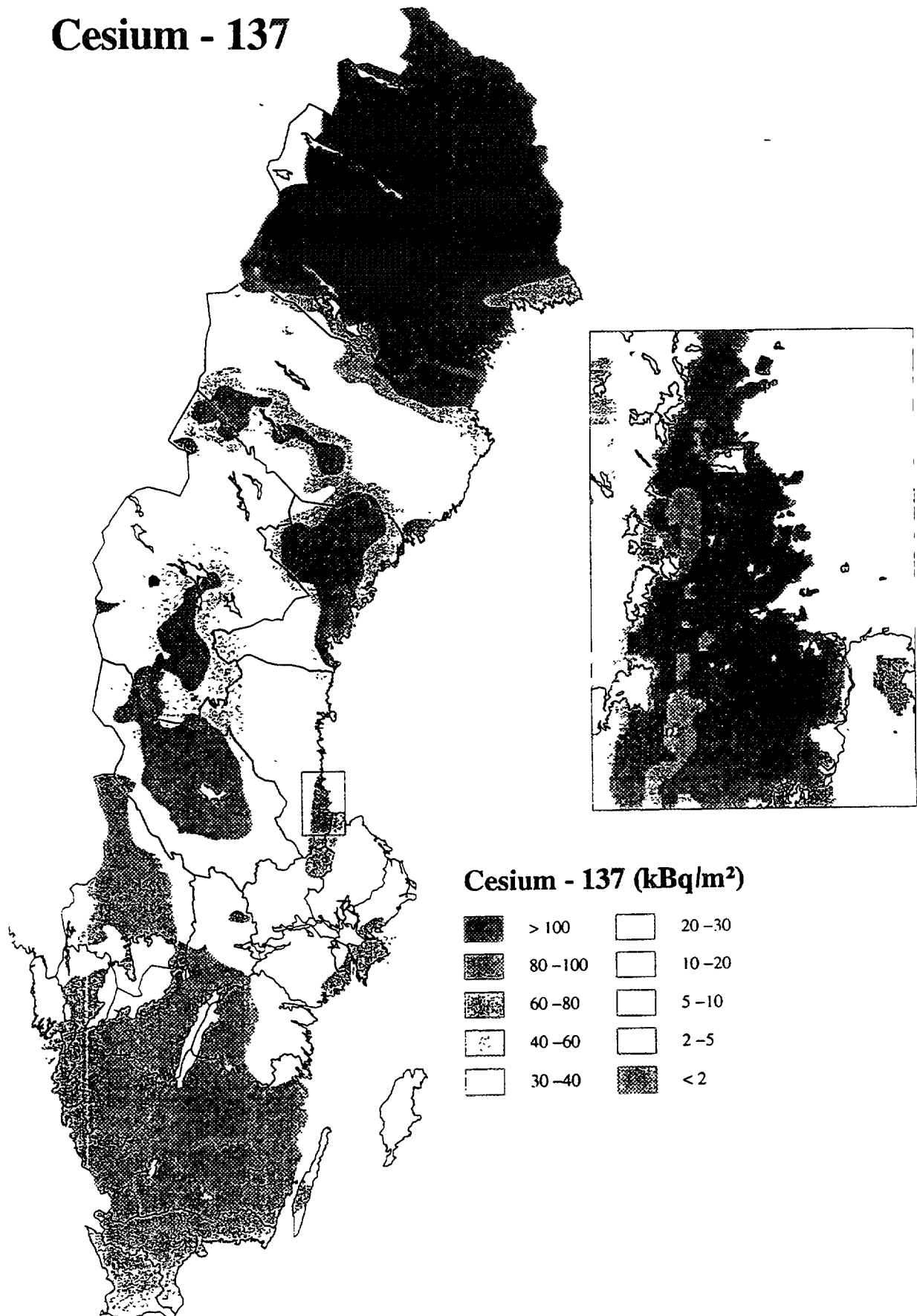


Fig. 1. Corrected ^{137}Cs deposition in 1986 based on aerial measurements, *in situ* gamma spectrometry and other measurements. GIS techniques have been used in the compilation of the map. The high deposition area around the town of Gävle is shown in more detail.

event. However, the nuclide composition varied considerably between different parts of Sweden. Later ^{134}Cs and ^{137}Cs were the dominating contributors to the dose rate. After more than a year they were the only nuclides giving a significant gamma dose contribution.

The results of the *in situ* measurements and the soil sample analyses were used to calculate correction factors for penetration in soil to be applied to the aerial measurements of ^{134}Cs and ^{137}Cs . For the locations where such measurements were made in 1986 - 1989 the average ratio between the deposition density determined by soil sample analysis and by *in situ* measurements increased regularly from 1.6 to 2.4. This increase corresponds quite well to the change with time of the equivalent surface deposition density values observed in the wet deposition area. The ratios have been used as correction factors for estimating the actual deposition density and the equivalent dose rates from the surface equivalent deposition density. The correction factors for calculating equivalent dose rates from the aerial measurements were quite small, they increased from about 1.15 to 1.25 in the same time period.

The *in situ* measurements were also used to calculate the one-year, two-year and fifty-year doses per unit deposition density of ^{134}Cs . The estimates of the dose equivalent rate were made based on results showing an initial depth distribution length of one centimeter and a regular increase to three centimetres after three years. For the following years the depth distribution was assumed to be unchanged according to the results of aerial measurements. It was found that the one-year effective dose equivalent estimates varied with low values in the range 80 to 100 μSv per kBq/m^2 in the wet-deposition area where the caesium isotopes dominate the one-year dose. High values of 200 to 300 μSv per kBq/m^2 in the Stockholm-Gotland and southeast coast areas reflect the fact that shortlived nuclides dominate the first-year dose in this dry deposition area.

A population weighted ^{134}Cs deposition density, i.e. the number of person-Bq per unit area was calculated by combining the population number with the average deposition density in the area. Depending on the area of the administrative units and variability, the averaging was performed over parishes, communes or counties. For the counties along the Gulf of Bothnia, where the deposition density varied strongly and the population is quite unevenly distributed, a demographic data base from Statistic Sweden (SCB) was used. As a rule the averaging in these counties was made over 5 kilometer squares although sometimes it was found necessary to use one kilometer squares.

The shielding effects of dwellings and the time people actually are staying indoors are important modifying factors when estimating the dose received by the population. The average shielding effects in different regions, taking into account house type distribution, occupancy factors and the effect of snow cover were calculated.

2.1. Results from measurements and dose calculations

By combining the population-weighted ^{134}Cs deposition density with the appropriate dose factors and other modifying factors the collective doses for the counties and Sweden as a whole were calculated. It was found that the collective doses over one year, two years, and fifty-years for Sweden were, respectively, about 600, 1000 and 5000 manSv. The counties receiving the highest collective doses were, as expected, in the wet-deposition area. About two thirds of the fifty year collective dose was estimated to be received by the population living in the wet deposition area. It was further estimated that 70 percent of the population received one-year doses less than 0.04 mSv and 95 percent doses less than 0.3 mSv. The highest doses were received on coast areas along the Gulf of Bothnia (Fig. 1). In this region it was estimated that some 250000 persons received one-year doses above 0.5 mSv and about 40000 doses above 1 mSv. The highest one-year doses, about 2 mSv, were received by less than 1000 persons.

2.3. Uncertainties in the dose estimates - on-going studies

The dose and deposition density estimates are primarily based on nuclide-specific measurements of surface equivalent deposition densities. Comparisons between the aerial measurements and the high

resolution measurements indicated that results from the two systems agreed by twenty percent or better in high-deposition areas. Repeated aerial measurements along the same flight paths show that the reproducibility is within a few percent for averages over one kilometer or more. The total error in equivalent surface deposition density of the caesium isotopes is estimated to be better than ten percent for such averages. In areas with low deposition densities the aerial measurements give lower estimates than the *in situ* measurements by a factor 2-3. In such areas the *in situ* measurements were used for calibrating the aerial measurements. In general these aerial measurements will, however, have a far larger uncertainty than the *in situ* measurements in the wet-deposition area.

The conversion from equivalent surface deposition density to open-air effective dose equivalent rate, which is determined by the dose conversion factors of the relevant nuclides and the nuclide composition as determined by the *in situ* measurement, does not introduce any appreciable errors. The conversion from area-averaged to population-averaged deposition density and shielding correction is quite straightforward and does not introduce any appreciable errors. The correction for depth distribution may introduce a systematic error of perhaps ten percent. The conversion from effective dose equivalent rate to first-year and two-year dose equivalent is straight-forward. The fifty-year dose estimate depends on assumptions regarding the future behaviour of ^{137}Cs . The assumption used is that the depth distribution will not change after the first three years. This should give an over-estimate of the fifty-year dose. The results from the aerial measurements indicate that the movement of the ^{137}Cs in the soil profile is quite small after a few years so there is no indications that this over-estimate should be important.

In urban areas, where many dwellings are surrounded by "hard surfaces", the dose-rate both indoors and outdoors may be significantly affected by weathering [7], including effects as wash-off, resuspension, road sweeping and migration. Quantification of this effect will be the aim of a recently launched urban radioecology study at the Swedish Radiation Protection Institute (SSI). A new system developed at SSI will be used for detailed measurements in an urban area affected by a significant fallout after the Chernobyl accident. The system [8] consists of a small mobile gammaspectrometer with automatic positioning using DGPS (Differential Global Positioning System). The system can be used carried as a backpack or in cars or helicopters. Preliminary measurements of primary ^{137}Cs photon fluence have been made. A comparison between reference areas, grass areas within the city boundary, and the average along streets and pavements indicates that the average street value is 10-30 % of the average reference value. The effect on individual and collective dose will be investigated in the study.

At present, a subjective estimate is that the county averaged first- and second-year doses have an overall uncertainty of less than 20 percent in the wet-deposition areas and somewhat more, perhaps 30 percent in other parts of Sweden.

3. INTERNAL RADIATION

The estimate of the committed internal dose to the Swedish population from the fallout in Sweden after the Chernobyl accident is based on whole-body measurements and supported by results from measurements of food-stuffs and of human tissues. Since the radiation dose to humans in Sweden is so low that no somatic detriments are expected and the preliminary estimation of the collective dose to the population is so low that no significant changes of the overall risk for detrimental effects late in life can be expected, many studies have been focused on understanding the behaviour of caesium in our environment and the resulting body burden of caesium in man.

The radionuclides giving the main part of the internal radiation dose are ^{134}Cs and ^{137}Cs . During the first weeks after the release, internal contamination of ^{131}I and "hot particles" was observed but the resulting doses were small compared to the doses from radioactive caesium [9],[10]. The inhalation dose was estimated to be in the range 1-20 μSv including the dose from "hot" particles as well as from ^{131}I . The few measurements made on ^{131}I in human thyroid showed maximum concentrations of 1 kBq [11]. The total 50-year collective dose from inhalation has been estimated to 150 manSv [9].

3.1. Some performed studies

Since 1959 a reference group of about 36 persons employed at SSI have regularly been whole-body measured. During the years 1986 and 1987 frequent measurements were performed of this group to study both the short and long time changes of radioactive caesium in the body. Additional staff members at SSI and their children were measured to establish possible differences in dose between adults and children belonging to the same family. The reference group at SSI is presently measured twice every year. Two groups from the high deposition area of Gävle are regularly monitored at the SSI with the aim to follow the changes in body burden over a longer period of time. Farmers with food-stuffs based on domestic production form one of the groups while the other group (non-farmers) living in the same area buy their food-stuffs in shops.

People from forest provinces and Laplanders in mountain areas with a relatively high fallout were studied as they could be expected to have a high intake of caesium [12]. This study was performed by the Radiation Physics Department at the University of Umeå.

In order to better assess the collective dose to the Swedish population from radioactive caesium in food, a random sample of 218 individuals from the whole country was whole-body counted one year after the Chernobyl accident. Half the group returned one year later, in 1988, for a second measurement. To ensure a statistically correct sample with few drop-outs from the measurements, a stratified selection in two steps was performed [13]. During the autumn 1994 a third random sample of 200 persons from the Swedish population was whole-body counted. The selection of these persons was done in the same way as the previous random samples. At the same time, in 1994, a foodbasket study was performed to assess the average intake of ^{137}Cs by the Swedish population. The standardised foodbasket was collected from two grocers in 10 localities, of which the majority came from areas with the highest fallout. Each food basket contained 104 different provisions covering 90 % of the consumption, and was subdivided in common foodstuffs and locally produced foodstuffs [14].

To obtain a better knowledge of the intake of radioactive caesium of people consuming products from the forest, whole-body measurements were performed on hunters and their families living in three different areas of northern Sweden. This study was made by FOA in Umeå in 1994 [15]. During the years 1988 to 1993 the concentration of ^{137}Cs in the population of northern Sweden was also measured on muscle samples from medico-legal autopsies [16].

3.2. Results from measurements and dose calculations

Figure 2 shows the bodyburden of ^{137}Cs expressed as Bq/(kg body weight) in a number of groups measured between 1959 and 1995 [13,17,18]. As can be seen, the variation of the body burden can be as large as two orders of magnitude between different groups. It can further be seen that the weighted average bodyburden for individuals in Sweden (three data points representing the three random samples) follow closely the data for the SSI reference group.

From the foodbasket study [14] the population weighted average intake in 1994 is estimated to be 270 ± 50 Bq/year. From this intake and metabolic data for different population groups [13] the calculated bodyburden would be 1.3 Bq/kg for the average citizen. The measured average bodyburden of the random sample at same time was found to be 2.0 Bq/kg. The difference between estimated and measured bodyburden can be explained by the 10 % of the foodstuffs not included in the food basket. These foods are home produced or forest products such as moose, roe deer, fish, mushrooms and wild berries.

Based on whole-body measurements in 1994, 90 % of the population is estimated to have a bodyburden of less than 5 Bq/kg and 99% of the population less than 10 Bq/kg body weight. Only a limited number of persons are expected to have a body burden exceeding 100 Bq/kg. The average bodyburden of the random sample, 2 Bq/kg, corresponds to a dose rate of 5 $\mu\text{Sv}/\text{year}$. The dose from the measured body burden of ^{134}Cs and ^{137}Cs is calculated using a model described by Leggett [19], which takes into account the body size.

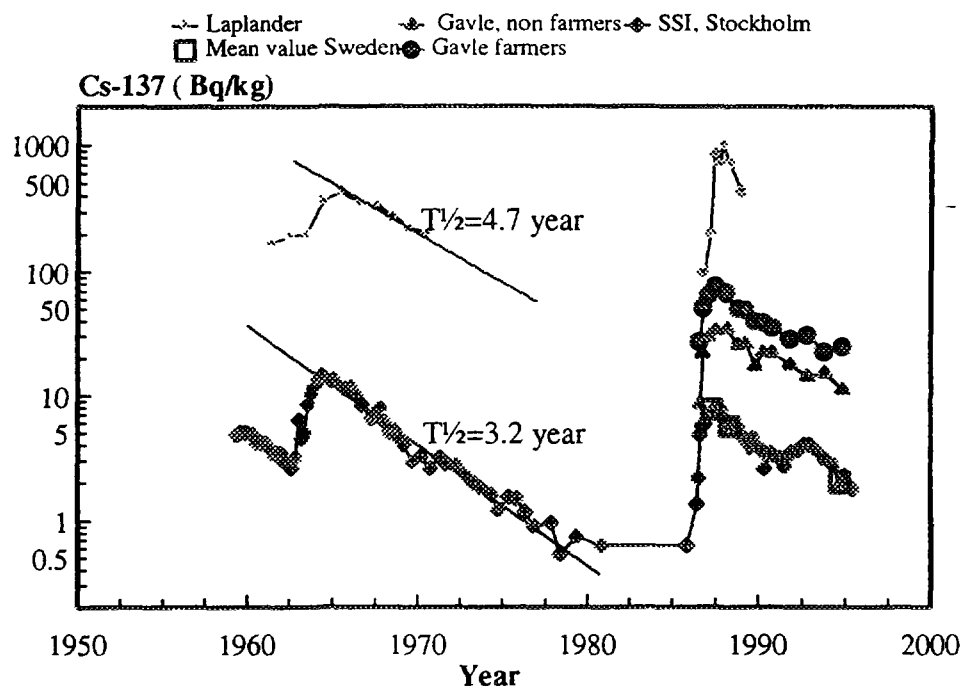


Fig. 2. Measured body burden of ^{137}Cs (Bq/kg body weight) in a number of groups in Sweden between 1959 and 1995. During the period 1965 to 1975, the yearly intake of ^{137}Cs decreased with a half time of 3 - 5 years. The squares show the measured average body burden of the whole population.

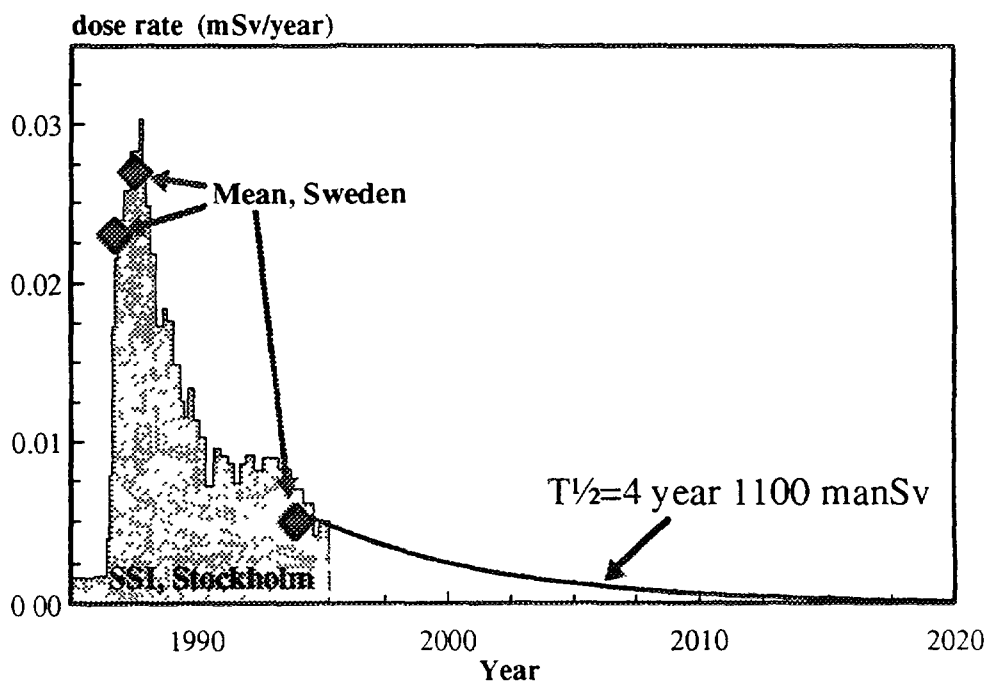


Fig. 3. The committed collective dose estimate of 1100 manSv from caesium in food is based on the measured average body burden of the population, the variation of the body burden in the SSI group and a decrease in intake corresponding to a half time of 4 years.

The prediction of the cumulated committed dose to the Swedish population is based on the observation that the change of bodyburden for an average person during the first nine years has followed the pattern shown by the SSI reference group (Fig. 2). With the assumption that the yearly intake of caesium will decrease with a "half-time" of 4 years (Fig. 3), which is slightly longer than the value, 3.7 years, estimated from the measurements of muscle samples [16] and from the experience after the atmospheric bomb tests during the sixties (Fig. 2), the cumulated committed 50 year dose to the whole Swedish population is estimated to 1100 manSv. Under these assumptions the uncertainty is estimated to ± 200 manSv.

3.3. Dose estimates based on whole-body measurements as compared to concentrations in food

Many measurements have been done of ^{137}Cs concentrations in foodstuffs. In particular, these measurements show that the concentration of caesium in game meat (moose and roe deer) have decreased very little or not at all [20]. Based on this fact, the calculated amount of activity transferred to man from game and freshwater fish was estimated to have an essential influence of the cumulative collective dose. The food consumption data and available data from activity measurements were used to estimate the dose to the Nordic population [21]. The reported internal committed collective dose to the Swedish population was 9000 manSv which is almost nine times higher than the prediction of 1100 manSv calculated above from whole-body measurements. According to earlier experience, use of food consumption data and data on activity concentrations in food could be expected to give a slight overestimation as the use of activity data in foodstuffs often have been found to predict a too high body burden [13].

The results from our whole-body measurements of the random sample of the Swedish population, the study on the sub-population hunters and their families [15], the study on the muscle samples [16], and the results from the food-basket study [14] lead to our conclusion: It is important to use representative food samples for the estimation of intake for a population. In principle, we believe that the best estimate is obtained with well planned whole-body measurements.

4. HEALTH EFFECTS IN SWEDEN

The fallout from the Chernobyl accident caused no acute health effects in Sweden. It is unlikely that any late effects (cancer) will be possible to detect.

The total 50-year collective dose to the Swedish population due to the radioactive fallout from the Chernobyl accident is estimated to be 6000 ± 1000 manSv, mainly caused by external irradiation from radionuclides deposited on the ground and internal irradiation from ingested foodstuffs. With the presently accepted risk factors (ICRP 60) this would lead to about 300 cases of fatal cancer. Even though these cases will appear predominantly in the high deposition areas of Sweden, the increase will be very low ($<0.3\%$ over 50 years) also in the county of Västernorrland which received the highest deposition. For the whole of Sweden the relative increase will be ten times lower.

During the first years after the accident, a number of actions were taken by the Swedish authorities to limit the effects of the fallout. Of particular importance in respect to dose were the restrictions on food: both limits for sale in the shops and diet recommendations to certain groups of people. The restrictions on milk during the first weeks also reduced the dose consequences. It is difficult to estimate the additional collective dose to the Swedish population without restrictions.

There has been a discussion whether the radioactive fallout in Sweden could lead to an observable increased incidence of childhood leukemia. An estimate based on radiation doses and risk factors from the ICRP shows that this is very improbable. In an epidemiological study covering the years 1986-1991 [22] it was concluded that there has been no significant increase in the incidence of acute childhood leukaemia in areas of Sweden contaminated after the Chernobyl accident.

Even though the Chernobyl accident has not caused, and is not likely to cause, any observable somatic health effects in Sweden it has lead to substantial worry and concern especially in areas with a high deposition of radioactive caesium. These effects were particularly evident the first years after the accident. However, in September 1994, around 200000 people in these regions (5 counties) still state that they have some, mostly minor, changes in their diet due to the accident. This can be compared to 350000 in February 1987 (Statistic Sweden, SCB). The figures for the whole of Sweden is about twice as high. It is particularly forest products like meat from moose and roedeer, wild berries and mushrooms that are of concern as well as lake fish. Nine years after the accident, these products can still contain more than 1500 Bq/kg of ^{137}Cs , which is the limit for sale. A more general conclusion is that many people experience that the Chernobyl fallout to some extent has affected their quality of life.

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ASSESSMENT OF RADIATION-INDUCED CANCER RISKS FROM THE CHERNOBYL FALLOUT IN FINLAND



XA9745474

A. SERVOMAA, T. KOMPPA, M. SUOMELA
Finnish Centre for Radiation and Nuclear Safety,
Helsinki, Finland

INTRODUCTION

Application of detailed radiation risk models to populations affected by radiation doses from the Chernobyl fallout allows forecasting and estimation of the consequences of the accident in countries far from the place of the accident, and comparison of the model estimates with epidemiological observations in low-dose conditions among large populations. Both tasks need time-dependent estimates of the radiation doses caused by the fallout, including future doses, and both have also severe problems and statistical limitations. Problems in the forecasting originate from the large uncertainties in the risk estimates, especially in the details and in the basic assumptions included in the models. In a large population, the predictions may show considerable numbers of exposure-induced cancers; the numbers may still remain under the statistically significant levels if they are a small fraction of all cancers in the population. One may ask whether it is too confusing to present such uncertain estimates of non-significant size. On the other hand, similar estimates are implicitly applied and generally used in radiation protection, and, even with the limitations, the model predictions may be the only piece of information available in advance while potential latent cancers are developing among the population during tens of years.

Epidemiological comparisons are possible already for leukaemia because of its short latency, and also for thyroid cancer. Now, ten years after the accident, the minimum latencies of all cancers begin to be over and, as time goes on, all late consequences of the Chernobyl accident can be used to test radiation risk models and estimates. Within the limits of relevant uncertainties, the radiation risk models should be compatible with epidemiological observations. The lack of statistical significance of the observations will then be a problem. In most cases it will be possible to set an upper limit to the risk but not a definite lower limit other than the zero risk level. In the following, some examples of model predictions are given, and a calculated estimate for childhood leukaemia is compared with an epidemiological study.

MATERIAL AND METHODS

In 1986 and 1987, doses from external radiation were determined by measuring the dose rate and the amounts of radionuclides deposited using a germanium gamma spectrometer and a Geiger-Müller tube [1-3]. The estimation of external doses in 1991 and 1994 was based on these measurements and on a survey performed using thermoluminescence dosimeters [4]. The doses for the intermittent years were estimated by interpolation. The estimation of internal doses from ^{134}Cs and ^{137}Cs was based on whole-body counter measurements of groups of children and adult men and women, representing the whole Finnish population. The group measured was chosen using stratified random sampling. The first sampling was done in 1986, and additional samplings later, to ensure that a sufficient number of people was measured annually. The group was measured once a year in 1986-1990 [5-8]. For 1991-1994, internal doses were estimated using measurements on a reference group, and its comparison with the population group in 1990. The effective doses in the future were estimated assuming an exponential decrease with an effective half-life of 5 years for internal doses and 22 years for external doses [9].

The modified relative risk model presented in the BEIR V report [10] includes cancer mortality functions for radiation-induced cancers, separately for leukaemia and breast cancer, cancers

of respiratory and digestive organs and for all other cancers combined. For a single exposure to dose equivalent d , the excess risk at age a is the product $\gamma_0(a)f(d)g(\beta)$, where $\gamma_0(a)$ is the age-specific baseline risk for unexposed population [11]. Function $g(\beta)$ depends on sex, on the age at exposure, and on the time elapsed since exposure. The dose-dependent function $f(d)$ is linear-quadratic for leukaemia, and linear for all other cancers. In our calculations, the dose rate effectiveness factor of $DREF = 2$ was used explicitly for non-leukaemic cancers. The risk of exposure-induced death (REID) and the loss of life expectancy (LLE) were calculated according to Thomas et al. [12]. The individual REID values, as calculated from the estimated annual fallout doses, were summed up to get the REID as the probability of death induced by the cumulative lifetime exposure to the Chernobyl fallout. Similarly, the individual LLE values from the annual doses were summed up for the cumulative loss of life expectancy. Further, the quotient of LLE/REID is the mean loss of life expectancy among people expected to die of radiation-induced cancers [12].

RESULTS

The mean annual effective doses caused by external radiation and by internal radiation from ^{134}Cs and ^{137}Cs for the whole population are 1.0 mSv (0.5 mSv internal and 0.54 mSv external) for the period of 10 years, and 1.7 mSv (0.63 mSv internal and 1.1 mSv external) for the period of 50 years from the Chernobyl accident [9]. The estimated annual effective doses for children and for adult men and women are presented in Fig. 1. If the internal doses from other radionuclides are added, the 50 years' dose is rounded up to 1.8 mSv. The radiocaesium isotopes give the same numerical value in about 70–80 years.

To illustrate the method of calculation, the REID of a single exposure, as a function of the age at exposure, is presented in Fig. 2. Assuming that the effective half-lives of the external and internal doses remain constant after 1994, the REID of the cumulative exposure, as a function of the time of birth, is presented in Fig. 3. Data included in Figs. 1 and 2 were used in the calculation. Taking the age distributions of the Finnish population (see Fig. 4) into account, the estimated number of fatal cancers induced by the Chernobyl fallout in Finland is about 240 cases for males and 220 cases for females (see Table I). The years of birth used in the calculation ranged from 1900 to 2080. The estimated number of exposure-induced fatal cancers, as a function of the time of birth, is presented in Fig. 5. The area under the curve is the expected number of exposure-induced deaths in the Finnish population, for any year of birth, and including all years and ages of death. As indicated in the figure, about 180 cases are expected for males and 150 cases for females born in 1986 or earlier, and about 60 cases are expected for males and 70 cases for females born after 1986.

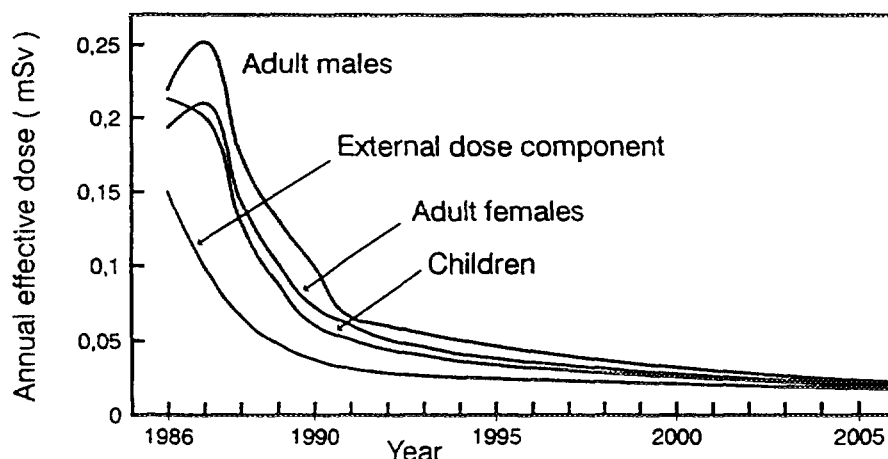


Fig. 1. Estimated annual effective doses from the Chernobyl fallout in Finland [9].

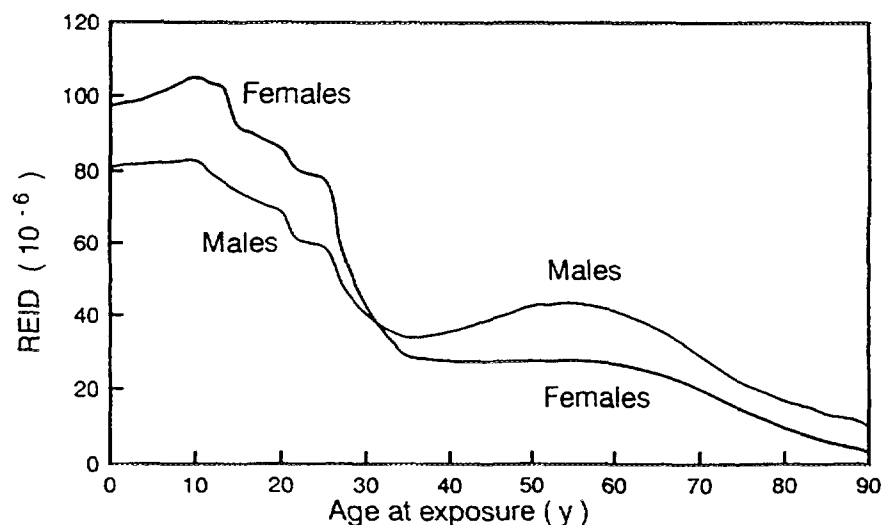


Fig. 2. REID, calculated as the probability of death from cancer induced by a single exposure to a uniform dose of 1 mSv, presented as a function of the age at exposure.

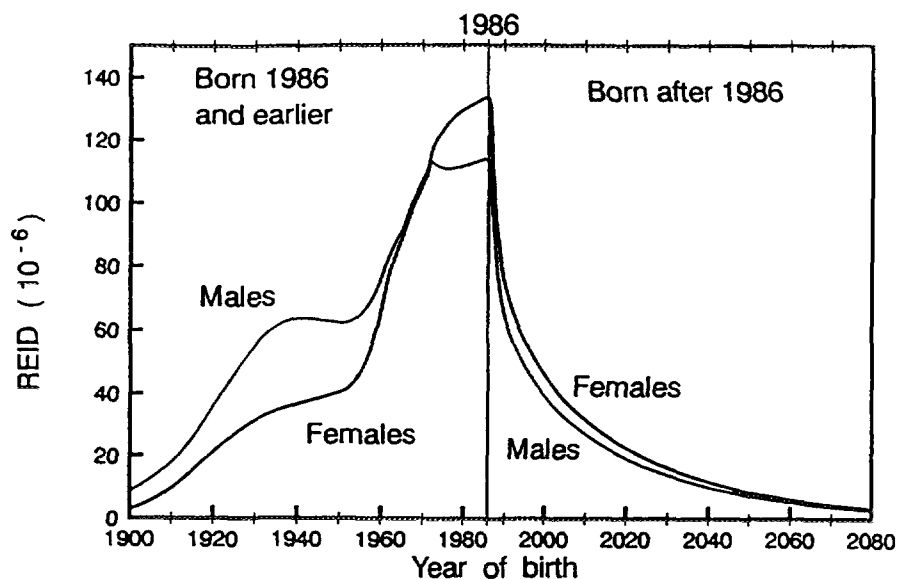


Fig. 3. REID, calculated as the probability of death from cancer induced by cumulative exposure to the Chernobyl fallout in Finland, presented as a function of the time of birth.

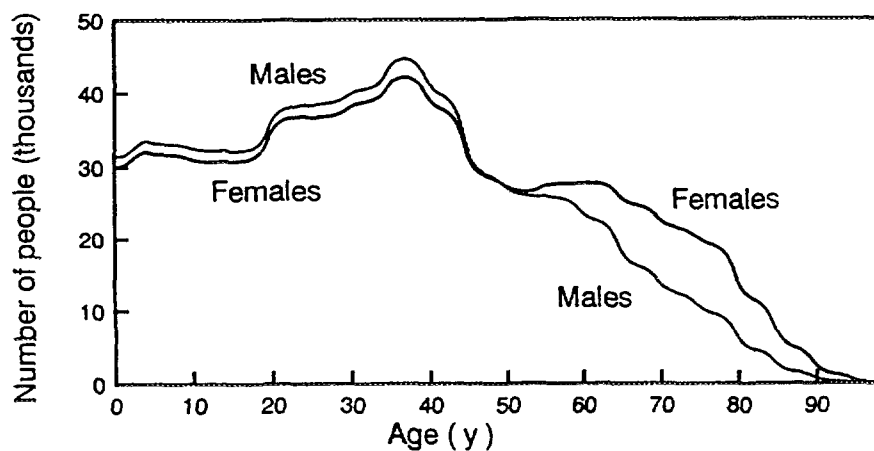


Fig. 4. Age distributions of the male and female populations in Finland in 1986–1989 [11].

Table I Expected consequences of the Chernobyl fallout in Finland: the estimated number of exposure-induced cancer deaths, and the mean loss of life expectancy per exposure-induced death (LLE/EID), for classified cancer groups.

Cancer group	Number of exposure-induced deaths		Mean LLE/EID (years)	
	Males	Females	Males	Females
Leukaemia	41	29	19	19
Respiratory cancer	58	19	11	13
Digestive cancer	55	96	10	10
Breast cancer		11		24
Other cancers	81	61	10	12
Total (rounded)	240	220	12	13

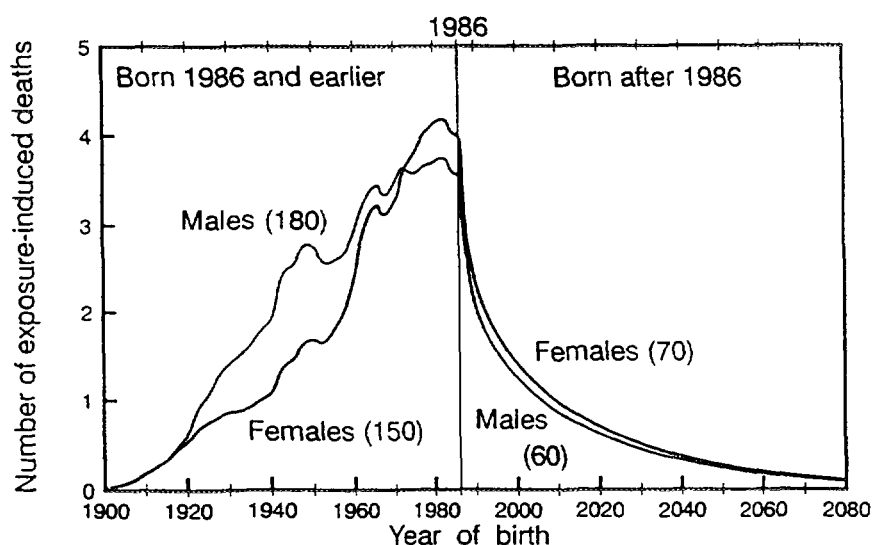


Fig. 5. Estimated number of deaths from cancer induced by the Chernobyl fallout in Finland, as a function of the time of birth.

Figures 6 and 7 show more detailed REID curves for the groups of cancers classified according to the BEIR V report [10], separately for males and females. Curves of the loss of life expectancy (LLE) are not shown because their shapes seem to be very similar to the REID curves. The difference between LLE and REID can be seen indirectly in the curves showing the ratio, LLE/REID in Fig. 8. Figures 9 and 10 show the detailed LLE/REID curves for the classified cancers. Most LLE/REID curves are practically constant for people who were children or young adults in 1986 and for people who are born later. LLE/REID, the mean loss of life expectancy in case of exposure-induced cancer death, has a typical value for each classified cancer group, determined by the risk model and the cancer mortality statistics. The values are lower for elderly people who have, on average, less lifetime to be lost after the years of latency and cancer progress. The leukaemia curve differs clearly from the other curves because of the short latency and prominent steps in the age-dependence of the relative risk in the leukaemia model. A numerical summary of the expected consequences of the Chernobyl fallout in Finland is presented in Table I. The collective loss of life expectancy among the Finnish population is about 2700 years for males and 2800 years for females.

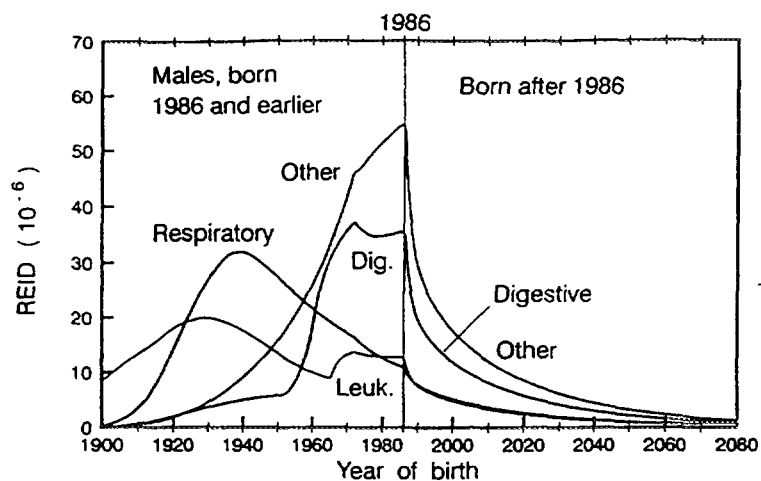


Fig. 6. REID in classified cancer groups among Finnish males. Otherwise, see Fig. 3 caption

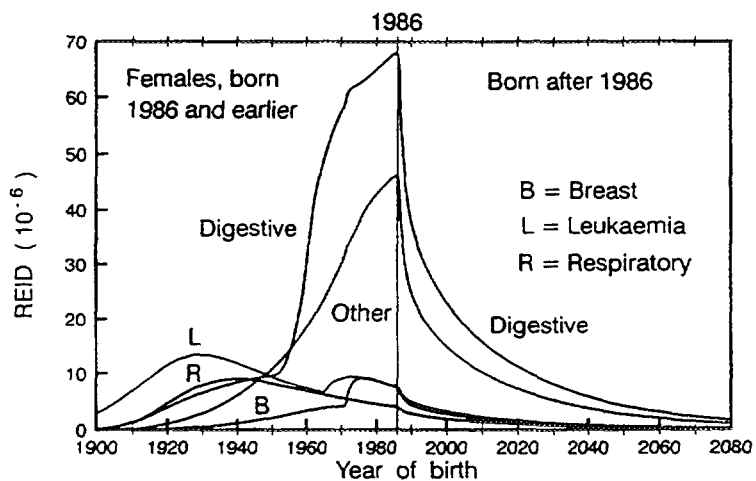


Fig. 7. REID in classified cancer groups among Finnish females. Otherwise, see Fig. 3 caption

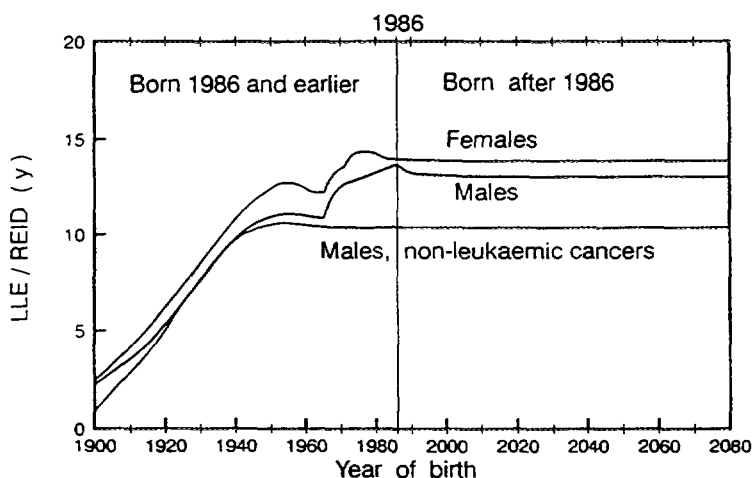


Fig. 8. LLE/REID, the mean loss of life expectancy among people who die from cancer induced by the Chernobyl fallout in Finland, presented as a function of the time of birth.

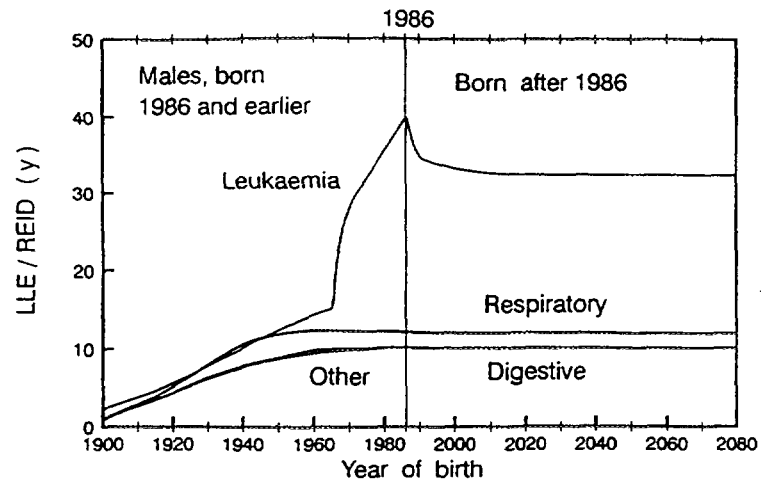


Fig. 9. LLE/REID in classified cancer groups among Finnish males. Otherwise, see Fig. 8 caption.

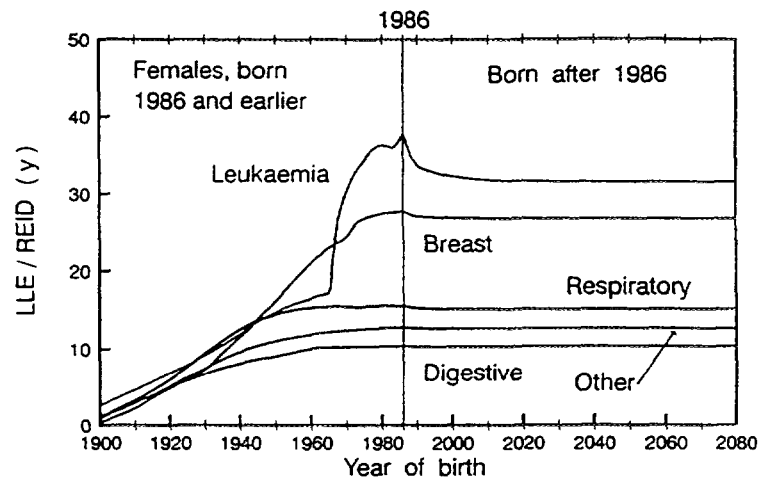


Fig. 10. LLE/REID in classified cancer groups among Finnish females. Otherwise, see Fig. 8 caption.

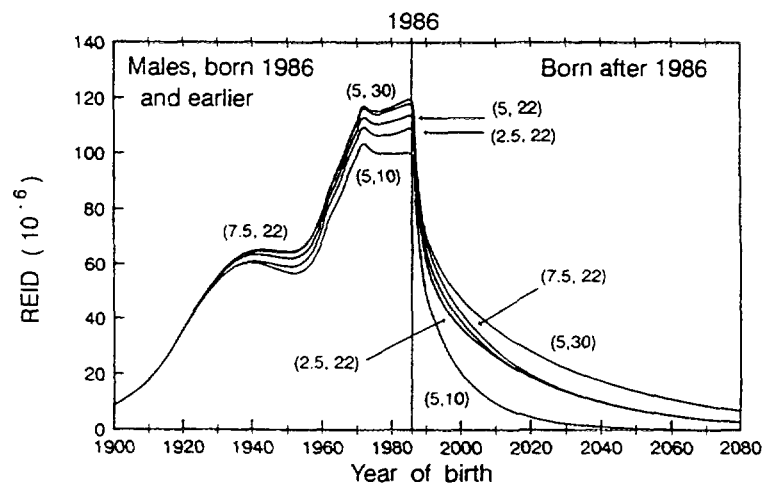


Fig. 11. Effects of effective half-life variations on the total REID among Finnish males. The numbers in parentheses indicate the internal and external half-life (in years) used in the calculation. The median curve (5, 22) is the same as shown in Fig. 3.

As an arbitrary example of uncertainties, Fig 11 shows some effects that variations in the effective half-life have on the total REID. Compared with the median curve, the internal effective half-life estimate has been changed by $\pm 50\%$ or the external effective half-life to 30 years or to 10 years in the other curves. The measured or interpolated dose values from 1986–1994 were not changed in the example, and that is why the changes do not have more effect on the REID values and on the number of fatal cancers. A change of 50% in the external half-life has an effect of about 15% on the number of fatal cancers; for a change of 50% in the internal effective half-life the effect is less than 4%.

DISCUSSION

The Finnish population totals about 5 million, the proportion of females is 51.5%. According to the ICRP 1990 [13] risk factor of 0.05 Sv^{-1} , the total number of radiation-induced fatal cancers caused by the Chernobyl fallout in Finland is about 450, as estimated from the cumulative effective dose of 1.8 mSv over a period of 50 years, including also the internal doses from ^{90}Sr and ^{131}I [9]. Our calculation for an extended period, without the internal doses from strontium and iodine, gives about 450–460 cases, depending on the actual period of time used in the calculation and on the rounding of the numbers of males and females. Thus, for the Finnish population, the ICRP risk factor applied to the cumulative effective dose, and the BEIR V model with DREF=2 give about the same total number of radiation-induced fatal cancers. The risk is the highest for people who were young or children at the time of the accident, or were born soon after it. The collective loss of life expectancy among the whole population is about 5500 years.

All annual doses and the cumulative effective dose are very low, thus allowing the use of the value of DREF=2 and the direct addition of the individual REID and LLE values calculated from the annual exposures. In Finland, the cumulative fallout dose over a period of 50 years (1.8 mSv) is comparable with the mean annual dose from natural radiation (about 3 mSv), and with the mean annual effective dose caused by the medical use of radiation (about 1 mSv). Thus, the risk to an individual seems to be very low. However, a low probability of death of an order of 10^{-4} applied to millions of people gives hundreds of deaths. In this case, one may think that the collective consequences arise from the high number of people exposed to radiation, rather than from the amount of radiation the people are exposed to. On the other hand, there are many substantial sources of uncertainty in the radiation risk estimates [10,12,13]. According to the BEIR V report (page 181), the range of uncertainty in the risk estimates should extend down to zero risk at low doses in the millisievert range because the possibility cannot be ruled out that there may be no risks from exposures to such low doses.

The mean annual number of all cancer deaths in Finland is about 10000, with a standard deviation of about 100 and a rising long-term trend of about 100 per year. Because the exposure-induced cases will be distributed over tens of years, it does not seem possible to show the effect statistically in the scale of the Finnish population, provided that the present risk estimates represent the correct order of magnitude. Curves like those shown in Figs 2,3,5–7 may help in identifying groups suspected of having such effects. If any statistically significant effects can be linked reliably to the fallout exposure, they will lead to re-evaluation of radiation risk models and estimates.

In an epidemiological study on childhood leukaemia in Finland [14], no statistically significant effect on incidence of childhood leukaemia was detected during 1989–1992. The study yielded a point estimate of 1.3 cases per year, which is not significantly different from zero, and has an upper 95% confidence limit of eight extra cases per year. Calculations corresponding to Figs 6 and 7 give a total of nine fatal leukaemia cases for children who were less than 15 years old during the period 1989–1992. According to the BEIR V model, the leukaemia deaths are evenly distributed over a period of about 15 years. Thus the expected average is about 0.6 cases per year which is well within the confidence limits of the epidemiological estimate.

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DOSES TO DIFFERENT GROUPS OF THE POPULATION IN TURKEY AFTER THE CHERNOBYL ACCIDENT

E. BIROL, G. BUYAN, H. ALKAN, C. GÜVEN, I.H. ARIKAN,
F. K. ERTÜRK, B. ONAT
Turkish Atomic Energy Authority,
Ankara, Turkey



1. INTRODUCTION

The Chernobyl nuclear accident took place on Saturday 26 April 1986. Within the period of ten days, rather large quantities of radioactive material were released into the atmosphere and this matter were distributed via atmosphere over a large area. The first radioactive clouds reached Turkey about a week later. An extensive survey programme was started immediately after the detection of a considerable increase in the external gamma radiation level above the natural background. Significant activity concentrations of I-131 detected in milk in the first days of May were explained by the intensities of the precipitation during the passage of the contaminated air masses. Also measurements showed that radiocaesium activity of the surface air was considerably high. In the following weeks and months, an extensive measurement programme on foodstuffs was initiated. The radionuclide Cs-137 was used to characterize the observed nuclide spectrum because of both its dominant dose contributions and its physical half-life. Doses of radioactivity to the Turkish population resulting from the intake of radiocaesium in food were estimated. The estimated average effective dose equivalent was found to be 0.32 mSv due to ingestion for the first year after the accident.

2. MATERIAL and METHOD

Airborne radionuclides reached the ground and vegetation mainly by way of precipitation. Regional differences in amounts of maximum deposits can be explained by the date at which precipitation occurred. Therefore, although, high fall-out level was found in some areas in Thrace and Eastern Black Sea region, it was negligible in the most parts of the country.

Over 40000 measurements on foodstuffs were performed by the two laboratories of the Turkish Atomic Energy Authority (TAEA) located in Ankara and Istanbul. In addition measurements on hazelnut were carried out by a local laboratory, particularly appointed for this task in Black Sea region. All laboratories were equipped with the same set of instruments such as Canberra series 10, 10 plus, S35 connected with NaI(Tl) and HpGe detectors. Calibrations were performed by the Çekmece Nuclear Research and Training Center in Istanbul. In addition, during the investigation of the development of radiation exposure after the period of activity depositions due to the Chernobyl accident, for the following 6 years, whole body counting activity concentrations for caesium via ingestion of contaminated foodstuffs were used to estimate average individual effective doses.

The instrument used for the whole body measurements was the FASTSCAN utilizing 2x4"x4"x16" NaI detector with a multichannel analyzer (Canberra S35). The person to be monitored was placed facing the detector tower, hands at sides and back resting in the grained area on the back wall. Integration time was one minute. The whole body counting programme was performed on some 10000 individuals during spring of 1987 through 1993 [1].

The average annual consumption and production data of the most important food products was taken from the Report of the Committee for Investigation the Consequences of Chernobyl Accident [2]. In view of limited resources available, it was necessary to limit the measurements to a few of the most important food products. The following five were included: 1) Milk and dairy products, 2) Fruit and vegetable, 3) Meat and fish, 4) Food made of flour, especially bread, 5) Tea.

Annual consumption rates and average concentrations for the foodstuffs are shown in Table I.

TABLE-I. Annual Consumption Rates and Average Concentration of Foods in 1986

Food	Consumption (Kg/Year)		Average Concentration (Bq/Kg) -	
	Infants	Adults	Cs-134	Cs-137
Milk and Dairy Products	200	125	11	21
Fruits and Vegetables	15	250	5	9.5
Meat and Fish	3	40	9	17
Food made of floor	5	200	2	4
Tea	-	2	3700	7500

**TABLE-II. Average Individual Effective Dose Equivalents
Committed from the First Year (May 86-April 87) after Chernobyl Nuclear Accident
(mSv)**

Pathways		Critical Group		Members of Public	
		Infants	Adults	Infants	Adults
EXTERNAL	Cloud Radiation	0.0026	0.0026	0.0004	0.0004
	Ground Radiation	0.0180	0.0180	0.0027	0.0027
INTERNAL	Inhalation	0.0508	0.0523	0.0072	0.0075
	Ingestion	0.0949	0.3173	0.0949	0.3173
	<i>Milk & Dairy products</i>	<i>0.0903</i>	<i>0.0538</i>	<i>0.0903</i>	<i>0.0538</i>
	<i>Fruit & Vegetables</i>	<i>0.0031</i>	<i>0.0487</i>	<i>0.0031</i>	<i>0.0487</i>
	<i>Meat & Fish</i>	<i>0.0011</i>	<i>0.0139</i>	<i>0.0011</i>	<i>0.0139</i>
	<i>Food made of flour</i>	<i>0.0004</i>	<i>0.0164</i>	<i>0.0004</i>	<i>0.0164</i>
	<i>Tea</i>	-	<i>0.1845</i>	-	<i>0.1845</i>
Total Dose		0.17	0.39	0.10	0.33

**TABLE-III. Average Individual Effective Doses to the Members of Public
From Ingestion of Contaminated Foods 1-7 Years after Chernobyl Nuclear Accident**

Time	Dose (mSv)
1 st year (May 86-April 87)	0.3173
2 nd year (May 87-April 88)	0.0201
3 rd year (May 88-April 89)	0.0136
4 th year (May 89-April 90)	0.0041
5 th year (May 90-April 91)	0.0021
6 th year (May 91-April 92)	0.0018
7 th year (May 92-April 93)	0.0017

TABLE-IV. Average Individual Effective Dose Equivalents Committed for 10 years

	Doses (mSv/10 year)	
	Infants	Adults
Members of Public	0.10	0.37
Critical Group	0.17	0.43

3. RESULT and DISCUSSION

Average activity concentrations presented for both Cs-134 and Cs-137 are believed to be representative for the traded part of those foodstuffs included. As illustrated, the highest activity concentrations were found in tea. In fact, values several times of the highest activity registered in this paper were encountered during measurements, however, due to the introduction of action limits of activity concentration in tea by the Turkish Radiological Safety Committee, 12000 Bq per kg was adopted as the upper value for caesium in tea [2].

Tea forms an important part of the diet of most of the Turkish population. Taking into account that habit of drinking at least several glasses of tea on average everyday is very common throughout the country, it is apparent that the main source of radiocaesium contributing to doses during the first year after the accident was tea. The contribution from food items is shown in Table-II. As it is seen, contribution to the average individual effective dose equivalent mainly comes from tea which is both a significant part of the dietary habits and had been the most affected agricultural product by the fall-out. Although the second vulnerable item was hazelnut by the accident, taking into account its very little consumption (100 g per year), contribution of hazelnut to doses is neglected. Some 3000 Bq per kg for caesium in hazelnut was measured [2]. Activity measurements were performed, regardless local differences in dietary habits, on some foodstuffs considering which were significant parts of the diet of an average Turkish consumer. Therefore, radiation dose due to intake of contaminated foodstuffs appeared to be the same for both selected critical groups and the members of the public. An additional radiation dose due to external exposure and inhalation were resulted in an effective annual dose of 0.01 mSv for population groups who lived in some more severely impacted areas of Thrace and Eastern Black Sea region. When calculating the infant radiation exposure due to the caesium isotope, activity uptake via tea was left out taking into consideration that drinking tea does not form a part of the diet of the infant. Average individual effective doses to the members of the public via ingestion of contaminated food items for following seven years after the Chernobyl accident and average individual effective dose equivalent committed for 10 years are shown in Table-III and Table- IV, respectively.

The average effective dose equivalent from external fall-out radiation during the first year has been estimated to 0.003 mSv. The effective dose equivalent from foodstuffs in the first year thereby about 100 times the average from external fall-out radiation. Therefore it is apparently seen that ingestion dose forms the most important fraction of effective dose equivalent whereas external fall-out radiation is negligible comparing to ingestion doses to the population groups in Turkey.

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CHILDHOOD LEUKAEMIA, NON-HODGKIN LYMPHOMA AND HODGKIN DISEASES IN EASTERN ROMANIA BETWEEN 1980 AND 1994

D. DAVIDESCU, C. DIACONESCU, O. IACOB, R. ONETE, R. TULBURE
Institute of Hygiene,
Iasi, Romania



XA9745476

1 INTRODUCTION

The greatest power plant accident released into the environment large quantities of radioactive materials and consequently human exposure raised in surrounding territories

Romania, by his geographical position was amongst the most unfortunate countries and his Eastern territory was the most exposed [1]

We wanted to find out if some childhood malignant disorders as leukaemia, lymphoma and Hodgkin disease incidence were influenced by the exposure levels

2 SUBJECTS AND METHODS

2.1. Population and incidence data

The incidence of leukaemia, non Hodgkin lymphoma (NHL) and Hodgkin disease (HD) in children aged between 0-14 years, from 8 districts (Suceava - SV, Botosani - BT, Neamt - NT, Iasi - IS, Vaslui - VS, Bacau - BC, Galati - GL, Vrancea - VN) in Eastern Romania (1 320 153 people) was followed between 1980-1994

Annual data on childhood population in each district, by age, sex and residence area (urban, rural) was obtained from Districtual Offices of Population Censuses

Every district has an oncology department where these cases must be recorded

Completeness of registration was checked by comparing with medical files obtained from each districtual paediatric clinics and from University Hospital of Iasi were nearly all oncopaediatric cases were treated. For the children treated only in Bucuresti hospitals the data were obtained from Institute of Hygiene, Public Health, Health Services and Management Bucuresti

Overall, 847 new cases were diagnosed in this period. 60.1% (509) of the cases in the study, were defined as leukaemia, 23.6% (200) as non Hodgkin lymphoma, and 16.3% (138) as Hodgkin disease

The diagnoses were based on clinical examination, histology of bone marrow, lymph nodes or tumours, haematology (the total white blood cell count and blood smears) and other laboratory tests (radiological and echography exams)

For nineteen patients (11 leukaemia, 2 NHD and 6 HD) the medical recording didn't specify the age or the birth place. We have included these cases confirmed in Teaching Centre of Iasi only in the final analyses and not in that on age group

2.2. Dose assessment

The radiation exposure of children during the first 3 years following the Chernobyl accident (May 1986 - April 1989) was expressed in terms of effective dose, the dosemetric quantity recommended by ICRP in Publication 60 [2]

The effective doses resulted from internal radiation by ingestion of contaminated food were estimated from the radioactive content of foodstuffs (134 - Cs, 137 - Cs determined by high-resolution gamma spectrometric techniques and 90 - Sr by a sensitive radiochemical methods). The average annual food consumption [3] and the corresponding ICRP dose factors [4, 5]

The effective doses from gamma external radiation due to radiocaesium deposit in soil of Chernobyl origin were calculated from the population weighted mean activity concentrations of 134 - Cs and 137 - Cs in soil, determined by gamma spectrometrical measurements. The methods of food sampling measurement and dose calculations have been described previously [6]

According to our dose estimated, summarised in table I the district were classified in four exposure levels illustrated in fig. 1

TABLE I - The radiation doses in the first three years after the nuclear accident for the 0 - 14 years-old children

Exposure levels	Mean effective dose (mSv)		
	Internal	External	Total
1	0.30	0.26	0.56
2	0.56	0.49	1.05
3	0.93	0.80	1.73
4	1.26	1.08	2.34
Whole territory*	0.67	0.57	1.24

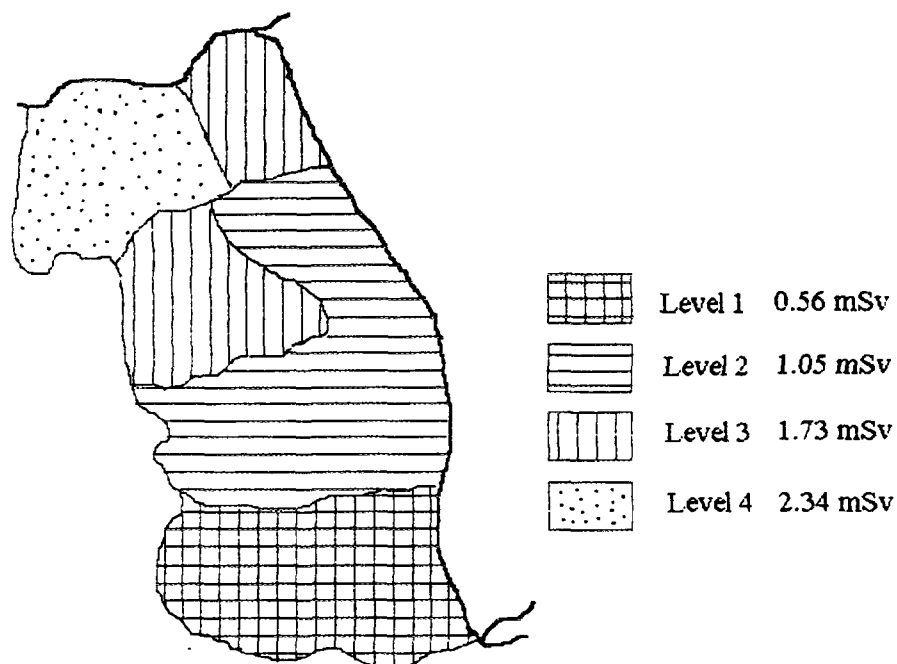


Fig 1 - Geographical distribution of exposure (mean 3 years effective dose per capita) in Eastern Romania

271 406 children (20.57 %) were exposed at the minimum exposure dose; the most people (573 803 children - 43.49 %) lived in areas with an exposure of 1.05 mSv and only 189 731 children (14.38 %) received the highest dose of 2.34 mSv.

2.3. Analysis

The observation period was divided in three parts: the first one 1980-85 prior the accident was considered as control. The cases found between 1986-88 (the second period) and 1989-94 (the third period) were compared with those diagnosed in the first period.

The expected number of cases was calculated for each district on the basis of incidence by sex and age group (0-4, 5-9, 10-14 years) in whole Eastern territory in the 1980-85 period and the size of the population in each age and sex stratum.

Standardised incidence ratio (SIR) was calculated as ratio of observed to expected number of cases x 100.

For the 1989-94 period using as control the same area, the excess risk (ER) and excess relative risk (ERR) were correlated with dose levels as shown in fig. 2 and 3 [7].

3. RESULTS

3.1. Leukaemia

The SIR for leukaemia in the whole Eastern territory was 63 (95% CI=52-74) for the first 3 years after the accident and soar to 106 for the next six years (95% CI=91-122) as shown in table II.

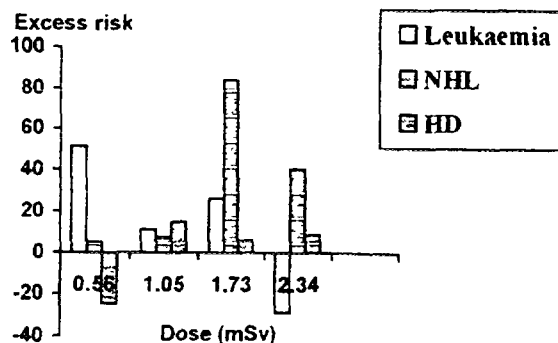


Fig 2 - Excess risk of leukaemia, NHL and HD

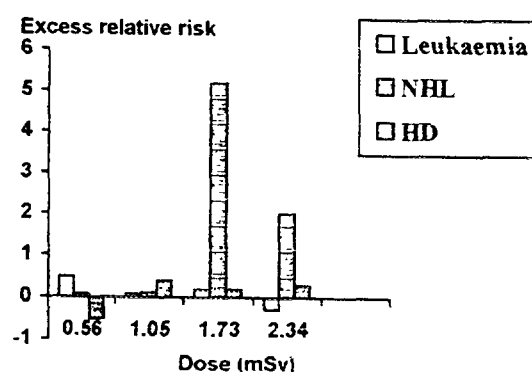


Fig 3 - Excess relative risk of leukaemia, NHL and HD

TABLE II - Childhood leukaemia by district and period

District	Period	No. of cases			SIR	
		O	E		95 % CI	
			A	B	A	B
SV	1980-85	31	27.05	28.57	115 (74-155)	109 (70-147)
	1986-88	18	25.85	27.19	70(37-102)	66(36-97)
	1989-94	23	24.53	25.98	94(55-132)	89(52-125)
BT	1980-85	18	19.18	20.31	94(50-137)	89(48-130)
	1986-88	11	17.36	18.28	63(26-101)	60(25-96)
	1989-94	14	15.66	16.63	153(92-215)	144(87-202)
NT	1980-85	25	22.79	24.10	110(67-153)	104(63-144)
	1986-88	17	21.37	22.46	80(42-117)	76(40-112)
	1989-94	19	19.50	20.71	97(54-141)	92(50-133)
IS	1980-85	32	33.19	35.01	96(63-130)	91(60-123)
	1986-88	19	32.36	33.89	59(32-85)	56(31-81)
	1989-94	30	29.53	31.31	102(65-138)	96(62-130)
VS	1980-85	17	19.85	21.04	86(45-126)	81(42-119)
	1986-88	17	19.43	20.30	87(46-129)	84(44-124)
	1989-94	20	17.20	18.18	116(65-167)	110(62-158)
BC	1980-85	38	29.43	31.27	129(88-170)	122(83-160)
	1986-88	16	27.87	29.27	50(24-77)	55(28-81)
	1989-94	32	25.36	26.93	126(82-170)	119(78-160)
GL	1980-85	24	24.86	26.21	97(58-135)	92(55-128)
	1986-88	12	23.33	24.59	51(22-81)	49(21-76)
	1989-94	22	21.50	22.88	102(60-145)	96(56-136)
VN	1980-85	6	14.65	15.51	41(8-74)	39(8-70)
	1986-88	10	13.96	14.43	72(27-116)	69(26-112)
	1989-94	17	12.56	13.30	135(71-200)	128(67-189)
TOTAL	1980-85	191	191	202	100	100
	1986-88	120	181.52	190.79	65(53-77)	63(52-74)
	1989-94	187	165.83	175.92	113(97-129)	106(91-122)

A - on the basis of 191 cases, B - on the basis of all cases (202)

Between 1989 and 1994, an excess of leukaemia cases appeared at ages 0-4 years (SIR=169; 95 % CI=133 - 205). Most of the cases were diagnosed in Botosani district (15 observed v. 4.63 expected; $p < 0.01$) as shown in table III.

Acute lymphocytic leukaemia accounted for 75.6% (385 cases) of all leukaemia and there were 3 cases of chronic lymphocytic leukaemia (2 before the accident and 1 in 1994 in BT district that has the third level of exposure).

TABLE III - Observed (O) and expected (E) number of cases of childhood leukaemia by age groups

District	Period	Age 0 - 4 y.		Age 5 - 9 y.		Age 10 - 14 y.	
		No. of cases		No. of cases		No. of cases	
		O	E	O	E	O	E
SV	1980-85	11	8.39	9	11.39	11	7.26
	1986-88	6	7.81	9	11.18	3	6.86
	1989-94	10	7.58	8	10.21	5	6.74
BT	1980-85	6	5.93	4	7.99	8	5.27
	1986-88	1	5.26	3	7.46	7	4.64
	1989-94	15	4.63**	6	6.52	3	4.51
NT	1980-85	6	7.01	11	9.56	8	6.22
	1986-88	5	6.24	5	9.38	7	5.75
	1989-94	7	5.79	8	8.11	4	5.60
IS	1980-85	8	10.65	12	13.90	12	8.65
	1986-88	8	9.65	8	14.37	3	8.34
	1989-94	11	8.85	10	12.34	9	8.34
VS	1980-85	5	6.07	9	8.26	3	5.52
	1986-88	6	5.91	7	8.65	4	4.87
	1989-94	8	5.15	8	7.28	4	4.77
BC	1980-85	14	9.05	19	12.09	5	8.30
	1986-88	4	8.55	6	12.08	4	7.24
	1989-94	14	7.69	9	10.49	9	7.19
GL	1980-85	6	7.48	15	10.67	3	6.72
	1986-88	4	6.68	7	10.17	1	6.47
	1989-94	12	6.31	4	8.90	6	6.30
VN	1980-85	3	4.43	1	6.15	2	4.07
	1986-88	3	4.08	5	5.88	2	4.01
	1989-94	7	3.84	5	5.23	5	3.49
SIR 95%CI	1980-85	100		100		100	
	1986-88	68(46-90)		63(46-81)		64(42-87)	
	1989-94	169(133-205)		84(62-106)		96(68-124)	

**p<0.01

3.2. NHL and HD

The NHL was also significantly increased (table IV) in the whole territory investigated (SIR=160; 95 % CI=127 - 192) especially in Neamt district (16 observed v. 6.84 expected cases) and Iasi (18 observed v. 10.33 expected cases). This increase (table V) was more pronounced in 0-4 y. age group (SIR=165; 95 % CI=108 - 222) as well as in 5 - 9 y. age group (SIR=158; 95 % CI=105 - 210). As table IV data shows we didn't find a significant increase of HD cases after Chernobyl accident.

In the following tables (VI, VII, VIII) using the same indicators, we analysed the quality of the informations available for each malignant disease investigated. So, the highest percentage of "unspecified" leukaemia cases was found during 1986-88 (3.3 - 11.1) and dropped in the following years to 0.9 (table VI). The histologic examination which were more frequently performed before the accident, had a minimum usage during 1986-88 and slowly increased in the last period. Remarkably, in 3 districts (BC, GL, VN) the use of histology significantly improved the quality of diagnosis after 1989. Histology was used for NHL cases (table VII) in higher percentage before the accident than in the next years (83.6 v. 77.4), too.

Unexpected, most of the HD cases with histology exams (table VIII) were found in the second follow-up period (1986-88).

A remarkable aspect is the continuous diminishing number of cases diagnosed only at death during 1980-94, excepting leukaemia cases which reached a peak just after the accident.

Most of the cases of these diseases (over 90 %) were diagnosed in teaching centres.

TABLE IV - NHL and HD observed (O) and expected (E) number of cases by district and period

District	Period	NHL No. of cases			HD No. of cases		
		O	E		O	E	
			A	B		A	B
SV	1980-85	4	9.50	9.76	6	7.24	8.34
	1986-88	4	9.04	9.29	2	7.19	7.94
	1989-94	11	8.61	8.87	7	6.81	7.59
BT	1980-85	3	6.73	6.94	6	5.32	5.93
	1986-88	5	6.08	6.25	1	4.83	5.34
	1989-94	10	5.49	5.68	3	4.37	4.86
NT	1980-85	2	7.99	8.23	4	6.33	7.04
	1986-88	4	7.46	7.67	7	5.97	6.56
	1989-94	16	6.84**	7.07**	7	5.43	6.05
IS	1980-85	15	11.65	11.96	10	9.17	10.22
	1986-88	8	11.30	11.57	4	9.02	9.90
	1989-94	18	10.35*	10.69*	11	8.22	9.14
VS	1980-85	12	6.96	7.19	2	5.51	6.14
	1986-88	2	6.79	6.94	5	5.40	5.93
	1989-94	10	6.02	6.21	8	4.79*	5.31
BC	1980-85	14	10.34	10.68	11	8.17	9.13
	1986-88	6	9.75	10.00	5	7.74	8.55
	1989-94	12	8.90	9.20	9	7.05	7.87
GL	1980-85	12	8.70	8.95	12	6.92	7.65
	1986-88	5	8.15	8.40	3	6.53	7.18
	1989-94	11	7.54	7.82	4	6.00	6.68
VN	1980-85	5	5.14	5.30	2	4.08	4.53
	1986-88	4	4.89	4.93	1	3.90	4.21
	1989-94	5	4.41	4.54	2	3.49	3.89
SIR 95%CI	1980-85		100	100		100	100
	1986-88		58(40-77)	58(40-77)		55(35-76)	50(32-69)
	1989-94		160(127-192)	155(123-186)		110(80-141)	99(72-126)

A - on the basis of 67 cases for NHL and 53 cases for HD; B - on the basis of all cases (69 NHL and 59 HD)
 *p<0.05, **p<0.01

TABLE V - Age group distribution of observed (O) and expected (E) number of cases of NHL

District	Period	Age 0 - 4 y.		Age 5 - 9 y.		Age 10 - 14 y.	
		No. of cases		No. of cases		No. of cases	
		O	E	O	E	O	E
SV	1980-85	0	3.27	4	3.56	0	2.67
	1986-88	0	3.05	2	3.49	2	2.50
	1989-94	4	2.96	3	3.19	4	2.46
BT	1980-85	1	2.31	0	2.50	2	1.92
	1986-88	0	2.05	3	2.33	2	1.70
	1989-94	5	1.80	2	2.04	3	1.65
NT	1980-85	0	2.73	2	2.99	0	2.27
	1986-88	4	2.43	0	2.93	0	2.10
	1989-94	6	2.26	5	2.53	5	2.05
IS	1980-85	6	4.15	3	4.34	6	3.16
	1986-88	5	3.76	2	4.49	1	3.05
	1989-94	7	3.45	8	3.86	3	3.05
VS	1980-85	5	2.37	5	2.58	2	2.02
	1986-88	1	2.30	1	2.70	0	1.78
	1989-94	2	2.01	5	2.28	3	1.74

TABLE V - Age group distribution of observed (O) and expected (E) number of cases of NHL(continued)

District	Period	Age 0 - 4 y.		Age 5 - 9 y.		Age 10 - 14 y.	
		No. of cases		No. of cases		No. of cases	
		O	E	O	E	O	E
BC	1980-85	5	3.53	5	3.78	4	3.03
	1986-88	2	3.33	0	3.78	3	2.64
	1989-94	2	3.00	7	3.28	3	2.63
GL	1980-85	3	2.91	5	3.33	4	2.45
	1986-88	3	2.60	2	3.18	0	2.37
	1989-94	4	2.46	3	2.78	4	2.30
VN	1980-85	3	1.73	1	1.92	1	1.49
	1986-88	1	1.59	1	1.84	2	1.46
	1989-94	2	1.50	1	1.63	2	1.27
SIR 95%CI	1980-85	100		100		100	
	1986-88	76(39-113)		44(18-71)		57(21-92)	
	1989-94	165(108-222)		158(105-210)		157(98-217)	

TABLE VI - Indicators of data quality for leukaemia

District	% Unspecified (a)			% Histology (b)			% DCO (c)			% Teaching Centre (d)		
	80-85	86-88	89-94	80-85	86-88	89-94	80-85	86-88	89-94	80-85	86-88	89-94
SV	0.0	11.1	0.0	83.9	83.3	73.9	0.0	0.0	0.0	100	100	95.7
BT	5.6	0.0	4.2	83.3	100	79.2	16.7	0.0	0.0	83.3	100	87.5
NT	0.0	0.0	0.0	100.	88.2	73.7	0.0	0.0	0.0	100	94.1	94.7
IS	3.1	0.0	0.0	93.8	89.5	90.0	0.0	0.0	0.0	100	100	100
VS	0.0	0.0	0.0	94.1	64.7	80.0	5.9	5.9	0.0	94.1	76.5	100
BC	0.0	6.3	0.0	81.6	81.3	84.4	2.6	6.3	0.0	92.1	93.8	93.8
GL	4.2	8.3	5.0	87.5	50.0	90.9	0.0	25.0	4.5	79.2	100	86.3
VN	0.0	0.0	0.0	50.0	70.0	82.4	0.0	10.0	0.0	100	100	94.1
WHOLE AREA	1.6	3.3	0.9	87.4	80.0	82.9	3.1	5.0	0.5	93.7	95.0	94.1

(a) - Leukaemia cases of "unspecified" type, (b) - Cases with histology exam, (c) - Cases diagnosed at death (in hospital only), (d) - Cases diagnosed in Teaching Centre

TABLE VII - Indicators of data quality for NHL

District	% Histology (b)			% DCO (c)			% Teaching Centre (d)		
	80-85	86-88	89-94	80-85	86-88	89-94	80-85	86-88	89-94
SV	75.0	50.0	100.0	25.0	25.0	0.0	100.0	100.0	0.0
BT	100.0	80.0	80.0	0.0	0.0	0.0	100.0	100.0	0.0
NT	100.0	75.0	73.7	0.0	0.0	0.0	100.0	100.0	93.8
IS	93.7	100.0	66.7	0.0	0.0	0.0	100.0	100.0	0.0
VS	91.7	50.0	90.0	8.3	0.0	0.0	91.7	100.0	0.0
BC	78.6	50.0	75.0	0.0	8.3	0.0	100.0	100.0	75.0
GL	75.0	80.0	72.7	0.0	0.0	0.0	100.0	100.0	0.0
VN	60.0	50.0	80.0	0.0	0.0	0.0	100.0	100.0	0.0
WHOLE AREA	83.6	71.1	77.4	3.0	2.6	0.0	98.5	100.0	95.7

(b) - Cases with histology exam, (c) - Cases diagnosed at death (in hospital only), (d) - Cases diagnosed in Teaching Centre

TABLE VIII - Indicators of data quality for BH

District	% Histology (b)			% DCO (c)			% Teaching Centre (d)		
	80-85	86-88	89-94	80-85	86-88	89-94	80-85	86-88	89-94
SV	100.0	50.0	71.4	0.0	0.0	0.0	100.0	100.0	0.0
BT	100.0	100.0	66.7	0.0	0.0	0.0	100.0	100.0	0.0
NT	50.0	100.0	42.9	0.0	0.0	0.0	100.0	100.0	0.0
IS	80.0	100.0	72.7	0.0	0.0	0.0	100.0	100.0	0.0
VS	100.0	100.0	87.5	0.0	0.0	0.0	100.0	100.0	0.0
BC	54.5	80.0	88.9	0.0	0.0	0.0	100.0	100.0	77.8
GL	83.3	66.7	50.0	8.3	0.0	0.0	100.0	100.0	50.0
VN	50.0	0.0	50.0	0.0	0.0	0.0	100.0	100.0	0.0
WHOLE AREA	77.3	85.7	70.6	1.9	0.0	0.0	100.0	100.0	92.2

(b) - Cases with histology exam, (c) - Cases diagnosed at death (in hospital only), (d) - Cases diagnosed in Teaching Centre

There was no association between the studied diseases incidence and estimated cumulative doses. Excess risk (fig. 2) and excess relative risk (fig. 3) are higher in the less contaminated areas (51.51; 0.50) and lower in the most contaminated areas (-28.68; -0.27) for leukaemia.

4. CONCLUSIONS

1. Overall, this findings provide a significant increase of leukaemia and NHL only after 1989
2. The most affected age groups were 0-4 y. for leukaemia and 0-4 y , 5-9 y for NHL.
3. These excesses were not correlated with dose levels.

5. DISCUSSION

The haematopoietic system is highly vulnerable to radiation carcinogenesis. Leukaemia is one of earliest (the latent period is brief beginning 3-5 years after exposure) and highest oncology effect [8].

This finding agrees with results of similar epidemiological studies in Finland, Sweden and collaborative European study which didn't show any correlation between leukaemia and radiation exposure [9, 10, 11].

It is possible that SIR calculated using completed data was subestimated because of some uncertainties of incomplete data found in registers.

The lower percentage of histologically confirmed leukaemia and NHL after the nuclear accident compared with the baseline period could underestimate SIR for this periods too.

The excess of the leukaemia and NHL found in our study could be determined from the exposure of other risk factors (chemicals infectious or ultraviolet-light) that may be involved as they were suggested by other studies [12, 13, 14].

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THE IMPACT OF THE CHERNOBYL ACCIDENT ON THE ITALIAN POPULATION: A REASSESSMENT

S. FABBRI, R. SOGNI
CRR-PMP-SFA, Azienda USL,
Piacenza, Italy



XA9745477

G. TARRONI
ENEA-AMB-IRP,
Bologna, Italy

E. TABET, A. ROGANI
National Institute of Health,
Rome, Italy

1. RADIOACTIVE CONTAMINATION DISTRIBUTION IN ITALY

As the radioactive contamination distribution has been very inhomogeneous in Italy, the dosimetric evaluations have been carried out on the basis of radioactivity values averaged over three geographical areas corresponding to Northern, Central and Southern Italy.

The most significant food matrices, in addition to air and soil, have been taken into account: milk, cereals, meat, vegetables and fruit.

The highest contamination levels have been found in Northern Italy; for this area, figures 1 and 2 show, as an example, the specific activity of iodine 131 in leafy vegetables and of caesium 137 in milk and cow meat until the end of 1992.

Specific Activity [Bq/kg]

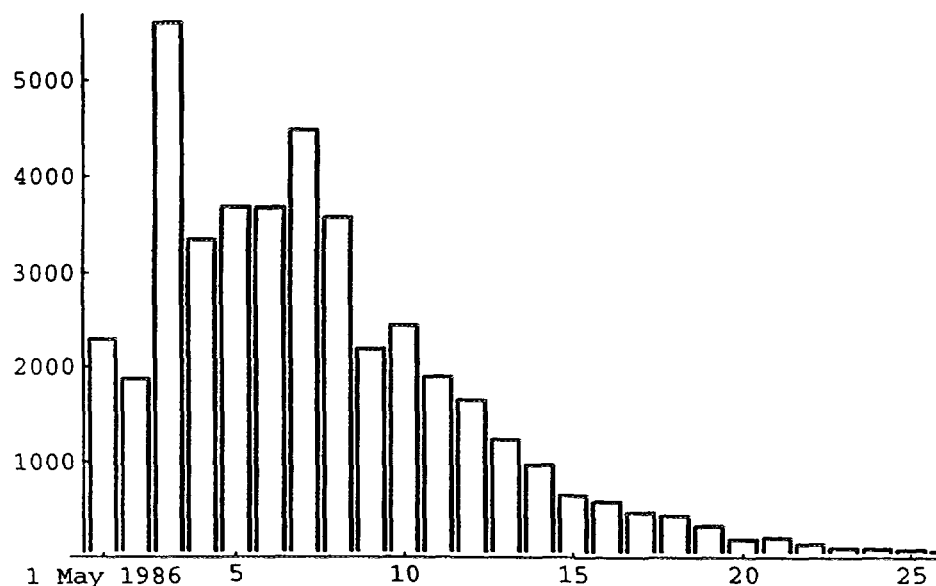


Fig.1 Iodine 131 average specific activity in vegetables, in Northern Italy, in the first month after Chernobyl accident.

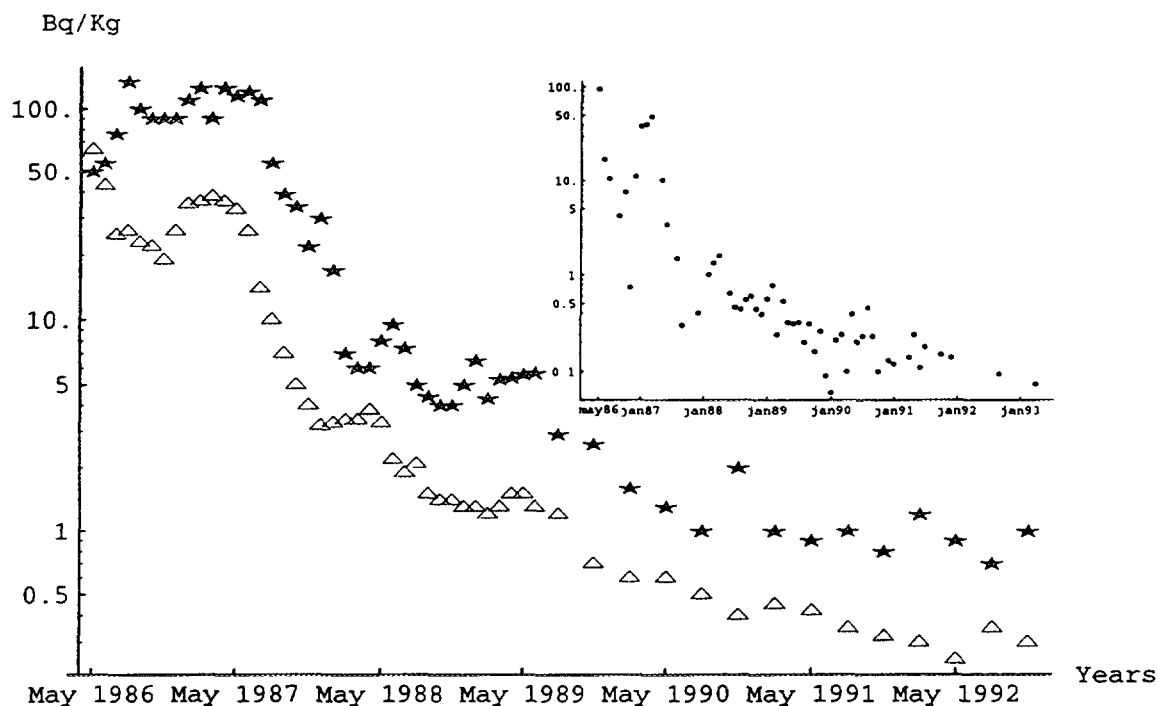


Fig.2 Cs-137 contamination levels in cow meat (indicated with the stars) and milk (triangles) in Northern Italy. The figure in the upper right corner shows the Cs-137 contamination of milk in the Emilia-Romagna district (see text for the meaning of these data in the context of global dose evaluation).

In the other areas the radioactivity levels were lower by a factor 1.5÷3. Ground deposition data for caesium 137 (the major term for external dose) were about 13 kBq/m² in Northern Italy, 4.5 kBq/m² in Central Italy and 3 kBq/m² in Southern Italy and were approximately twice as large as those for caesium 134. Nevertheless, the soil contamination data showed a strong dependence on local fluctuations in the rain-fall and this caused markedly different contamination levels also in adjacent areas.

2. DOSIMETRIC EVALUATIONS

The individual dose calculations have been carried out according to three age-groups: infants (0-1 year); children (7-12 years); adults .

The following exposure pathways have been considered: external irradiation from deposited material, inhalation of contaminated air and ingestion of contaminated food. The other exposure pathways (external irradiation from the cloud and inhalation of resuspended material) were negligible in Italy.

The dose coefficients internationally adopted for different pathways [1,2,3] have been used. The dose from material deposited on the ground has been calculated on the basis of average values of activity measured on the ground and a dynamic model describing the time trend of radioactive contamination [4]. The most significant contributions come from I-131, Ru-103, Ru-106, Cs-134 and Cs-137.

The exposure from inhalation and ingestion has been calculated using the average values of measured concentrations of radionuclides in air and in food, together with appropriate breathing rates [5] and dietary intake rates[6].

During the first month, three radionuclides (I-131, Cs-134, Cs-137) contributed for most of the ingestion dose; during the following time after the accident only the caesium isotopes were still significant. For the inhalation dose the most significant radionuclides were Ru-106, I-131 and Te-132.

2.1 Committed effective dose in the first year

Figure 3 shows the individual effective doses in the first year following the Chernobyl accident according to age-groups, geographical areas, and exposure pathways.

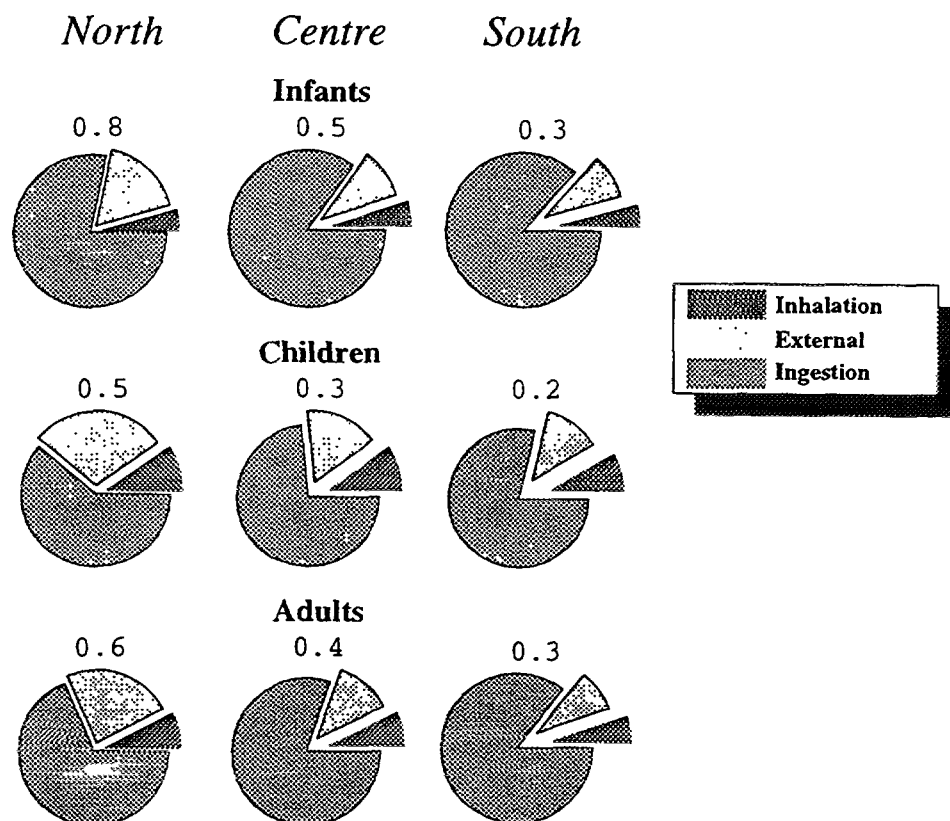


Fig. 3 First year effective dose distribution in the three main areas in Italy [values are given in mSv].

These doses have been calculated taking into account the countermeasures adopted in Italy for the consumption of milk and vegetables as shown in Table I. In all the areas the infants represent the critical group, with the highest dose being received in the North for all ages groups. Ingestion appears to be the main pathway, ranging from 60% to 85% of the total dose, according to the geographical area and the age group.

Table I. Food restrictions imposed in Italy: countermeasures period in the different areas

	North	Centre	South
Ban on sale of leafy vegetables	3/5 - 17/5	3/5 - 12/5	3/5 - 12/5
Consumption of milk by children and pregnant women	3/5 - 24/5	3/5 - 24/5	3/5 - 24/5

2.2 The effect of countermeasures

The effectiveness of the restrictions adopted in Italy on milk and vegetables consumption has been assessed, assuming that the bans were abided by strictly. The countermeasures introduced until the end of May 1986 have allowed a significant reduction of the ingestion dose from iodine 131. The largest reduction in thyroid dose is that for infants whose ingestion dose decrease ranges from 68% to 85%, according to the geographical area. Figure 4 shows the collective thyroid dose saved in Italy, equal to 105 000 person-Sv; in the same figure is reported the collective thyroid dose committed in Italy in the first year, according to age groups. In both cases, the largest contribution to collective doses comes from adults, but the other age groups contributed more than their percentage ratio with the combined population.

The overall collective thyroid dose reduction the restrictions allowed has been equal to about 54% of the expected value.

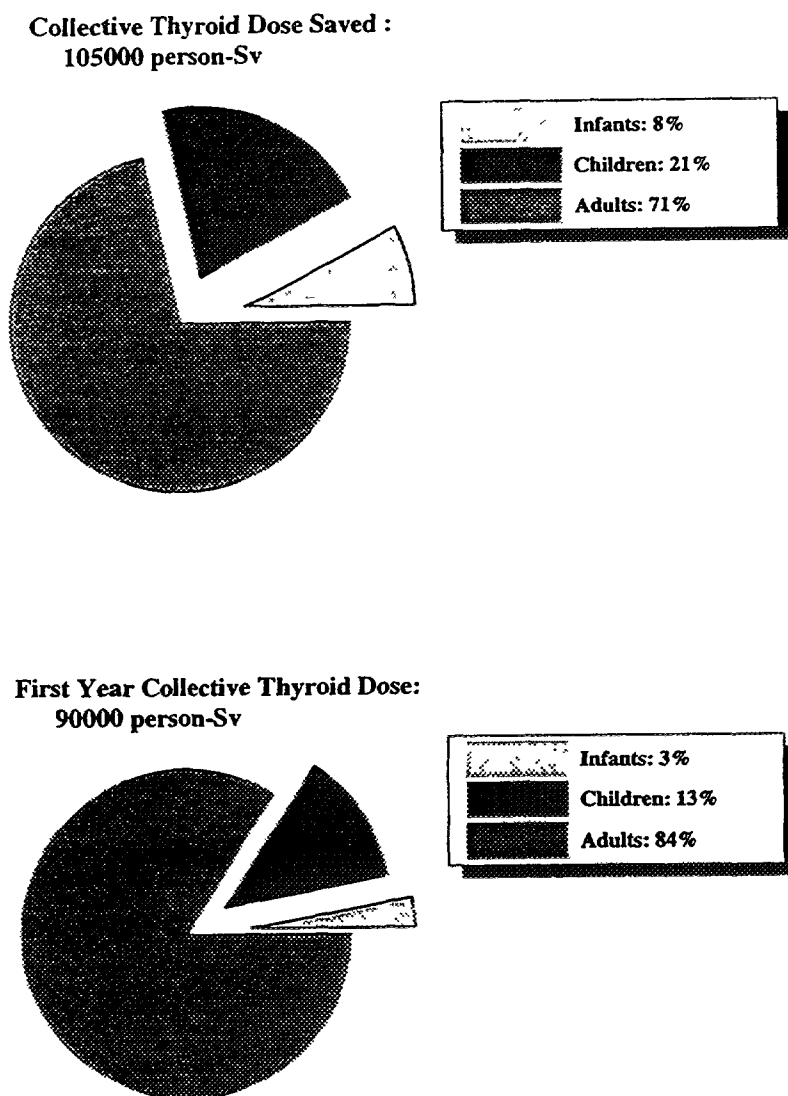


Fig.4 The effect of countermeasures in thyroid dose saving.

2.3 Time trend of the ingestion dose

In order to calculate the time trend of ingestion effective dose, the food activity levels measured in Northern Italy up to December 1992 have been considered.

In this geographical area, indeed, the values of ingestion dose have decreased down to about 1 μSv after 6 years following the accident, while in the other areas this dose value has been reached already after 3-4 years.

In order to check the time trend of ingestion dose obtained by radiometric data averaged on extensive geographical areas, the radioactivity levels measured in Emilia Romagna district (Northern Italy) have been also considered. In that district, indeed, the measurements have been both systematic and highly reliable.

As can be seen in Fig. 5, the time trend of ingestion dose calculated for adults living in Emilia Romagna matches the time behaviour of that obtained for Northern Italy.

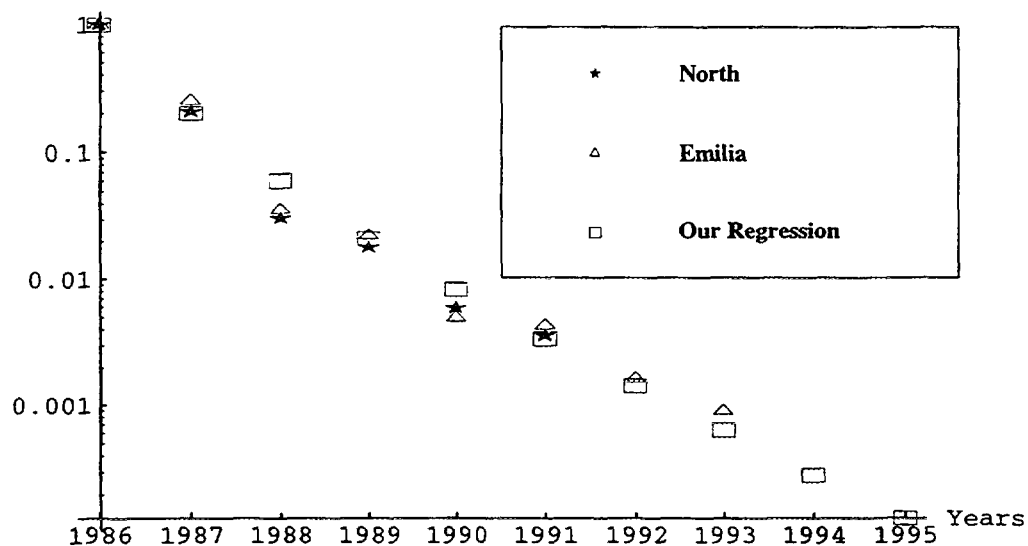


Fig.5 Ingestion doses for the North and for the Emilia district. The values, including those of our regression [with $R^2 \approx .99$], have been normalised to the initial (1986) value.

All the ingestion data, including those from the Central and Southern areas, and even those for the different age groups, can be shown to follow a rather simple equation of the form $x^{-a} \text{Exp}[-bx]$ with a and $b \approx 1$. One should, finally, stress that the dominant contribution to ingestion doses, for all the three areas, comes from the few first years terms, where the doses are still of the order of hundreds or tens of μSv .

3. EFFECTIVE DOSE COMMITMENT

By using a model which takes into account the migration of nuclides in soil [4], the effective dose commitment due to external irradiation has been assessed.

In Fig. 6, the ingestion and external irradiation doses as a function of time in the first ten years following the Chernobyl accident are compared for Northern Italy. This figure shows that the external irradiation contribution to the effective dose becomes very soon the main term.

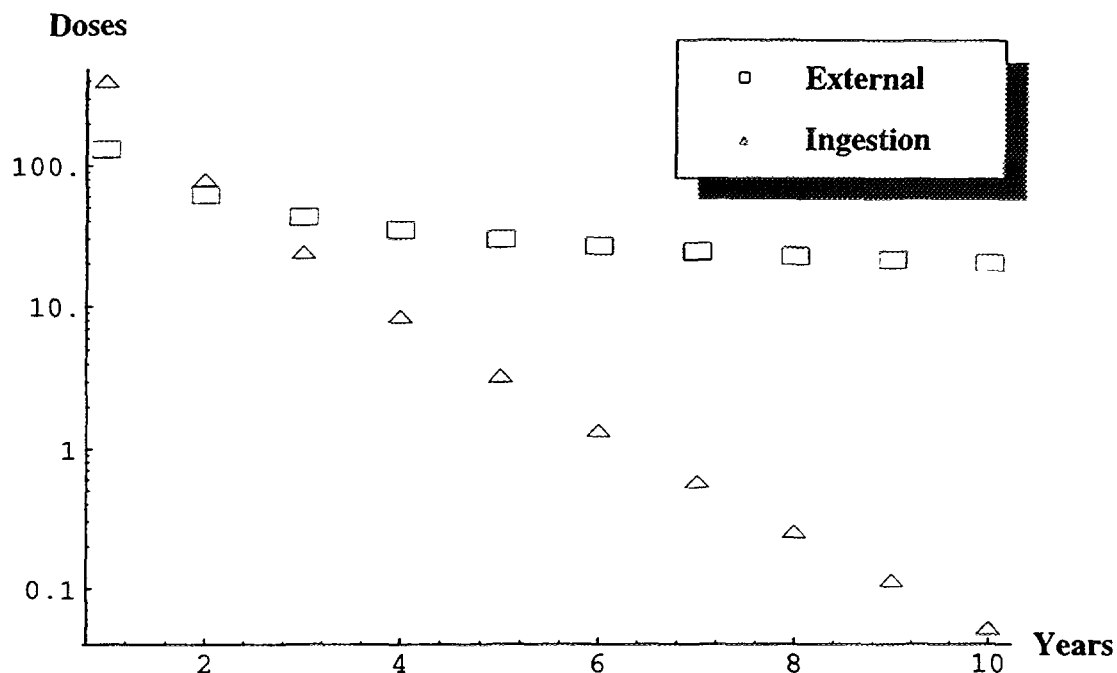


Fig.6 External and ingestion effective doses [μSv] in Northern Italy as a function of time.

Here and elsewhere, the ingestion doses on the long term have been calculated by means of the non linear fit discussed in the previous paragraph. The dosimetric evaluations as for the effective dose commitment values are shown in Table II.

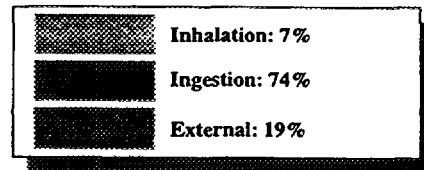
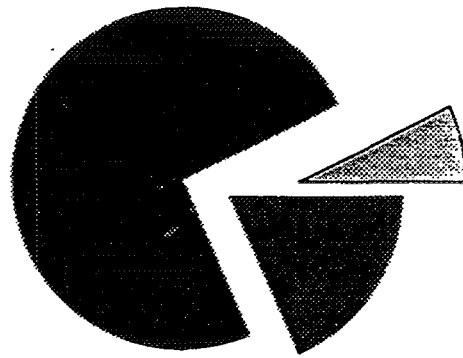
Table II. Effective dose commitments [mSv] in Italy for different age groups in the three geographical areas.

	Infant	Children	Adults
North	1.8	1.4	1.6
Centre	0.9	0.7	0.8
South	0.6	0.5	0.6

The average effective dose commitment for an Italian individual is equal to about 1.1 mSv. Figure 7 shows the collective effective dose commitment in Italy, compared with the committed collective effective dose in the first year for the main exposure pathways.

The first year collective dose represents about 41% of the total dose. Moreover the ingestion is the most important pathway in the first year (75% of the total dose), while the external irradiation gives the largest contribution to the dose commitment (about 60% of the total dose).

**First Year Collective Effective Dose:
25000 person-Sv**



**Collective Effective Dose Commitment:
61000 person-Sv**

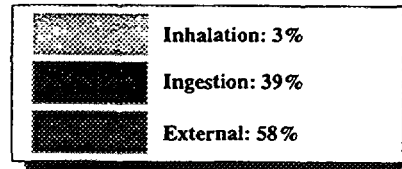
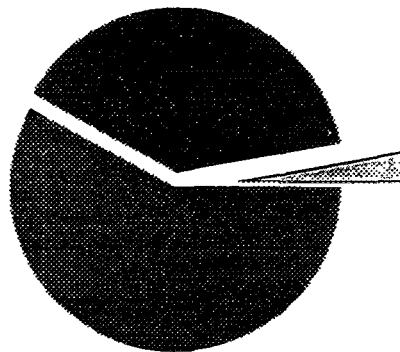


Fig. 7 Collective dose commitment and first year collective dose in Italy.

4. COMPARISON WITH DATA FROM WHOLE BODY COUNTER

Mean body activity of Cs-134 and Cs-137 were measured until September 1989 by means of the whole body counter by the ENEA laboratory in Bologna[7]. The data are referred to adults living in Bologna (Reference Group), but measurements performed on other adults living in areas surrounding Bologna (up to a distance of about 100 km) have shown that the mean activity measured in Reference Group can be taken as representative of the adults living in Emilia

Romagna district. The individual effective dose due to Cs-134 and Cs-137 ingestion from WBC data have been calculated by applying the ICRP 30 metabolic model [8]; it resulted equal to 234 μ Sv in the period from 1 June 1986 to 30 September 1989.

This dose value has been compared with the Cs-134 and Cs-137 adults ingestion dose of 250 μ Sv evaluated in the same period using the food activity concentration and the dietary intake rates in Emilia Romagna [9]. Then the ingestion dose from WBC data differs only about 10% from the calculated dose.

Figure 8 shows the remarkably good agreement between the Cs-137 mean body activity measured in the Reference Group and the Cs-137 body content calculated from radioactivity levels in the food for adults living in Emilia Romagna district.

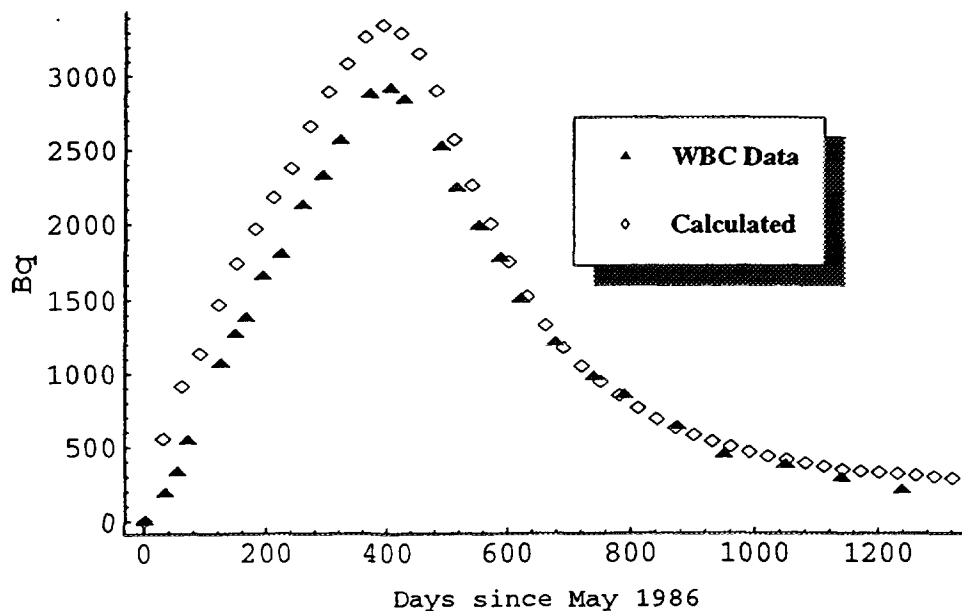


Fig.8 Mean Cs-137 body activity in adults, relative to Emilia-Romagna, compared with our calculations. The last data have been taken in September 1989.

5. STRONTIUM 90 CONTAMINATION

In the Chernobyl reactor at the time of the accident, the Sr-90 activity could be compared with that of Cs-137, whereas the OECD-NEA evaluation [10] ascribed to Sr-90 a release fraction approximately eight times as little.

The measurements in different European countries show a $\sim 10^{-2}$ ratio between strontium 90 and caesium 137. Our data confirms this ratio in the first year following the accident. In Fig. 9 the time trend of Sr-90 concentration in milk in Emilia Romagna district, compared with that of Cs-137, clearly shows the well-known effect by which Sr-90 activity will in time equal that of Cs-137, due to the strong unbalance between the biological half-lives of the two nuclides.

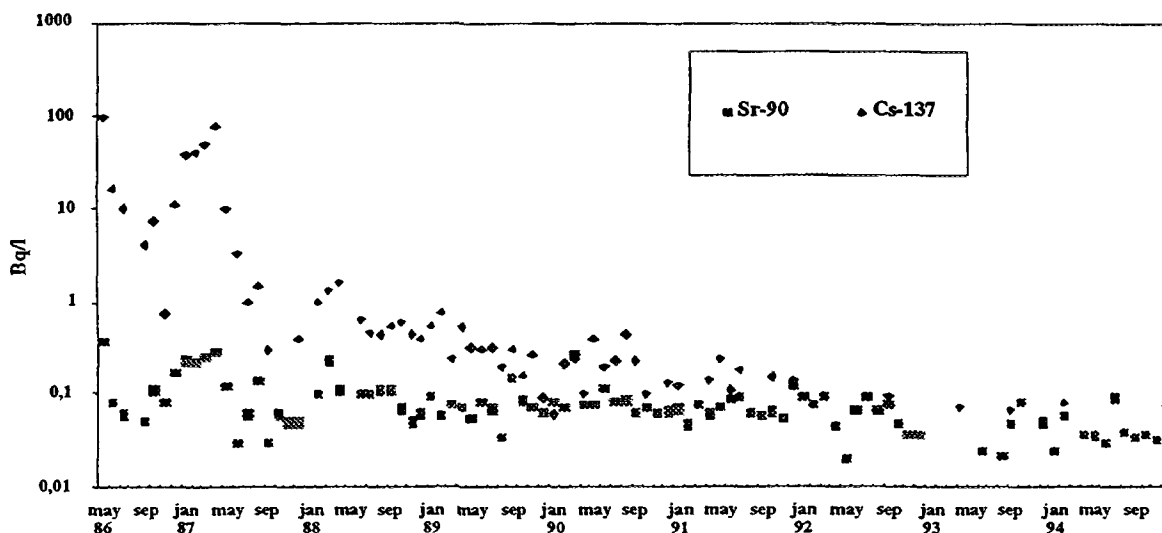


Figure 9. The time trend of Sr-90 and Cs-137 concentration in milk in Emilia Romagna district.

Dose evaluations have been performed in order to take into account the contribution to ingestion dose from the relatively weak contamination from Sr-90. The Sr-90 ingestion dose for infants starts from a few percent of the Cs-137 dose and reaches values which are comparable with those from the other nuclide in August 1987. In 1994 the ingestion dose ratio Sr/Cs is approximately equal to ten. The overall Sr-90 contribution equals about ten percent of the global ingestion dose for infants {these data are relative to the Emilia district}.

6. CONCLUSIONS

In 1987 a preliminary evaluation of the radiological impact of Chernobyl accident on Italian population was performed [11]. This evaluation took into account both the first year activity levels measured in various matrices and models for the time behaviour of radioactive contamination. It comes out that the dose assessment which was then performed is in good agreement with the present evaluation, with some differences that should be noticed. The ingestion dose, as evaluated in 1987 from the models that were then available [12], turns out to be lower than the dose now calculated from the real experimental data. Moreover, the recent change in the dose coefficients [1,2] leads to a new distribution of individual doses according to age groups, as the dose to children is significantly lowered, and becomes even smaller than that of adults.

Last, but not least, the 1987 values for the thyroid dose have been strongly reduced, mainly as a consequence of the reassessment of the corresponding dose coefficients.

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CUBAN STUDIES OF CHILDREN FROM AREAS AFFECTED BY THE CHERNOBYL ACCIDENT

O. GARCÍA, R. CRUZ, M. VALDÉS, J. CÁRDENAS, L. JOVA
Centro de Protección e Higiene de niños Ucranialas Radiaciones,
Havana, Cuba



SUMMARY

Children from areas affected by the Chernobyl accident have been receiving medical care in Cuba since 1990. The assessment of the radiological impact includes: measurement of ^{137}Cs body burden; internal, external, thyroids and total dose estimation; evaluation of the overall health condition and behavior of hematological, endocrinological, and cytogenetic indicators.

Measurements of body activity and dose estimation have been performed on 4506 children from Ukraine (69.3%), Russia (22.5%) and Beloruss (8.1%). Assessments of overall health conditions hematological and thyroid indicators have been made in five groups (1...5) established according to the surface contamination levels (^{137}Cs) of the children's local origins. Groups cover a total of 3033 children from Ukrainian townships. Surface contamination increase from group 1 to 3 and is unknown in group 5, group 4 include evacuated children. Chromosome and micronuclei aberration rates were established in 28 children evacuated from Pripjat, 21 living in Kiev and 20 in Ovruch.

In 69% of the children, contents of ^{137}Cs activity was detected in the body. Specific activity fluctuated from 1.5 to 565 Bq/kg. Of the children measured, 90% showed a specific activity under 20 Bq/kg.

For the study year estimated doses were: external, 0.04-31 mSv (90% of children with values under 2 mSv), internal (^{137}Cs), 2 μSv - 5 mSv; in thyroids, 0-2.Gy (44 % of the children with values under 40 mGy) totals, 0.2-84 mSv (80% of the children with values under 5 mSv). Thyroid hyperplasia increased from group 1 (51%) to group 4 (69%). All other diseases and indicators examined showed no variations between groups 1-5. Dicentric and micronuclei rates per one hundred cells were 0.02 and 0.56 in Pripjat, 0.04 and 0.6 in Kiev and 0.03 and 0.6 in Ovruch. All individual rates were normal.

I - INTRODUCTION.

There were social organizations of the former Soviet Union that by the end of the 1980's requested effective co-operation in medical care for the people linked to the accident from the world scientific community. Responding to the appeal, the Government of the Republic of Cuba set up a comprehensive medical care program for children of these areas that started operating on March 1990.

The program began by selecting and classifying the children from affected areas that would travel to the island. This process was implemented by a Cuban medical team, in co-ordination with local health authorities and the support of the social organizations sponsoring this endeavor. The main selection criteria was health status and possible health rehabilitation. Surface contamination of children's living location, body burden or other radiological parameters were not taking into account and were not know by a medical team.

Those selected were divided into four groups, according to ailments and required level of medical care. Group I included children with onco-hematological disorders, some 3% of all selected cases, and are cared for in specialized hospitals. Group II had the children with chronic or acute intercurrent diseases that required hospitalization at arrival to Cuba and represented some 17% of the selected cases. Group III included children with diseases that could be treated through outpatient services and represented approximately 60% of all cases. Group IV was made up by relatively healthy children, representing 20% of the total [1]. Children from groups III and IV were selected for the studies. The main stage of the studies were:

- The measurement of ^{137}Cs body burden.
- The doses estimation through different pathway.
- The biomedical evaluation.

A computerized system was developed, which allows automated processing and analyses of the studies results.

2 - MEASUREMENTS OF ^{137}Cs BODY BURDEN.

Of the gamma emitters radionuclides released during the Chernobyl accident, ^{137}Cs has the longest half-life and for that reason it contributes significantly to the doses for a long period of time. In people living in areas affected by the accident it is possible to detect the presence of this radionuclide in the body and make an estimate of the doses due to internal contamination.

2.1.- Materials and methods

Table I shown general characteristic of the group of children studied.

Table I - General characteristics of the group of children studied.

Republic	Number of towns	Amount of children	Age (years)	Sex (%)	
				M	F
Beloruss	82	367	7 - 16	49	51
Ukraine	421	3121	1 - 17	54	46
Russia	156	1018	3 - 16	56	44
Total	659	4506	1 - 17	53	47

Two whole-body counters with partial shadow shield (5 cm lead) and stretcher geometry, were installed. A 150*100 mm NaI(Tl) detector and an AMC-01 domestic-made multi-channel analyzer were used in each facility.

A set of phantoms made up of plastic containers were used to calibrate the system. They cover from a 5 kg child to the 70 kg Reference Man [1]. The radionuclides used in the calibration were gamma emitters with 511-1460 keV energies: ^{85}Sr , ^{54}Mn , ^{137}Cs and ^{40}K . The phantom used to measure background has an amount of potassium and calcium corresponding to each weight [2,3], which makes ^{137}Cs determination more precise since the contribution of the ^{40}K present in each child is well known.

In the case of the ^{137}Cs , detection efficiency for each phantom was adjusted through the minimal square method, depending on its ratio (weight/high) [1]. Minimum detectable amount (MDA) was established according to the ratio others have recommended [3].

Detection efficiency and minimum detectable amount values are shown in Table II. Measurement error of an activity for a 90% confidence interval was estimated at 32%.

Table II.- Whole Body Counters Characteristics

Radionuclide	Counter-1		Counter-2	
	e (cps/Bq)*	MDA (Bq)**	e (cps/Bq)	MDA (Bq)
^{137}Cs	3,09 E-3	105	2,66 E-3	126
^{40}K	1,63 E-3	1036	1,69 E-3	804

* Phantom of Reference Man

** Measurement Time 25 min.

The behavior of activity distributions measured in the children of each region was studied. Equality hypothesis of distributions found with respect to log-normal distribution was subjected to the Kolgomorov-Smirnov bond adjustment test.

2.2.- Results and discussion

Table III shows the general results of the measurements made in the three republics.

In 69% of the children, contents of ^{137}Cs activity was detected in the body with values that were higher than minimum detectable amount. Specific activity fluctuated from 1.5 to 565 Bq/kg. Of the children measured, 90% showed a specific activity under 20 Bq/kg. Activity distribution had a log-normal character in each region studied. Adjustment bond test was accepted.

Table III. - General Results of ^{137}Cs Measurement in the Body of the children for the Three Republics Studied.

Republic	Number of children measured	Measurement with total activity higher than MDA		Total activity interval (kBq)	Specific activity interval (Bq/kg)
		Amount	%		
Beloruss	367	324	88,3	0,1- 8,5	1,5-363
Ukraine	3121	2239	71,7	0,1-31,8	1,5-565
Russia	1018	548	54,1	0,1-11,5	1,5-195
Totals	4506	3111	69,1	0,1-31,8	1,5-565

Figure 1 shows values of activity measured for different age groups in the region of Kiev. It is noted that the larger number of measurements were made on children of 8 to 14 years of age. The activity's value interval is similar for each age, which may confirm that measured activity values have no direct relationship to the age of the children. There was no relation found between levels of internal contamination and eating habits either.

Relations between mean values of specific activity of the children from different regions and levels of surface contamination reported by others [4,5] are shown in Figure 2. An increased contamination was noted in the body as surface contamination increased, although it is not possible to establish a defined functional character with appropriate statistical rigor.

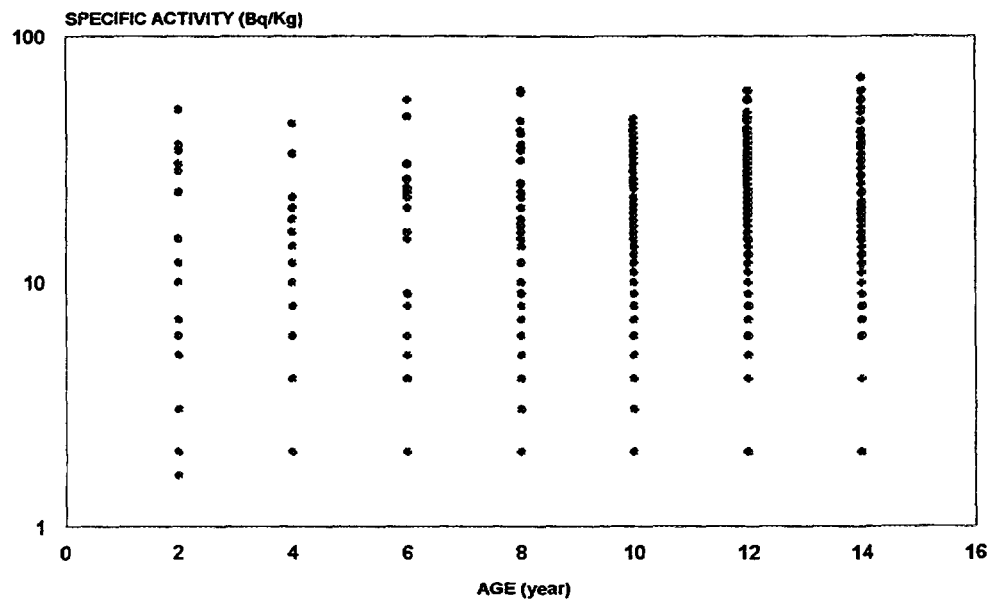


Fig. 1 Values of Mean Activity for Different Age Groups in the Region of Kiev.

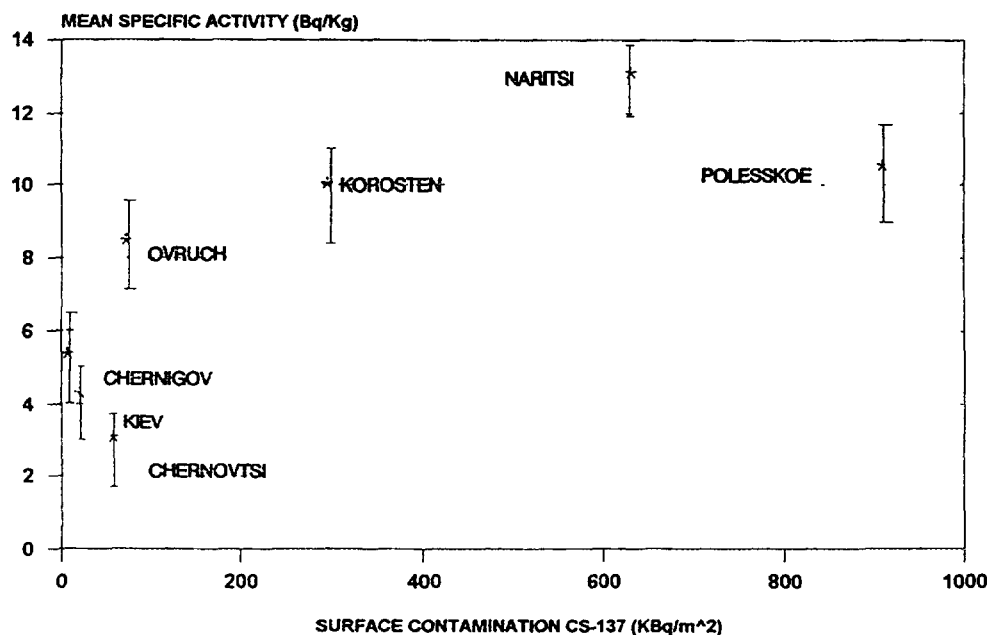


Fig. 2 Relation Between Mean Values of Specific Activity and Levels of Surface Contamination

3- DOSES ESTIMATION THROUGH DIFFERENT PATHWAYS

To make an approximate evaluation of the accident's radiological impact in children assisted in Cuba and to advice local health authority, several doses estimates were made, including: external radiation doses; ^{131}I doses in thyroid; ^{90}Sr contamination doses and integrated effective doses in 70 years due to ^{137}Cs incorporation to the body of the children, assuming a chronic incorporation model. Of these estimations, only ^{137}Cs internal doses are based on direct measurements. The others doses were estimated by modeling and are not of the same level of accuracy.

3.1.- External Radiation Doses

The preliminary data to estimate the doses equivalent due to external radiation was obtained through a survey made with each child to learn about their geographic origin and location after the accident, and life and eating habits during and after the accident. Doses were estimated from Ukraine official data and from other international agencies where values of doses rates and surface contamination of the regions of origin of the children had been published [4,5].

Radionuclides ^{103}Ru , ^{131}I , ^{134}Cs and ^{137}Cs were used to estimate external radiation doses for the first year after the accident.

Distribution of children per external radiation doses intervals for the fourth year shows that 90% of the children received radiation doses under 2 mSv while only 5% received doses higher than 5 mSv. The highest estimate for that period was 31 mSv. The behavior of doses values for the study year and forecast in 70 years is linear.

3.2.- Internal Doses

The estimate of effective doses produced by the ^{90}Sr was limited to a small group of 1314 children from areas where surface contamination values with this radionuclide are known. Transfer factors recommended by UNSCEAR were applied [6].

The thyroid-absorbed doses produced by ^{131}I were hypothetically estimated, knowing the ratio of this radionuclide with ^{137}Cs on the ground. Transfer factors [6] were applied to the areas, in line with ^{137}Cs surface contamination presented in other papers [4,5].

To estimate internal contamination doses, the methodology used was the one recommended by ICRP publication 30 [7], with some modifications for children.

The ^{137}Cs integrated effective doses was estimated for the study year and for 70 years since intake began, assuming a chronic incorporation model. The distribution of children per doses intervals show that 76% of children received doses under 0.1 mSv. Maximum estimated values have mSv unit values.

The distribution of the effective doses due to ^{90}Sr shows that 25% of the children receive higher doses than the mSv unit. Maximum doses are not higher than 5 mSv.

The hypothetical estimation of thyroid-absorbed doses in some regions showed values of up to 2 Gy. It should be noted that it is a conservative estimate since a $^{131}\text{I}/^{137}\text{Cs}$ quotient in the environment is assumed, something not well known by specific locations. It is estimated that 44% of the children received doses in thyroid higher than 40 mGy.

3.3.- Total Doses

The contribution of all doses components are outlined in Table IV. The highest contributors in the first time interval are external radiation and ^{131}I hypothetical contribution. As a whole, external radiation is the main contributor. Children distribution per total doses intervals show that 90% received total doses under 5 mSv. Maximum values are not higher than 0,2 Sv.

Table IV – General Results for the Group of Children Studied.

Doses component	Doses intervals (mSv)		
		For 4 years	For 70 years
External Doses		< 1 - 31	4 - 87
Internal Doses	^{137}Cs *	<< 1 - 5	< 1 - 7
	^{90}Sr	< 1 - 4	< 1 - 4
	^{131}I **	2 - 84	2 - 61
Total doses		< 1 - 84	8 - 171

* Assuming chronic intake up to the fourth year.

** Effective doses.

4 - BIOMEDICAL EVALUATIONS.

The medical diagnoses and laboratory tests results done on 3033 children from 421 townships of the Republic of Ukraine were used for the evaluation of the overall health condition and behavior of hematological and thyroid indicators.

Bearing in mind the many townships and the small number of children per township, 5 groups were set up for the study (Table V).

Table V.- Groups Set Up for Biomedical Studies.

Group	Contamination [kBq/m ²]	Number of towns	Number of children (%)	Age (years)		Sex (%)	
				Average	Interval	M	F
1	<37	33	831 (27.4)	10.8	2-17	54	46
2	(37-185)	63	512 (16.9)	11.1	1-16	59	41
3	>185	19	192 (6.3)	11.4	4-17	42	58
4	evacuated	13	719 (23.7)	11.2	5-20	57	43
5	unknown	293	779 (25.7)	11.4	1-17	59	41

The main dosimetric characteristics of these groups are observed in Table VI.

Table VI- Main Dosimetric Characteristics of the Groups Studied. Mean Values.

Group	Cases >MDA %	Sp. Act. (Bq/kg)	External Doses(mSv)		¹³⁷ -Cs Int. Doses (μSv)		Thyroid Doses (mGy)	Total Doses (mSv)	
			study year	70 years	study years	70 years		study years	70 years
1	65	6	< 1	1	40	60	43	2	3
2	85	14	1	5	90	140	148	6	11
3	97	21	7	29	140	210	890	35	57
4	70	6	< 1	1	40	60	—	< 1	1
5	74	10	—	—	70	110	—	< < 1	0,1

In the valuation of obtained results the characteristics of the Cuban Program must be take into account.

4.1.- Morbidity

The most common diseases, according to the World Health Organization's International Classification of Diseases [8] were: Endocrine-Metabolic 62%, Hematological 37%, Respiratory 26%

Thyroid hyperplasia represent 99% of endocrine-metabolic diseases. Grades IA and IB hyperplasia predominate among them.

Non-specific chronic limphaadenitis represent 99% of cases diagnosed with hematology pathologies. The cases diagnosed and treated as anaemia, with hemoglobin values under 100 g/L, represent less than 1%.

In respiratory diseases, chronic infectious processes of the upper respiratory tract, mainly the oropharynx and nasopharynx (88%), predominated.

4.2.- Hematology Indicators

The hematological indicators examined in the study were haemoglobin, haematocrites and leucocytes, eosinophils, monocytes, polymorphs and lymphocytes count. All indicators showed not variation between groups. In the total of the cases studied the most significant results were: fifteen percent (15%) of cases have hemoglobin levels under values considered normal. Lymphocitosis was present in 59% of cases, supposedly linked to parasitary infectious diseases. Leucopenia levels varied from 4% (group 4) to 2% (group 3). Eosinophilia, that fluctuates between 19% (group 4) and 27% (group 5), seems to be related to immunoallergic (29%) and parasitary (39%) diseases.

4.3.- Thyroid Indicators

The indicators taken into account to assess the condition of the thyroids were tiroxine hormone levels (T4), thyroid stimulant hormone(TSH) and clinical thyroid hyperplasia diagnosis.

Hormones T4 and TSH were determined with the ultra-micro-analytic system (SUMA) that uses an automated detection system based on immune-enzymatic processes. Hyperplasia presence and level were determined through palpation by a team of endocrinologists.

The percentage of cases with high TSH levels goes from 0 (group 2) to 1 (group 1).

The main anomaly in thyroid function in the groups studied is associated to an increased T4 with respect to normal values. This increase, fluctuating between 13 % (group 3) and 23% (group 2).

Analysis of the simultaneous behavior of both hormones shows that normal TSH values are accompanied by normal T4 values in 82% of cases. Reduction of T4 with normal TSH values under normality only takes place in 0.6% of cases. Some 17% show a high T4 with a normal TSH.

Thyroid hyperplasia increased from group 1 (51%) to group 4 (69%).

Hyperplasia is present in 61% of the cases in this study, 90% of which are degree 1A (60%) or 1B (30%).

4.4 - Cytogenetic Indicators

The indicators used were: frequency of chromosome aberrations and micronuclei on peripheral blood lymphocytes.

Chromosome and micronuclei aberration rates were established in 28 children evacuated from Pripyat, 21 living in Kiev and 20 in Ovruch.

Dicentric and micronuclei rates per one hundred cells were 0.02 ± 0.01 and 0.56 ± 0.06 in Pripyat, 0.04 ± 0.03 and 0.6 ± 0.06 in Kiev and 0.03 ± 0.03 and 0.87 ± 0.09 in Ovruch. All individuals rate were normal.

5.- CONCLUSIONS

- The ^{137}Cs body burden in 4500 children from areas affected by the Chernobyl accident was established. Levels of internal contamination in the universe studied fluctuate between 1.5 and 565 Bq/kg, 90% showing activities under 20 Bq/kg
- Estimated doses shown that the doses component due to external radiation was the most important contributor to total doses which fluctuate between 8 - 170 mSv.
- The frequency of diseases and the behavior of hematology , thyroid and cytogenetic indicators was similar in groups formed according to the surface contamination of children living location.

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MEDICO-DEMOGRAPHIC CRITERIA IN ESTIMATING THE CONSEQUENCES OF THE CHERNOBYL ACCIDENT

I.I. LINGE, I.A. MELIKHOVA, O. PAVLOVSKI

Nuclear Safety Institute, Academy of Sciences,
Moscow, Russian Federation

1. INTRODUCTION

Upon the Chernobyl accident, there were many preconceived interpretations of the demographic evolution of the contaminated territories, in particular, those concerning quantitative estimates of the additional mortality caused by the accident. Regardless of the opinion of specialists^(1,2) the public associates every manifestation of worsening health of emergency workers and residents of contaminated areas with radiation factor.

Correct comparison of population statistics in affected and unaffected areas prior to and after the accident allows to detect any noticeable deviations in basic medico-demographic parameters in contaminated territories from a common trends, if at all. In view of that when in 1990 in Nuclear Safety Institute a start has been made on construction of an information support system for government and regional executives to overcome the consequences of the Chernobyl disaster⁽³⁾ a specialised data bank on demography and medical statistics (MDBD) was created. Nowadays it embraces official population statistics for almost all regions

of Russia for the period 1982-1994. For example there is a structure of data bank on mortality from different reasons being a constituent of MDBD shown in Fig. 1.

Data of MDBD are also valuable as a broad-based reference in study of emergency workers (EW) health statistics. For the majority of EW registered in Russia participation in decontamination work was a short-term episode (2-3 months)⁽⁴⁾ which superimposed on their different base health levels depending on their native regions. So, it is particularly important to take into account territorial features as well as disadvantageous trends in people health all over Russia.

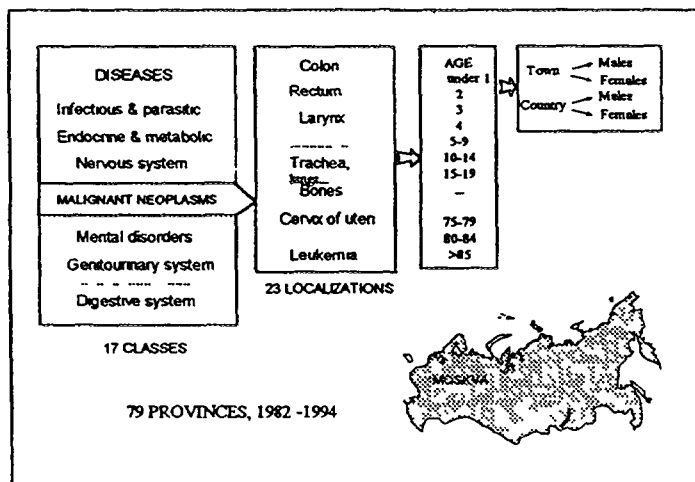


Fig 1 Structure of data bank on mortality from different reasons

2 MATERIALS AND METHODS.

In the Russian Federation there are about 56.0×10^3 km² contaminated areas (¹³⁷Cs density >37 kBq m⁻²) assigned to 17 provinces with 2.7 million people. The population fell into 3 groups according to the zoning of contaminated territories. Some 90,000 live in the zone of boundary resettlement, ZR (> 555 kBq.m⁻²), another 325,000 live in the zone of voluntary resettlement, ZVR (185 - 555 kBq.m⁻²) and the others live in favourable social and economic status zone which is of 85% of the affected territories.

In fact there is no specialised statistics on the exposed population systematically collected to cover all contaminated areas. The most primitive data of variations of population size have been collected by the State Committee on Statistics since 1992 in ZR and ZVR only. Actually health statistics available for areas of different contamination density are rather poor and some serious omissions in organisation of statistical data collection were made. In spite of that altogether with all the data collected in MDBD it allows us to be sure of not overlooking radiation health effects in demographic development of the affected populations in Russia. To follow long-term trends we can refer to the whole province (oblasts) population statistics. Territories referred as ZR are located in one province (Bryanskaya oblast - BO) and those referred as ZVR are spread over four provinces of central Russia (BO, Kaluzhskaya, Orlovskaya and Tulsckaya oblasts). Residents of both

Table I. Characteristics of population in the most contaminated oblasts in Russia.

Oblast	Population size, 1994 $\times 10^3$	Percentage of zone residents in population, %		
		Oblast	Villages	Towns
Bryanskaya	1470.9	33	26	8
Kaluzhskaya	1092.0	10	7	19
Orlovskaya	914.3	31	14	61
Tulskaya	1820.1	51	46	74

zones are a considerable part of the oblast populations (except Kaluzhskaya oblast), countryside in particular (Table I). In comparative analysis of oblast statistics we can use standardised indexes since detailed information on population size and age-sex structure is available from MDBD, for the zones only crude indexes are used.

As a reference we take national average values and data averaged over Central Economic Region (CER) being an administrative union of 12 oblasts and Moscow city with

some 30 million people of which 7% are under exposure.

To form reference group for EW cohort we took selected age group of 20-45 (as of 1986) of urban males in various regions of Russia as it is known that approximately 90% of EW are males mostly from towns ⁽⁴⁾.

3. RESULTS

3.1. Dynamics of population size and age structure.

Present demographic situation in Russia accumulated the problems of the past, including consequences of the World War II, and recent social, and economic difficulties, including decrease in life standard and crisis of national medical surveillance.

Table II. Change of population size and its components

Territory	Population size, $\times 10^3$			Natural decrease, 1994 per 1000	Migration coefficient, 1994 per 1000
	1992	1993	1994		
ZR	89.9	90.6	89.9	- 8.7	14.1
ZVR (BO)**	152.0	151.7	151.7	- 5.7	9.0
BO	1463.8	1465.4	1470.9	- 7.1	12.5
ZVR***	314.6	325.5****	325.2	- 10.0	10.8
CER	30383	30277	29872	- 10.4	7.2
Russia	148295	148146	147968	- 6.1	5.5

* permanent residents

** ZVR assigned to Bryanskaya oblast

*** ZVR located in 4 oblasts

**** In 1993 several new settlements came into ZVR.

Since early 90s changes of population size in Russia were determined by two opposite processes - natural decrease and positive migration balance. For the whole Russia population it resulted in depopulation. In CER this process evolved even more rapidly. In contrast to that in the most contaminated areas number of inhabitants was about the same owing to newcomers (Table II). In ZR immigration in the past few years has become a considerable phenomenon in demographic situation.

For the period 1992-1994 total number of new residents in ZR was 15,000 people, that is about 16% of the population. The only possible reason attracting newcomers might be compensations and economic privileges granted by the federal government to residents of contaminated areas. It should be noted that emigrants have not been exposed and they bring their own reproduction traditions and different health problems. If uncontrolled migration goes on it will certainly misrepresent health statistics in the zone.

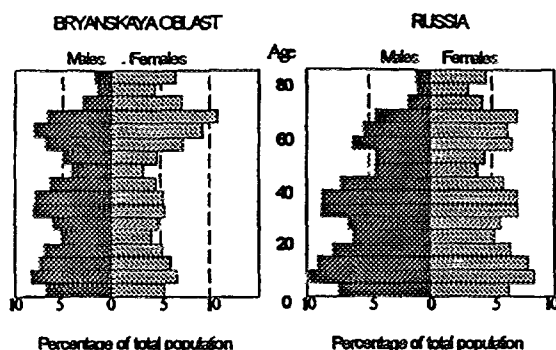


Fig. 2. Age-sex pyramid for rural population in BO and Russia, 1994.

Age structure of CER population is demographically 'old' one^(5,6). In 1994 proportion between the young, working-age people and pensioners was as follows: 24%, 59% and 17%. In towns part of working-age people (62%) is higher than that in country (54%). In the oblasts of interest part of pensioners is even higher, it is about one third of rural population⁽⁷⁾.

Deficiency in young and working age people in rural population is clearly demonstrated in Fig. 2. It is a reason for high mortality crude indexes. The very small part of fertile age females is quite important for understanding of low birth-rate.

3. 2. Birth-rate

Economic difficulties and deficiency of women of fertile age caused by birth-rate reduction in the 60s resulted in long-term tendency for the birth-rate to decrease in all regions of Russia since 1986. In 1993 some increase in number of women in fertile stabilised the situation (Fig. 3).

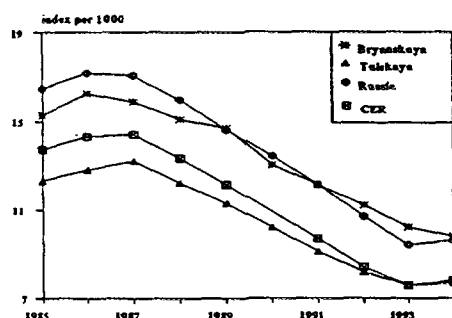


Fig. 3. Birth-rate dynamics in Bryanskaya and Tulsckaya oblasts, CER and Russia (crude index).

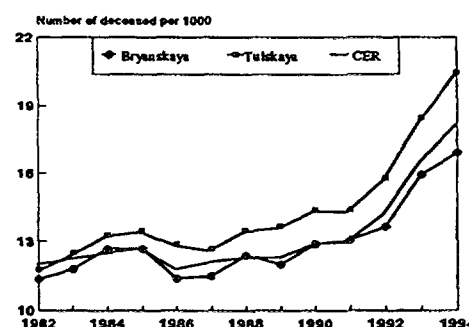


Fig. 4. Dynamics of total mortality in Bryanskaya, Tulsckaya oblasts and CER (crude indexes).

Table III. Crude indexes of birth-rate and mortality in tested and reference territories.

Territory	Percentage of countryfolk in population, 1994 (%)	Birth-rate, index, per 1000			Total mortality, index, per 1000		
		1992	1993	1994	1992	1993	1994
ZR	53	13.1	12.3	11.2	15.1	18.4	19.8
ZVR	51	10.2	9.4	9.5	15.1	17.9	19.5
Bryanskaya	32	11.2	10.2	9.8	13.7	15.9	16.9
Kaluzhskaya	26	9.2	8.0	8.2	13.2	15.8	17.4
Orlovskaya	37	9.7	9.2	9.5	14.0	16.0	16.8
Tulsckaya	19	8.2	7.7	7.6	15.8	18.4	20.5
CER	17	8.4	7.6	7.8	14.3	16.6	18.2
RUSSIA	27	10.7	9.4	9.6	12.2	14.5	15.7

In general in Russia birth-rate in country areas is higher than that in towns. Hence urbanisation degree (Table III) should be taken into account as well as difference in population age structure when one compares birth-rate baselines in the oblasts of interest. Against the baselines the birth-rate situation in contamination

zones is appreciably better. Every year in the period 1992-1994 ZR birth-rate ranked first, birth-rate in ZVR was a little lower but still well above CER average values (Table III).

Both in ZR and ZVR in rural areas birth-rate declined even slower than the broad base values, in contaminated towns it was about the same as in unaffected ones (Table IV). So, disadvantageous processes occurring in contaminated zones, are not as intense as in unaffected territories in the country in particular.

3.3. Total Mortality

In Russia in recent years very low birth-rate combined with a rapid growth in mortality. In fact total mortality started to increase in the oblasts of interest well in advance of the accident. The tendency was broken off in 1985 only and resumed after 1987 (Fig. 4).

Table IV. Birth-rate in rural and urban areas in tested and reference territories (index per 1000)

Territory	Rural			Urban		
	1992	1993	1994	1992	1993	1994
ZR	12.7	12.0	11.7	13.5	12.9	10.7
ZVR (BO)*	11.6	11.0	10.7	12.4	11.5	10.5
BO		10.9	10.3		9.9	9.6
ZVR **	10.0	9.3	9.4	10.3	9.5	9.5
CER		8.4	8.3		7.4	7.8

* Territories in BO assigned to ZVR

** All territories with ZVR status

Table V. Mortality of rural and urban subpopulations in BO (index per 1000)

Territory	Rural population			Urban population		
	1992	1993	1994	1992	1993	1994
ZR	18.3	22.4	24.7	11.6	13.9	14.3
ZVR (BO)	15.8	18.1	18.8	12.0	13.2	13.9
BO	18.5	21.5	22.7	11.4	13.3	14.2

* - territories in BO assigned to ZVR

This phenomenon was seen everywhere in Russia and it is believed to be a short-term effect of the anti-alcohol campaign conducted in those years^(5,6). The early 90s were marked by accelerating growth of mortality rates.

In the past decade in Russia growth of rural mortality (in standardised indexes) overtakes the urban one^(7,8). Higher percentage of countryfolk in ZR and ZVR populations is one of the reasons for crude mortality indexes in ZR and ZVR being higher than the broad-based values (Table III). But if we take rural and urban people separately the excess over entire oblast values both for ZR and ZVR is less (Table V) is much less.

In BO difference in rate of true growth of mortality (standardised index) in post-accident period and prior to the accident was not significant: average annual increase of standardised index was 0.33 (± 0.09) deceased persons per 1000 a year in 1982-1985 and 0.41 (± 0.13) in 1987-1993⁽⁶⁾. A dramatic increase of mortality seen after 1992 was a common effect for all territories in CER. As to

long-term trends (1982-1994) the analysis of test to reference ratio of standardised mortality indexes showed that in BO mortality rate grows slower than in neighbouring oblasts: for rural subpopulation in BO annual increase of mortality rate is 2.1% less than in control (at significance level 99.99%) that is 28 deceased persons per 100,000 in a year.

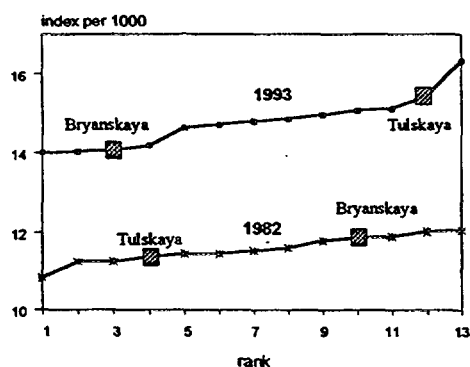


Fig. 5. Standardised mortality indexes (see explanation in text).

As a result the difference between sexes reached extremely high value of 13.4 years. It should be noticed that for rural males in Tulsckaya oblast life expectancy is even less than in BO (55.9 against 58.6). It means that

To provide another support to the conclusion that the most contaminated oblast is in better condition now let us compare the mortality situation in BO with that in other oblasts in CER. Fig. 5 presents standardised total mortality indexes in 13 administrative units of CER according to their ranks in 1982 and 1993. In other words, the oblast that holds the first place has the lowest mortality level, the highest mortality level corresponds to the thirteenth place. One can see that mortality levels have risen everywhere since 1982 and BO changed from tenth position to third while in many others the situation became worse, for instance in Tulsckaya oblast.

For the past decade reduction of lifetime expectancy of rural males in BO was more substantial than that for the population at large but not for females (Table VI).

there are more important factors responsible for the shortening of lifetime than radiation. In towns the situation in BO is better than in Russia (Table VI).

3. 4. Mortality from different reasons.

In connection with radiological consequences of the accident the public is very anxious about cancer mortality. In fact it does grow in the oblasts of interest; also in all other regions in CER. For the period 1982-1994 in rural areas in BO standardised indexes (all site neoplasms) increased from 131 to 171 deceased person per 100,000 against 150 and 185 in control population in 4 unaffected neighbouring oblasts.

Statistics show that standardised cancer mortality rate in BO population has been one of the lowest one in CER in the period 1982-1994. For example, in 1993 BO held the second place (rank = 2) among 13 others in 1993. Besides, there is no any correlation between growth of mortality and average individual or collective doses: Orlovskaya, Tulsckaya and Kaluzhskaya oblasts held 3, 7 and 10 places correspondingly. And in oblasts of interest rates of cancer mortality growth prior to and after the accident were the same statistically.

Analysis of test to reference population index ratio displayed that at 95.5% significance level cancer mortality standardised indexed grew in rural subpopulation in BO more rapidly than in control (0.8% a year). Having the better situation with the other indexes it is reasonable to attribute this fact to special attention to cancer problems and better cancer certification in the affected areas ⁽⁹⁾.

Certainly, epidemiological researches and statistics of cancer incidence will give more convincing data on stochastic effects of radiation exposure. But as to people health statistics recent increase of accidental

Table VI. Average expected lifetime in rural and urban areas in tested and reference territories (years)

Territory	1982/83		1992/93	
	Rural	Urban	Rural	Urban
Bryanskaya oblast				
Males	61.7	64.8	58.6	62.3
Females	72.4	72.8	72.0	71.8
Russia				
Males	59.8	63.1	59.4	61.0
Females	73.0	73.7	70.6	71.4

mortality (accidents, injuries, poisoning etc.) causes more alarm than does cancer mortality. Since 1987 standardised accidental mortality indexes have increased 5 - 6 times everywhere as cancer mortality increase was well beyond that (less than 30% for the same time). As a result approximately equal number (in some oblasts even more) of people die in accidents and from cancer nowadays although ten years ago the proportion was 2:3.

The most frequent cause of accidental death is acute alcoholism (24% in BO, 16% in CER, 15% in Russia, 1994), suicides rank next in frequency (10-15%). Although data are not available it is reasonable

to think that the situation is even worse as people there have extra money as a compensation from government for being irradiated.

Another reason for the rapid increase in mortality rates in the past few years was the disorganisation of the state health surveillance resulting from economic difficulties. In villages it has never been good and is now about to disappear. Although there were no marked changes in provision of doctors and beds in hospitals (Table VII) it did not reflect the real situation.

Table VII. Provision of doctors and beds (per 10, 000)

Territory	doctors			beds		
	1985	1989	1993	1985	1989	1993
ZR			20			136
BO	33.1	35.6	36.7	128	140	127
CER	58.2	59.7	50.7	136	141	130

Number of doctors in contaminated areas is about half as many as in BO as a whole so there is no much benefits for the affected people in excess of beds in hospital. According to some indirect indexes the health care in rural areas was adversely affected everywhere in CER ⁽⁸⁾. For instance, in rural areas in Ryazanskaya oblast index reflecting the accessibility and quality of medical surveillance dropped by almost 1000 times in the past decade. In villages in BO it was

3 times only, possibly owing to more attention being paid by federal and local administrations to health care in connection with the accident.

3. 5. Prognosis up to 2010

Calculations of perspective population size and age-sex structure were made to follow the future demographic development in BO and in whole Russia. To do that we used method of movement of age distribution with one year interval. Under unstable social situation and economic difficulties the demographic situation will very much depend on dynamics of such economic factors as national income and national product. If optimistic scenario realises ⁽¹⁰⁾ recession in industry will be overcome in 1996 and pre-crisis level of economics will be restored by 2000 followed by national product steady increase by 3.5% a year. In this case by 2010 living standard of the population will be about the present one of EC population. Pessimistic scenario imitates prolonged economic stagnation till 2000 and about 20-year time delay in restoration of living standard.

Experts in demography predict further drop in birth-rate till the beginning of XX century, by that time percentage of one-child families in the population at large will run to 40-50% and of childless families - to 30-35%, by 2010 the situation won't be a great deal better (50 and 15-20% correspondingly) in case of pessimistic scenario ⁽¹¹⁾. If economic reforms are in progress birth-rate may show compensative growth. Infant mortality being at the present-day level or even higher for next 10 years will decrease by 2010 in optimistic scenario only. Specialists do not see chance for drop in mortality rate till 2000. At best, some reduction is possible near 2010.

Based on these estimates we calculated some characteristic parameters for BO population and national averages under optimistic and pessimistic scenarios. Migration was omitted because of highly unpredictable character of the process. Briefly results are as follows. Depopulation will be overcome, at best, by 2010 both in BO and in Russia. Under stagnation conditions drop in size of population will be more significant in BO (up to 15-20% and 5-10% in Russia). Number of women of fertile age will increase till 2003 (by 2-3% in BO and 1-2% in Russia) and then decline all over Russia in any case. And in pessimistic scenario low birth-rate will contribute to depopulation along with high mortality rates.

We concluded that further changes in demographic situation being not very sizeable will be more adverse in BO since its population is 'older' and therefore, more sensitive to negative factor influence. For example, percentage of old people (older 60) in population in 1994 was 20.7 in BO and 16.7 in Russia. By 2000 in pessimistic scenario it will increase by 1-2% and then decline up to 16-18% in BO and 14-16% in Russia in 2010. Population will rejuvenate at the sacrifice of old people dying out. And it will be more intensive in BO than in Russia. In optimistic scenario BO will be again in worse situation as by 2010 every fourth will be older 60, that will cause losses in labour reserves and require additional financial support of medical and social surveillance of old people.

3. 6. Emergency workers.

Analysis of published data on liquidator health statistics⁽⁴⁾ against the background of population statistics discovered particular important points.

Temporal changes. The disadvantageous tendencies typical for population act for EW too, in particular alcohol-dependent hypermortality of working-age males mentioned above. That explains to some extent increase of mortality indexes in the cohort.

While the negative trends are in progress EW get older with time. Changes that occurred in liquidator health conditions for the past 10 years just due to that reason were appreciable. It is well known that total

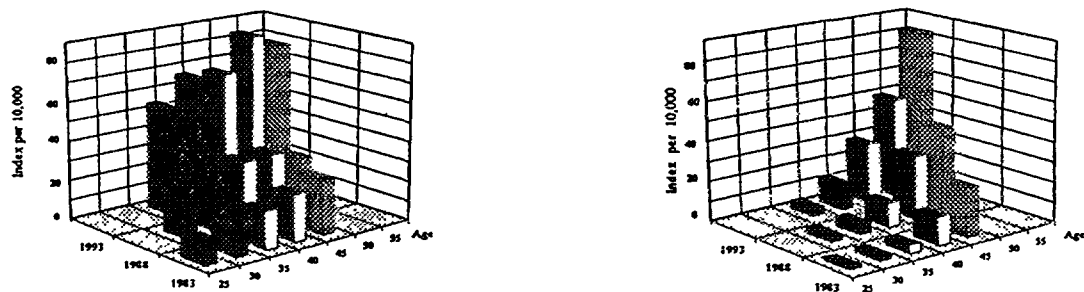


Fig 6. Accidental (left) and cancer (right) mortality rate, rural males in Tulskeya oblast

mortality intensity increases exponentially with age and even more rapid for cancer mortality. For instance, cancer mortality index doubles in going from age group 40-44 to the next group 45-49. Fig. 6 demonstrates with rural male subpopulation of Tulskeya oblast (where approx. 10% of EW live) that in case of accidental mortality (accidents, injuries, poisoning etc.) social and economical difficulties make greater impact than the 'ageing effect' while in case of cancer mortality the latter is the crucial factor.

Spatial distribution. EW live in all regions of Russia but in different proportions: about 18% in CER, 21% in Northern Caucasus Region, 16% in Ural Region etc. ⁽⁴⁾. Russia features strongly pronounced distinctions in character of demographic development of different regions, that is determined by social and economic variations, ecological factors, national traditions and habits, and different levels and quality of medical aid. As a result even standardised mortality indexes deviate widely (up to 2 times) through this country. It is seen in Fig. 7 where the territorial variety of total mortality rates (standardised indexes) with urban males in all provinces in 1992 and 1993 is shown. Territories are ranked according to index in 1992 and for every one there is a corresponding value in 1993. A spread of values ranged up to 100% in 1992 and became even more in 1993. Lowest mortality rates were fixed in Northern Caucasus provinces and the highest in Far-East Region. Note that in 1993 mortality increased all over Russia.

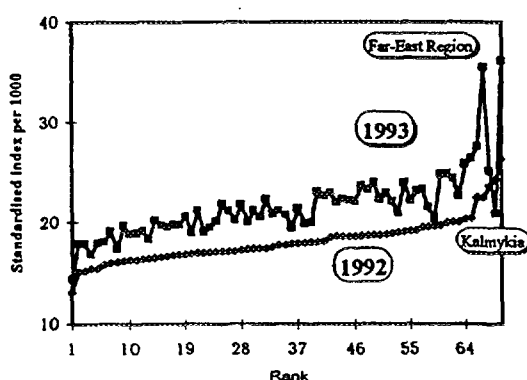


Fig. 7. Urban male total mortality rate distribution through all provinces of Russia.

Table VIII. Total mortality rates for EW cohort and reference groups in different regions, per 1000.

	Min	EW ⁽⁵⁾	Russia	Max
1991	5.3	5.1	7.6	11.1
1993	7.7	9.5 (12.2*)	11.8	17.7

* EW exposed in 1986.

Table IX. Disease incidence for EW cohort and population in different regions, 1992, per 10,000.

Disease	Min	Russia	EW	Max
All site neoplasms	2.4	5.9	7.3	10.4
Malignant neoplasms	1.3	2.7	2	3.4
Endocrine system	1.6	4.2	4.7	9.6
Hemogenetic system	0.7	1.9	3.8	7.9

Territorial variations through one economic region may be considerable as well. For instance, in CER for crude index maximum to minimum ratio showed variations in the range 1.33 for cancer mortality, 1.77 for accidental mortality, 2.7 for respiratory system diseases mortality and 12.3 (!) for mental diseases mortality in 1993. Obviously in such a case one should not take average over economic region but use a proper weighting factors when compare liquidator statistics with population reference group statistics.

Social factors. Many other factors like living in town or country, belonging to certain social group etc. should be taken into account in comparison study of that kind. For example, in some oblasts average expected lifetime for urban males was more than 5 years above than that for rural males (5.5 in Kaluzhskaya oblast, 1993). Pauperisation of pensioners was many times the working people. According to results of selective questioning of among EW conducted in 1994 pensioners were 50% of them but only 20% were of pensionable age⁽¹²⁾. Amongst able-bodied people those who work in State institutions become poorer while business men improve their welfare.

Comprehensive study of EW health is in the future, in this report we show the effect of 'spatial distribution' only. In Table VIII total mortality crude index of EW is compared with that of reference groups (see Materials and Methods) in different regions in 1991 and 1993. EW values were well below the Russia reference group values. The scatter in the indexes through regions was considerable and even very high value of EW of 1986 was substantially below the maximum value (Tyva Republic).

Table IX presents disease incidence for EW cohort and for total population in Russia and peak values. This is the diseases that caused most agitation as to EW health statistics. In all cases EW values are about in the middle of the range limited above and below by peak values.

Relatively good situation with EW health statistics might be a result of special medical surveillance and better clinical examination. However, high proportion of registered invalids among EW and rapid increase that number reported recently, in particular among those who took part in decontamination work in 1986, pointed to certain social and psychological problems being in progress. That may reflect on EW health conditions in near future.

4. CONCLUSIONS.

To summarise, we can say that in the past decade the demographic situation in contaminated areas has been developing in a bad way just as in unaffected territories. Some departures from common tendencies arose from changes in numbers of country people living in the most contaminated areas (ZR). Due to the compensations and economic privileges, which are particularly inviting in severe economic crisis conditions, positive migration increases were higher than in other oblasts in CER. Relocation measures have changed age structure of the affected population so that being a constituent of 'old' population living in CER it is even 'older' than the population at large.

In some respects the most contaminated areas were in a better situation than unaffected ones. Disadvantageous trends in birth-rates and total mortality rates seen in the years following to the accident developed a little more slowly in the zones of interest. According to cancer mortality indexes in CER the situation in BO is not at all bad. Rapid growth of accidental mortality causes more alarm than the dynamics of cancer mortality. There are some reasons to believe that in BO and in the most contaminated areas the prompt attention paid to detect medical consequences of the radiation exposure have mitigated the effect of overall disintegration of medical surveillance, typical all over the country. It can be concluded that the deviations in demographic development of the affected population from a common trends might be attributed to the influence of nonradiation factors arising from countermeasures and at the level of population statistics an influence of radiation has not been revealed yet.

By virtue of excessively 'old' age structure affected population is more sensitive to social and economic changes than the population at large. If economic stagnation continues in near future BO is threatened with more intensive old people dying out followed by certain rejuvenation of the population. If more optimistic scenario realises noticeable increase of old people portion in total population will demand special social and medical care of pensioners.

Against the background of negative common trends EW health statistics is not as bad as the public believes if correct reference group from population is taken. To form control group for EW cohort one should take proper age-sex group from population with the same social status and take into account drift of indexes in time, ageing of the cohort, wide territorial dispersion of indexes etc. Only if the control group meets all these criteria one can discuss role of radiation induced health effects in EW statistics. It should be noted that the build-up of social and psychological problems of liquidators in recent years may affect their health conditions eventually. So, we can establish that the most acute problems of both EW and affected population are in social, economic and psychological spheres but not of radiological nature.

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**IMMUNOLOGICAL AND EPIDEMIOLOGICAL INVESTIGATIONS
IN REGIONS CONTAMINATED BY RADIONUCLIDES AFTER THE
CHERNOBYL ACCIDENT**



XA9745480

V.M. SHUBIK
Institute of Radiation Hygiene,
St. Petersburg, Russian Federation

The views of researchers and physicians on the aftereffects of the Chernobyl accident are contradictory. Numerous publications indicate disorders in immunity and health in the residents of the radiocontaminated areas. However, a number of leading specialists in radiation medicine and radiobiology point to the fact that at low level ionizing radiation to which is mostly exposed population in the contaminated regions the disorders of health are usually lacking.

The existing contradiction may be solved if the clinical and epidemiological evaluation of health would be supplemented with results of unprejudiced methods of investigation. As such immunology provides unique possibilities. Although individual immune characteristics can vary notably, some of them are singularly radiosensitive. Radiation immune disturbances play important part in development of early and late consequences of the radiation effect (cancer, infections, sight disorders, disorders of reproductive function etc). Immune disturbances are nonstochastic. To prove that the disease developed after the accident is due to radiation effect it is necessary to reveal the dependence of its rate and severity on radiation dose, to establish this dose-response relation for the immune reactions.

Data on dose-response dependence in immune disturbances or on relation of immune disorders and the level of radiocontamination are very few and not always convincing.

We have carried out in Novozybkov district of Bryansk region, Russia, immunologic inspection of residents with simultaneous evaluation of radionuclides content in the body and individual dose burden. We have not found any correlation between the dose and immune characteristics: amount of T and B lymphocytes, antibodies level.

Only 3 months after the accident increased level of antibodies against thyroid antigens, thyroglobulin and microsomes was found at thyroid doses over 75 cGy (Table 1).

Table 1. Antibodies against thyroid antigens induced by radioiodine in children 3 months after the Chernobyl accident.

Antigens	Thyroid dose (cGy)		
	Up to 15	15-75	75-200
Thyroglobulin	10 ± 2	8.5 ± 0.5	18.5 ± 5
Thyroid microsomes	4.5 ± 2	6.5 ± 2.5	$30 \pm 11^*$

Note. Mean reciprocal values \pm mean error.

*Difference from corresponding data for group exposed to radiation dose less than 15 cGy is statistically significant, $p < 0.05$.

As seen from Table 1 at thyroid doses of 75-200 cGy the antibody titers with respect to thyroglobulin and microsomes were 2 -6.5 times higher than in children exposed to doses less than 15 cGy. The rise in content of antibodies specific for microsomes was statistically significant, $p < 0.05$. The dose of 75 cGy is a threshold for development of thyroid autoimmune reactions.

Autoimmune reactions were still recorded 7 years after the Chernobyl accident (Table 2). At thyroid hyperplasia (HTG) the increased amount of antibodies against thyroid antigens was demonstrated by the reaction of passive hemagglutination and by immunoenzymometric assay.

Table 2. Antibody titers at thyroid hyperplasia (HTG)

Place of examination	HTG	Reciprocal Antibody Titers			
		Passive hemagglutination		Enzyme immunoassay	
		Thyroglobulin	Microsomes	Thyroglobulin	Microsomes
Novozybkov	Yes	14.5±1.5 ^{***}	11±1.5 [*]	13.5±9	3.5±1
	No	3.5±1.5	1.5±1.5	0	1±1
Surazh	No	7±1.5	5±2	7±6.5	2±2

Note. *, *** Difference from the corresponding data for the reference group (Surazh) is statistically significant, $p < 0.05$; 0.001.

The investigations performed in Novozybkov and neighbouring Surazh (town free of radiocontamination, reference) show, that at thyroid hyperplasia the titers of antibodies against thyroid antigens are higher than in persons unaffected by this disease. The difference from the reference value of the figures obtained by reaction of passive hemagglutination were statistically significant. These findings support the assumption on the role of autoimmune processes in development of goiter, and on importance of radiation in thyroid pathology.

Reaction of inhibition of leukocytes migration demonstrated sensibilization of lymphocytes against thyroglobulin and thyroid microsomes, thus revealing autoimmune disturbances both of humoral and cellular type which presumably result from the effect of radioiodine. However, the factors favoring goiter endemy in the Novozybkov district should also be taken into consideration.

Our analysis of dynamics in development of malignant tumors in the contaminated districts of Bryansk region has not revealed any consistent relation between the level of soil contamination and cancer mortality. The significance of radiation for development of thyroid cancer also requires further proofs. We have observed increase in goiter morbidity, in particular, of its nodal forms, at higher levels of radiocontamination and higher thyroid doses.

Table 3. Morbidity of intestinal and droplet infections in children before and after the Chernobyl accident.

Diseases	Morbidity per 10 thousand children ($M \pm m$)	
	Before accident	After accident
Dysentery	68.3 ± 8.7	30 ± 7.5
Acute intestinal infections	83.9 ± 3.6	87.2 ± 5.5
Measles	6.2 ± 1.7	17.3 ± 14.6
Whooping cough	3.5 ± 1.8	2.2 ± 0.9

Note. $M \pm m$ is mean annual figure \pm mean error.

In Table 3 are presented comparative data on morbidity of intestinal and droplet infections in children before and after the Chernobyl accident. As can be seen from Table 3, no connection is

observed between morbidity of intestinal infections including dysentery and factors due to the Chernobyl accident. The number of dysentery cases in the contaminated areas of Bryansk region even decreased after the accident (statistically significant data). Although the measles morbidity after the accident seems higher, the variations in morbidity between years are greater, and thus this figure is statistically insignificant. Moreover, we carried out evaluation of postvaccination immunity against measles and did not observe any relation of the findings to the radiation dose.

After the Chernobyl accident in radiocontaminated regions including Novozybkov district some rise in morbidity of acute respiratory diseases (ARD) was recorded. These diseases are known to be influenced by immune distortions. We are inclined to consider the rise in ARD morbidity as a result of combined effect of ionizing radiation, stress, and chemicals in foodstuff. The high level of food contamination with pesticides and nitrates was shown by Bryansk regional and Novozybkov town sanitary control. It is also known that high level of anxiety was registered in over 70% of residents of Novozybkov.

Our experimental studies described in the monograph of 1987 showed that such combined action can result either in independent operation of the factors and even in antagonism, or in their summation and potentiation. The latter effects are practically significant, and they presumably play part in immunity and health disorders observed at the contaminated territories.

The possibility of such effects was found in observations on animals kept in vivariums placed in the 10-30 kilometer zone around Chernobyl Nuclear Powerplant as compared to animals who remained in "clean" vivariums. Immune distortions in the former case were recorded at 10-fold lower radiation dose than in the

latter. Similar difference exists between the doses that caused immune distortions in the victims of the Chernobyl accident, and those of the accident in South Ural. But after the Chernobyl accident both animals and humans were subjected to combined action of radiation and nonradiative factors (toxic chemicals, stress etc). In South Ural the latter factors operated to notably lesser extent.

It is presumable that the disorders in immunity and health after the Chernobyl accident result from the combined effect of radiative and nonradiative factors. Only the thyroid disorders are due mostly to radiation influence, but here also may operate factors favoring development of endemic goiter.



STATE OF HEALTH OF THE CHERNOBYL ACCIDENT CLEAN-UP PERSONNEL, THE POPULATION OF CONTAMINATED AREAS AND PERSONS INVOLVED IN NUCLEAR WEAPONS TESTING

Eh.V. MOKROUSOVA, Eh.G. KUTERGINA, K.O. PROKOF'EVA
Institute of Radiation Hygiene,
St. Petersburg, Russian Federation

V.B. KARPOV, N.G. YAKOVLEVA, L.V. ZAMANOVA
St. Petersburg Scientific Research Institute for Radiation Hygiene,
State Committee of the Russian Federation for Epidemiological Monitoring,
St. Petersburg, Russian Federation

НЕКОТОРЫЕ ОСОБЕННОСТИ СОСТОЯНИЯ ЗДОРОВЬЯ ЛИКВИДАТОРОВ АВАРИИ НА ЧАЭС, НАСЕЛЕНИЯ ЗАГРЯЗНЕННЫХ ТЕРРИТОРИЙ И ЛИЦ, ПРИНИМАВШИХ УЧА- СТИЕ В ИСПЫТАНИЯХ АТОМНОГО ОРУЖИЯ

Санкт-Петербургский НИИ радиационной гигиены ГКСЭН РФ
Карпов В.Б., Яковлева Н.Г., Мокроусова Э.В., Заманова Л.В.,
Кутергина Э.Г., Прокофьева К.О.

С 1986 года сотрудниками СПб.НИИ радиационной гигиены совместно с врачами Диспансера радиационной профпатологии и Областной больницы проводится наблюдение за состоянием здоровья ликвидаторов аварии на ЧАЭС, проживающих в Санкт-Петербурге и области (около 5 тыс. человек). Специальное медицинское наблюдение включало в себя анализ доз внешнего облучения, определение содержания радиоцезия в организме (включая измерения ОИЧ), осмотр врачами-специалистами, психологическое тестирование, ЭКГ и ЭЭГ исследования, цитогенетические, морфоцитохимические и др.

Средние дозы внешнего гамма-облучения ликвидаторов составляли в 1986 г. - $19,4 \pm 0,46$ сГр, 1987 г. - $12,3 \pm 0,56$ сГр, 1988 - $2,1 \pm 0,71$ сГр. Суммарная активность цезия в организме у большинства обследованных не превышала 0,5 мКи, максимальные значения составляли в 1986 - 3,3 мКи, 1987 - 2,1 мКи, 1988 - 1,7 мКи. В 1990-94 гг. у 80% обследованных содержание цезия в организме не превышало 20 нКи.

В первые 3 года после аварии наиболее частыми были функциональные заболевания нервной и сердечно-сосудистой систем - астено-невротический синдром, в сочетании с вегетативной дисфункцией, и нейро-циркуляторная дистония (у 22,4% ликвидаторов 1986 г.), заболевания органов пищеварения (у 17,2%), заболевания сердечно-сосудистой системы (у 15,3%) и др. У ликвидаторов 1986 г. по сравнению с 1988 отмечалось большее количество лиц, имевших те или иные заболевания (82,1%), большее количество случаев гипертонической болезни и функциональных заболеваний нервной системы. В последующие годы отмечалось увеличение числа заболеваний желудочно-

-кишечного тракта, сердечно-сосудистой системы, органов дыхания, костно-мышечной системы и др.

По результатам анкетных исследований было определено, что среднее значение уровня личностной тревожности у ликвидаторов 1986 г. (43,3 балла по шкале Опилбергера) были близки к граничному значению для высокого уровня тревожности, низкий индивидуальный уровень тревожности отмечался у 3,1% обследованных. Наиболее частыми были жалобы на головные боли, раздражительность, повышенную утомляемость, нарушения сна. Около 80% опрошенных связывали ухудшение своего здоровья с аварией на ЧАЭС.

Анализ изменений ЭКГ показателей свидетельствует, что у ликвидаторов 1986 г., по сравнению с 1988 отмечается большая частота нарушений сердечного ритма в форме синусовых аритмий и брадикардий (у лиц моложе 40 лет), нарушений проводимости и наличие единичных экстрасистол (в более старшем возрасте). В динамике отмечается увеличение числа нарушений проводимости.

При анализе гематологических показателей у ликвидаторов было определено некое снижение количества тромбоцитов, лейкоцитов и эритроцитов, а также увеличение количества клеток с качественными структурными изменениями (двухъядерных лимфоцитов и гиперсегментированных нейтрофилов). У ликвидаторов 1986 г. отмечалось 2-4-х кратное увеличение числа этих клеток по сравнению с доаварийным уровнем. В дальнейшем наблюдалась нормализация показателей.

Согласно результатам исследований 1992-93 гг., средняя частота хромосомных aberrаций у ликвидаторов 1986 г. при дозах II-25 cГр составляла $4,0 \pm 0,6$, дицентрических хромосом - $0,11 \pm 0,04$ на 100 клеток, число микроядер $49,2 \pm 2,0$ на 1000 клеток, что свидетельствует о постепенном снижении цитогенетических изменений.

Проведенный анализ динамики заболеваемости около 10 тыс. работающих жителей г.Новозыбока Брянской области (плотность загрязнения по $Cs > 15 \text{ Ки/км}^2$) в 1983-92 гг., показал увеличение общего числа случаев заболеваний в 1986-88 гг. по сравнению с 1983-85 гг. В послеаварийный период было определено достоверное увеличение числа заболеваний нервной и костно-мышечной систем, числа дней нетрудоспособности при осложнениях беременности и заболеваниях почек, а также снижении числа случаев пневмонии.

Согласно результатам цитогенетического обследования 75 человек, подвергшихся радиационному воздействию при испытаниях ядерного оружия и радиационных авариях 20-45 лет назад, часть из которых перенесла в прошлом лучевую болезнь, средняя частота хромосомных aberrаций составила $6,86 \pm 0,26$, количество дицентриков $0,70 \pm 0,10$, центрических кольцевых хромосом - $0,04 \pm 0,03$ на 100 клеток, количество микроядер $52,37 \pm 2,62$ на 1000 клеток, что существенно превышало показатели контроля. У 41,3% обследованных ЧХА составляла 8 и более, при количестве дицентриков $1,36 \pm 0,17$ на 100 клеток.

Полученные данные свидетельствуют о комплексном влиянии факторов аварий на ЧАЭС (радиационного, психо-эмоционального и других) на состояние здоровья человека.

PREVENTATIVE ANTICARCINOGENIC TREATMENT USING ANTIOXIDANT IMMUNOPROTECTIVE PREPARATIONS

L.P. VARTANYAN

Central Research Institute of Roentgenology and Radiology,
St. Petersburg, Russian Federation



XA9745482

G.Y. DUBUR

Institute of Organic Chemistry,
Riga, Latvia

T.V. PONOMAREVA, E.I. IVANOV, G.N. MERKUSHEV, M.I. BOKK

Institute of Radiation Hygiene,
St. Petersburg, Russian Federation

METHODS

On experimental model of external and internal exposure simulating various post-accidental situations, the effects of nitrogen - containing heterocyclic compounds with antioxidant and antiradical properties have been studied. The following irradiation schemes were used:

- Chronic gamma-exposure with dose rates of 0.25 and 0.50 Gy per week with accumulated dose 19 and 25 Gy.

- Continuous prolonged exposure with accumulated dose 10 Gy per month.

- Fractionated X-ray exposure 20 times per month, accumulated dose 10 Gy, with preliminary 2 days before single local 10 Gy exposure of the thyroid.

- Oral administration of ^{137}Cs (18.5 kBq/kg) every two months during 1.5 years. After 10 times administration for 600 days accumulated dose exceeded 21.0 Gy.

Survival rate, lethality dynamics, mean life span, cause of death and tumour induction rate have been registered as well as routine immunological, hematological and biochemical data.

RESULTS

The administration of the studied antioxidant compound as food additive increased the life span by 10-20. % in irradiated and non-irradiated animals showing the general positive gerontological effect (Fig.1a and 1b). At all levels of lethality of irradiated animals the mean life span was 2-2.5 months longer after the treatment in comparison with irradiated controls, and after exposure the effects of shortening of life span was diminished by 2 times. These data were statistically significant.

The mean life span is directly interrelated with lethality dynamics, and effect of antioxidant compound on this indicator has been confirmed, as for instance in the experiments with internal ^{137}Cs exposure (Fig.2). Lethality dynamics after 6 months of ^{137}Cs administration practically did not differ from intact controls. At the same time lethality of exposed animals without preparations significantly increased up to 24 %.

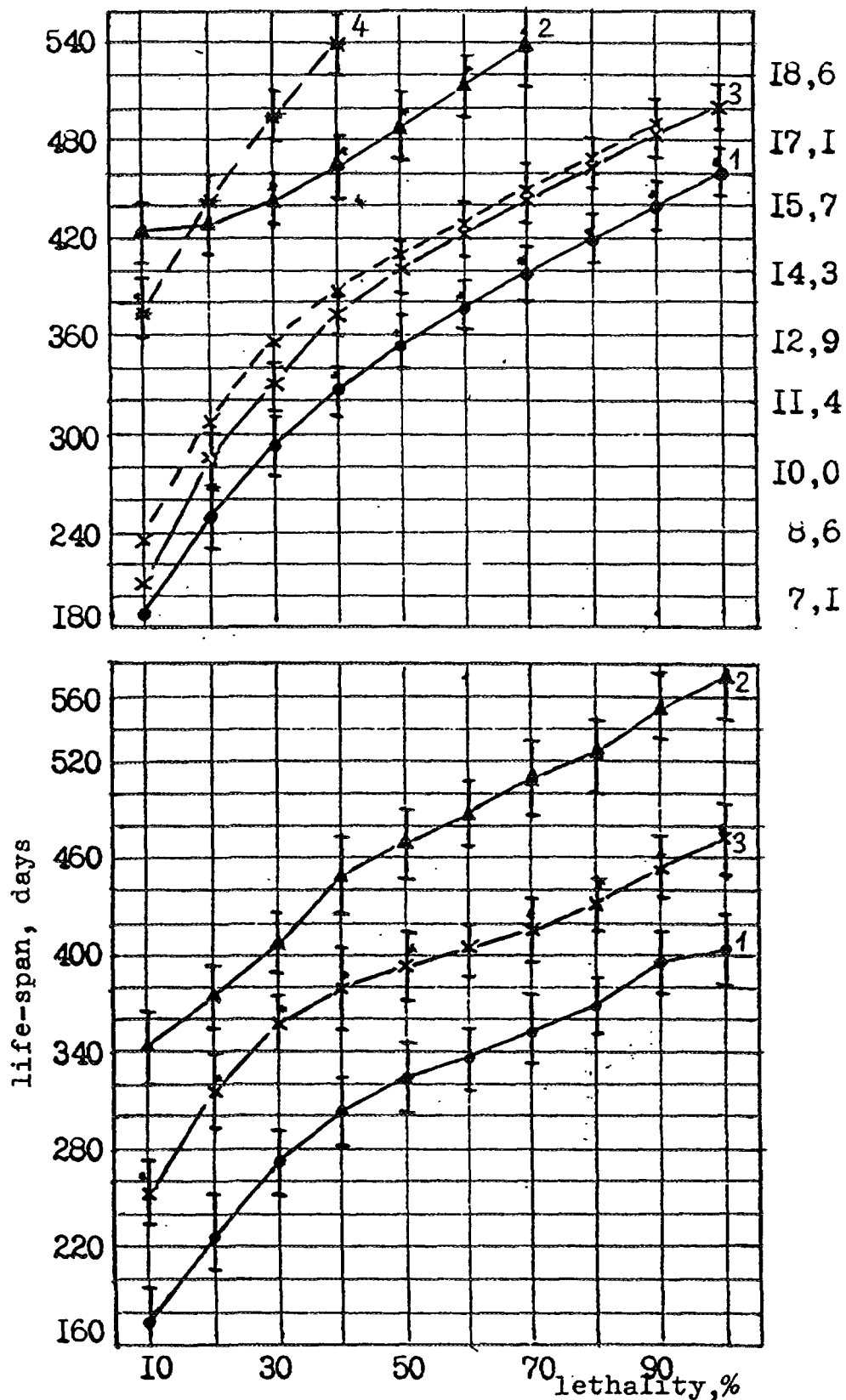


Fig. 1
Life-span after chronic gamma-exposure of mice
0.25 Gy/week (A); rats after fractionated X-ray
exposure (10.0 Gy accumulated) (B)
1. Irradiation
2. Control
3. Irradiation+compound
3-1. Irradiation+compound 1mg/kg
3-10. Irradiation+compound 10mg/kg
4. Compound

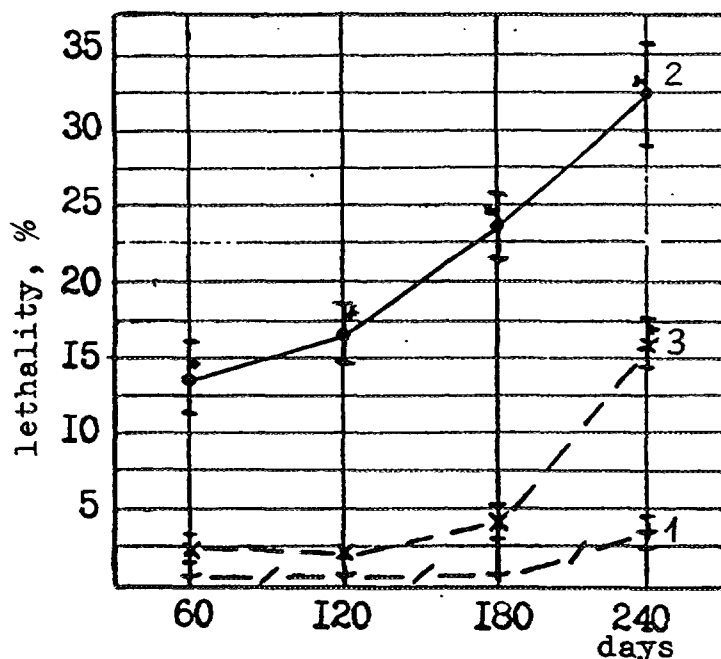


Fig. 2
Lethality after internal exposure (^{137}Cs , rats)

1. Control
2. ^{137}Cs administration
3. ^{137}Cs and compound administration

The lethality of treated animals at 240 days corresponded to that of nontreated group at 120 days (4 months advantage) and was two times lower than in the exposed controls at the same period.

The study of the compound effect on carcinogenesis first of all revealed 1.9 times lower incidence of spontaneous tumours in non-irradiated mice than in intact animals during 1.5 years of observation with some extension of life span (Fig.3). After protracted gamma-exposure and compound administration a number of animals with tumours was 1.7-2 times lower than in irradiated but not treated rats.

Similar data have been obtained in cases with fractionated X-ray exposure. The effectiveness of the compound was mostly pronounced after 15-18 months, when lethality reached plateau. At this time tumorogenesis was inhibited by 2-2.5 times and corresponded to the levels in intact animals. The period of cancer mortality in treated animals was postponed up to 4-9 months (Fig. 3b), that indicated the maximal anticarcinogenic effect. In most experiments the highest effectiveness of antioxidants was observed after 1.5 years and later, when in irradiated control group a number of animals with tumours was at highest level. Fig. 4 presents data on a number of tumour carriers after 1.5 years in various chronic exposure models in comparison with irradiated non-treated and intact control groups taken as 100 % level. In all types of exposure with different doses of the administered antioxidant, significant anticarcinogenic effect has been observed, including the effect on spontaneous carcinogenesis (reduction of a number of tumours by 1.5-1.9 times) (Fig. 4).

The antioxidant also decreased the proportion of malignant tumours by 2-3 times and number of animals with multiple tumours (Fig. 4b). After sublethal exposure the antioxidant was highly effective in the improvement of general health indicators of the animal, such as weight increase, 30 % decrease of immunodepression, 1.5 times lower the leucopenia and some biochemical indicators.

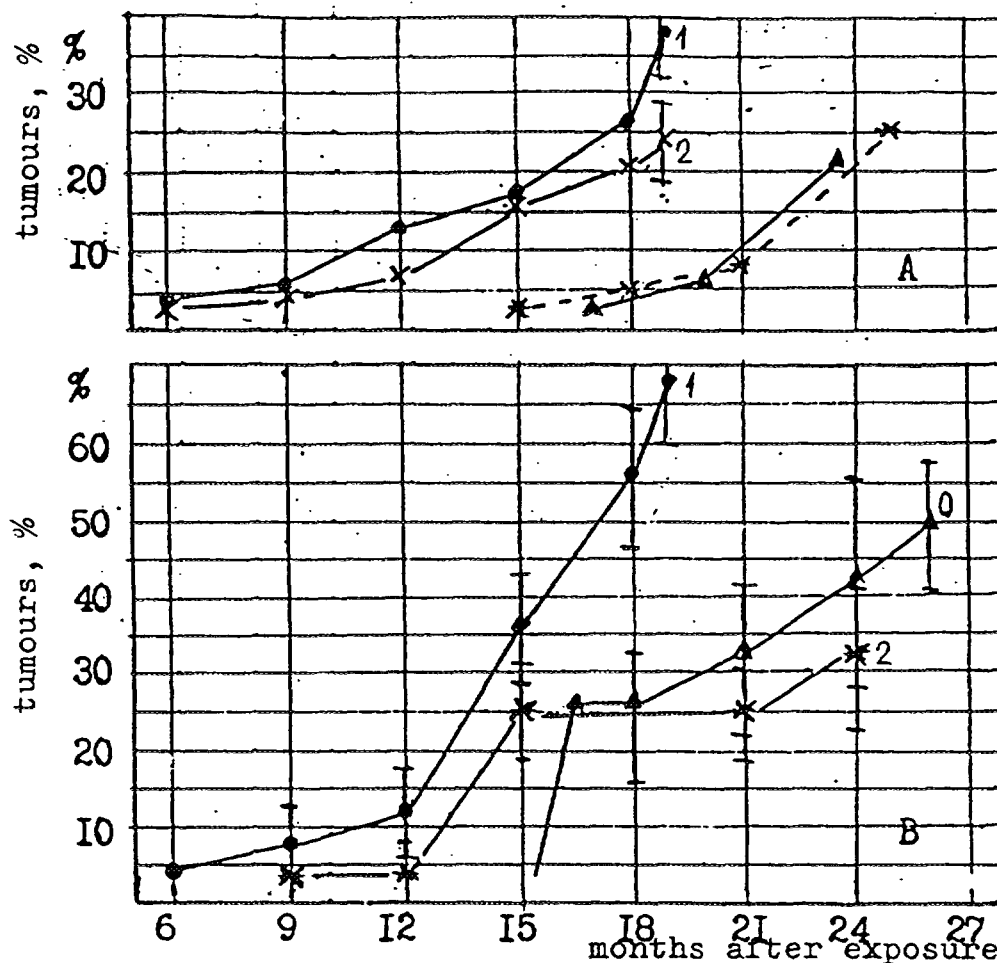


Fig. 3 a, b

Tumour induction in rats after protracted gamma-exposure (10 Gy accumulated) - A; fractionated X-ray-exposure (10 Gy accumulated) - B

- | | |
|----------------|-------------------------|
| 0. Control | 2. Irradiation+compound |
| 1. Irradiation | 3. Compound |

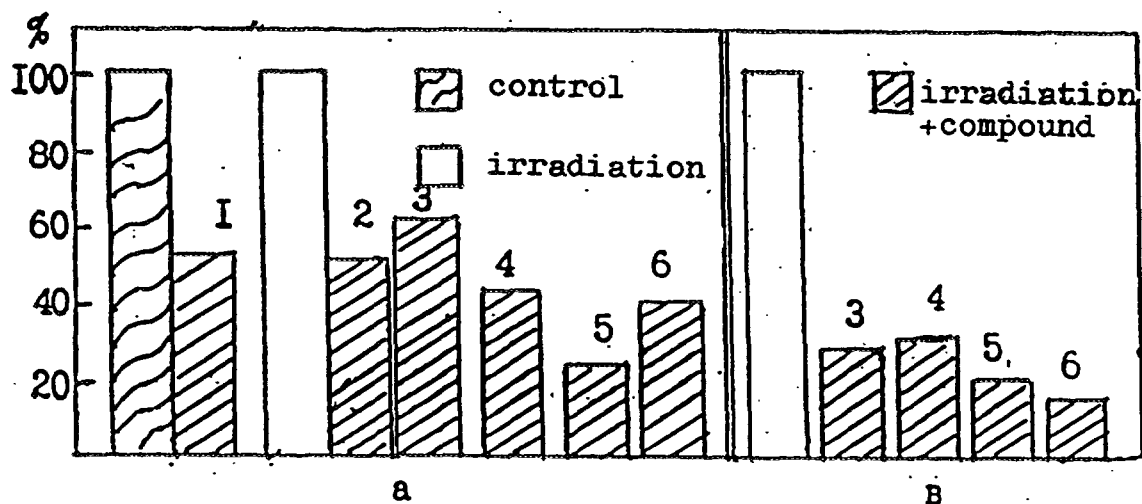


Fig. 4

Antioxidant compound effect on general number of tumours (A) and number of tumours (B). 1.5 years after exposure

- | | |
|------------------------------|----------------------|
| 1. Control | 4, 5. X-ray-exposure |
| 2. Chronic gamma-exposure | 6. Internal exposure |
| 3. Protracted gamma-exposure | |

SUMMARY AND CONCLUSION

1. The tested compound is non - toxic and effective in relation to life span prolongation, mortality decrease etc., including general positive gerontological effects.

2. As radioprotector, the compound is effective before and after exposure administration and could be used for prevention and treatment.

3. Compound is effective as a general anticarcinogenic agent for radiation-induced and spontaneous carcinogenesis.

4. The compound is non - toxic with the wide therapeutic spectrum in doses from 1.0-50.0 mg/kg of body weight and might be used as a food additive for a wide preventive distribution in population.

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CHANGES IN THE DYNAMICS OF HEMOTOLOGICAL INDICES ONE DECADE AFTER THE CHERNOBYL ACCIDENT: DATABASES, MATHEMATICAL MODELLING, MEDICAL DATA ANALYSIS

V.M. JANENKO, K.L. ATOEV
Glushkov Institute of Cybernetics,
Kiev, Ukraine



V.G. BEBESHKO, V.I. KLIMENKO
Institute of Clinical Radiology of NCRM,
Kiev, Ukraine

1. CLINICAL INVESTIGATION

The changes in dynamic of clinical and immunological indices of preleucoses and hemoblastosies one decade after Chernobyl accident was carry out. The results of retrospective estimation of leucoses frequency among participants of Chernobyl accident consequences elimination show, that level of disease has risen from 4.41 to 12.02 per 100000 men since 1987 till 1992 years. So, the radiation factor is one of most important in hemoblastosies dynamic activation. The investigation, that were elaborated in hematological clinic of ICINCRM, had demonstrated the complex of distinct clinical, morphological and functional changes in hemopoesys system for above mentioned group of patients. One of the form of hemopoesys system defeat, that precedes the tumor rise development, is mielodysplastic syndrom (MS). It is one of the important manifestation of preleucoses. The group with different forms of MS was distinguished among patients that were examined. 107 patients with stable hemopoesys - 12 of them with MS (6 cases were transformed in leucosies) and 120 patients with preleucosies were examined.

The correlation analysis of indices of peripheral blood, marrow bone and other clinical parameters for determination of additional criteria of different forms of MS prediagnostic was carry out.

The results, that were obtained show that most important for prediagnostic parameters are the hemopoesis signs, the number of blast elements and obvious dishemopoesis in marrow bone and peripheral blood. All other changes have less important significance.

2 MATHEMATICAL MODEL

The main regulation mechanisms of immune response include mainly the parameters which can be attributed to different links of regulation, that include antigen (Ag), pool of cells effectors, pool of cells-predecessors, immunocorrectors (ic) (cortizol, thymalin, vilosen), pool of cell-suppressors, active biological substances — heparin and histamine [1] In models of the interaction between the immune system and cells with antigen determinants (CAD), that indicate the level of environmental pollution, it is often difficult to recognize the picture of the immune system as it is changing under the action of various factors (including Ag). Adaptation of the immune system alters the activity of some of the links, while other links adequately (or inadequately) compensate these changes [2] . Therefore it is important to estimate the degree of change in the immune system by recognizing the state of the so-called immune status of the organism (ISO) as an evolving system [3] ISO usually refers to a function which characterizes the balancing of different links in the immune system, but at this stage we have no formalized model of the ISO and the mechanisms responsible for the interaction between links of the immune system have not been fully studied.

The evaluation of health detriment will carried out on the basis of proposition that the antigen level indicates the degree of environmental pollution, utilizing proliferation index S, which characterizes the degree of balance between subpopulations of effectors and suppressors cells

Let us define the following variables of model such as cells precursors (Y_P), effector T-cells (Y_E), cells with antigen determinants (Y_{CAD}) — characterize the impact of polluting factors in the food-chain on the vital functions of organism, T-suppressors (Y_S), heparin (Y_{HP}), histamine (Y_{HS}), calcium in cytoplasm (Y_{C1}), calcium in intracellular compartments (Y_{C2}), degree of phosphorylation of membranous proteins (Y_F), ic — the level of immunocorrectors, v_{C1} and v_{C2} are speeds of binding of Ca^{2+} ions by intracellular and membranous proteins respectively; parameters d_j ($j = \overline{0,4}$), characterize nonlinear effects of interconnection of Ca^{2+} ions at dephosphorylation of proteins; I_k ($k = \overline{1,2}$) are currents of Ca^{2+} through cell membrane from places of safe inside cell; α_F — quantity of Ca^{2+} ions, binding by systems of phosphorylation in one molecule of phosphorylating protein; a_l ($l = \overline{1,5}$), β_n , γ_n , τ_n ($n = \overline{1,2}$), ξ_m ($m = \overline{1,4}$), M , N — model parameters.

Then the mathematical model of interaction between immune system and environmental pollution for risk assessment of public health detriment can be presented as follows:

$$\begin{aligned}
 \frac{dY_P}{dt} &= (k_1 + d_1 ic) Y_{CAD} Y_P Y_{HS} - k_2 Y_P + (k_3 + d_3 ic) Y_P Y_E - (k_4 + d_4 ic) Y_{C1} Y_P Y_S; \\
 \frac{dY_E}{dt} &= (k_3 + d_3 ic) Y_P Y_E - k_5 Y_E - M k_6 Y_E Y_{CAD} (N - Y_S); \quad \frac{dY_{HS}}{dt} = k_{12} Y_E Y_{CAD} (N - Y_S) - k_{13} Y_{HS}; \\
 \frac{dY_{CAD}}{dt} &= k_7 Y_{CAD} (d_0 + d_2 Y_{11}) - k_8 Y_{CAD} - k_6 Y_E Y_{CAD} (N - Y_S); \quad \frac{dY_{C1}}{dt} = I_1 + I_2 - v_{C1} - v_{C2} + \alpha_F v_F; \\
 \frac{dY_S}{dt} &= (k_4 + d_4 ic) Y_{C1} Y_P Y_S - k_9 Y_S; \quad \frac{dY_{C2}}{dt} = v_{C2} - I_2; \\
 \frac{dY_{HP}}{dt} &= k_{10} Y_E Y_{CAD} (N - Y_S) - k_{11} Y_{HP}; \quad \frac{dY_F}{dt} = v_{C1} - \alpha_F v_F.
 \end{aligned} \tag{1}$$

where

$$I_1 = \alpha_1 [1 - \exp(-\zeta_1 t)] \exp[-\zeta_2 (t - \tau_1)^2], \quad I_2 = \alpha_2 Y_E Y_{CAD} (N - Y_S) Y_{C2} [1 - \exp(-\zeta_3 t)] \exp[-\zeta_4 (t - \tau_2)^2],$$

$$v_F = \alpha_3 Y_F, \quad v_{C1} = (\beta_1 Y_{C1} - \gamma_1 Y_{C1}^2), \quad v_{C2} = (\beta_2 Y_{C1} - \gamma_2 Y_{C1}^2)(\alpha_4 + Y_{HS})(\alpha_5 - Y_{CAD}).$$

We use the results of investigation [4] to estimate the proliferation index S , which characterizes the degree of balance between subpopulations of effectors and suppressors cells.

$$S = \frac{P_{Y7}}{(T_{MAX} - t_0)P_{Y4} + s_0} \tag{2}$$

Here T_{MAX} — time of maximum concentration of effector cells; P_{Y4} and P_{Y7} — respectively the general amount of effector cells and cells with antigen determinants, which participate in an immune response on interval $[t_0, T]$; s_0 — model parameter.

3. THE INVESTIGATION OF THE DIRECTIONAL EFFECT OF IMUNOCORRECTORS ON THE INTERACTION BETWEEN ANTIGEN, EFFECTORS AND SUPPRESSORS

The mathematical problem of the directional effect of immunocorrectors on the interaction between antigen, effectors and suppressors tests was formulated as a problem of dynamics: to determine the domains of the model parameter ic , corresponding to various immune responses. The analysis of model results has shown the existence of ic concentration intervals where immunocorrectors exert opposite influence on effector and suppressor cell populations. Results of investigation under different values of parameter ic are presented on Fig. 1. Increasing of immunocorrectors in the intervals $[0,1]$ decreases index ISO at chosen values of parameters and consequently increases reserve possibilities of immune system. Further ic increasing under condition when $ic > 1$, gives rise of index ISO and consequently increases reserve possibilities of immune system.

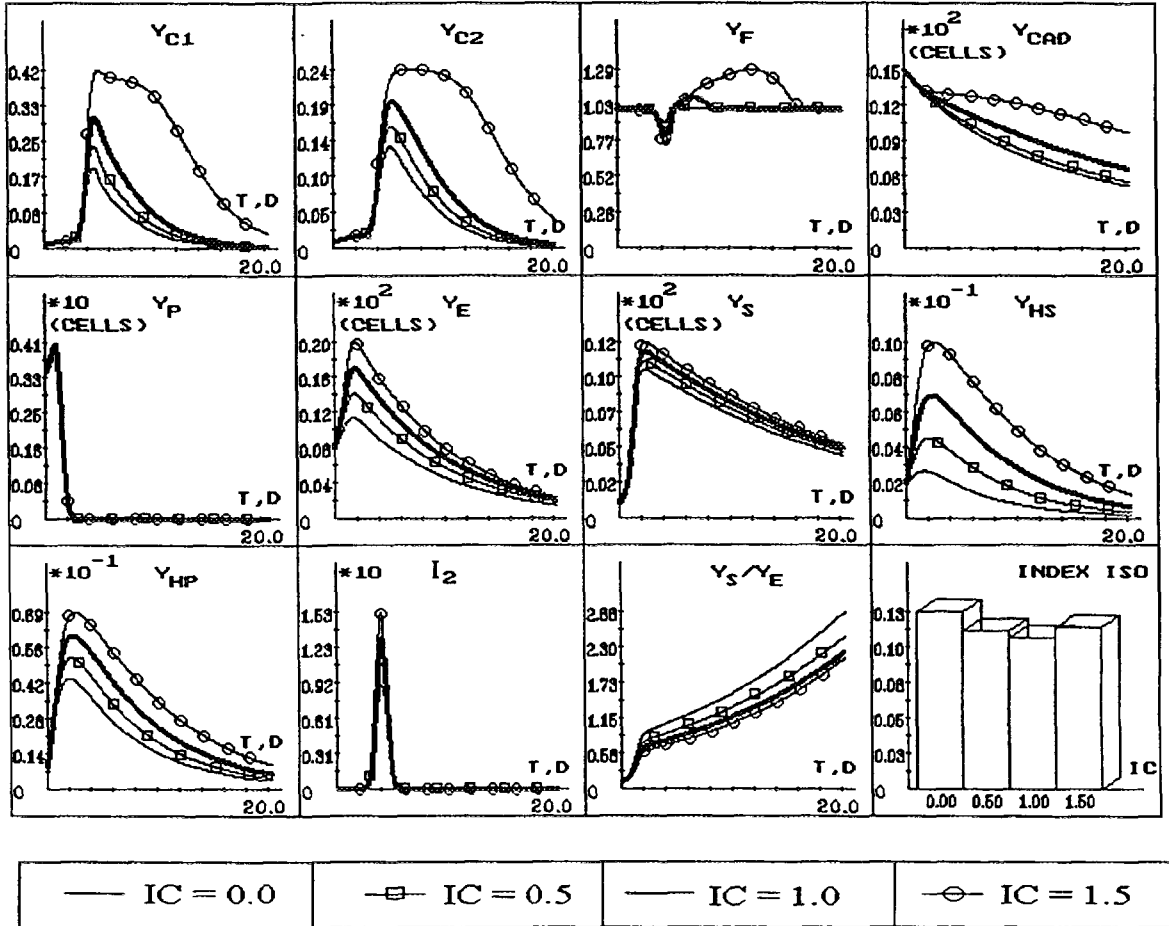


Fig. 1. Results of investigation under different values of parameter ic .

4. OPTIMAL CONTROL OF IMMUNE RESPONSE, PROVIDING PREVALENCE OF NORMALIZING EFFECTS OF IMUNOCORRECTORS

The problem of optimal control of immune response is formulated as follows: it is required to define control influence of ic , which minimizes functional:

$$S(t) = \frac{\int_0^T Y_{CAD} dt}{(T_{MAX} - t_0) \int_0^T Y_E dt + s_0} \quad (3)$$

at following limitations:

$$Y_P \in [Y_{Pmin}, Y_{Pmax}], Y_E \in [Y_{Emin}, Y_{Emax}], Y_{CAD} \in [Y_{CADmin}, Y_{CADmax}], Y_S \in [Y_{Smin}, Y_{Smax}], \\ Y_{HP} \in [Y_{HPmin}, Y_{HPmax}], Y_{HS} \in [Y_{HSmin}, Y_{HSmax}], Y_{C1} \in [Y_{C1min}, Y_{C1max}], Y_{C2} \in [Y_{C2min}, Y_{C2max}], \\ Y_F \in [Y_{Fmin}, Y_{Fmax}], ic \in [0, ic_{max}].$$

Results of numerical experiment for determination of dynamics of control influences, which minimize functional (3), are presented on Fig. 2.

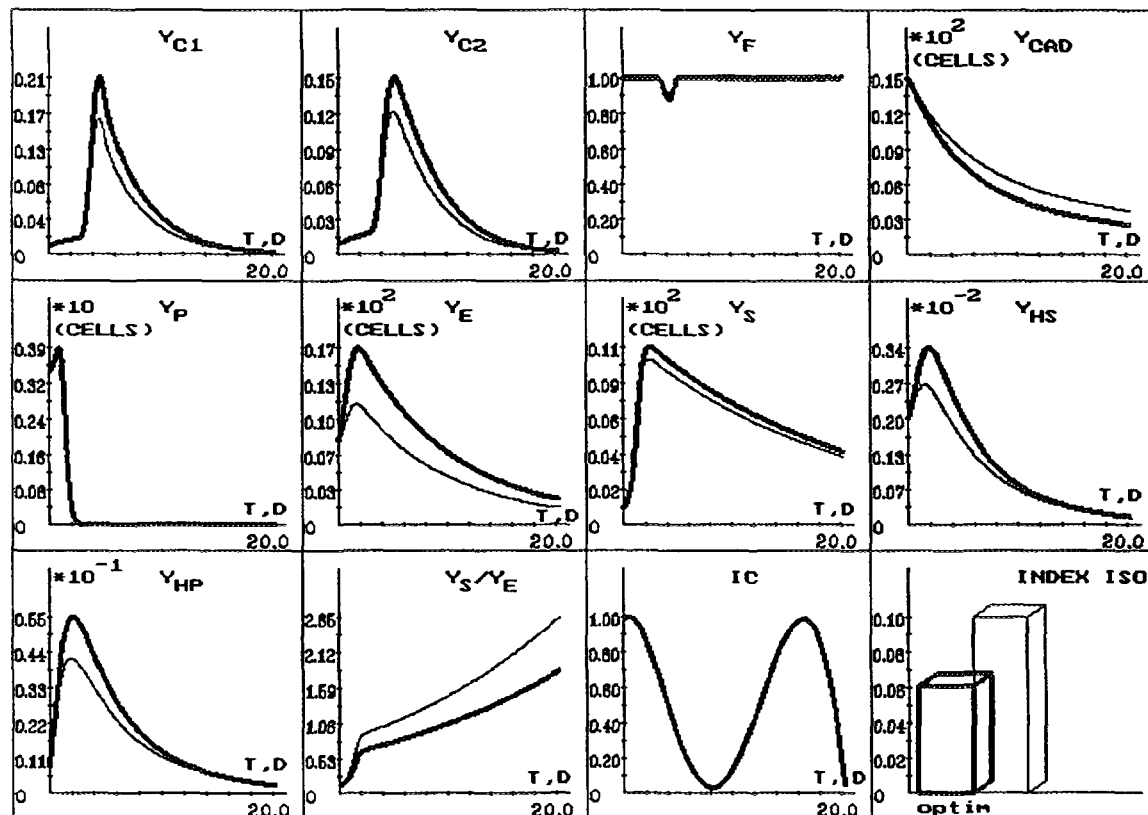


Fig. 2. Determination of dynamics of control influences for ISO optimization.

Thin line corresponds to results, which were obtained without optimization. Bold line corresponds to results, which were obtained with optimization.

Carrying out investigation permitted to determine optimal conditions of change of parameter ic , which imitates action of immunocorrector. Minimization of ISO index is reached under oscillating conditions of parameter ic changes.

Therefore optimal control results into maximum activation of function normalization processes and minimum activation of processes reducing protective functions of organism.

5. THE MODEL OF METABOLIC CHANGES AT STRESS CONDITIONS

State of cyclic nucleotides system along with parameters describing synthesis and energy consumption is important rang of reserve possibilities. That system is one of the important regulation systems of biosynthesis processes and proliferation of cells. Mathematical models describing this link of regulation were elaborated in [3]. We have added these models a contour that accounts influence of thromboxanes on activation of endonuclease, in presence of radionuclides.

The mathematical model can be presented as follows:

$$\frac{dE}{dt} = k_1(k_2 - E)(k_3 - E)E - k_4v_1 - k_5v_2 - k_6v_3 - k_7v_4 \quad (4)$$

$$\frac{dF}{dt} = a_1(1 - F)C(1 - a_2A) - a_3F$$

$$\frac{Lp}{dt} = a_{18}Ar(a_{19} - H) - a_{20}Lp$$

$$\frac{dAr}{dt} = a_4F(a_5 - F) - a_6Ar$$

$$\frac{dC}{dt} = a_{21}[1 - e^{-\alpha t}]e^{-\beta t} - v_1$$

$$\frac{dL}{dt} = a_7F(a_8 - F) - a_9L$$

$$\frac{dG}{dt} = v_2 - a_{26}G(a_{27} + C)$$

$$\frac{dPr}{dt} = a_{10}Ar(a_{11} - Ar) - a_{12}Pr$$

$$\frac{dA}{dt} = v_3 - a_{31}A(a_{32} + C)(a_{33} + G)$$

$$\frac{dTr}{dt} = a_{13}Ar(a_{14} - Ar) - a_{15}Tr$$

$$\frac{dEn}{dt} = a_{34}TrR - a_{35}En$$

$$\frac{dH}{dt} = a_{16}Ar - a_{17}H$$

$$\frac{dM}{dt} = v_4 - b_5M(b_6 + b_7En)$$

$$v_1 = a_{22}(C - a_{23}) \frac{(a_{24} + C)^3}{c_1 + (a_{24} + C)^4} \frac{E}{a + E},$$

$$v_2 = a_{25}L(c_2E + c_7),$$

$$v_3 = a_{28}(c_3E + a_{29})(a_{30} - L)(c_4Pr + c_5),$$

$$v_4 = (b_1 + G)(b_2 - A)(b_3 + Lp) \frac{E}{b + E},$$

where E - energy substrates, F - phospholipase, Ar - arachidonic acid, L - leukotrienes, Pr - prostaglandines, Tr - thromboxanes, H - 5HETE and 15HETE, Lp - lisophosphatidylcholine, C - Ca^{++} , G - cGMP, A - cAMP, En - endonucleas, R - radionuclides, M - level of proliferation.

The problem of determination of effect influences on cellular metabolism is appeared at the investigation of action of therapy preparations exerting onedirect effect on opposite groups of cells. We shall consider the model (4) with point of view of optimal control theory including the control influences, which connect with action of therapy preparations. Control influences are model parameters characterizing the intensity of the transmembran calcium fluxes in cell (a_{21}), speed of the removing Calcium ions from cell (a_{22}), intensity of energy syntesis in cell (k_1), intensity energy consumption at proliferation (b). In the order to distinguish control influences from constants of the model (4) we denote them as follows: $a_{21} = U_1$, $a_{22} = U_2$,

$k_1 = U_3$, $b = U_4$. Besides we denote variables $E = Y_1$, $F = Y_2$, $L = Y_3$, $Tr = Y_4$, $Lp = Y_5$, $G = Y_6$, $En = Y_7$, $Ar = Y_8$, $Pr = Y_9$, $H = Y_{10}$, $C = Y_{11}$, $A = Y_{12}$, $M = Y_{13}$.

The problems of optimal control of balance of the syntesis and consumption of energy are formulated such way: the mathematical model (5), minimum and maximum values of variables Y_k ($k = 1, 13$) and the control parameters U_i ($i = 1, 4$) respectively Y_{kmin} , Y_{kmax} and U_{imin} , U_{imax} are given. It is required to determine control influences and phase tracks on interval $(0, T)$, which: 1) minimize functional F ; 2) maximize functional F under following limits:

$$Y_k \in [Y_{kmin}, Y_{kmax}], U_i \in [U_{imin}, U_{imax}],$$

$$\text{where } F = F(U_1, U_2, U_3, U_4) = \int_0^T Y_{13} dt.$$

The problem of optimization was solved by the approach of occasional search [4].

The results of numerical experiment connected with the maximization of functional F are presented at Fig. 3. The dynamics of control influences maximizing functional F is presented at Fig. 4. Thin line corresponds to results, which were obtained without optimization. Bold line corresponds to results, which were obtained with optimization.

Results of mathematical modeling on $[0, 20]$ an hours interval are presented on Fig. 3-4 under condition: level of radionuclides $R=0.2$ Gy. Under maximization task the speed of proliferation increases as a result of changing of control influences. Under minization task the speed of proliferation decreases as a result of changing of control influences.

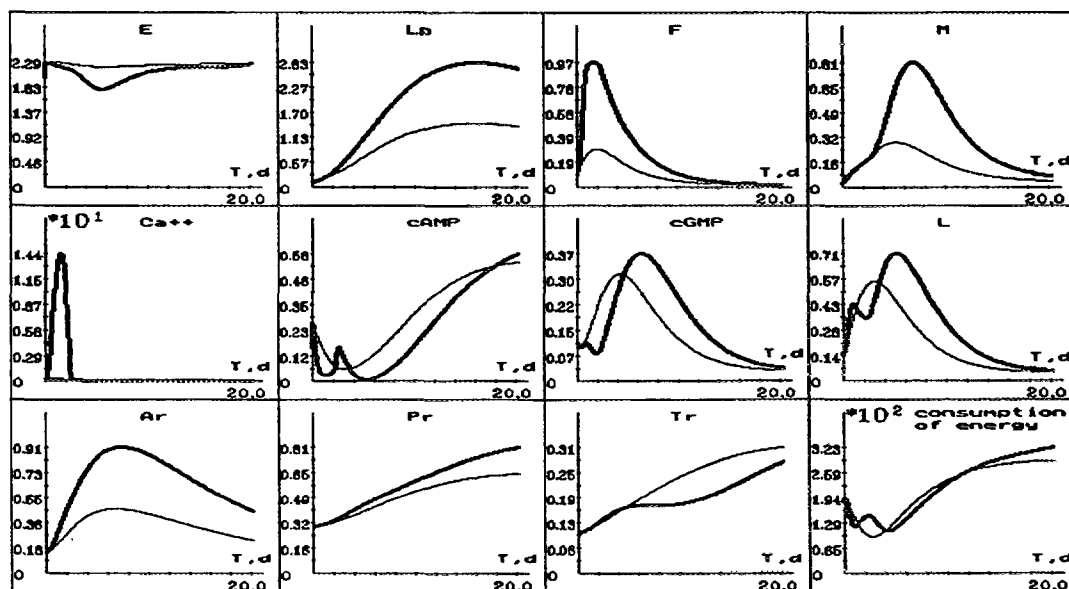


Fig. 3. Maximization task solution.

Obtained results give opportunity to calculate, connected with optimal therapy and ISI correction, dynamics of changes of parameters of B-link. Basing on obtained data we can conclude that optimal immune responds control is connected with therapy influences which provide the dynamics of model's (1) parameters given in table I.

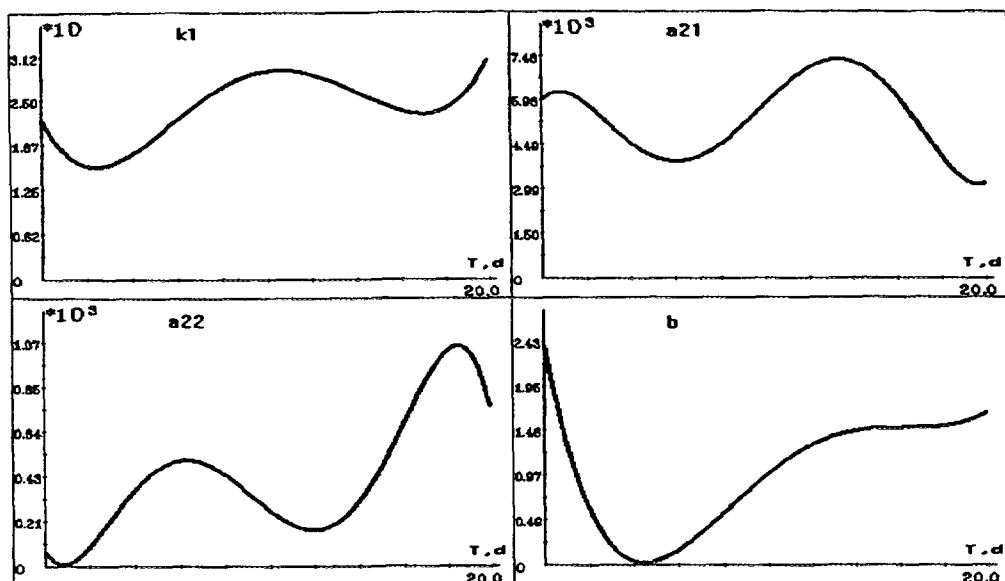


Fig. 4. Dynamics of control influences corresponding to task of maximization.

TABLE I.

Days after antigen injection	The Effect of Drugs which are needed to use			
	intensity of energy synthesis in cell (k1)	intensity of the transmembran calcium fluxes in cell (a21)	speed of the removing Ca ions from cell (a22)	intensity energy consumption at proliferation (b)
0.0-0.9	decreasing	increasing	decreasing	decreasing
0.9-2.3	decreasing	decreasing	increasing	decreasing
2.3-4.4	increasing	decreasing	increasing	decreasing
4.4-6.1	increasing	increasing	increasing	increasing
6.1-10.7	increasing	increasing	decreasing	increasing
10.7-11.9	insignificant increasing	increasing	decreasing	increasing
11.9-13.4	decreasing	insignificant increasing	increasing	increasing
13.4-14.3	decreasing	insignificant decreasing	increasing	increasing
14.3-17.3	decreasing	decreasing	increasing	insignificant increasing
17.3-17.8	decreasing	decreasing	increasing	insignificant increasing
17.8-18.5	increasing	decreasing	increasing	insignificant increasing
18.5-19.7	increasing	decreasing	decreasing	increasing
19.7-20.0	increasing	insignificant increasing	decreasing	increasing

6. RISK ASSESSMENT OF PUBLIC HEALTH DETRIMENT

For risk assessment of public health detriment we utilize the approach presented in [4]. Central in this approach is possibility of evaluation of functional organism state by means of state vector, whose components are variables of three types characterizing the levels of function — X , intensity of regulatory mechanisms — Y , reserve system possibilities — S . It is based on the theory of properties of smooth function which allows: a) to determine critical values of parameters under which irreversible changes begin in the system; b) to plan the ways of prevention of irreversible changes and recovery from a crisis. The minimum model can be reduced to catastrophe of "cusp" type. The model analysis shows that, when the Y increases the function's level creases gradually. This decrease happens to be insignificant until the upper bound of the trigger domain U (compensation limit) is reached. This domain corresponds to the stationary steady-state with high level of function's possibilities (norm). Once U is reached, function's level decreases sharply to the second stationary steady-state with low level of function's possibilities (pathology). In order to restore the normal function's level, Y must be lowered to the lower bound of the trigger domain L . The higher the degree of pollution p , lower ratio Y yields the vital functions disturbance. The decrease in Y can be gained either by low calorificity food or by limitation of lipid share in the ration.

The level of environmental pollution is utilized for Y estimation. ISO index indicates reserve possibilities of organism. The risk of public health detriment is determined as measure of upper bound of trigger domain reach. See Fig. 5.

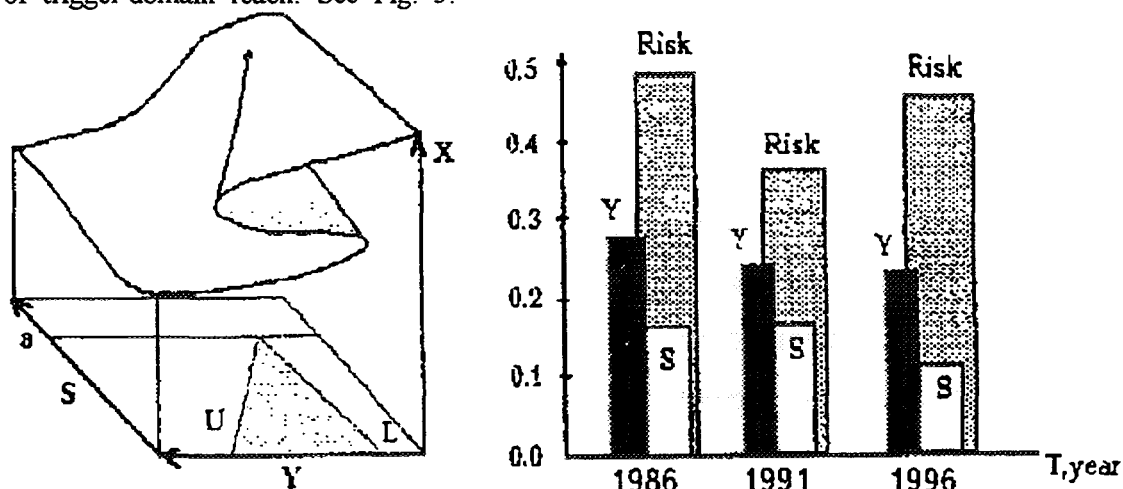


Fig. 5. Risk assessment of public health detriment

The model determines the risk of public health detriment and the individual compensation limits, i.e. the level of environmental pollution, that leads to sharp increasing risk of pathology under the given level of reserve possibilities of organism.

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EPIDEMIOLOGICAL ANALYSIS OF THE HEALTH OF THE VICTIMS OF THE CHERNOBYL ACCIDENT USING DATA FROM THE UKRAINE NATIONAL REGISTER

A.M. NAGORNAYA, V.M. PONOMARENKO
I.L. Medvedya Institute of Health, Ministry of Public Health,
Kiev, Ukraine



XA9745484

ЭПІДЕМІОЛОГІЧЕСЬКИЙ АНАЛІЗ ЗДОРОВ'Я НАСЕЛЕННЯ, ПОСТРАДАВШЕГО ОТ
ЧЕРНОБІЛЬСЬКОЇ АВАРІЇ, ПО ДАНІМ НАЦІОНАЛЬНОГО РЕГІСТРА УКРАЇНИ
А.М. Нагорная, В.М. Пономаренко

Объективное суждение о медицинских последствиях аварии на ЧАЭС может быть составлено на основе долгосрочного динамического наблюдения за состоянием здоровья пострадавшего населения.

Как известно, одной из основных задач Национального регистра и является контроль за состоянием здоровья и изучение ближайших и отдаленных медицинских последствий пострадавшего населения. Решение этой задачи осуществляется персональным наблюдением за состоянием здоровья лиц, внесенных в регистр, обеспечением автоматизированного сбора и долговременного хранения информации о состоянии их здоровья, собранной во время проведения целевой диспансеризации.

Анализ показателей здоровья населения, включенного в Регистр, является чрезвычайно сложной проблемой. Во-первых, диспансеризация населения в объеме, предусмотренном для пострадавших в Украине в целом и в контролируемых районах, до аварии не проводилась. Во-вторых, изменение медико-экономической ситуации в стране в последние годы не может не отразиться на формировании показателей здоровья населения. Следует заметить также, что положение о том, что в сравниваемых популяционных группах уровень здоровья по радиационного воздействия был одинаков не выдерживается. Поэтому основополагающими критериями достоверности изменений показателей здоровья пострадавших является их оценка в динамике послеварийных лет с учетом уровня радиационного облучения.

Нами для эпидемиологического анализа использовались данные о заболеваемости, инвалидности и смертности более чем на 405 тыс.

болезням крови и кроветворных органов. Статус "ликвидаторов" признано здоровыми 74,4% в 1988 году, 23,0 - в 1993 году. Среди этого контингента отмечается увеличение числа инвалидов в динамике 1988-1994 гг.

Темпы прироста смертности среди участников ликвидации последствий аварии выше, чем среди населения. Выявленные закономерности в заболеваемости и смертности ликвидаторов имеют место и в стандартизованных показателях. Что касается показателей здоровья эвакуированного населения, то число признанных здоровыми в 1987 году составляло 56,8% и в 1993 - 24,3%. Отмечается увеличение темпов прироста заболеваемости почти по всем классам болезней среди этого контингента по сравнению со всем населением Украины. В структуре общей заболеваемости взрослого населения увеличился удельный вес болезней эндокринной системы, расстройства питания, нарушения обмена веществ и иммунитета, крови и кроветворных органов, нервной системы и органов чувств, новообразований.

Среди постоянно проживающих на радиационно контролируемых территориях структура общей заболеваемости в послеаварийный период сохранила тенденции формирования, характерные для доаварийного периода. Показатель смертности среди этого контингента выше, чем среди населения других территорий.

Следует отметить, что заболеваемость среди женщин выше во всех возрастных группах. По отдельным нозологическим формам имеются достоверные возрастно-половые различия.

Среди детского населения признано здоровыми в 1988 году среди эвакуированных 43,9%, среди постоянно проживающих на контролируемых территориях - 52,9%, среди родившихся от родителей 1-3 групп первичного учета - 77%, в 1993 году - 23,9; 27,4; 30,9% соответственно.

В структуре заболеваемости эвакуированных детей лидирующее место принадлежит болезням органов дыхания (38,61%), на 2-ом - болезни органов пищеварения (23,52%), затем - болезни эндокринной системы (11,91%) и нервной системы и органов чувств (10,33%). У детей, проживающих на контролируемых территориях, первые места

занимают эндокринные болезни (31,2%), органов дыхания (28,69%), пищеварения (15,09%). В динамике общей заболеваемости (673,4‰ - в 1988 году. 149 5,0‰ - в 1994 году) наибольший рост отмечается по болезням эндокринной системы (176,9 - 467,8 ‰ соответственно).

Наиболее высокие показатели заболеваемости отмечаются у детей, которые эвакуированы из 30 км. зоны ЧАЭС в контролируемые районы.

Представляют интерес данные о заболеваемости детей, родившихся после аварии на ЧАЭС от родителей I-3 групп первичного учета. В структуре заболеваемости у них более половины занимают болезни органов дыхания (55,5%), на втором месте - пищеварения (8,0%), на третьем - эндокринной системы (7,95%), на четвертом - болезни нервной системы и органов чувств (5,9%). Динамика общей заболеваемости не имеет четких тенденций. Уровень ее стабильно высокий за все годы наблюдения.

Таким образом, основные тенденции в состоянии здоровья пострадавшего населения направлены в сторону его ухудшения. Выявить долю влияния радиационного облучения, нервно-психического напряжения, демографических и социально-экономических процессов дело многих и многих ученых, которые уже накопили немало результатов.

На основании эпидемиологического анализа показателей здоровья лиц, включенных в Регистр, ответить на все вопросы, касающиеся развития болезней и дозы облучения, отдельных видов патологии и их однозначного прогноз, болезней и возраста, в котором получено облучения и других детальных аспектов на сегодняшний день не представляется возможным, для этого требуются еще долгие годы наблюдений.

**ENVIRONMENTAL EFFECTS ON CHILD HEALTH IN UKRAINE
(TEN YEARS AFTER THE CHERNOBYL ACCIDENT)**

T.I. BOGDANOVA, N.D. TRONKO
Institute of Endocrinology and Metabolism,
Kiev, Ukraine



O.A. BOBILJOVA, L.O. BEZROOKOV, N.G. HOIDA A.M. SERDJUK,
D.D. ZEBRINO
Ministry of Public Health,
Kiev, Ukraine

I.A. LIKTAREV
Scientific Centre of Radiation Medicine,
Kiev, Ukraine

Ukraine, one of the largest countries of Europe, situated on the northern shore of the Black Sea has a population of over 52 million, on which 12 million are children. It is experiencing a severe health crisis due to many factors, the two most important being socio-economic and environmental mismanagement.

Environmental factors are one of the more important determinants of health in any nation. This situation cannot be better portrayed than in Ukraine, a region that has been polluted at will for many decades. The health of the population, especially the children has been affected in many ways. In the last several years Ukraine has experienced a negative birth rate.

Other than the cases of acute radiation illness after Chernobyl there has been a significant increase of childhood thyroid cancers in Ukraine. The incidence rate from 1981-85 ranged from 0,4-0,6 cases per million children per year. In 1990 this rate jumped to 2,3; in 1991 to 1,9; 1992 to 4,3 and in 1993 to 3,9. These statistics represent an overall increase of 6-10 fold above the pre-Chernobyl levels. The increase of these childhood malignancies is probably due to the release of excess radionuclides after the accident because 60% of all cases have been registered in the most radioactive contaminated regions.

The nuclear accident in 1986 at Chernobyl precipitated a further deterioration of the state of health in Ukraine. Not until 1992, only after Ukraine achieved its independence was Ukraine's parliament able to pass laws to register, classify the involvement, offer aid and plan for the surveillance of the victims of Chernobyl. Since then the offspring of the victims who had been born by 1994 (over 250,000) are manifesting increased health problems.

The population of large, heavily industrialized regions is being exposed to chronic excessive levels of air pollution, as in the city of Dnepropetrovsk. There the incidence of asthma has increased by 15%, bronchitis and emphysema by 77% and infant mortality by 9,3% in the last 10 years.

Such an environment is prone to unpredictable events. In 1988, in the city of Chernovtsy a mysterious epidemik occurred. Over a 4 month period above 200 children developed an illness manifested by hair loss, upper and lower respiratory and central nervous system involvement. The initial cases started in August with the maximum 66% being in October. Exept for two cases, only one sibling per family was involved and above 85% of these cases were children 6 years and younger.

At first paediatricians and toxicologists believed this to be of infectious origin but eventually the metal thallium was identified as the incriminating agent. The unique aspect of the Chernovtsy Chemical Disease is that it was most likely acquired through an airborne route. Unfortunately, the source of contamination has never been discovered, but many affected children have been left with multisystem residual symptoms.

The lack of effective laws, money and scientific expertise is turning an environmental crises into a health crisis. This is no better portrayed than in an increase in paediatric morbidity and mortality statistics.

CLINICAL AND PARACLINICAL ASPECTS OF CHILDREN'S HEALTH TEN YEARS AFTER THE CHERNOBYL ACCIDENT

E.M. LUKYANOVA, Y.G. ANTIPKINE, L.I. OMELCHENKO, V.P. CHERNYSHOV,
L.I. APUHOVSKAYA, L.F. OSSINSKAYA

Institute of Pediatrics, Obstetrics and Gynecology,
Kiev, Ukraine

Introduction. These investigations are devoted to the problem of medical consequences of Chernobyl catastrophe to the children's population of Ukraine.

Concerning different reports, Chernobyl accident negatively influenced to the children health indexes (1,2). Astonishing fact is that among children under radiation action only 2,1% have no functional deflexions (I group of health) and 28% have chronic diseases with often aggravation (3). Our previous investigation in children evacuated from 30 km zone showed an unfavourable changes in immune system. There are reports about disorder in immune, cardio-vascular and other systems in children suffered from Chernobyl accident (5,6).

We have shown the data of investigation carried out in the frames of National Program "Children of Chernobyl". We have studied the morbidity, immune some functional characteristics and metabolism indexes in 2700 children aged 0-15 years, continually living within radiation contaminated territories. The results were compared with the control indexes, obtained during examination of 980 children from conditionally "clean" regions.

Methods of study. Immunological investigations include determination of: 1) lymphocyte subsets by flow cytometry using monoclonal antibodies ("IMK Kit", Becton Dickinson, USA); 2) levels of immunoglobulins G.A.M. by laser nephelometry using polyclonal monospecific antisera ("Microplus", Russia); 3) phagocyte activity by flow cytometry using FITS labeled *St.aureus* (Wood 46) and

Some indices of morbidity structure in children

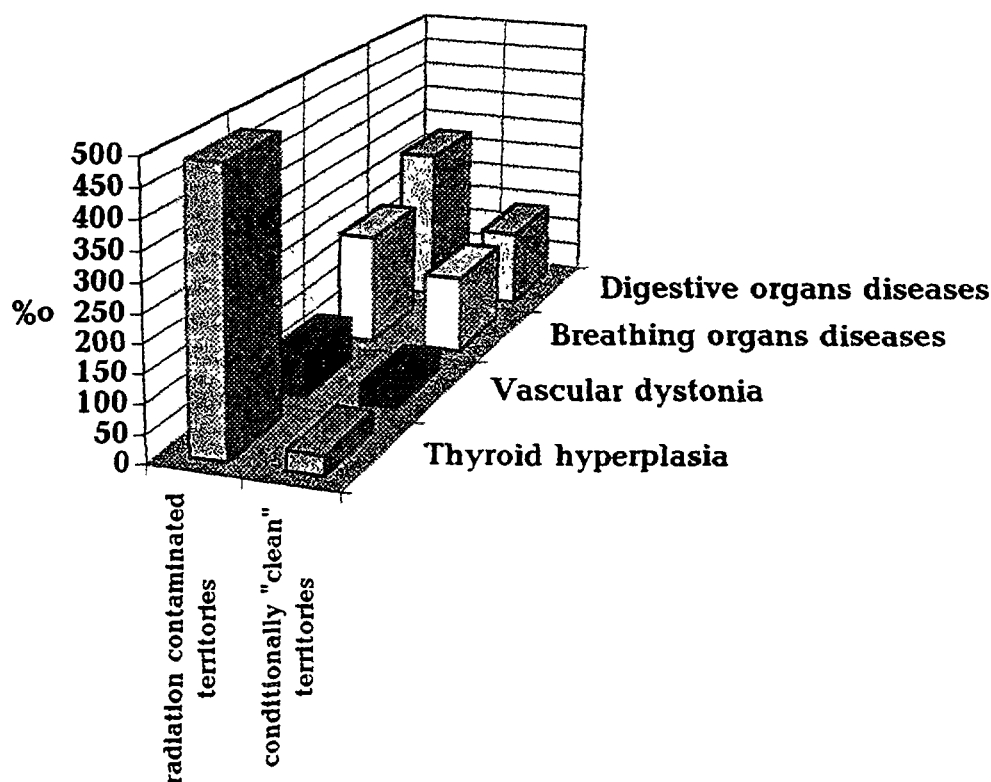


Fig. 1

**Correlation of different classes of lymphocytes in perypheral blood in children with
recurent respiratory diseases taking into account the absorbed dose of radioactive
iodine by thyroid**

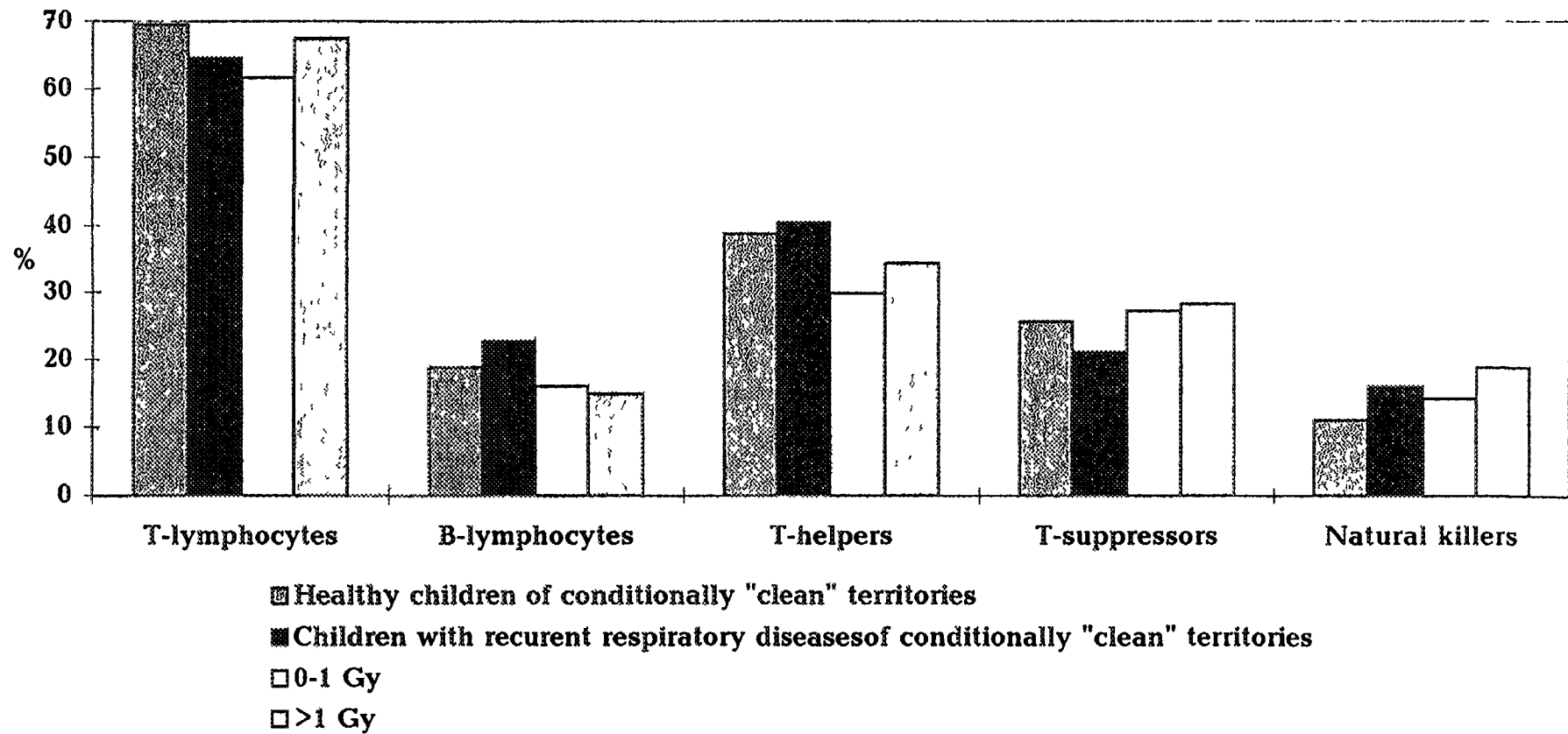


Fig. 2

Indices of bowels microbiocenosis in children from radiation contaminated and conditionally "clean" territories

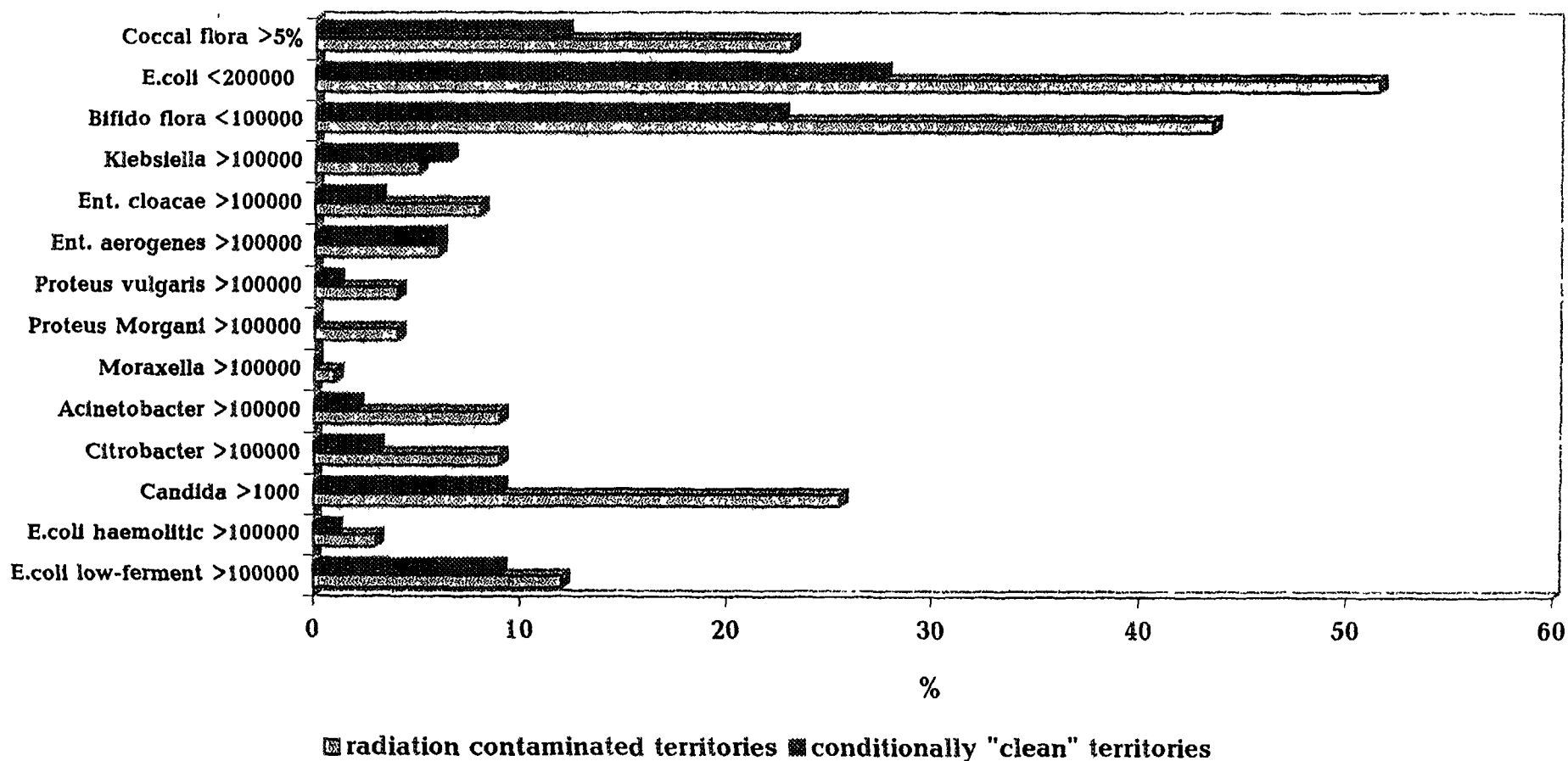
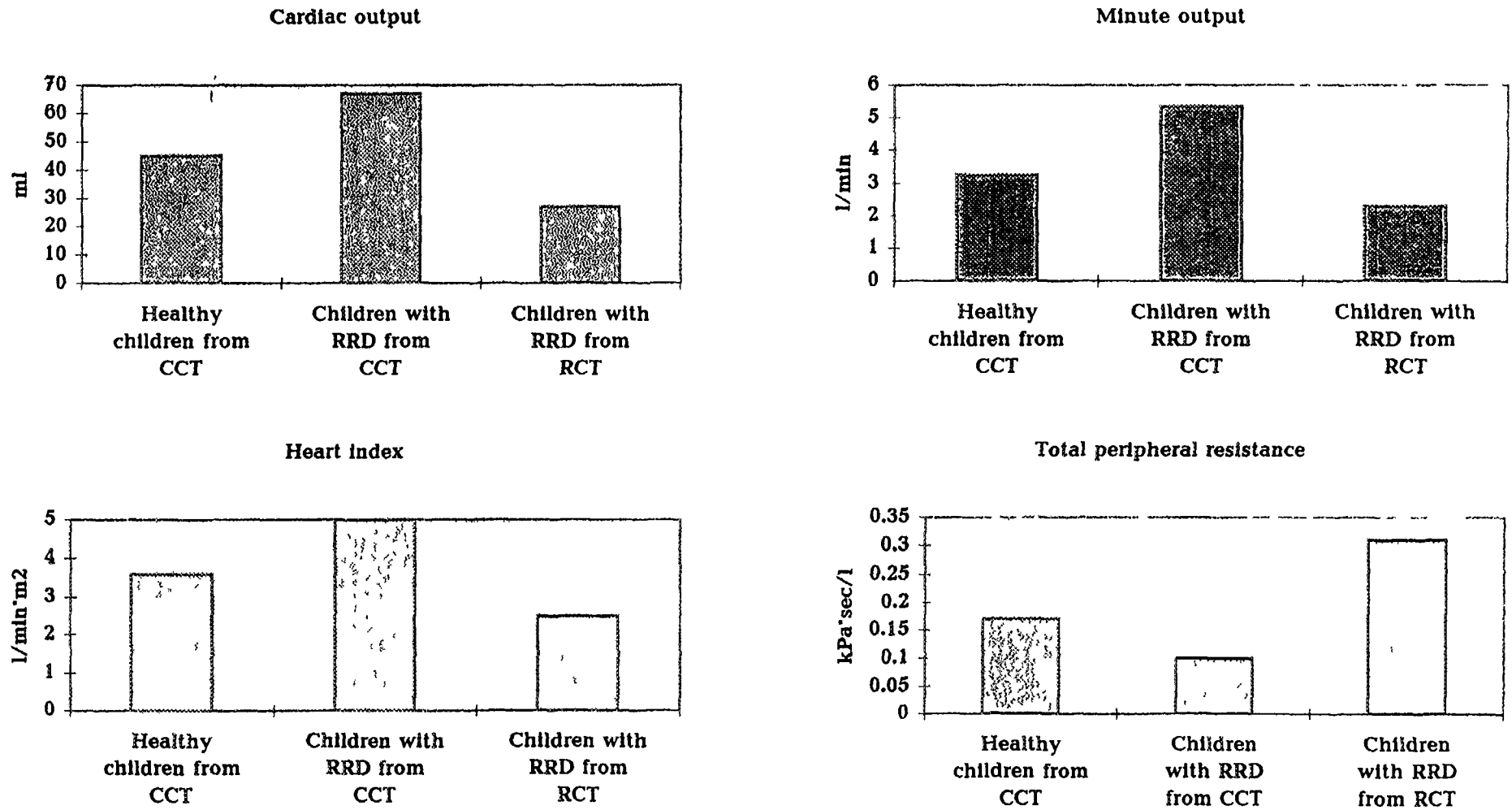


Fig. 3

Some indices of central haemodynamic in children with recurrent respiratory diseases



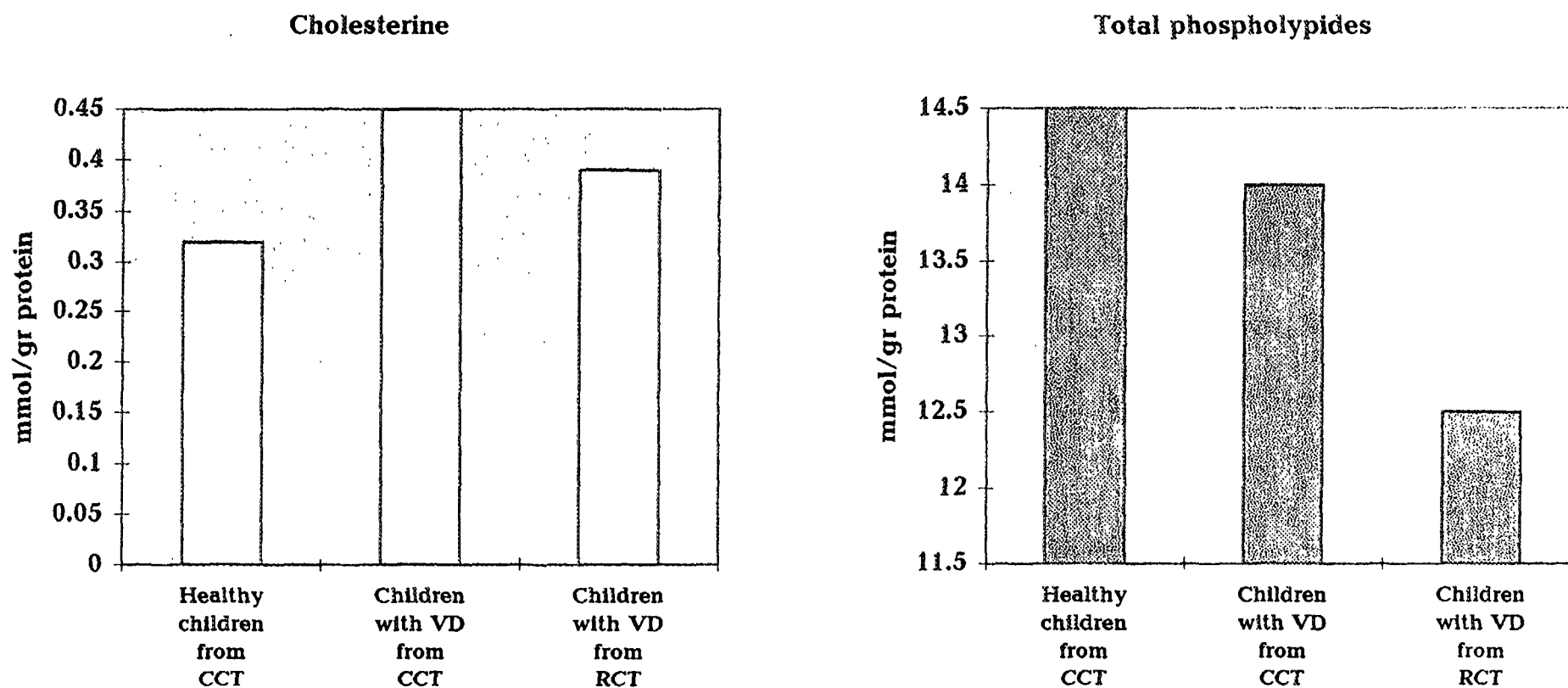
RRD - recurrent respiratory diseases

CCT - conditionally "clean" territories

RCT - radiation contaminated territories

Fig. 4

Total phospholipides and cholesteroline concentration in erythrocytes membranes in children with vascular dystony living within radiation contaminated territories



VD - vascular dystony

CCT - conditionally "clean" territories

RCT - radiation contaminated territories

Fig. 5

Table 1

**Indices of peroxid oxidation and antioxidant system in erythrocytes and plasma of blood of children
with vascular dystonia**

Region	Hydroperoxides suspension of erythrocytes, mmol Fe/l	Malon dialdehyde, mmol/l	Reduced glutation, mmol/l	Glutation peroxidase, mmol GSH/l
Conditionally "clean"	1,4±0,1	41,7±3,1	2,5±0,7	4,0±1,2
Radiation contaminated	2,6±0,3	67,3±1,8	2,8±0,5	5,0±1,2

latexmicrobeads ($d=1,1 \text{ mkm}$) Immunological studies were carried out in cooperation with Japanese (Institute of Nuclear Medicine and Biology, Hiroshima University) and German (Institute of Infectious and non-infectious diseases - Robert Koch Institute) specialists Bacteriological investigations used standard bacteriological medium for determination of dysbacteriosis degree Biochemical studies include the determination of calcium in serum and erythrocytes by biotest (Lachema, Czech Republic) and non-organic phosphorus by Dyce method [7] Osmotic resistance of erythrocytes determined in a condition of 50% hemolysis in 0,4% NaCl solution [8] Total lipid level in serum carried out by test (Lachema, Czech Republic) Hydroperoxide of lipid- by Romanov method with thiocyanate ammonium [9], diene-conjugate- by Kostuk method [10], malonaldehyde - by plager [11], the activity of glutathione-dependent antioxidant enzyme glutathione peroxidase by Olnessan [12], reduced glutathione - after Sedlak [13], catalase - after Beers [14], antioxidant activity - after Sevanian [15]

Results. Total morbidity in children, suffered from the radiation action is increased in comparison with the children morbidity in conditionally "clean" regions There is an increase of cases of thyroid hyperplasia, some breathing and digestive organs diseases, vascular dystonia in the structure of morbidity The number of healthy children is decreased among the children's population, permanently living within contaminated by radionuclides territories (fig 1)

It was determined, that the children with recurrent respiratory diseases have the disorder of mucous membrane resistance, the concentration of secretory Ig A in saliva is decreased The level of T-lymphocytes and true helpers ($CD3+/CD4+$) in patients with recurrent respiratory diseases (RRD) and absorbed dose of radioactive iodine in thyroid not exceeded 1 Gr, is lower than in patients from conditionally "clean" regions The content of B-lymphocytes in peripheral blood was in physiological level, but it was much decreased in patients with the absorbed dose of iodine in thyroid more than 2 Gr (fig 2) It was also found out the changes of intestinal microflora in children from basic group - the increasing of conditionally pathogenic microorganisms content, changes of their enzymatic peculiarities (fig 3)

The hypokinetic type of cardiac phase prevails in children with recurrent respiratory diseases, living within contaminated by radionuclides territories, and the oxygen consumption is decreased (fig 4) The hyperkinetic type of blood circulation prevails in patients from control group The oxygen consumption by tissues is increased It was determined that vascular dystonia in children from basic group is characterized by astheno-neurotic symptoms with a headache, vertigo, emotional lability, undue fatigability Patients from basic group have dystonia crisis (abdominal, cerebral and other) The cases of vascular dystonia in children from basic group were determined in earlier age (prepubertal) And the cases of vascular dystonia in children from control group were determined more late (in pubertal) period of development

Metabolic disorder prevails in patients with vascular dystonia from contaminated by radionuclides regions The content of calcium in plasma and erythrocytes in venous blood is decreased The content of cholesterol is increased The content of total phospholipids in erythrocytes membranes is decreased (fig 5) It was also determined the increasing level of erythrocytes diene conjugate, malonaldehyde and free radicals in plasma (tab 1) The changes of osmotic and acidic resistance of erythrocytes in peripheral blood in patients was found out

Conclusions The health state of children's population of Ukraine suffered from radiation action is characterized by higher total morbidity, the increasing of cases of thyroid hyperplasia and vascular dystonia Children with recurrent respiratory diseases have symptoms of immune dysregulations This fact in future may cause the autoimmune pathology, decreasing of antiviral and antitumor organism protection The increasing of cases of vascular dystonia, metabolic disorders in children suffered from the Chernobyl catastrophe show the possible risk of development of cardio-vascular pathology, including early atherosclerotic changes These results testify about the necessity of following scientific investigations, including clinical observation and laboratory examination of above mentioned group of children in dynamics, and also control investigations in children living within conditionally "clean" territories It is also necessary to estimate the significance of radiation factor in genesis of health, immune and metabolic disorders in children's population suffered from radiation Children who are living within contaminated by radionuclides territories need a permanent medical observation Healthy life, giving bad habits up, timely social and medical rehabilitation are quite important for them

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EVALUATION OF THE FREQUENCY OF T-CELL RECEPTOR GENE MUTATIONS IN THE VICTIMS OF THE CHERNOBYL ACCIDENT

B.I. GERASHCHENKO, V.A. MALYZHEV

Scientific Centre for Radiation Medicine, Ukraine Academy of Medical Science,
Kiev, Ukraine

ОЦЕНКА ЧАСТОТЫ МУТАЦИЙ ГЕНА ЛИМФОЦИТАРНОГО Т-КЛЕТОЧНОГО РЕЦЕПТОРА У ЛЮДЕЙ, ПОСТРАДАВШИХ В РЕЗУЛЬТАТЕ АВАРИИ НА ЧАЭС

Геращенко Б.И., Малышев В.А.

Научный Центр радиационной медицины АМН Украины, Киев

In the present study, the frequencies of in vivo lymphocyte T-cell antigen receptor (TCR) gene mutations in people exposed to ionizing radiation due to liquidation of Chernobyl accident consequences were determined. A total of 43 male persons were examined from April to December 1995 (9 years after the accident). Their ages varied from 30 to 50 at the time of examination. The group of exposed people consisted of 31 individuals. Their estimated doses ranged from 0.01 to 1.0 Gy. As a control, 12 individuals were not exposed. Peripheral blood lymphocytes were prepared from heparinized venous blood and were stained with monoclonal antibodies. The number of mutant T-cells with a phenotype $CD3^+4^+$ was determined by flow cytometry. Differences in the TCR mutant frequencies between considered groups were not significant. However, in this preliminary study, we found that one person from the group of exposed people had high mutant frequency.

1. ВВЕДЕНИЕ

Известно, что ионизирующая радиация является фактором риска возникновения рака. Так как она может индуцировать соматические мутации, то существует необходимость определения их частот для оценки этого риска. Современное развитие технологии производства моноклональных антител, а также лазерной проточной цитофлуориметрии, открыло новую эпоху в плане быстрого анализа и выделения редких типов мутантных клеток крови. Данный подход, основанный на идентификации биологических маркеров, имеет хорошие перспективы для оценки риска здоровью населения. В настоящее время для изучения частот соматических мутаций *in vivo* наиболее широко проводятся исследования мутаций эритроцитарного гликофорина А (GPA) [1-4] и лимфоцитарного Т-клеточного антигенного рецептора (TCR) [5,6]. Исследования людей, пострадавших в результате атомной бомбардировки в Японии и аварии на ЧАЭС, обнаружили повышение частоты мутаций GPA, а также ее зависимость от дозы облучения [2-4]. Хотя эффект радиации атомной бомбардировки на TCR не был обнаружен, полностью исключать то, что такой эффект не будет обнаружен в случае с черновильской радиацией не стоит ввиду возможных различий в факторах ее влияния на организм, а также времени, прошедшего с момента после облучения. Существует предположение, что TCR-мутанты постепенно элиминируются *in vivo* в течение времени после облучения [6]. Исходя из вышеизложенного, нами было проведено предварительное исследование частоты мутаций TCR у ликвидаторов аварии на ЧАЭС.

Известно, что TCR у значительного большинства зрелых Т-лимфоцитов образован гетеродимером, состоящим из α - и β -цепей. Он в свою очередь ассоциирован с CD3-молекулой, образуя комплексную структуру [7]. TCR/CD3-комплекс играет центральную роль в распознавании антигена и активации зрелых Т-клеток. Инактивация генов, кодирующих белковые структуры TCR/CD3-комплекса, ведет к потере экспрессии этого комплекса на клеточной поверхности и последующему отсутствию ответа Т-клеток к антигенному стимулу. При воздействии радиации или химических мутагенов Т-лимфоциты могут терять на своей поверхности TCR/CD3-комплексы и при двойном флуоресцентном анализе они распознаются как CD3⁺4⁺-клетки. К настоящему времени существуют доказательства в пользу того, что TCR-гены больше подвержены мутагенезу, чем CD3-гены. Любой дефект в одной из двух молекул, образующих TCR-гетеродимер, ведет к потере экспрессии CD3-молекул на поверхности Т-лимфоцитов, хотя они и накапливаются внутри клетки. Таким образом, экспрессия CD3-антигена на клеточной поверхности может служить в качестве маркера для выявления факта мутации TCR.

2. МАТЕРИАЛ И МЕТОДИКА

Исследования проводились с апреля по декабрь 1995 г. Исследовались мужчины в возрасте от 30 до 50 лет ($n=31$), установленные дозы облучения которых находились в пределах от 0,01 до 1,0 Гр. Контрольная группа состояла из мужчин того же возраста ($n=12$). Лимфоциты периферической крови выделялись из гепаринизированной венозной крови на градиенте фиколл/верографин и окрашивались моноклональными антителами: anti-Leu-3a (CD4), меченный флуоресцеином и anti-Leu-4 (CD3), меченный фикоэритрином (Becton Dickinson). До цитометрии в клеточную суспензию был добавлен йодистый пропидиум в финальной концентрации 10 мкг/мл с целью исключения из анализа мертвых клеток. Экспрессия соответствующих антигенов анализировалась с помощью проточного цитофлуориметра FACStar Plus той же фирмы. Всего анализировалось 1×10^5 клеток с каждого образца. Частота мутаций определялась как отношение количества CD3⁺4⁺-клеток к общему количеству CD4⁺-клеток.

3. РЕЗУЛЬТАТЫ И ОБСУЖДЕНИЕ

Исследования показали, что средняя частота мутаций TCR в группе облученных лиц составляет $2,8 \pm 1,1 \times 10^{-4}$, а в контрольной группе - $3,0 \pm 1,2 \times 10^{-4}$. У одного человека с дозой облучения 0,3 Гр наблюдалась повышенная частота мутантных Т-хелперов - $28,0 \times 10^{-4}$. Для сравнения следует заметить, что у человека с дозой облучения 1,0 Гр частота мутаций составляет $4,5 \times 10^{-4}$. Уровень, при котором выход мутантных клеток составлял более пяти на 10 000 CD4⁺-клеток, принимался за повышенный.

Таким образом, согласно нашим предварительным наблюдениям, высокая частота мутантных Т-хелперов встречается только у одного человека из тридцати одного пострадавшего, хотя в целом значимых различий в частотах мутаций TCR между рассматриваемыми группами людей не обнаружено. Какой-либо корреляции частоты мутаций с дозой облучения также не обнаружено. Вероятно, это может быть связано с такими факторами, как время, прошедшее с момента облучения, неравномерность действия радиации и др. Не исключено, что у ошутимого количества облученных лиц могут регистрироваться мутантные клетки по фенотипу CD3⁺4⁺ с повышенной частотой и это определенным образом может составить риск возникновения рака. Решение этого вопроса требует более глубоких исследований.

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HEALTH CONDITION OF CHILDREN IRRADIATED IN UTERO

E. STEPANOVA

Research Center for Radiation Medicine,
Kiev, Ukraine

INTRODUCTION

Among children exposed to ionizing radiation, the irradiated in utero ones are the contingent of the prevailing observation. It depends on the greatest organism sensivity to the effect of radiative factors in the neonatal period of the development and on the greatest duration of forthcoming life under the irradiation risk.

RESEARCH SUBJECT AND METHODOLOGY

The three study groups were studied with 1144 children - involved.

1st group. Children with acute exposure to radiation - born from women pregnant at the moment of accident and evacuated from Pripjat city.

2nd group. Children with chronic exposure to radiation - born from women pregnant at the moment of accident and remained staying in radiation control zone.

3rd group. Control group - children born in 1986 and still now resident in normal radiation situation region.

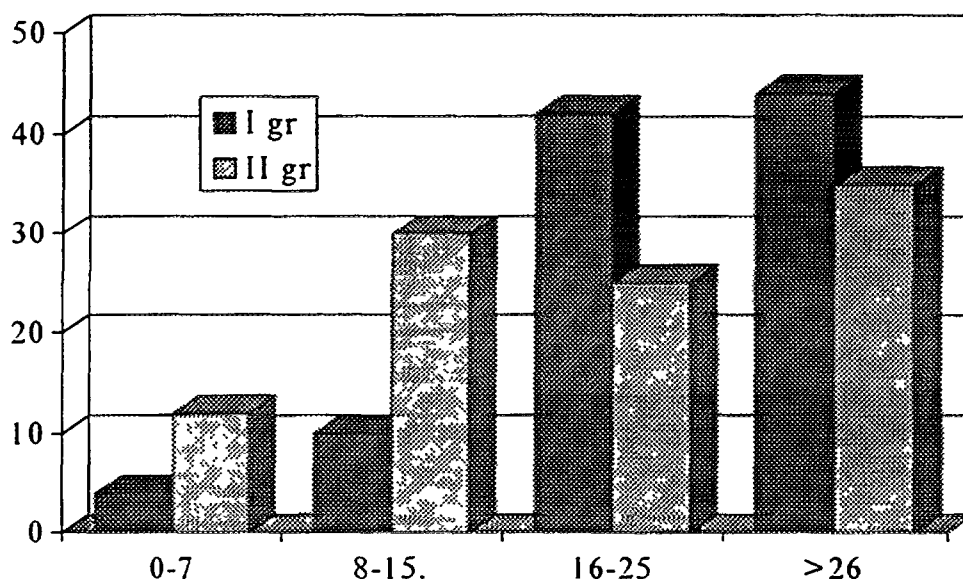


Fig.1. Disribution of children irradiated in utero according to gestation age at the moment of the Chernobyl accident (%)

Thyroid dose exposure of fetus ranged from 0,0 to 334,0 cGy. The doses of total - body irradiation in the 1st group varied from 0,5 to 37,6 cSv, in the 2nd - from 0,1 to 3,3 cSv.

The general clinical, instrumental, hemathological, biochemical, immunological, cytochemical, electronmicroscopic studies both with psychologic testing were held.

RESEARCH RESULTS

No significal differences were found with data obtained studing medical documentation, and the results of mass screening under the condition of intrauterine development in children of the 1st and 2nd groups as well as in valuess of physical development of neonates and adaptation processes in neonatal period. However great variability of individual indices in body mass of childrens irradiated in utero was noted. The cases of children born with head dimension less than the age normal values were not found (Tabl.1).

Table 1

The physical development values in birth of children irradiated in utero

Parameter	Study groups		
	I	II	III
Body weight, g	3524,0 \pm 70,00	3272,30 \pm 74,70	3304,00 \pm 59,10
Body length, cm	52,62 \pm 0,31	52,10 \pm 0,37	51,04 \pm 0,28
Head Circumference	35,83 \pm 0,55	33,90 \pm 1,05	35,76 \pm 1,01
Diwension (HCD), cm			
Chest Circumference	35,00 \pm 0,61	33,50 \pm 0,51	34,50 \pm 0,51
Diwension (CCD), cm			

Average monthly augmentation of mass and body length at the 1st year of the life in children of the 1st group were in accordance with the age. In children aged 1 of the 2nd group the lower body mass was registered while no differences in doby length and that of children in control group were revealed. Psychomotor development of children corresponded to the age. A structure of pathology revealed in babies was such as in children of the control group. However among children irradiated in utero, more numerous group of children being often ill was already formed at the 1st year of life.

No significant differences from the age norma in mean quaity of indices for physical development of children from the 1st and the 2nd groups in pre-school age were registered. An increase in a number of disharmonious development was found by the evaluation of individual parameters.

The somatic status estimation in dynamics revealed the number of children irradiated in utero decrease with higher rate compared to that in control group (Fig.2).

The most unfavourable changes were registered in children exposed to irradiation in early gestation terms (Fig.3).

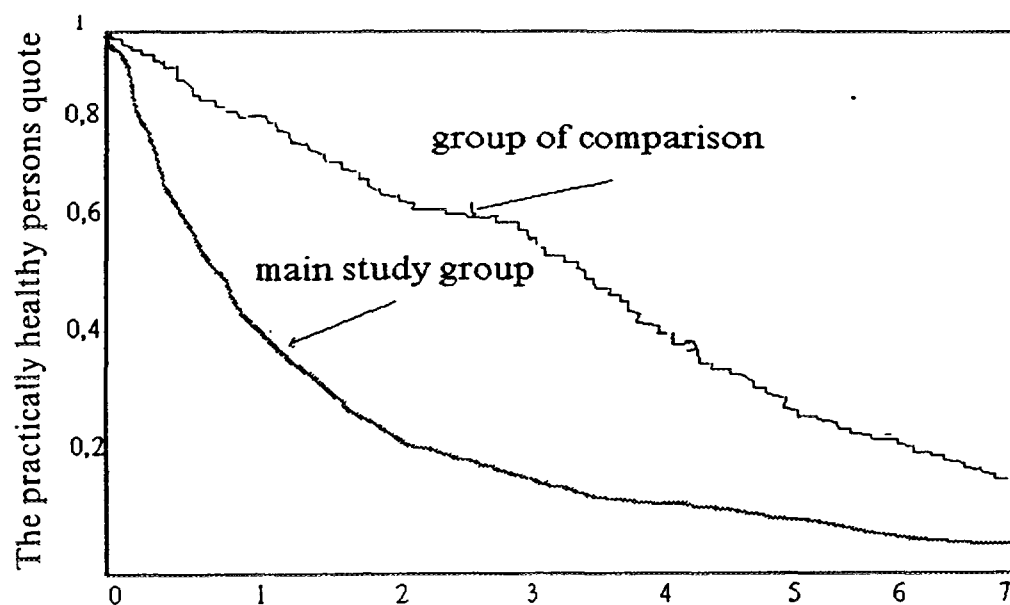


Fig.2. The age-related health status dynamics in children of main study group and that of comparison one

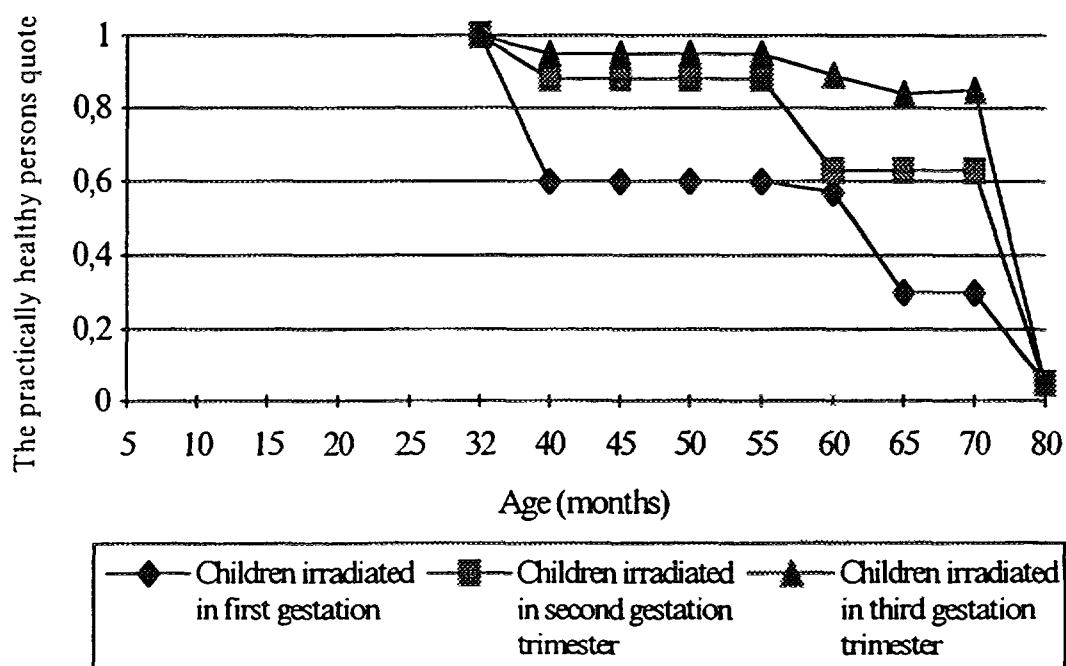


Fig.3. The children health status dynamics depending on various gestation terms

The thyroid enlargement of IA&IB degree was rather more frequently registered in children irradiated prenatally (Tabl.2).

Table 2

The thyroid enlargement frequency in post-accidental period (in %)
dynamics among children irradiated in utero

Gaiter degreI	1st group				2nd group				Control			
	1989	1991	1993	1995	1989	1991	1993	1995	1989	1991	1993	1995
0	72,3	60,7	11,4	10,2	87,0	57,7	16,1	15,1	92,6	87,0	83,6	54,5
I	26,8	37,9	80,4	75,2	12,5	39,7	72,1	70,2	7,4	13,0	13,2	34,0
II	0,9	1,4	8,2	14,6	0,5	2,6	11,8	14,7	0,0	0,0	3,2	11,5
III	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

The ultrasound topograms analysis revealed the echostructure and echodensity presence in 14,0-29,9 % cases.

The TSH bias from normal values were registered in 5,2 % (1989) and in 8,6 % (1994).

An evaluation of blood system revealed the more rare optimal hemoglobin level of children irradiated in utero in the all periods of observations (Fig.4) .

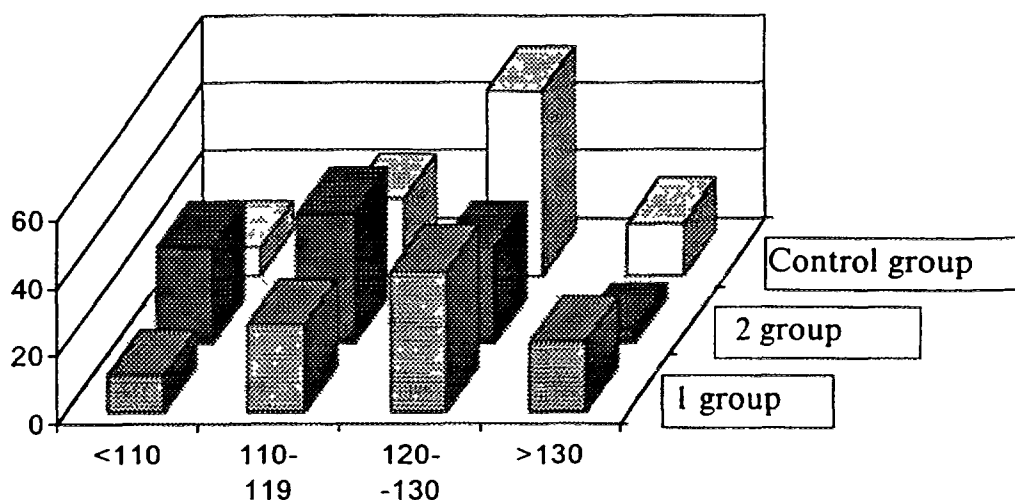


Fig.4. Distribution of children irradiated in utero at the age of 2 years (%)
by number of hemoglobin

They have characteristic tendency to the lower number of leucocytes (Fig.5), and more frequent changes in leucocyte formula. These changes were more pronounced in children of group 2.

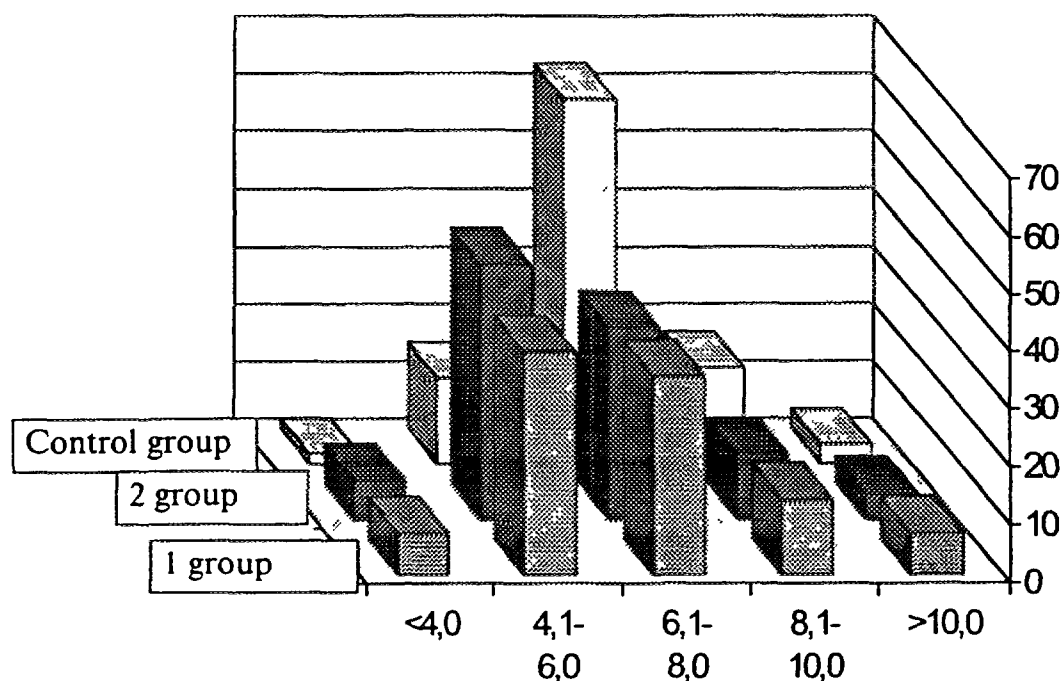


Fig.5. Distribution of children irradiated in utero at the age of 2 years by number of leucocytes (%)

Significant changes on the side of superficial architectonics in blood cells were noted. So discocyte number between erythrocytes of peripheral blood was decreased and varied within range of 62,5 - 59.8 % during all the time of observation with simultaneous increase in the number of transient and prehemolytic forms cells with degenerative changes and pathologic form of superficies were appeared (Fig.6).

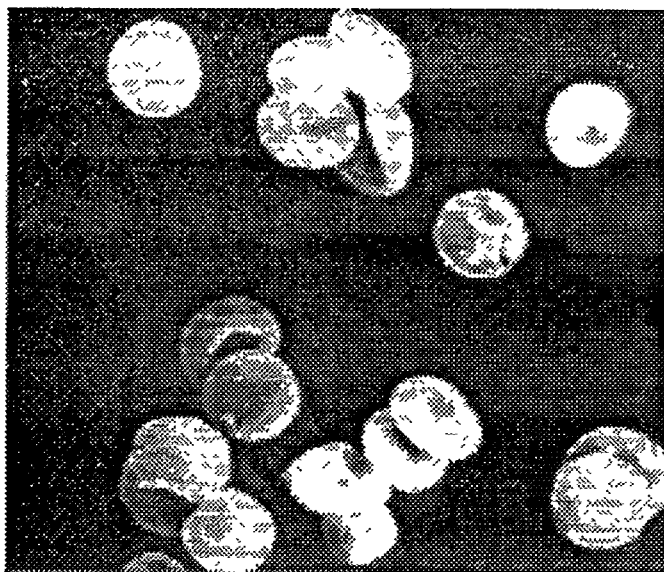


Fig.6. Erythrocytes of peripheral blood of children irradiated in utero

Lymphocyte metabolism of children irradiated in utero in 1987-1989 was characterized by the activation of energyproduction processes with all paths involving into this process for receiving cell energy but the level of glycolysis enzymes was increased to the greater degree (Fig.7).

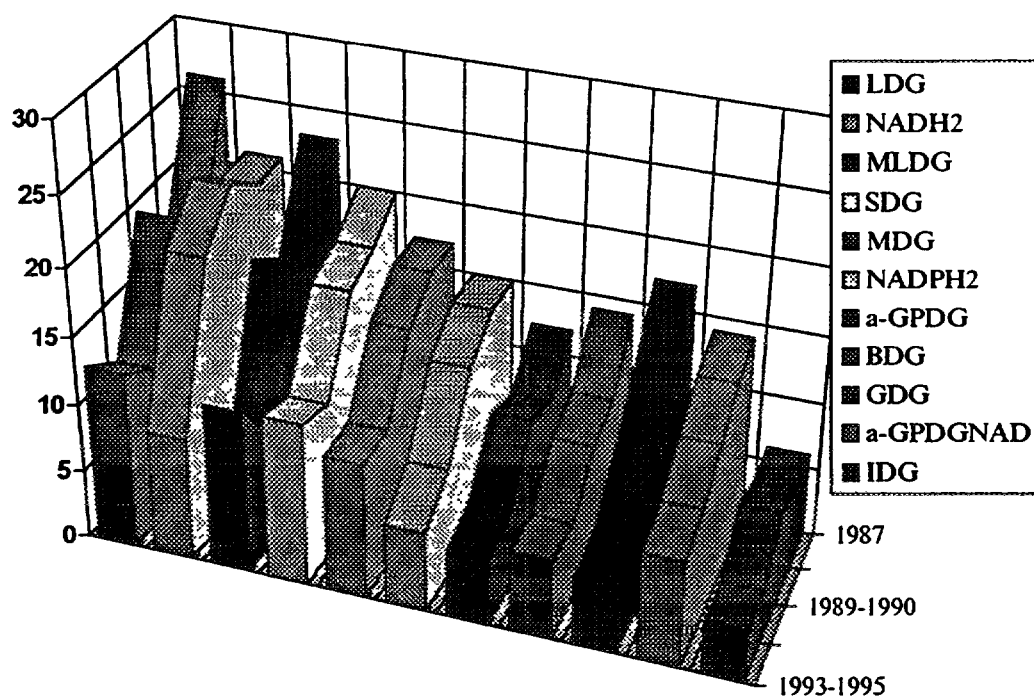


Fig.7. Cytochemical parameters of lymphocytes for children irradiated in utero

Neutrophiles differed from control by higher content of lipides, peroxidase, glycogen, alkaline and acidic phosphatases (Fig.8).

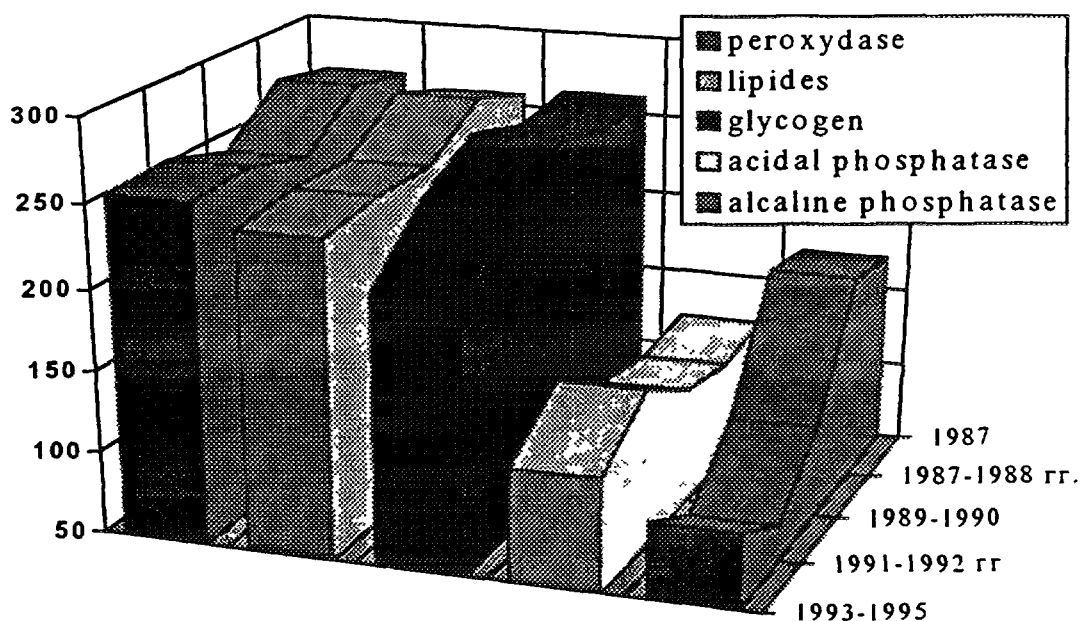


Fig.8. Cytochemical parametres of neutrophiles for children irradiated in utero

Next years a non - stability in neutrophiles functioning that was characterized by the suppression of phagocytic and tetrasoliumreducing activity against a baskground of an decrease in the level of all intracellular enzymes (with the exception of acidic phosphatase) and cytochemically detected substances preserving the ultrastructural changes was distinctly revealed.

An intellectual evaluation revealed that a number of children with mean level of mental faculties was identical in the all groups. No differences in a number of children with degree of intelectual defects in these groups were registered. It can de marked only the tendency to decrease in percentage of children with high IQ and the increase in a number of children with decreased IQ in the 1st and 2nd groups comparing with decreased IQ in the 1st and 2nd groups comparing with the controls (Fig.9).

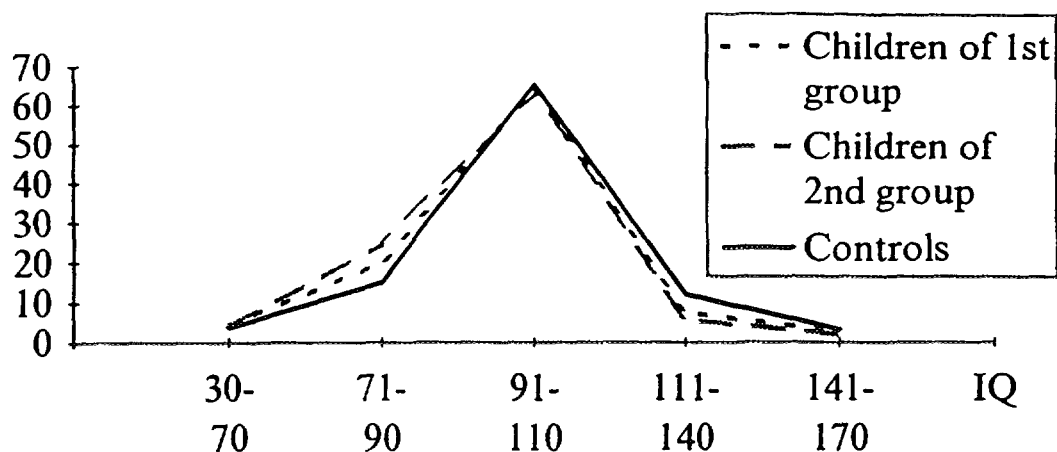


Fig.9. Percent distribution of children, irradiated in utero, according to date of total intellect

Mathematical analysis of data obtained revealed that the group risk of health aggravation in children irradiated in utero ranged from 1,63 to 2,94. This means that during 1 year among 100 children 16-29 have the chance to pass into the less benefit health group. In control group these data are significantly lower and are 0,85 -1,13 e.g. among 100 children 8 -11 have the chance to pass into less benefit health group. Significant influence on the risk quantity of health aggravation rendered the mean level of dose loading accumulated in the living regions.

CONCLUSION

Thus, multicomponent effect of radiation and nonradiation factors of the Chernobyl accident on the body during antenatal period of ontogenesis resulted in decrease of adaptation possibilities of born children and stipulated their health aggravation with shortening the practically health subjects of population from 35,7 to 5,0 % in 1987 and 1995, respectively.

EPIDEMIOLOGICAL AND THEORETICAL ASSESSMENTS OF LONG TIME MEDICAL EFFECTS IN VICTIMS OF THE CHERNOBYL CATASTROPHE

A.E. ROMANENKO

Research Center for Radiation Medicine,
Kiev, Ukraine



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ЭПИДЕМИОЛОГИЧЕСКАЯ И ТЕОРЕТИЧЕСКАЯ ОЦЕНКА ДЛИТЕЛЬНЫХ КЛИНИЧЕСКИХ ЭФФЕКТОВ, НАБЛЮДАЕМЫХ У ПОСТРАДАВШИХ ВСЛЕДСТВИЕ ЧЕРНОБЫЛЬСКОЙ КАТАСТРОФЫ РОМАНЕНКО А.Е.

Научный центр радиационной медицины АМН Украины, Киев

Reconsideration of results of clinical studies allows to estimate in different way meaning of number of factors of radioecological catastrophe and their combined health effects. Epidemiological studies of dynamics of malignant neoplasms among population of radiation contaminated territories have shown that for 10 years after the Chernobyl accident there was no sufficient excess of oncological morbidity. Whereas considerable excess of thyroid cancer frequency has been revealed, especially at children. It is established that for 10 years after the Chernobyl catastrophe essential worsening took place in health condition of suffered contingencies and population in general. Postchernobyl morbidity of suffered population is the integral result of both polyfactoral influence and stable prechernobyl tendencies. On areas exposed to radioactive contamination process of formation of new social and economic environment is taking place. It is characterised by disruptions of processes of vital activity of huge population contingencies, additional irradiation of people, high level of situation anxiety (which has long-time and mass character), social and psychological tension, unsatisfaction of people with their health condition. Here new interpersonal relations are being formed, and old ones are being disrupted. Necessity of unusual social roles and duties appears, it requires tension of adaptation mechanisms and influences negatively at formation of individual and public health.

Эпидемиологические исследования динамики злокачественных новообразований среди населения радиоактивно-загрязненных территорий Украины, показали, что за прошедший после Чернобыльской аварии период существенного прироста онкозаболеваемости не произошло, сохраняются такие же тенденции, как и в предшествующие годы. Вопреки существовавшим ранее мнениям в послеаварийном периоде не наблюдается изменений тренда динамики заболеваемости гемобластозами. В то же время выявлен значительный прирост частоты рака щитовидной железы, особенно у детей [1]. Насколько сохранятся такие соотношения динамики онкологических заболеваний в дальнейшем, покажет время, однако уже сегодня можно сделать вывод о необходимости дополнения существовавших ранее взглядов на развитие онкологических стохастических последствий облучения и продолжения исследований в данном направлении.

В то же время установлено, что за 10 лет после Чернобыльской катастрофы в состоянии здоровья пострадавших контингентов и популяции в целом произошло существенное ухудшение. Это подтверждается одним из самых объективных показателей - смертностью пострадавшего населения,

которая из года в год возрастает. Наибольший уровень смертности наблюдается в группе населения, проживающего на контролируемых территориях. Показатели смертности участников ликвидации аварии также растут, но они характеризуются более низким уровнем, что объясняется особенностями возрастной структуры этой группы и более высоким исходным уровнем здоровья. В затронутых аварией районах отмечается рост большинства общих соматических и психосоматических заболеваний. Они сейчас являются основной причиной инвалидизации и смертности, однако четкой зависимости от величины дозы облучения, как правило, не наблюдается. В литературе практически отсутствуют данные о риске общих соматических заболеваний, обусловленных действием малых доз ионизирующего излучения, характерных для подавляющего большинства пострадавших от аварии на Чернобыльской АЭС. Поэтому особое значение приобретают исследования в данном направлении, изучение причинно-следственных связей развития патологии и роли радиационного фактора. Переосмысление результатов клинических исследований позволяет иначе оценить значимость ряда факторов радиозкологической катастрофы и их сочетанного воздействия на здоровье [2].

Синергизм отрицательных факторов Чернобыльской катастрофы, включая дистресс, является характерной чертой современной клинической практики. У многих пострадавших не достигается реабилитация после устранения радиационных дефектов, регуляторные связи не могут вернуться на прежний уровень организации, дисрегуляторные и дезинтегративные дефекты разной степени выраженности продолжают сохраняться. Они могут быть благодатной почвой для функционального предболезненного состояния или различной соматической патологии, пролонгирования и утяжеления течения различных заболеваний.

Цитогенетические индикаторы радиационного воздействия, частота которых положительно коррелирует с интенсивностью первоначального острого облучения, выявляются у участников ликвидации аварии и в настоящее время. Обнаружено, что хроническое радиационное воздействие приводит к накоплению цитогенетического эффекта со временем из-за преобладания процессов аккумуляции индуцированных повреждений хромосом над их элиминацией. Полученные данные, являющиеся показателями общей мутагенной нагрузки на человека, свидетельствуют о дестабилизации генома соматических клеток у ряда пострадавших (прежде всего у участников ликвидации аварии и проживающих на загрязненных радионуклидами территориях), что побуждает отнести их к группе повышенного риска.

Имеющиеся в литературе сведения указывают на снижение иммунного ответа и неспецифической резистентности под влиянием ионизирующего излучения, а также о зависимости этих изменений от дозы облучения [3]. Специальные исследования, проведенные в Научном центре радиационной медицины, позволили существенно расширить представления по данному вопросу. В частности, была обнаружена гетеротропность изменений клеток в зависимости от поверхностного иммунного фенотипа [4]. К настоящему времени установлено, что эффекты воздействия радиации на иммунную систему определяются не только поглощенной дозой облучения, но и уровнем элиминации стабильных повреждений иммунокомпетентных клеток, нарушением взаимных связей иммунной и нейроэндокринной регуляции, наличием предшествующей или сопутствующей соматической патологии.

Восстановление иммунной системы после облучения может сопровождаться снижением функциональных резервов и стабильными изменениями гомеостатических систем.

Анализ полученных данных подтверждает существование баланса регуляторных процессов между повреждением и компенсацией, имеющего важное общебиологическое значение. Молекулярная и клеточная репарация в тканях с высоким уровнем обмена (кровенворная, иммунная) выходят из-под контроля поврежденных высокодифференцированных постмитотических нервных и эндокринных клеток, у которых скорость репарации и компенсации на клеточном уровне значительно слабее и может определяться только на системном уровне. В случае, когда повреждающий эффект не преобладает над репаративной активностью, происходит тотальное восполнение радиогенного эффекта. Продолжающееся облучение в низких дозах может стимулировать репаративную активность и приводить к гиперкомпенсации или так называемому "радиационному гермезису". Однако во многих случаях наблюдается преобладание повреждающего эффекта над репаративной активностью и "радиационный гермезис" не проявляется. По нашему мнению, в клиническом плане отношение к "радиационному гермезису" должно быть очень осторожным. В пользу такой сдержанности свидетельствует и отсутствие объективно подтвержденных положительных эффектов в отношении здоровья при длительном наблюдении больших контингентов населения, подвергшихся радиационному воздействию.

Послечернобыльская заболеваемость пострадавшего населения интегральный результат как полифакторного воздействия, так и устойчивых до-чернобыльских тенденций. В подвергшихся радиоактивному загрязнению районах происходит процесс формирования новой социально-экономической среды, характеризующийся нарушениями процессов жизнедеятельности больших контингентов населения, дополнительным облучением людей, высоким уровнем ситуационной тревожности (имеющей длительный и массовый характер), социально-психологическим напряжением, неудовлетворенностью людей состоянием своего здоровья. При этом разрушаются старые и формируются новые межличностные отношения, возникает необходимость в непривычных социальных ролях и обязанностях, что требует напряжения адаптационных механизмов и отрицательно влияет на формирование индивидуального и общественного здоровья.

Среди факторов, влияющих на здоровье населения в течение всего послеаварийного периода, социально-психологические являются одними из наиболее длительных, устойчивых, обладающих травмирующим потенциалом, детерминирующим как психопатологические состояния в остром периоде, так и пролонгированные психосоматические последствия. Это комплекс факторов, обусловленных в первую очередь процессами социальной дезорганизации в связи с аварией, загрязнением больших территорий долгоживущими радионуклидами. Он характеризуется возникновением и интенсификацией следующих явлений: эвакуация и переселение больших масс населения в новые условия, значительные нарушения процессов жизнедеятельности, разрыв социальных связей и изменение традиционного образа жизни, работа в экстремальной ситуации, влияние средств массовой информации на формирование общественного мнения. Радиационный фактор приобретает социальную и психологическую значимость (наряду с другими) и также становится стрессогенным фактором среды обитания.

Таким образом, из всех патогенных факторов Чернобыльской катастрофы можно выделить два наиболее значимых: радиационный и социально-психологический. Если на первом сконцентрировано внимание подавляющего большинства исследователей, то второй до последнего времени в силу ряда обстоятельств недооценивался, хотя без его учета не могут быть решены задачи организации научно обоснованных профилактических мероприятий.

На основании наших наблюдений можно утверждать, что низкие (малые) дозы ионизирующего излучения совместно с другими факторами обладают отрицательным действием на человека. И вместе с тем при оценке последствий Чернобыльской катастрофы нельзя ограничиваться только влиянием ионизирующего излучения. Необходимы исследования, в которых внимание было бы обращено на глобальную проблему - окружающая среда и человек, его экономическое и социальное положение.

Таким образом, к решающим причинам ухудшения здоровья населения следует относить также социальные факторы: низкий доход на душу населения, плохое жилье, неудовлетворительное питание и т.п. Только когда в Украине будет достигнут оптимальный уровень жизни, научные изыскания о влиянии малых доз ионизирующего излучения на людей в постчернобыльский период смогут дать исчерпывающий ответ, в какой степени такое радиационное воздействие влияет на здоровье, число врожденных уродств и мертворождений, на продолжительность жизни и преждевременное старение, на рост заболеваний крови и злокачественных новообразований.

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LYMPHOCYTE GENOME INDICATORS IN PROFESSIONALS AND INDEPENDENT SETTLERS IN THE CHERNOBYL NPP EXCLUSION ZONE

I.P. DROZD

Intersectorial Scientific and Technical Center "Ukritic",
Chernobyl, Ukraine

L.K. BEZDROBNAYA, E.P. ROMANOVA, S.A. SHOVKUN

Science Centre "Institute for Nuclear Research",
Kiev, Ukraine

1. INTRODUCTION

As the result of Chernobyl NPP (CNPP) accident different groups of people were exposed to a wide range of doses of additional suprabackground radiation. These groups include: 1) the immediate participants in the liquidation of the accident in 1986 -87 and of its consequences in the following years, the professionals working at the unit "Shelter" among them; 2) residents of the radionuclide contaminated territory which is under strict radiation control. A 30 km alienation zone was established and its population was evacuated on May,4, 1986. However in June - September 1986 part of the evacuated people returned as self-settlers to the least contaminated villages. By the beginning of the 1996 the number of self-settlers in the alienation zone has been about 800. Undoubtedly it is of great interest to study the state of cell genome of the professionals who participated in the clean-up after the accident and who are still working at the "Shelter" unit and of the self-settlers who have been living in the alienation zone for almost ten years being constantly subjected to the influence of small doses of both internal and external irradiation.

A number of publications has already presented results of the cytogenetic examination of the individuals who took part in the liquidation of the Chernobyl accident consequences and of the individuals who dwell in the areas due to this accident contaminated[1,2,3 and other.]. However no data were presented on the state of genome of the liquidators professionals who continue their work at the "Shelter" unit and of the self-settlers dwelling in the alienation CNPP zone.

The aim of this study was to investigate the genome of the peripheral blood lymphocytes of the abovementioned groups of people as to the following indices: level of instability of the DNA structure in the nick translation test, the frequency of micronuclei (MN) and the cell DNA index (DI).

2. MATERIALS AND METHODS

Samples of human heparinized peripheral venouse blood were used in the experiments. Lymphocytes were isolated from blood by Ficoll/Verografin density gradient centrifugation. For the MN assay the whole blood was analysed.

2.1. Nick translation assay

Lymphocytes were suspended in a solution containing 0.25 M sucrose, 0.1 M Tris- HCl (pH 7.4), 10 mM MgCl₂ and 0.5 mM dithiothreitol. Then the cells have been permeabilized by exposure to 0.02% Triton X-100 for 2 min. at 4 °C. The nick translation reaction was carried out as described in [4]. The reaction was terminated by moving the entire sample mixture onto the Whatman 3MM filter discs prewetted with 2% pyrophosphate. The discs were conventionally washed. Acid insoluble radioactivity was measured in a scintillation counter Beta-1219 (LKB Wallac).

2.2. Micronucleus assay

0.2 ml of the whole blood was mixed with 2.0 ml RPMI - 1640 medium (Sigma) containing 20% fetal calf serum and 0.02% PHA-P (Sigma). The cell culture was incubated at 37 °C. The cytochalasin B at final concentration of 6 µg/ml was added after 44 h to the PHA stimulated

lymphocyte cultures In the following 24 h the micronucleus slide preparations were made following the method of [5] fixing in 3 l ethanol acetic acid with cold hypotonic treatment and dropping of the cell suspension onto clean cold slides, which were then stained with Giemsa Cells with two macronuclei with cytoplasm surrounded by cell membrane were scored in order to find micronuclei It was done at x800 magnification and 1000 binucleated cells (CB cells) were scored per each individual

2.3. Flow cytometric analysis of the DNA content

Lymphocytes were suspended in cold phosphate-buffered saline (PBS) pH 7.4 containing 0.5 mmol EDTA and 10% fetal calf serum (Sigma) The cell suspension was fixed in 50% ethanol at a concentration of 10^7 cells/ml The samples were stored at 4 °C Prior to the analysis the fixative was removed and the cells were resuspended in PBS Chicken erythrocytes were used as internal standard to determine zero point on histograms [6] DNA of the cells (3×10^5 cells/ml) have been stained with ethidium bromide (15.5 µg/ml final concentration) (Serva) for 5 min after the 30 min RNase-A (37 µg/ml final concentration) (Sigma) treatment The measurement was carried out on the flow cytometer FACStar Plus (Becton Dickinson, USA) For each histogram 10000 cells were analysed DNA content in the lymphocytes was expressed as DI

2.4. Calculation of the dose loadings

Calculation of the dose loading was made according to take standard programmes [7] using data on radionuclide contamination of the territories [8] In calculation the doses of external irradiation shielding by buildings and snow and the depth of penetration of radionuclides into the soil were taken into account For the calculation of the internal irradiation doses it was considered that the self-settlers used all the food products (except bread and sugar) grown at their own formsteads

3 RESULTS

Three groups of individuals were examined CNPP professionals, who had participated in the liquidation of the Chernobyl accident consequences and are still working at the "Shelter" (20 individuals), self-settlers from five villages in the alienation zone (26 individuals), the Kyivans, who have never worked at atomic or chemical enterprises, have not undergone radiotherapy, and for the period of the past six months have not been X-ray diagnosed and have not had any viral infections (20 individuals) The age of those examined was within the range of 22-60 years

3.1. The study of the instability of the DNA structure

The level of instability of the DNA structure of peripheral blood lymphocytes of the professionals was defined by the incorporation of [3 H] dTTP into the permeabilized cells in the

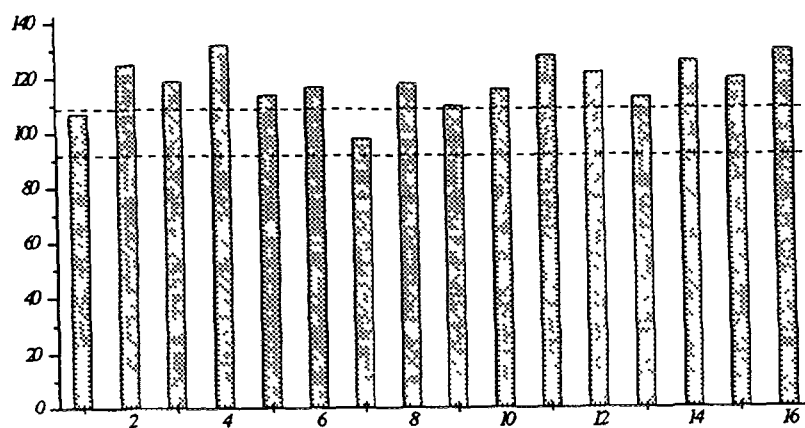


Figure 1 Incorporation of [3 H] dTTP into the lymphocyte DNA of the professionals (Y axis), % to the group of Kyivans (X axis) Dash lines show the top and low error limits of the average meaning for the Kyivans group

conditions of the nick translation reaction. The degree of incorporation of the radiolabelled DNA precursor reflects the level of 3'-OH single-strand breaks of DNA. We have examined 16 individuals in four experiments. Simultaneously two Kyivans were examined during each experiment. As the [^3H] dTTP incorporation depended upon the degree of the cell permeability obtained, in each separate experiment the index of its incorporation into the lymphocytes of the professionals was compared to that of the Kyivans and was expressed in relative units. The degree of incorporation of [^3H] dTTP into the cells of the Kyivans was taken as 100%. The half examined professionals showed the increase of the level of 3'-OH DNA single-strand breaks of lymphocytes as compared to the Kyivans by 20-32% (Fig 1).

3.2. The study of the chromosomal damage by micronuclei registration

The probability of the genome damage on the chromosomal level was studied by MN analysis method proceeding from the following. According to the data [3] the dose- response dependance is analogous for both chromosomal aberrations and MN in irradiation of the donors blood *in vitro* within the dose range up to 2 Gy. According to [9] at small doses of irradiation (up to 0.5 Gy), the MN assay is more sensitive than the analysis of the unstable chromosomal aberrations. Moreover the MN analysis is easier and quicker. As is seen from Table I the spontaneous frequency level of lymphocytes with MN in the group of the Kyivans varies from 4 to 19 per thousand of cells. These data quite agree with those for the healthy donors given in a number of publications [10,11].

On the average the number of cells with MN is 1% and the majority of them has one MN (only in 10% of the Kyivans investigated lymphocytes with two MN per CB cell were found). The analysis of lymphocytes of the CNPP professionals showed a significant increase of MN content as compared to that of the Kyivans. This increase mainly due to the increase of number of CB cells with two MN and the appearance of cells with three MN. In the blood of 87% of the professionals examined cells with two MN and in 36% - with three MN were found.

The analysis of MN in the lymphocytes of the self-settlers in the CNPP zone showed no significant difference in the mean total MN content and the range of the individual variation from those of the majority group of professionals examined (Table I). However if in the professionals as compared to the Kyivans, the increase of the number of MN is due to the appearance of cells with several MN in the self-settlers it is due to the valid increase of the number of CB cells with one MN. Only 19 % of the self-settlers examined have cells with two MN. Their number show no significant difference from that of the Kyivans. The group of self-settlers was comprised of the residents of five villages in the alienation zone. The volume of the groups being rather small, we nevertheless made an attempt to compare the frequency of the presence of MN in the lymphocytes of their blood with the level of

TABLE I Content of micronuclei in the peripheral blood lymphocytes of the professional and self-settlers of the Chernobyl NPP zone, ‰

The group examined	Range of the total number of MN	Mean total number of MN	Distribution of cells according to the number of MN			Mean number of cells with MN	Range of the number of cells with MN
			1	2	3		
Kyivans	4-19	10.8±0.8	10.6±0.8	0.1±0.1		10.7±0.8	4 - 18
Professionals	4-25	15.6±1.8*	12.0±1.2	1.2±0.3*	0.5±0.2	13.6±1.4	4 - 20
Self-settlers	7-24	14.6±0.8*	13.8±0.7*	0.4±0.2**		14.2±0.7*	7 - 24

* $p < 0.01$ in compared with Kyivans ** $p < 0.05$ in compared with professionals

TABLE II. Content of micronuclei in the peripheral blood lymphocytes of the self-settlers depending on the density contamination with radionuclides of the territories and dose loading.

Name of the village	Density of contamination Ci/km ²		Mean total dose of irradiation (1986-95) mSv			Range of the total number	Mean total number	Distribution of cells according to the	
			External	Internal				number of MN	
		¹³⁷ Cs	⁹⁰ Sr		on the whole body	on the red bone marrow	of MN	of MN	1
Gorodische n=5	2.0	0.9	17.5	20.9	24.1	10 - 14	12.2 ±0.8*	12.2 ±0.8	
Il'yincy n=6	2.2	1.1	19.3	24.7	26.3	7 - 19	12.2 ±1.7*	12.2 ±1.7	
Koupov atoye n=4	2.9	2.5	25.3	34.5	58.8	10 - 18	13.5 ±1.9*	13.5 ±1.9	
Louby- anka n=7	11.0	3.9	96.7	95.9	88.9	12 - 24	16.3 ±1.3	14.9 ±1.8	0.7± 0.5
Opachi- chi n=4	8.0	5.5	76.0	76.0	125.7	16 - 22	19.2 ±1.2	16.3 ±1.3	1.5± 0.8

* $p > 0.05$ in compared with Opachichi.

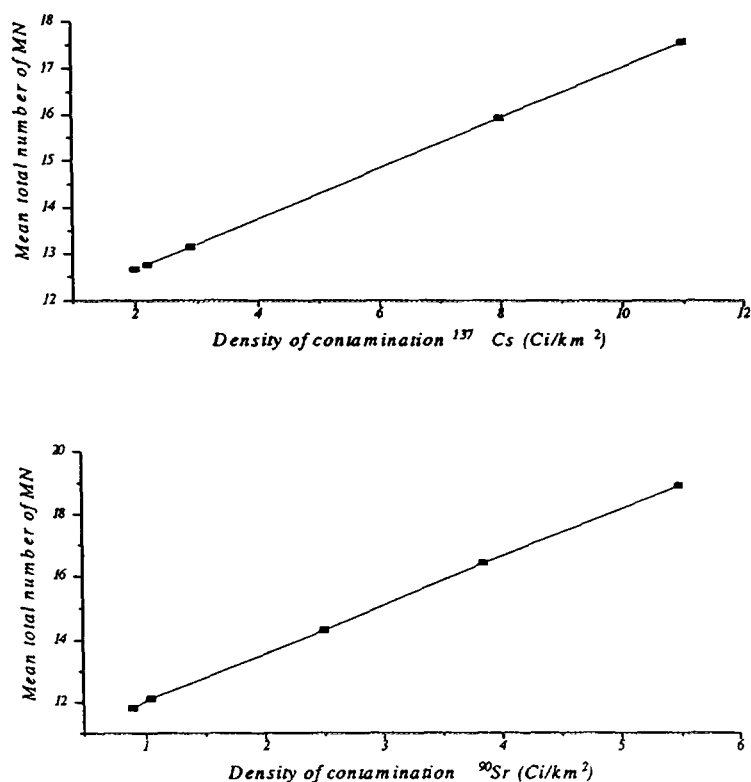


Figure 2. Dependence of the mean total number of MN on the density of radionuclides contamination of the territory. (For ¹³⁷Cs $r=0.51$; for ⁹⁰Sr $r=0.62$; $P=0.99$).

radionuclide contamination of the territory of habitation and the mean dose of radiation they are being exposed to. As is seen from Table II the largest content of MN in lymphocytes is found in the residents of Opachich village. This index is significantly higher than that of the residents of Gorodische, Il'yincy, Koupovatoye and shows no significant difference from that for the Loubyanka residents. In the blood of Gorodische, Il'yincy, Koupovatoye residents we found lymphocytes with only one MN per cell. Two MN cells were found only in the blood of the residents of Loubyanka (in 2 out of 7 examined) and Opach (in 3 out of 4 examined). Correlation analysis of mean content of MN in the lymphocytes of the residents of the abovementioned villages and the density of contamination with radionuclides of these territories and with the doses of external and internal exposure (of the whole body and of the red bone marrow), detected according to the contamination indices showed the valid correlation relationship. The highest level of correlation was found between the MN content and ^{90}Sr contamination and also between the MN content and the dose of red bone marrow irradiation (Fig 2).

3.3. Estimation of the DNA index

Flow cytometry analysis of the DNA content in lymphocytes of the professionals and self-settlers of the alienation zone showed the presence of the single cell population with coefficient variation of the G_1 peak about 3%. No deviation from the DNA diploid content was found in the examined individuals.

3 CONCLUSIONS

The presented results of the comparative study of the state of genome of the professionals, the self-settlers of the CNPP alienation zone and of the group of donors - Kyivans show the increased level of the genome instability in the contingent of the zone. In the professionals examined it was manifested by the increase of instability of DNA (by the yield of the DNA single-strand breaks) and of chromosomes (by the MN frequency in CB cells). The increased level of the genuine DNA SSB may be due to the DNA functional activity tension and to the shift to a different regime of transcription and reparation in the conditions of chronic exposure following the exposure to a greater dose.

Greater yield of cells with several MN in the professionals suggests that they could have been exposed to doses no less than 40 cGy [12]. Possible exposure to large doses of radiation soon after the accident when there had been no strict dosimetry control is still shown in the increased instability of lymphocyte chromosomes. It is likely that cells with several MN found are either long-life mitotically inactive lymphocytes or the total result of the damages, being preserved in the genome of the lymphoid tissue cells for several generations (the possibility of such preservation had been shown on the different cells lines [13] and those being induced at present by small doses).

The increased instability of the lymphocyte chromosomes of the self-settlers is mainly due to the presence of cells with one MN (mean frequency of cells with MN in the professionals and the self-settlers being equal). This testifies to the fact that dose loading in these two groups was significantly different. The found correlation between the density of radionuclides contamination of the territory and the content of MN in lymphocytes of the self-settlers shows that the micronucleus assay is quite sensitive and adequate method to bioindicate the constant influence of small doses of irradiation on a human being. In all investigated groups DNA diploid content was retained.

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

G. VASILEV, A. BAYRAKOVA

National Center of Radiobiology and Radiation Protection,
Sofia, Bulgaria

**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
T O T A L	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	363 cases overall	Severe hereditary effects
Nonfatal cancer	107 cases	
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 $5.0 \times 10^{-2} \text{ Sv}^{-1}$. 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 $1.3 \times 10^{-2} \text{ Sv}^{-1}$. 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 annually.

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, $25 \times 10^{-2} \text{ Sv}^{-1}$; 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 ($\mu\text{Sv/a}$)	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.

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THE ISRAELI CHERNOBYL HEALTH EFFECTS STUDY (ICHES)

G. RENNERT, S. SHAPIRO, H.S. RENNERT
National K.H. Cancer Control Centre,
Carmel Medical Centre,
Haifa, Israel

BACKGROUND

More than 100,000 people have immigrated to Israel since 1989 from areas in the former USSR in which radiation from the Chernobyl accident was measurable.

Exposure to radiation is known to be responsible for a variety of sequella. Among these are various malignancies and other chronic diseases. Pregnancy outcome is also possibly influenced by radiation exposure.

The Chernobyl accident is characterized by a long-term low-dose exposure. The health consequences of this type of exposure are not yet known to the scientific community.

AIM

To estimate the prevalence of various diseases among the immigrants to Israel from the radiation-inflicted areas around Chernobyl.

METHODS

A case-control study with on-going recruitment of cases and with two fixed control groups.

The cases group includes all immigrants who registered with the Study Center who were from one of 14 regions (oblasts) in the former USSR where evidence of Cs137 in the ground was found in 1990, following the Chernobyl accident.

This group currently includes 9,804 people.

The two control groups are:

7,000 immigrants from the same areas as the cases who did not register with the Study Center (to control for a possible selection-bias due to volunteer effect).

7,000 immigrants from non-exposed areas (Moscow and St. Petersburg) to provide the baseline disease rates for the (European) Russian-Jewish population.

All study participants were requested to complete a self-reported questionnaire. All participants of the cases group, but only about 10% of the participants of the control group have returned their questionnaires. An effort to increase compliance among the controls is under way.

RESULTS

The cases group (volunteers) includes about 10% of the target population. The age-sex distribution of the cases group is very similar to that of the target population of all immigrants as of 8.9%.

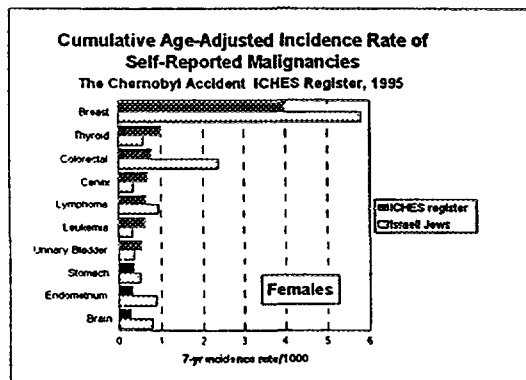
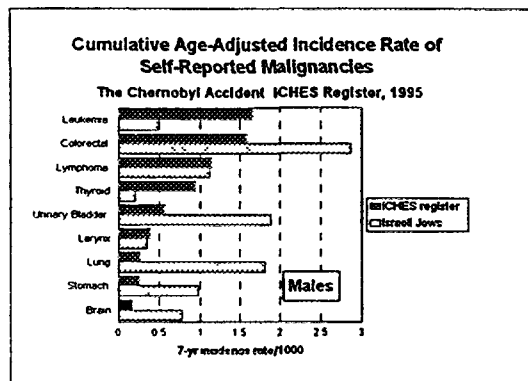
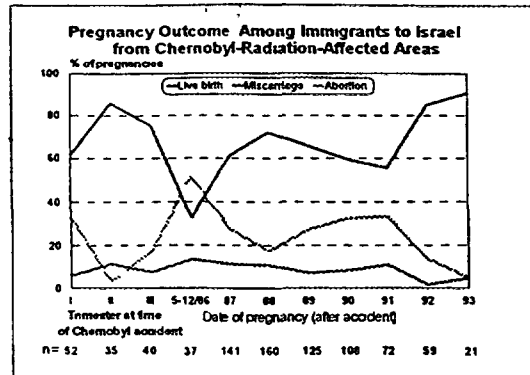
Pregnancy outcome - No increase in the rate of miscarriages was noted in the years following the accident among the exposed group (Figure 1).

Cancer - Cancer was self-reported at time of registration by 165 (1.7%) of the cases group; a prevalence rate of 1683/100,000. The most prevalent cancers reported are breast cancer, colorectal cancer and leukemia (Figures 2,3).

DISCUSSION

The current results need to be interpreted with caution. They are as yet uncontrolled, and are based, at this stage, on self-reports only. The study team is currently making an effort to increase compliance of the control group as well as to validate the health status of the participants by reports from the treating physicians.

The study participants have reported a high prevalence of health problems. Whether this reflects a true health consequence of the Chernobyl accident or is only a reflection of the anticipation of disease in this group remains to be established.



HOSPITALIZATION PATTERNS OF IMMIGRANTS FROM THE CHERNOBYL AREA IN ISRAEL

G. RENNERT, S. SHAPIRO, H.S. RENNERT
National K.H. Cancer Control Centre, Carmel Medical Centre,
Haifa, Israel

Background

More than 700,000 immigrants from the former Soviet Union (FSU) have arrived in Israel since 1989. Of them, more than 100,000 arrived from areas exposed to radiation from the Chernobyl accident. Among residents of the exposed areas in the FSU an increase in thyroid cancer but no increase in leukemias has been reported.

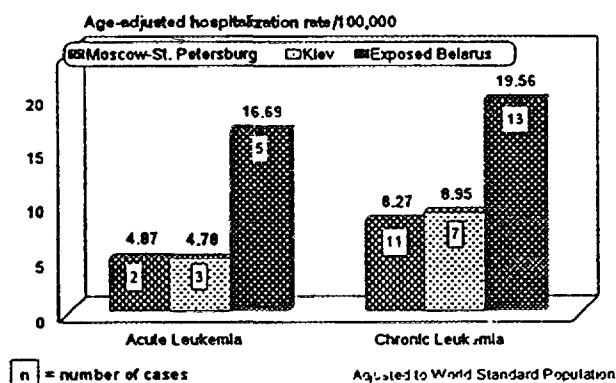
Methods

All hospitalizations of immigrants from the FSU in 7 general hospitals of the major Health Maintenance Organization (HMO) in Israel during the years 1990-1994 were studied. These hospitals serve the general population of the geographical areas in which they are located, regardless of their health insurance affiliation. Of all hospitalizations the following diagnoses were sought: acute leukemia, chronic leukemia, thyroid cancer, brain cancer, breast cancer, hypothyroidism, hyperthyroidism. Records were included if any of the abovementioned diagnoses was registered either as the main diagnosis or as an accompanying diagnosis, based on the ICD codes registered on the discharge letters. Cases with multiple hospitalizations with the same diagnosis were counted only once.

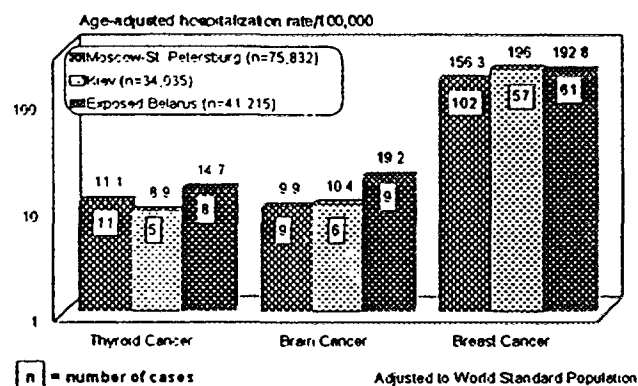
Three groups were compared:

1. Immigrants from areas in Belarus which were strongly affected by radiation from the Chernobyl accident (n=41,215).
2. Immigrants from the oblast of Kiev in Ukraine, considered to be mildly affected by radiation (n=34,035).
3. Immigrants from the non-radiation-affected cities of St. Petersburg and Moscow (n=41,215).

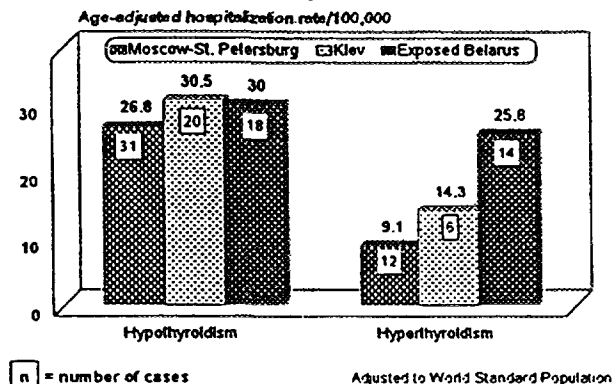
① Hospitalization of New Immigrants from the FSU in Kupat Holim Hospitals, Israel, 1990-1994
Acute and Chronic Leukemia



② Hospitalization of New Immigrants from the FSU in Kupat Holim Hospitals, Israel, 1990-1994
Radiation-related Carcinomas



③ Hospitalization of New Immigrants from the FSU in Kupat Holim Hospitals, Israel, 1990-1994
Benign Thyroid Disorders



Five-year age-adjusted hospitalization rates per 100,000 population and 95% confidence intervals were also calculated for each disease and each study group.

Results

During the period of investigation there were 66,913 hospitalizations of immigrants from the FSU. Of these, 410 were for the selected diagnoses in the relevant study groups.

a. Leukemias (figure 1)

The age-adjusted hospitalization rate from acute leukemia was higher for immigrants from Belarus; 16.7/100,000 (4.9-28.7) than for immigrants from Kiev, Moscow-St. Petersburg (4.8/100,000 and 4.9/100,000 correspondingly).

The age-adjusted hospitalization rate from chronic leukemia was also highest (19.6/100,000, C.I. 10.8-28.3) among the immigrants from the exposed areas in Belarus.

Radiation-related solid tumors (figure 2)

The differences in hospitalization rates of thyroid cancer, brain cancer and breast cancer were small and not significant. Thyroid cancer (14.7/100,000) and brain cancer (19.2/100,000) were more common in immigrants from Belarus. Breast cancer was similar in immigrant females from Kiev (196/100,000) and Belarus (192.8/100,000) and higher than in immigrants from Moscow-St. Petersburg.

Non Malignant thyroid disorders (figure 3)

Hypothyroidism was similarly diagnosed in immigrants from the three areas (26.8/100,000 in Moscow-St. Petersburg, 30.0/100,000 in Belarus, 30.5/100,000 in Kiev).

Hyperthyroidism, though, was much more common among immigrants from exposed areas in Belarus (25.8/100,000, C.I. 16.0-35.7) than for immigrants from Kiev (14.3/100,000, C.I. 4.1-24.5) and immigrants from Moscow-St. Petersburg (9.1/100,000, C.I. 7.5-10.7).

Conclusions

These data provide some support to a possible radiation effect on the occurrence of leukemias and hyperthyroidism among immigrants from the FSU to Israel.

The data-base employed in this study is unique in its non-selectiveness. It is further relatively protected from detection-bias as all diseases of the hospitalized patient were taken into account, and not only the main diagnosis. There is no reason to believe that the medical teams in Israeli hospitals employ a different diagnostic approach for patients from within and outside of the Chernobyl area.

The current database, though based on a large number of hospitalizations, has come-up with only a small number of end-point events. This is due to the relative rareness of events such as leukemia, thyroid and brain cancers. In spite of the small numbers, the differences between the various study populations are easily visible, and even reach significance for leukemia and hyperthyroidism. As results from Ukraine and Belarus on leukemias are generally negative, these findings are of interest and call for more in-depth study of the issue. Thyroid diseases leading to hyperthyroidism, such as autoimmune thyroiditis have been recently mentioned to be on the increase among the exposed populations. Our data lends support to this finding.

DYNAMICS OF CANCER INCIDENCE AND MORTALITY IN THE WESTERN BRYANSK REGIONS OF RUSSIA BEFORE AND AFTER THE CHERNOBYL ACCIDENT

**G.I. MIRETSKY, P.V. RAMZAEV, I.E. SHUVALOV, A.A. DOUDAREV,
M.N. TROITSKAYA**

**Institute of Radiation Hygiene,
St. Petersburg, Russian Federation**



XA9745494

This study was undertaken to investigate cancer incidence and mortality in connection with enhanced radiation exposures after the Chernobyl accident in the most contaminated regions of Russia (Bryansk province).

A study was carried out in six western districts of the Bryansk province (total population 265 000) which are located close to the most contaminated regions of Belorussia and the Ukraine — the border of Bryansk province is 150 km from Chernobyl (density of radioactive fallouts was up to 4×10^{12} Bq/km²).

Conclusions: 1. There was no evidence of increased overall cancer rates due to radiation in the contaminated regions of the Bryansk province. 2. Before the accident in the regions corresponding to the “high cancer” zone, there was a sufficiently high quality of diagnostics — here the cancer rate after the accident did not change. In the “low cancer” zone, where the medical service probably was not so good, the enhancement of cancer rates was due to mass clinical examination of the population of the whole western Bryansk regions after the accident.

**DISTRIBUTION OF INDIVIDUAL DOSES IN THE MOST HEAVILY
CONTAMINATED AREAS IN RUSSIA FOLLOWING THE
CHERNOBYL ACCIDENT**



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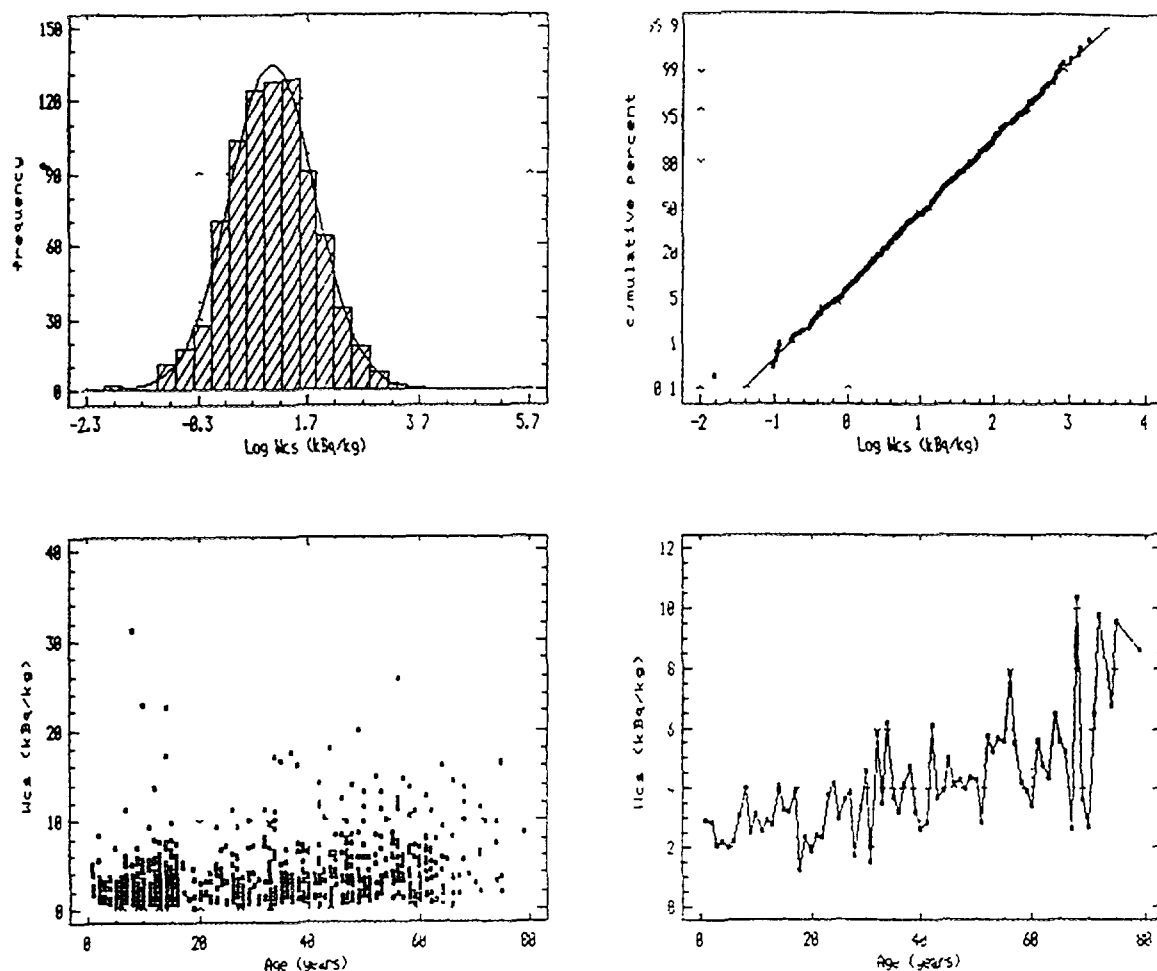
Yu. KONSTANTINOV, V.G. ERKIN, O.S. MOSKALEV
Institute of Radiation Hygiene,
St. Petersburg, Russian Federation

Whole body measurements on caesium radionuclide contents and individual TLD measurement of exposure to external irradiation were made in the western part of the Bryansk region where caesium-137 contamination from the Chernobyl accident exceeds 0.55 MBq/m² ("Strict control zone - SCZ"). Distribution of the annual ingestion dose from radiocaesium is shown for residents of a large rural settlement. Total dose to whole body (external and internal) is shown as a function of an occupational group. With use of questionnaire data on milk consumption and measurement data on radiocaesium body burden a distribution of the internal thyroid dose from radioiodine was derived for 14 thousand children in the SCZ. The data bank is under development with the aim to use available information for the reconstruction of individual doses.

The most affected by Chernobyl fallouts in Russia is the western part of the Bryansk Region. The territory initially specified as Strict Control Zone (SCZ, from 1991 officially assigned to "relocation zone") with caesium-137 contamination level (S) in excess of 0.55 MBq/sq.m (15 Ci/sq.km) covers an area of 2000 sq.km. At the time of the accident 112 thousands residents happened to live in the SCZ.

Over 250 thousands of whole body measurements on caesium radionuclides contents were carried out by the Institute of Radiation Hygiene in the SCZ and at some settlements in adjacent territory, including 150 thousands made in the first two years after the accident. 10 thousands individual measurements of exposure to external radiation were made with TLD in samples of people from settlements inhabited by 90% of the total population of the SCZ.

Processing of data on measurements of caesium radionuclides content in the body is demonstrated here for the village Yalovka situated in the highly contaminated area (S=2.4 MBq/sq.m). At the time of the accident Yalovka was the largest (in number of residents) rural settlement in the SCZ. 2311 individual whole body measurements were made for 1216 residents during four survey periods from summer 1986 to spring 1988. Figure 1 presents statistical characteristics of measured values for one of survey periods. In view of essential change (mainly decrease) of



**Figure 1. Specific activity of caesium radionuclides in the body (Wcs).
Yalovka, 20 August - 8 September 1986.**

- A. Frequency distribution of the logarithm of Wcs**
- B. Log-normal probability plot**
- C. Scatter diagram of Wcs versus age**
- D. Average value of Wcs as a function of age**

radiocaesium body content after the early summer 1986, relevant model was employed to calculate personal doses taking into consideration the time points of whole body measurements during a period of dose accumulation. The median levels of annual internal dose were 9.5 mSv in 1986 and 2.4 mSv in 1987. Figure 2 shows the distribution of calculated ingestion dose in 1987. Analysis of dose distribution and questionnaire data revealed a dominating role of food habits, especially milk consumption and the time after the accident at which the individuals ceased to consume locally produced milk.

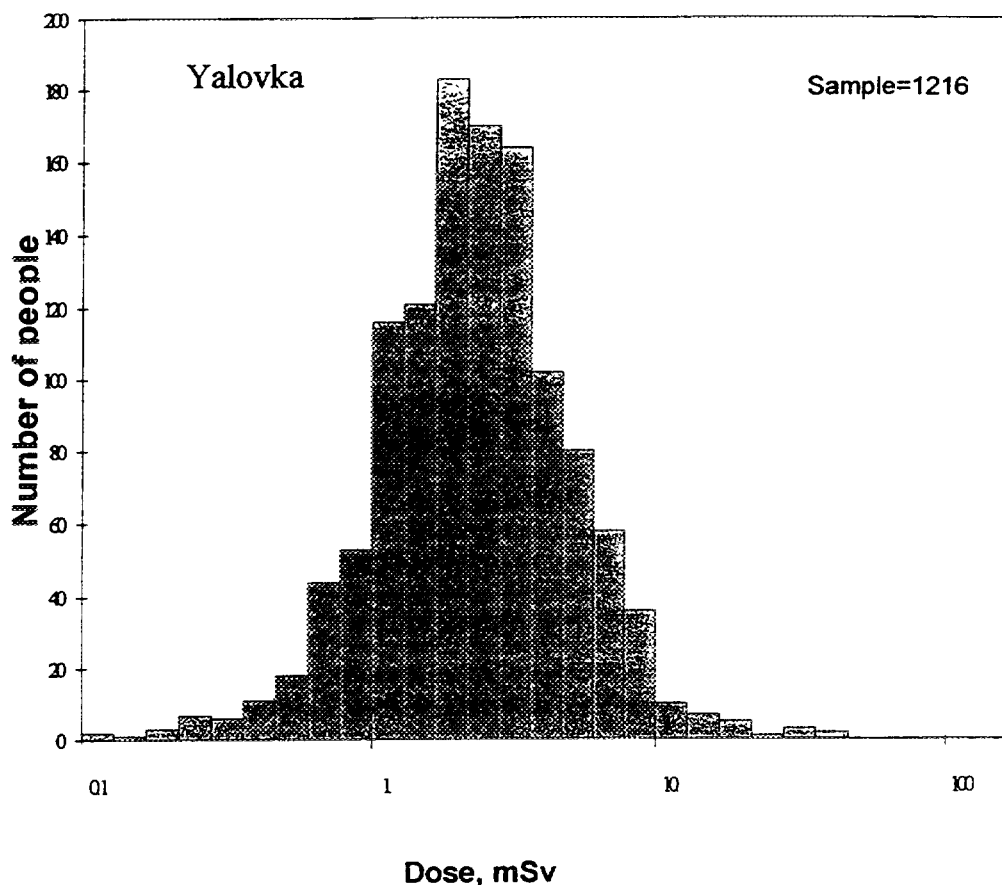


Figure 2. Radiocaesium ingestion doses, Yalovka , 1987

Restrictions in consumption of contaminated food averted essential fraction of the projected ingestion dose and resulted in predominant contribution of external radiation into the total effective dose to the whole body. Figure 3 shows the total dose in Stary Vyshkov ($S=1.2 \text{ MBq/sq.m}$) for individuals who were measured for both external dose (with TLD) and radiocaesium body burden. The total dose is dependent upon occupational activity with those individuals who spend more time outdoors receiving higher dose.

Due to results obtained from a limited set of reliable measurements of iodine-131 in the thyroid gland made in May 1986, a method of thyroid dose reconstruction was developed using data on environmental radiation, on consumption of milk, on the early measurements of radiocaesium contents in the body (Balonov, Bruk, Konstantinov, Korelina, Zvonova). The method was employed to

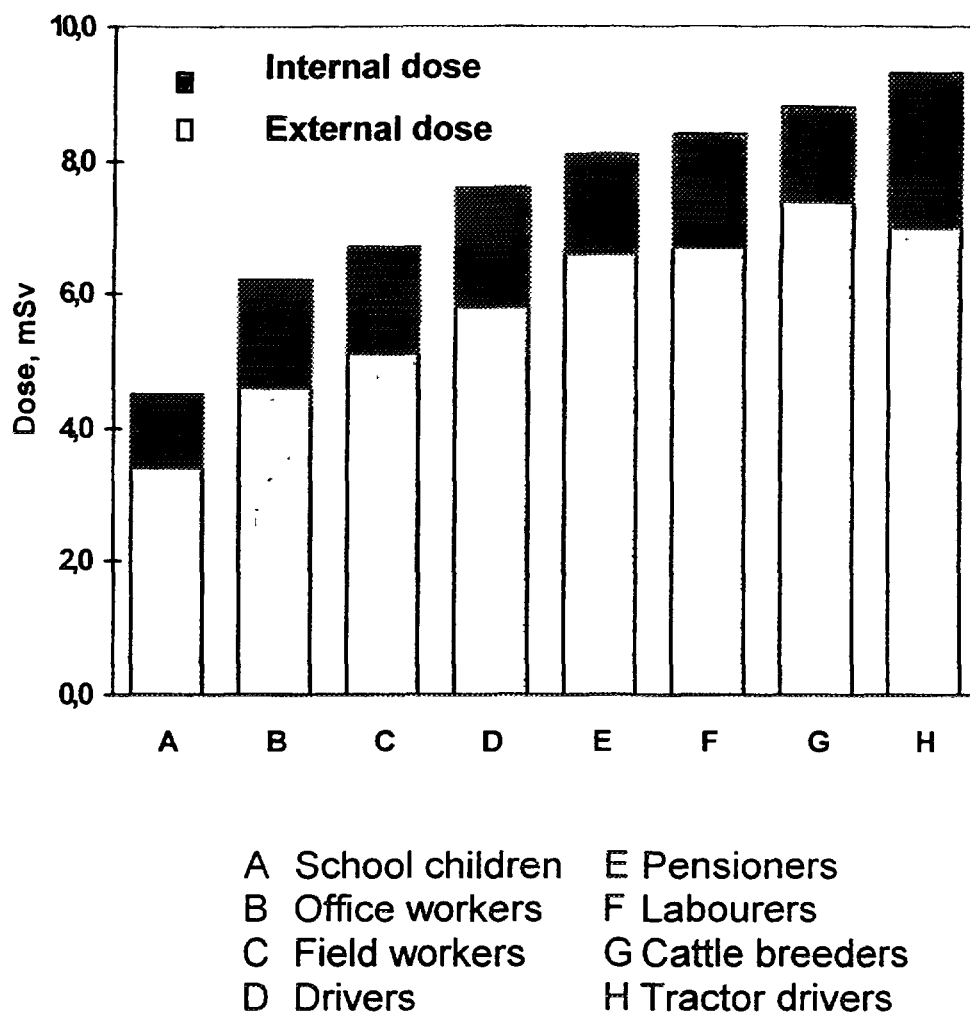


Figure 3. Total dose as a function of occupational group, Stary Vyshkov, 1987

assess the distribution of individual thyroid doses at residents of the SCZ. Distribution of calculated doses for children up to 14 years old is shown on Fig.4. The 'formally' calculated doses were a justified base to design a general dose distribution and to derive mean values for regional and/or age groups of people, but not for use as real personal doses.

Unlike mean doses and dose distributions averaged for large population groups, personal doses (PD - individual dose ascribed to an identified person) may be assessed with high degree of uncertainty. The error in reconstructed numerical value of personal dose may vary from several tens per cent (the best case) to several hundreds per cent depending on availability of

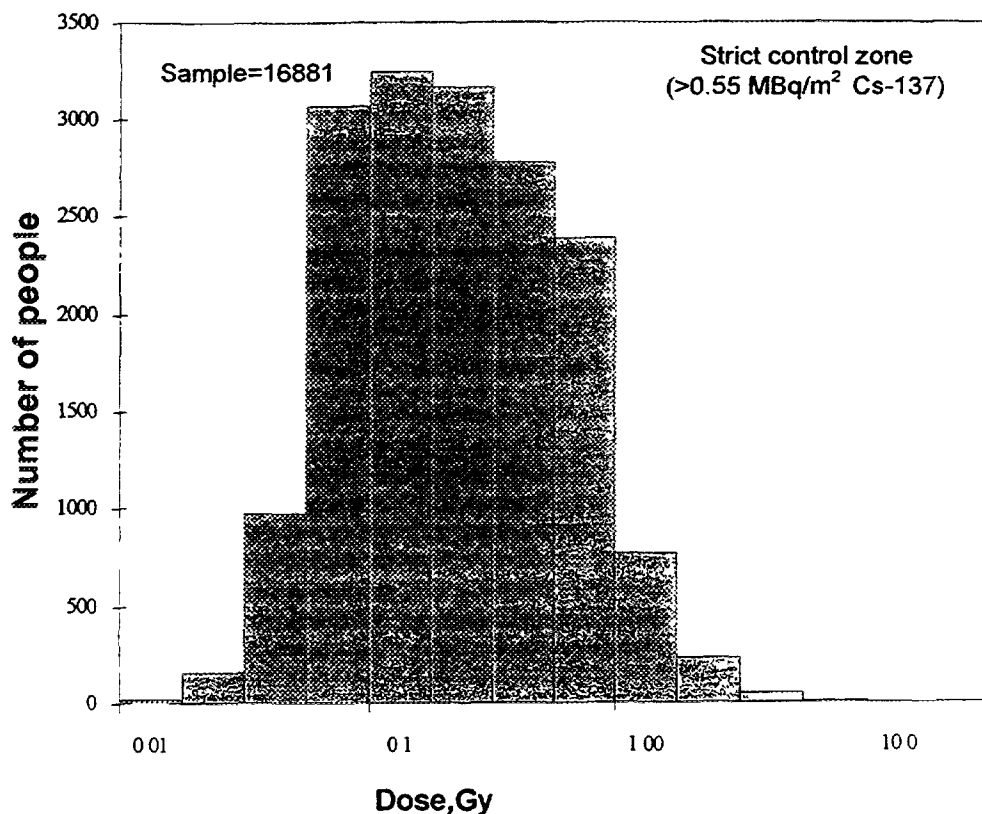


Figure 4. Distribution of thyroid dose at children 0-14 years old

individual dosimetry data and relevant environmental and social information (including questionnaire data on human habits after the accident). It means that stochastic (statistical or probabilistic) presentation of PD is more reasonable than a deterministic one. The specific form of presentation of PD values should be a matter of choice derived from the kind of application of dosimetric data for medical, scientific or/and social purposes.

With the aim to effective use of available data to reconstruct doses to people living in SCZ a data bank is under development in the Institute of Radiation Hygiene, St.Petersburg. The data bank includes data bases of personal dosimetry primary records and of environmental and social information relevant to exposure conditions. The latter includes individual responses to questionnaire on human habits after the accident, including time spent daily outdoors, in wooden houses, stone houses at various seasons of a year, milk consumption, date of taking advice to

stop consumption of locally produced milk, dates of temporal relocation in 1986. The current functioning of the data bank suggests development of software modules for cross-checking, verification and correction of primary records from radiometric and questionnaire surveys of population, production and processing of secondary radiological information. In spite of the system is currently under development, it is already in use for some needs related to the consequences of the Chernobyl accident, including social and legal purposes as well as needs of medical surveillance and epidemiology.



LEUKOSIS DISEASES IN TERRITORIES WITH DIFFERENT LEVELS OF RADIONUCLIDE CONTAMINATION AFTER THE CHERNOBYL ACCIDENT

A.R. MARTIROSOV, B.V. ZINGERMAN, V.Y. POPOV, D.Y. SHORIN,
M.G. SEVASTIANOVA, D.M. MESHARIKOVA, G.I. SIDOROVICH,
I.V. OSECHINSKI
Haematological Scientific Centre of the Russian Academy of Medical Sciences,
Moscow, Russian Federation

A.D. PROSHIN, G.I. MILUTINA
Main Department of Health in the Bryansk region,
Bryansk, Russian Federation

1. INTRODUCTION

Increase in risk of leukemia is an earlier and marked stochastic effect of irradiation. Its epidemiological regularities were established mainly in studies of effects of acute irradiation as a result of A-bombing of the Nagasaki and Hiroshima population as well as radiological procedures. Occurrence of leukemia and other haemoblastosis is relatively rare: the total incidence of the diseases does not exceed 16 or 18 cases per 100,000 persons in a year. Comprehensive epidemiological information on haemoblastosis can be collected in special investigations of initial documents under special protocol. It is caused by the following reasons:

- lack of statistical registration of individual forms of haemoblastosis which are dependent on radiation exposure to variable extent;
- available information on morbidity with haemoblastosis collected in the system of cancer registration is incomplete.

2. POPULATION AND AREA UNDER STUDY

The area of Bryansk oblast is 34.9 thousand sq.km. According to the census of 01.01.1989 the population of the Oblast was 1,470,129 persons: urban population - 984,996 persons, rural population - 485,133, male - 671,376, female 978,762, children to 15 years old - 316,151 persons. 6 south-western rayons of Bryansk Oblast contaminated with radio nuclides as a result of the Chernobyl accident are: Gordeevsky, Zlynkovsky, Klimovsky, Klintsovski, Krasnogorsky, Novozybkovsky. Cs-137 contamination density in these rayons is above 37 KBq/sq.m. The above rayons cover the study area on the protocol of Epidemiological study within frame of the Pilot project HAEMATOLOGY under IPHECA. Economic activity of 143 collective farms, 151 private farms is performed in the study area. According to the official information (1.04.92) 1,637.4 thousand hectares or 41.5% of the agricultural area is contaminated with radio nuclides, Cs-137 contamination density is above 37 KBq/sq.m.

3. METHODS OF EPIDEMIOLOGICAL FOLLOW-UP

To compile, store and analyse of epidemiological, dosimetric and demographic information specialised registry of blood diseases has been established. The following work is carried out within the frame of the registry:

- a search for and registration of epidemiological and clinical data at institutions located in study areas;

- investigation of archive documents and specimens at central specialised institutions Haematological Research Center, Medical Radiological Research Center, Botkin's Hospital, Morozov's Children Hospital, Institute of Children Haematology, Oncological Scientific Center, Herzen's Research Institute of Oncology, Russian research Center of Haematology and Transfusion) verification of the information on fallen ill persons by inquiry hospitals, study of health history and diagnostic material;
- primary processing and sorting of epidemiological charts;
- study of archived laboratory materials to verify diagnosis;
- urgent and planned clinical advice of fallen ill persons by clinicians of Haematological Research Center;
- collecting of demographic data in study areas at Oblast, Rayon levels as well as in separate settlements;
- search for and recording of individual dosimetric information related to registered persons with haemoblastosis;
- sampling and sending of material to biodosimetry;
- inputting the following information into the database:
 - a) list of settlements related to geographical co-ordinates and demographic features;
 - b) level of contamination with radioactive and nonradionuclear substances;
 - c) cases of disease detected among residents.

Teams of epidemiologists and haematologists have collected epidemiological information in Bryansk Oblast in field missions. Clinical expertise of validity of the diagnosis on results of laboratory and clinical examination has been performed in analysis of initial clinical information. Morphological validation of the diagnosis has been judged.

4. RESULTS

The total population of Bryansk Oblast was 1,464.1 thousand in 1991. It was 9.4 thousand persons less than in 1985. The increase in urban population +59.4 thousand, decrease in rural population -68.8 thousand persons were registered. Size of children population did not change. At the same time the number of persons of young and old age decreased, the size of the age group of 30 - 44 years old increased.

The size of urban population in study areas did not practically change in 1991, however the size of rural population decreased of 22% (-20,000 persons) in total and in individual rayons: Gordeevsky -16%; Zlynkovsky - 17%; Klimovsky - 10%; Klintsovsky - 21%; Krasnogorsky - 48%, Novozybkovsky -20%.

Epidemiological data on 3,036 patients with haemoblastosis compiled for the period from 1979 to 1993 are kept in the registry of blood diseases at Haematological Research Center.

The following abbreviates are used:

ALL- acute lymphoblastic leukemia; AnLL-acute non lymphoblastic leukemia; nsAL- non-specified acute leukemia; AAL- all acute leukemias; CLL - chronic lymphoid leukemia; CML - chronic mieloleukemia, E - erithremia; ACL- all chronic leukemias; PPHB -paraproteinemic haemoblastosis; HD - Hodgkin disease, nHD - non-Hodgkin disease (lymphomas); AHB - all haemoblastosis.

Retrospective data are not exhaustive because initial medical documents mainly health history have been lost at hospitals and archives in individual cases. For the period from 1979 to 1993 in 449 persons living in 6 study rayons haemoblastosis was first diagnosed. The annual average morbidity rate is 13.71 per 100,000. Comparison between rates of different types of haemoblastosis in 6 study rayons and in other 21 rayons of Bryansk Oblast as well as in Bryansk city has been performed. Since compared groups of the population are varied by age because of migration and other reasons rates of morbidity for the period from 1986 to

1993 have been standardised by sex and age with the use of direct method. Age structure in 21 rayons of the Oblast fixed in the census of 1989 has been used as a referent.

The standardised rates in 6 study rayons are either less or slightly differ from those in 21 rayons of the oblast for the period after the accident. Incidence of haemoblastosis in Bryansk city is markedly high than it is in the two compared areas.

From regression analysis of trends of morbidity in Bryansk Oblast for the period from 1979 to 1985 and 1986 to 1993 it is noted significant increase in incidence rate of nHD and AAL for the latter period. Comparing rate of diseases for three following periods one can see that increase in sick rate is observed in rural population of older age groups. Relative risks (RR) of a developing disease within period of 1986-1993 have been estimated for haemoblastosis in Bryansk city and 6 study rayons. Standardised expected number of cases of individual types of haemoblastosis has been estimated with the use of information on morbidity among urban and rural population of other rayons of Bryansk Oblast stratified on sex.

RR estimated for all types of haemoblastosis in Bryansk city exceed 1.0. At the same time relative risks in rayons under study do not exceed 1.0 for all haemoblastosis except ALL. The analysis of this irregularity is given below.

The comparative study of non-standardised incidence in areas of 6 rayons (1986-1993) with different level of ^{137}Cs contamination shows a higher (but not statistically significant) rates of ALL, HLL, HD for mostly devastated territories $> 555 \text{ KBq/sq. m}$. The crude rates for AHB are differed significantly. This result was proven by means of standardisation and space-time analysis by method of Knox. There were no statistically significant aggregations of diseases cases in 7 years before Chernobyl accident in mostly devastated territories of Russia. In distinction from this the significant time-space aggregation of AL occurred after the accident. The critical limits of these clusters being 3 years and 25 km contradict the possible influence of rural residents migration to towns. This phenomenon needs additional investigation.

Data on cases of disease in children after the Chernobyl accident, during the period from 1986 to 1991 have been collected and analysed. 58.6 thousand children to 15 years old live in study areas. 158.6 thousand children live in referent area, 98.9 thousand children live in Bryansk city. 75 cases of ALL, 10 cases of AnLL, 3 cases of ncALL, 39 cases of nHD, 1 case of CML were registered during 8 years. Since the part of children population is relatively small, about 20%, age structure of rural and urban population of Bryansk Oblast is of regressive type. According to data of 1992, of 58,500 children 34% of them live in areas with the level radio contamination above 555 KBq/sq. m , 26% of children live in areas with radio contamination density ranged between 185 and 555 KBq/sq. m and about 39% of children live in areas with radio contamination ranged between 37 and 185 KBq/sq. m . Novozybkov town and Novozybkovsky rayon are located in the most radio contamination area, which is the most populated with children.

The annual average number of cases of acute leukemia in children is 3.48 per 100,000 persons. It is close to that registered in developed countries. The average number of cases of nHD is 2 times less, it is 1.54 per 100,000 children. This index is close to that in economically developed countries.

The following main trends of individual types of haemoblastosis are marked: asymmetric, close to log normal age distribution of ALL, with maximum at the age of 3-5 years old, incidence of AnLL reaches maximum in older groups.

Average annual sick rate for AL is the most high in Bryansk city, it is 3.79. The probability of disease developing for the first 15 years is 0.057.

Average annual rate of disease in 6 study rayons is slightly less than in Bryansk city, it is 3.41, the probability of disease developing in the first 15 years is 0.051. According to data

of cancer registry published in the issue "Cancer in 5 continents" these rates are middle. Average annual incidence of ALL in referent areas it is 3.31 (the probability of disease developing is 0.049).

The marked variability of average annual rates attracts the attention. In referent areas (158,000 children) they are ranged from 1.89 to 5.04; in Bryansk city (98,900 children) -from 2.02 to 7.08, in study areas (58,600 children) - from 0 to 11.95. Increase in range of annual morbidity depending inversely on the size of population is natural for such rare events as childhood ALL. Nonetheless the incidence 11.95 estimated in areas under study in 1986 is statistically improbable (95% confidential borders are 4.9 and 24.62). When comparing there is no trend to increase in incidence rate of ALL in children in the three areas of Bryansk Oblast during 1987-1993.

The highest average annual incidence of nHD rate, 1.90, was in Bryansk city, probability of disease developing is 0.030. This was in accordance with average level of international data. At the same time the rate in referent areas and study rayons was 1.42 and 1.28 respectively, probability of disease developing is 0.021 and 0.018. For the period of the follow-up the rates of nHD developing varied within the range from 0 -5.06 (Bryansk city); 0-1.71 (6 study rayons); 0-5.04(referent areas).

Distribution of subjects with ALL by the age at the time of diagnosis establishing is consistent with standard asymmetric distribution characteristic of this type of leukemia: from 0 to 2 years old - 1 case (7%), from 3 to 5 years old - 7 cases (50%), 6-8 years old - 2 (14%), 9-11 years old-1 (7%), 12-14 years old - 3 case (22%). Two patients with nsAL were of 3 month and 12 years old. Of 6 patients with nHD was from 0-2 years old- 2 (35%) 9-11 years old- 3 (50%), 12-14 years old- 1 (17%). It was only one case of CML in girl of 14 years old. During every year of the follow-up except 1988, cases of disease among children have been registered. 4 cases annually in 1987 and 1991, 3 in 1989, 2 in 1993, 1 in 1992 and 7 cases in 1986.

Expected number of cases during 8-year period of the follow-up does not differ from empirical number relative risk is 1.08 (ALL), 0.9 (AnLL0; 0.9 (nHD). There is great difference between expected and true number of AL cases (relative risk is 6.31, $p=0.007$) in 1986.

During the following 5 years from 1987 to 1991 the relative risk of every haemoblastosis does not exceed 1.0. So, the excess of risk of ALL developing in children living in 6 study rayons in 1986 has been established, of 7 children with ALL in that year diagnosis was established in 2 patients before the accident, i.e. 30.03.86 and 03.04.85. Two children fell ill in June, 1986, two children - in July and 1 in August.

Three patients lived in Novozybkovsky rayon, 3 patients -in Klintsovsly rayon, 1 patient in Zlynkovsky rayon. Of 7 patients with ALL 6 were boys. This ratio differs from standard male-female ratio which is slightly varies around 1.2 in various countries.

There is no serious evidence to associate the detected excess of cases with exposure to radiation because of short latent period between the accident and time of the establishing of diagnosis. From the study of kinetics of leukemia cells population it is obvious that time is not sufficient to accumulate the pool capable to clinical manifestation of the disease.

The age of patients with ALL first diagnosed in 1986 is: 3 years old, 5 years and 2 months old, 5 years and 7 months old, 7 years and 4 months old, 7 years and 7 months old, 14 years and 3 months old, 14 years and 4 months old. It is widely distributed on age scale. More than a half of patients were of the age from 3 to 5 years old. At this age interval the maximum of standard distribution of ALL cases occurs.

Considering the possibility of build-up of ALL in study areas the incidence of the disease in adjacent area should be compared.

For this purpose we have used data of blood diseases Registry located at Haematological Research Center which were collected as a result of joint epidemiological study. Data of Belarus 6 rayons (Dobruzhsky, Vetkovsky, Kormiansky, Chechersky of Gomel Oblast, Kostyukovichsky and Krasnopol'sky of Mogili'ov Oblast) surrounded the study area from West and North and 3 rayons of Bryansk Oblast (Starodub'sky, Surazh'sky, Unech'sky) located to the East of the study area have been analysed. The level of contamination in these rayons is common to that in the study rayons. All cases of diseases diagnosed in children in 1986 have been selected. 4 cases of ALL and 2 cases of nHD have been detected in children lived in 4 of 9 adjacent rayons in 1986.

Distribution of numbers of cases of haemoblastosis detected in the adjacent rayons during the first 4 years since the accident was analysed. There were no features of morbidity excess in 1986, because the cases of haemoblastosis were registered only in 4 of 9 adjacent rayons. From 6 cases of hemoblastosis 4 were AL and 2 were nHD. Tendency to excess of ALL cases in areas surrounded the study rayons was not detected.

At the same time attention is drawn to unusual male-female ratio. It was 6:1 in study rayons, and 4 patients with ALL were boys in adjacent rayons. In contrast to this acute leukemias in the period from 1986 to 1993 for Bryansk Oblast except 6 study rayons the ratio 1.18 is in consistence with commonly accepted index.

The examination of place of residence of fallen ill children demonstrated that patients lived in settlements separated 8 to 60 km.. It is evident that there is no dependence of the disease distribution on a local factor.

The next step of study includes case-cohort analysis with an attempt of individual dose interval evaluation. As a first approach to this work a sample of approx. 2000 inhabitants of contaminated areas was examined. For every representative of this sample a detailed epidemiological data were collected and comprehensive medical examination was performed. As a result a strict dependence of internal radiation dose from combinations of behavioural characteristics was demonstrated. This approach could be a realistic bases for cohort under examination division into individual dose level groups. The such expensive and complex methods as tooth enamel ESR and stable chromosomal aberration analysis could be used as sample methods for limits of groups criteria correction.

**DYNAMICS OF THE STATE OF HEALTH OF PREGNANT WOMEN
AND NEWBORN BABIES FOLLOWING THE
CHERNOBYL NUCLEAR POWER PLANT ACCIDENT**



XA9745497

V.E. DASHKEVICH, L.B. GUTMAN, A.G. COLOMYITSEVA, N.N. BELIKOVA,
A.A. YAKOVLEV, L.I. TUTCHENKO, V.I. MEDVED

Institute of Pediatrics, Obstetrics and Gynecology, Academy of Medical Sciences of Ukraine,
Kiev, Ukraine

Introduction. From the first days after the Chernobyl catastrophe constant observation of health state in pregnant women, who are permanently living within contaminated regions of Ukraine was carried out. Pregnant were examined either in hospital or by ambulant teams. The examination consists of radiometry of incorporated radionuclids in organism, radioimmunologic, endocrinologic, biochemical, morphologic and paraclinical methods.

The analysis of pregnancy and delivery tendency, state of fetus and newborn takes place providing registration of the same indexes in the period from 1983 till 1986 and in conditionally "clean" Poltava regions. Also it is taken in consideration habitable zones with level of contamination by cesium, doses of radiation and period of pregnancy.

Results. The results of investigations of more than 20 000 women show that low doses of ionizing radiation have unfavourable influence to reproductive function of woman organism. We note the decrease of birth rate, the increase of pregnancy and delivery complications, of perinatal mortality, morbidity of pregnant and newborns.

It is interesting to mention that the screening investigations of pregnant and their newborns during first period after catastrophe hasn't showed any alterations in their health state.

The examination of health state in dynamics of pregnant and newborns showed significant alterations in functional systems and in neurohumoral mechanisms of their regulation in mother and fetus. There are the alterations of cardiovascular system, central and peripheric hemodynamics, pulmorespiratory apparatus, hormonal and immunologic status, system of hemostasis and processes of adaptation.

There are the disorders of psychoemotional state in 74,8 % of pregnant, which manifest by low level of functional abilities of psychic adaption, sharp weakening of physical endurance.

These alterations have a great influence to the development of obstetric and perinatal complications, the frequency of which exceed the average indexes all over the country. Significantly increased frequency of EPH-hetosis, threatened abortion, preterm labours, uterine bleedings (Fig 1, 2).

All these data were combined with the results of hormones concentration of feto-placental complex and system of hemostasis, which allow us to suppose the possibility of complications like mentioned above. The level of whole morbidity of pregnant women also increased, especially the level of anemia, neurocirculatory dystonia, pyelonephritis, pyo-inflammatory diseases (Fig 3). That could be connected with oppression of anti-infectious immunity system.

The structural and functional alterations in hypophyseal-thyroid system has been found out in 46,9% of pregnant. From 1993 we have observed hyperthyroxinemia. On the background of high level of thyroglobulin, the level of thyroxine binding globulin was reduced. The alterations in state of hypothalamo-hypophyseal-thyroid system in newborns from mothers who are living within contaminated areas are registered. The number of laboratory and transitory TTG-hypothyrosis raised also.

Asphyxia takes the first place in structure of newborns morbidity, that could be explained by high frequency of obstetric alterations. The level of fetal growth retardation syndrome is as much as 3 times higher at the most contaminated regions (Ovruch, Narodichi, Polesse) than in whole population. This connects with retardation of placental growth, its vascular insufficiency, disorder of blood circulation, which deteriorate the effect of radiation influence to fetal state. On the basis of study of immunity system in newborns the groups of high risk development of autoimmunologic pathology in children were created.

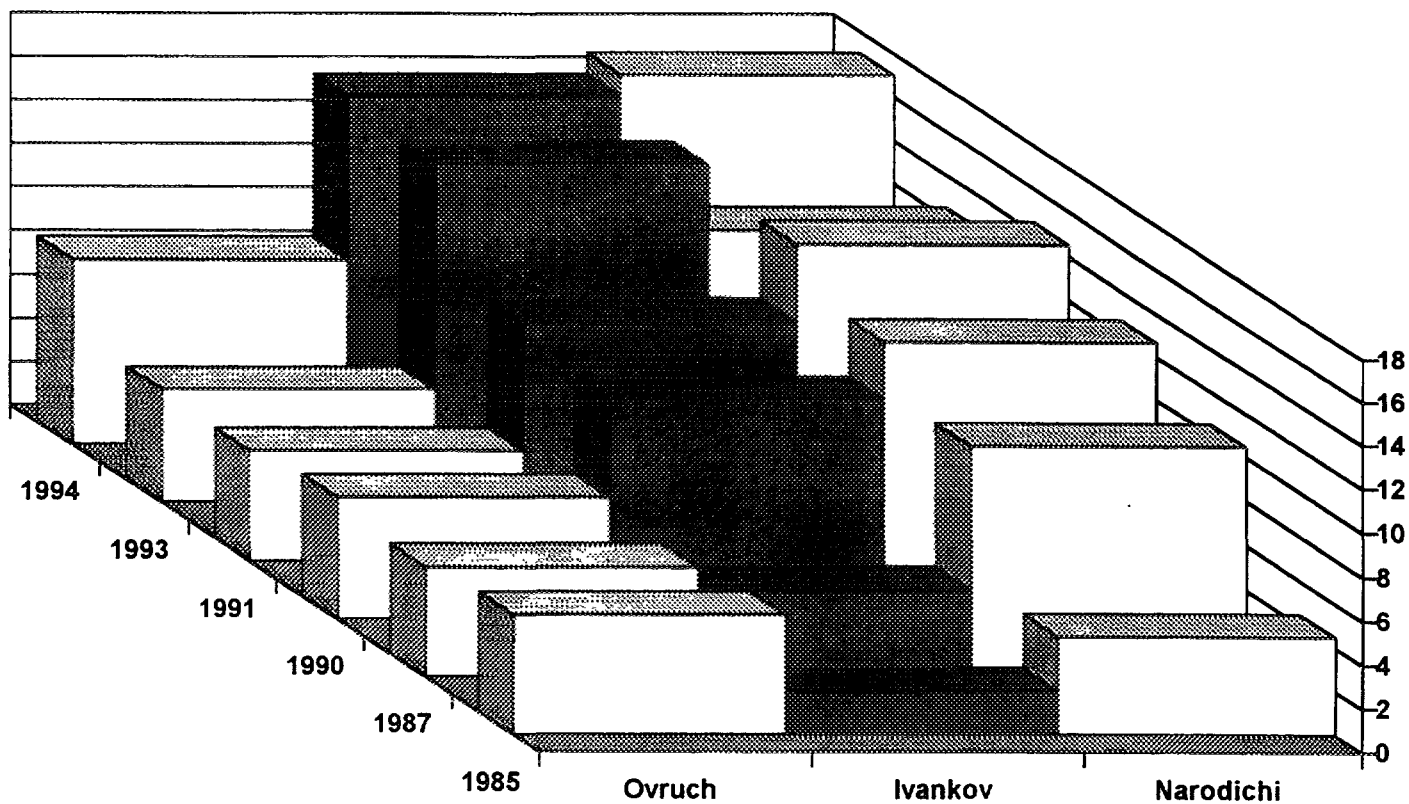


FIG. 1. Incidence of pregnancy toxemia in pregnant women who live in some controlled areas.

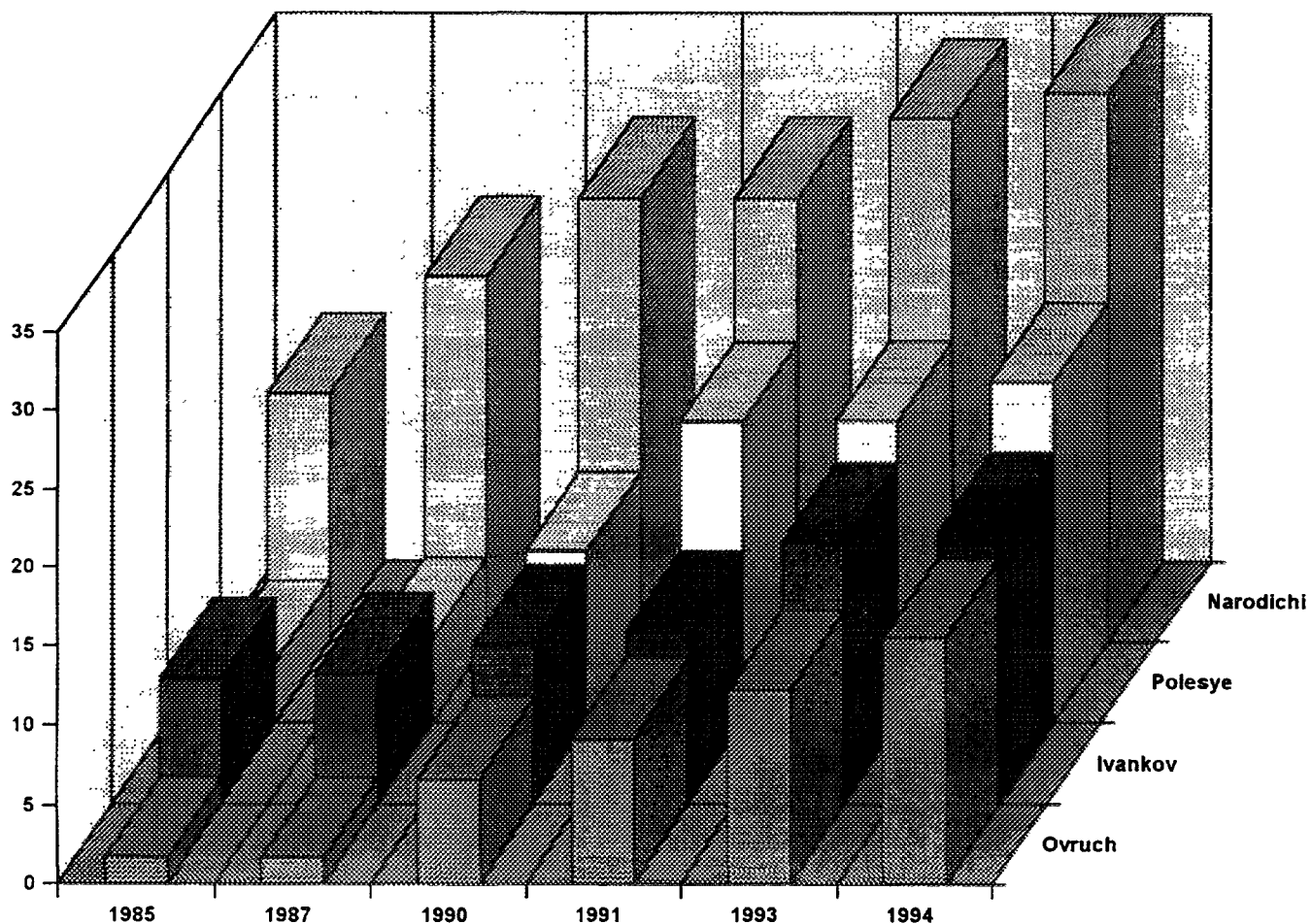


FIG. 2. Incidence of haemorrhage in some controlled areas.

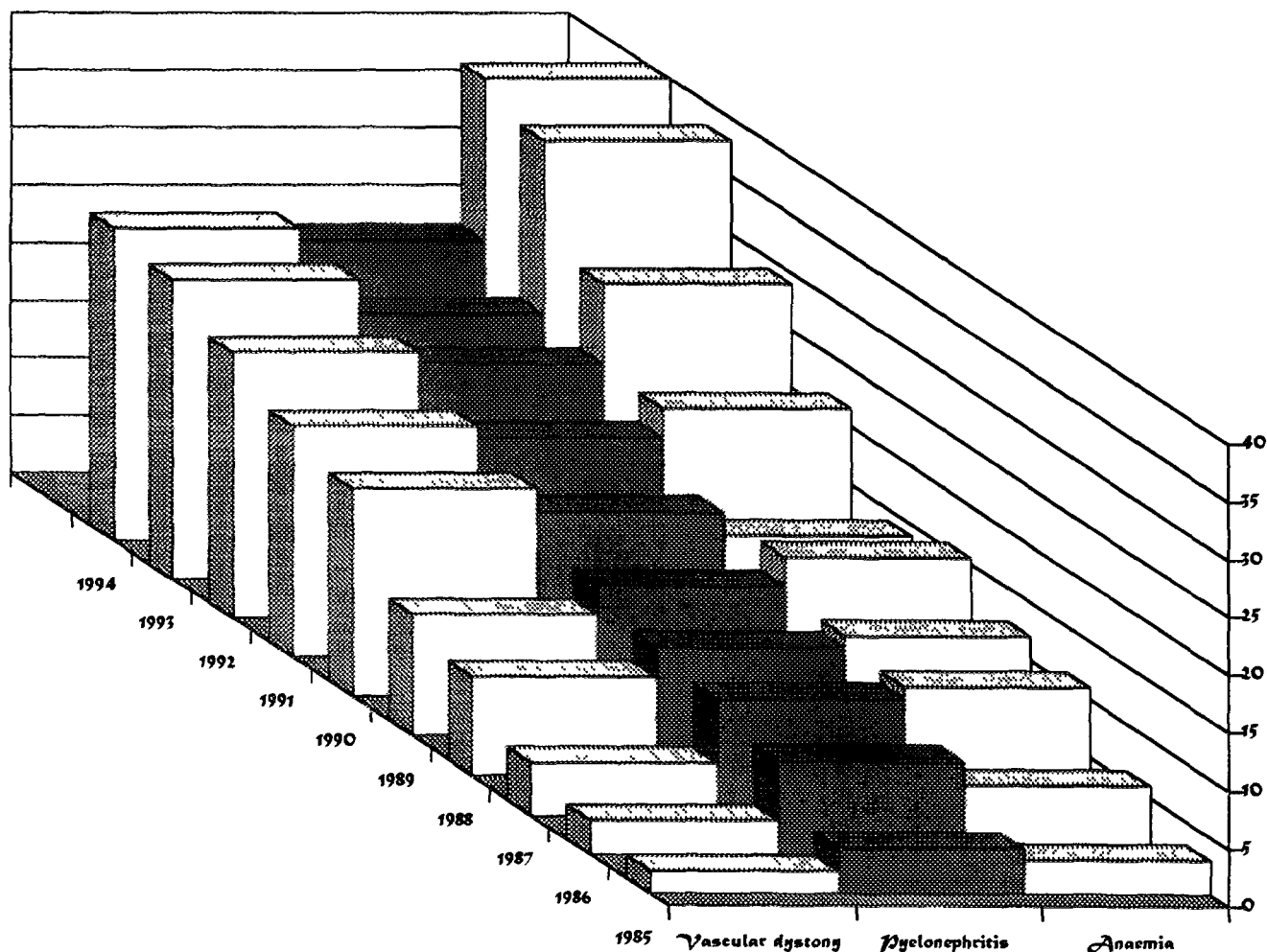


FIG. 3. Dynamic of morbidity of pregnant women from controlled areas.

Besides the radiation factors the great influence to the health state of women and newborn have social, medical and biological ones

The registry of pregnant and newborns was created with the aim of longterm observation under the pregnant women, the children and future generation, estimation of their health state and disorders in it. On the basis of these data the scientific programmes are fulfilled.

Based on registered alterations were carried out algorithms of prediction of obstetric and perinatal complications and complex of differential medical and prophylactic arrangements.

**EFFECT OF LONG-TERM LOW DOSE IRRADIATION ON PATHOLOGY AND
SOME METABOLIC MECHANISMS OF UROLOGICAL INFLAMMATORY
DISEASES IN PATIENTS FROM RADIOCONTAMINATED AREAS OF UKRAINE**

Ch. BUSCH

Department of Pathology, Uppsala University Hospital,
Uppsala, Finland



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V.S. KARPENKO, G.G. NIKULINA, S.P. PASECHNIKOV, A.M. ROMANENKO,
A.F. VOZIANOV

Institute of Urology and Nephrology, Academy of Medical Sciences,
Kiev, Ukraine

The aim of this pilot study is to establish some mechanisms of morphological, immunohistochemical and metabolic changes of chronic cystitis and pyelonephritis in patients inhabiting the radiocontaminated areas of Ukraine.

The first part of our study was based on 40 patients with symptoms of chronic cystitis which were referred for cystoscopy to the Institute of Urology and Nephrology in Kiev in connection with benign prostate hyperplasia. The experimental group included 20 patients (male, 30 to 76 years old) treated from 1992 to 1994, inhabiting the radiocontaminated areas of Ukraine and the control group included 20 identical patients who were treated from 1984 to 1985 i.e. before the Chernobyl accident.

Morphological, proliferative and indications of possible genetic changes in bladder urothelium from patients with chronic cystitis from both groups were compared by immunohistochemical staining of proliferating cell nuclear antigen (PCNA), Ki-SI and indication of p53 expression. Our study has shown that p53-immunoreactivity occurred in the nuclei of all layers of urothelium in 90% cases of experimental group. In the control group 70% of urothelia were p53 negative. The simultaneous p53 and PCNA overexpression as seen in urothelia in the experimental group possibly indicates the failure of check-point controls connected with their functions in cell-cycle phases. The results leave us with a possibility that continuous exposure to radioactive cesium which is known to concentrate in the urine during excretion adds to other possible carcinogenic influences. The study could also to the understanding of the progressive increase of bladder cancer in Ukraine.

The second part of our study based on 120 patients treated in the same Institute in period 1991-1995. 40 patients inhabiting the ecologically clean regions (group 1) and 80 patients living on the radiocontaminated areas (group 2). The third control group included 30 healthy people who had been examined before the Chernobyl accident. We studied the activity of free radical oxidation (FRO) by measurement of malonilaldehyde (MDA), antioxidant protection (superoxidedismutase), lactatedehydrogenase (LDH) and malatedehydrogenase (MDH) as the markers of energetic metabolism.

Patients with pyelonephritis from both groups had the increased MDA levels in cellular erythrocyte membranes and urine against the control, especially in the group 2. This data indicated the higher activity of FRO caused more significant unbalance of lipid structure of cellular membranes in comparison with the group 1. At the same time inhibition of superoxidedismutase activity was noticed in the blood serum of these patients. The total LDH and MDH activities were increased. Evidently, this data reflected the serious disorders in the aerobic and energetic metabolism in kidneys. The investigation of their isozymes discovered the more deep alterations in patients of the group 2 than in the group 1, such as the more expressive decrease of the mitochondrial m-MDH, the aerobic LDH-1 and LDH-2 fractions, on the one hand, and the increase of the cytoplasmic c-MDH, the anaerobic LDH-4 and LDH-5 fractions, on the other hand.

The early postoperative period in calculous pyelonephritis patients in the group 2 was accompanied by the deeper metabolic disorders, too.

In conclusion we could suppose that the long-term low doses of irradiation provoked the negative metabolic action followed by the progression of chronic pyelonephritis.

IRRADIATION OF POPULATION IN THE REPUBLIC OF SERBIA AFTER THE CHERNOBYL ACCIDENT



XA9745499

R. MAKSIC
Federal Ministry of Economy,
Belgrade, Yugoslavia

V. RADMILOVIC
Federal Ministry of Labour, Health and Social Policy,
Belgrade, Yugoslavia

G. PANTELIC, R. BRNOVIC, I. PETROVIC
Institute of Occupational and Radiological Health "Dr. Dragomir Karajovic",
Belgrade, Yugoslavia

1. INTRODUCTION

The radiation protection is very important interdisciplinary research field due to the presence of the radiation in daily life. For the sake of preventive protection of population and environment from the harmful effect of ionizing radiation, the national programme for monitoring environmental radiation became permanently established in Serbia from 1960.

The systematic examination of radioactive contamination of various samples from environment was established in the Institute of Occupational and Radiological Health "Dr Dragomir Karajović". The contents of radionuclides were determined in: aerosol, soil, fallout

(wet and dry deposition), rivers, lakes, drinking water, human and animal food. The samples were collected in certain locations of the Republic of Serbia and in regular time intervals [1], according to methods determined by the Regulations [2].

The regulations and the monitoring programmes were updated after the Chernobyl accident.

In 1992, Environmental Gamma Radiation Monitor RSS-112 (Reuter-Stokes) was established for continuous recording of a dose rate in Belgrade and Kladovo. These systems are connected to the Republic information center. They are

of primary importance for information about the increased levels of radioactivity.

Since 1992, measurements of external beta and gamma doses are performed by TL dosimeters which are located in 18 towns. They are read out twice a year.

High resolution gamma spectrometry measurement is performed as the

backbone of all monitoring programmes, because of their simple use and accuracy.

The Institute participated in international project GERMON (Global Environmental Radiation Network), with the programme of radioactivity monitoring in Yugoslavia from 1991.

2. METHOD AND RESULTS

The aim of the present study was to estimate the effective doses arising from ^{137}Cs and ^{90}Sr activity through food intake for the population of the Republic of Serbia after Chernobyl accident.

The samples (vegetables, fruits, meat, crops and dairy products) are collected twice a year (in the spring and in the autumn, in Belgrade, Niš, Zaječar, Užice, Novi Sad and Subotica regions – Fig. 1) except milk which is sampled monthly.

^{137}Cs activity was determined by gamma-spectrometry measurements using HP Ge detector (ORTEC), with relative efficiency of 25 % and energy resolution of 1.85 keV (1332.5 keV ^{60}Co). The calibration was made by Amersham standard in Marinelli beaker.

^{90}Sr activity was determined after radiochemistry separations, using $\alpha\beta$ proportional counter of 24% efficiency (Countmaster ORTEC).

The activity measurements in food in the Republic of Serbia are presented in table I for ^{137}Cs activity and in table II for ^{90}Sr activity (average annual values).

Using relevant dose coefficients [3] and data for food consumption in Yugoslavia [4] we have estimated average annual and daily intake and effective doses of these radionuclides for the adult population in the Republic of Serbia (table III).



Figure 1: The sampling locations in the Republic of Serbia

Table I: ^{137}Cs activity in food in the Republic of Serbia (average values) (Bq/kg)

Year	Vegetables	Fruits	Meat	Crops	Dairy products	Milk
1986	75.90	53.80	92.23	244.30	36.36	16.65
1987	37.65	9.43	92.45	37.96	7.58	16.67
1988	0.47	1.89	6.63	2.05	8.30	2.35
1989	0.43	1.87	–	1.20	8.44	6.05
1990	0.64	0.69	2.27	0.52	3.43	1.47
1991	0.23	1.19	0.09	0.03	0.34	0.45
1992	0.33	0.49	0.81	0.07	0.16	0.40
1993	0.20	0.54	0.23	0.13	–	0.13
1994	0.21	0.08	0.12	0.04	0.28	0.12

Table II: ^{90}Sr activity in food in the Republic of Serbia (average values) (Bq/kg)

Year	Vegetables	Fruits	Meat	Crops	Dairy products	Milk
1986	3.24	0.92	1.16	0.47	6.44	1.72
1987	0.63	0.31	0.26	0.77	0.65	0.16
1988	0.39	0.15	0.20	0.31	0.27	0.09
1989	0.40	0.18	–	0.58	1.09	0.13
1990	0.38	0.34	–	0.27	2.32	0.07
1991	0.33	0.37	0.20	0.12	0.20	0.13
1992	0.34	0.20	0.04	0.36	0.17	0.11
1993	0.34	0.09	0.04	0.15	0.10	0.06
1994	0.06	0.04	0.05	0.11	0.09	0.01

3. CONCLUSION

The main pathways of radionuclides in the human body are inhalation and ingestion through food and drinking water. This paper provides the data of activity for two important radionuclides Cs and Sr and effective doses

due to food consumption. The relevant dose coefficients were used in the estimate.

The effective dose due to ^{137}Cs and ^{90}Sr activity were decreased during 1986 to 1994 for the population in Serbia.

Table III: Average annual and daily intake of ^{137}Cs i ^{90}Sr and effective doses for population in the Republic of Serbia

Year	^{137}Cs			^{90}Sr		
	Bq/year	Bq/day	Doses (mSv/year)	Bq/year	Bq/day	Doses (mSv/year)
1986	47310	129.53	0.662	580	1.59	0.02
1987	11782	32.26	0.164	191	0.52	0.0027
1988	827	2.26	0.011	91	0.25	0.0013
1989	940	2.57	0.013	138	0.38	0.0019
1990	358	0.98	0.005	101	0.28	0.0014
1991	123	0.34	0.0017	74	0.20	0.0010
1992	11	0.30	0.0015	96	0.26	0.0013
1993	74	0.20	0.0010	54	0.15	0.0008
1994	39	0.11	0.0005	24	0.07	0.0003

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CHILDHOOD LEUKAEMIA IN EUROPE AFTER CHERNOBYL: FIVE YEAR FOLLOW-UP OF CANCER REGISTRY POPULATIONS

D.M. PARKIN, R.J. BLACK, E. KRÁMÁROVA
International Agency for Research on Cancer,
Lyon, France

D. CLAYTON
University of Cambridge,
Cambridge, United Kingdom

INTRODUCTION

The European Childhood Leukaemia-Lymphoma Incidence Study (ECLIS) aims to monitor trends in the incidence of these diseases in European populations in relation to estimated exposures to radioactive material released at the time of the Chernobyl accident. Thirty-six cancer registries in 23 countries are collaborating in ECLIS, coordinated by the International Agency for Research on Cancer (IARC).

DATA AND METHODS

Populations-at-risk and childhood leukaemia incidence data

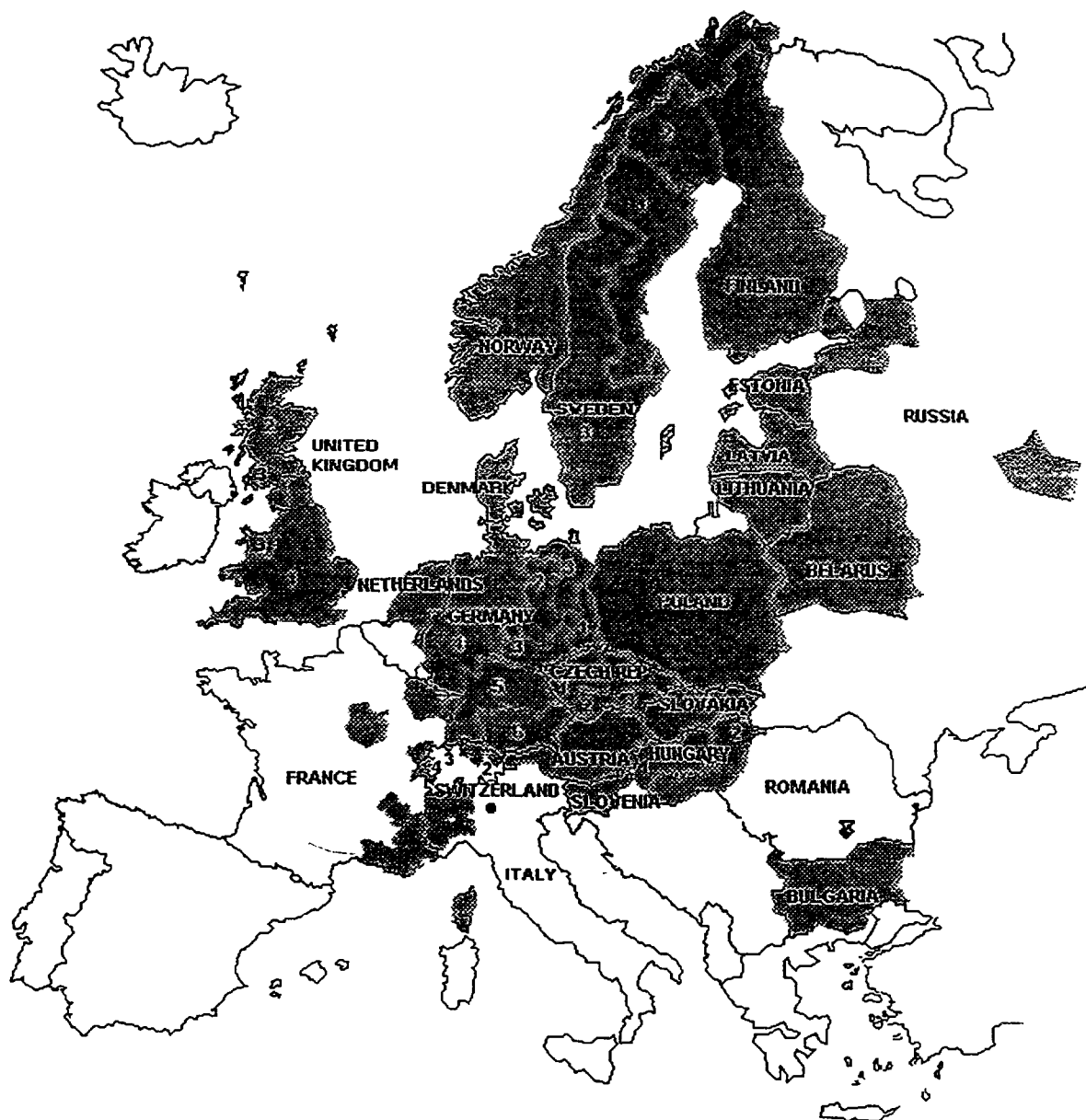
Registries provided listings of cases of childhood leukaemia for a period from 1980 up to the most recent complete year of registration (at least 1991), and estimates of the populations-at-risk broken down by sex and single years of age.

Radiation exposure assessment

Estimates of levels of radiation exposure due to the Chernobyl accident were obtained from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The countries participating in ECLIS are shown in figure 1. For countries with wide variations in exposure levels, sub-regions were used. The estimated mean effective dose equivalents at 1, 4 and 70 years after the accident are shown for the study areas in figure 2. An individual dose was imputed for each child-at-risk, based on age, year of follow-up and place of residence, under the following assumptions:

- the leukaemogenic effect of the exposures due to the accident has a latency of at least one year
- the effective dose to the foetus is equivalent to that of a free-living individual
- the total leukaemogenic dose is cumulative, starting from conception (Fig. 3)

Fig. 1: Europe, showing (shaded) areas for which data on exposures populations-at-risk and leukaemia incidence were available.



Note: the numbered regions within countries, for example Germany, represent areas for which regional dose estimates and cancer registry data were used. The numbering does not indicate ranking. Unnumbered regions in other countries, for example France, show the locations of regional cancer registries, whose data were pooled with exposure regions.

Fig. 2: Effective dose equivalents (mSv)
due to Chernobyl accident by region
Source: UNSCEAR, 1988

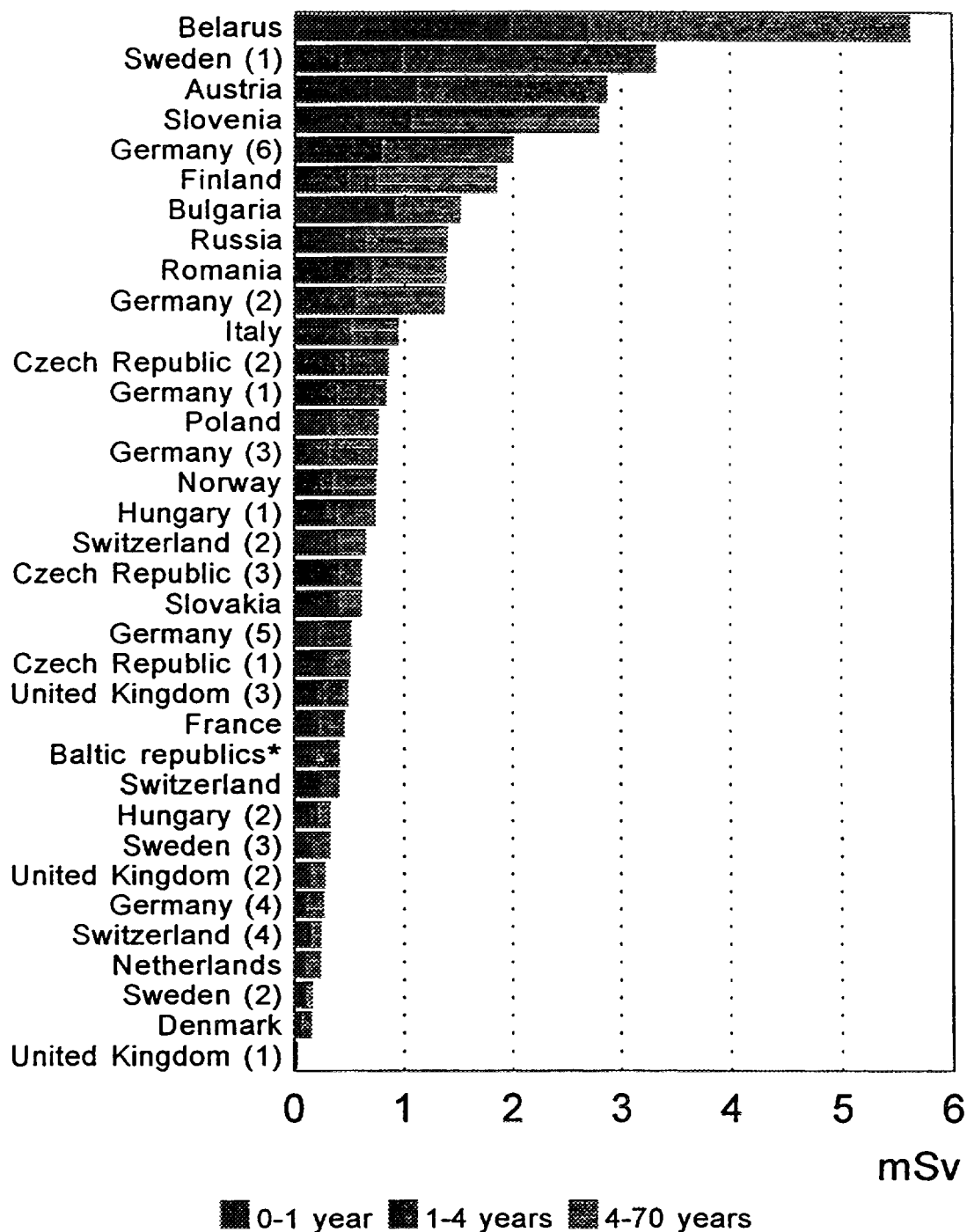
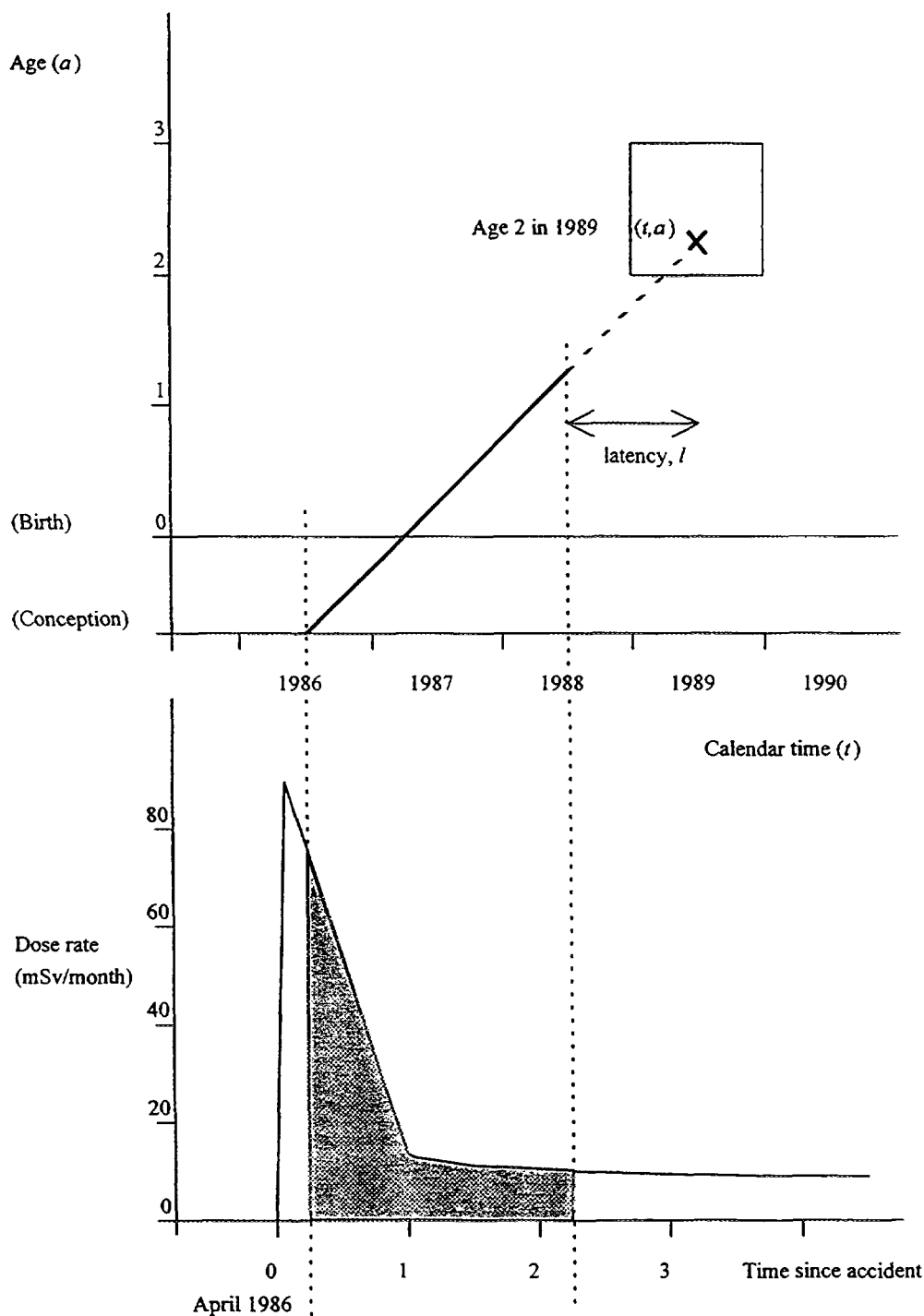


Fig. 3: Illustration of the method of calculation of dose.

The box in the upper graph contains all points (t, a) representing subjects aged 2 at any time in 1989. The method of estimating the effective dose at (t, a) consists of integrating the dose rate curve s



Statistical methods

Poisson regression models with terms for sex, age or birth cohort, region of residence and calendar year were used to establish the null distribution of childhood leukaemia in Europe since 1980. Likelihood ratio tests were then applied by adding parameters for dose

RESULTS

The estimated doses were generally very small, with 91 million person-years-at-risk at a cumulative dose of less than 0.06 mSv and 58 person-years-at-risk at more than 0.3 mSv. The highest doses were in Belarus, with an estimated dose of 2mSv in the first year following the accident.

In all study regions combined, there was an increase in the overall age-standardised rate of childhood leukaemia in the period 1980-86, during which the leukaemogenic dose attributable to the Chernobyl accident was zero (average annual change +0.6%). Thereafter, there was no evidence of an increase in this gradient (average annual change +0.4%). Table II shows observed and expected cases by cumulative dose. There was no indication of heterogeneity between the dose categories ($\chi^2=0.98$, 3df), or of a trend in incidence with dose when fitted as a continuous variable ($\chi^2=0.85$, 1df).

Table I: Observed and expected cases of childhood leukaemia and observed/expected ratios by dose category

Cumulative excess dose (mSv)	Observed cases	Expected cases	Ratio
0	15004	15004.0	-
0.01 - 0.05	3870	3862.2	1.002
0.06 - 0.12	2172	2151.7	1.009
0.13 - 0.29	2022	2037.7	0.992
0.30 +	2752	2764.5	0.995

This lack of effect of dose was also seen in the individual age groups (table II). The data are categorised by approximate birth cohort in table III. Of

Table II: Observed (O) and expected (E) cases of childhood leukaemia by age at diagnosis and estimated cumulative excess radiation dose due to the Chernobyl accident

Cumulative dose (mSv)	Age at diagnosis							
	0		1 - 4		5 - 9		10 - 14	
	O	E	O	E	O	E	O	E
0	775	775.0	6796	6796.0	4364	4364.0	3069	3069.0
0.01 - 0.05	513	506.3	2054	2048.8	767	772.2	536	534.8
0.06 - 0.12	43	53.7	1063	1084.3	644	608.5	422	405.2
0.13 - 0.29	6	7.6	977	952.7	652	655.0	387	422.4
0.30 +	13	7.3	982	990.2	1043	1070.3	714	696.7
χ^2 (1 df)	0.26		0.12		0.72		0.28	

Table III: Observed (O) and expected (E) cases of childhood leukaemia by approximate birth cohort and estimated cumulative excess radiation dose due to the Chernobyl accident

Cumulative dose (mSv)	Birth cohort							
	-1980		1980-1986		1987		1988-	
	O	E	O	E	O	E	O	E
0	12083	12083.1	2921	2921.0	0	0.0	0	0.0
0.01 - 0.05	852	872.7	1381	1340.4	319	327.7	1318	1321.4
0.06 - 0.12	691	651.1	925	938.5	225	237.1	331	325.0
0.13 - 0.29	617	647.1	1006	997.5	269	260.8	130	132.4
0.30 +	937	926.2	1426	1461.7	290	277.4	99	99.3
χ^2 (1 df)	0.02		0.36		0.72		0.24	

particular interest is the 1987 cohort, which includes children who received the largest exposures in utero. The trend in risk with dose for this cohort was not statistically significant ($\chi^2=0.72$, 1df).

DISCUSSION

Although we observed a small increase in the risk of childhood leukaemia in Europe during the 1980s and early 1990s, there was no evidence of an association between risk and the estimated doses received due to the Chernobyl accident (after allowance for the effects of sex, age or birth cohort, calendar year and region of residence). However, at this stage of follow-up, the study has low statistical power to detect such a trend. If the excess risks per unit dose estimated from the atomic bomb survivors are applied to the childhood population-at-risk in Europe following the accident, then the power of the study is about 50%. This may even overstate the statistical power, since the protracted low-dose exposures concerned differ in quality, and probably also in leukaemogenic effect, from the acute high-dose exposures experienced by the atomic bomb survivors.

The study has been analysed as a cohort study, it should be clear that the allocation of dose to individuals was determined by a function of place of residence and time since the accident. The actual exposure of individuals within the study populations was unknown, and imputed values from estimated population averages were used. Migration between study regions would give rise to exposure misclassification, which would attenuate any estimated dose effect. However, inter-regional migration of children in the five years of observation is unlikely to have been of a sufficient scale to have affected the results of the study.

A possible source of bias in the studies of cancer risk following radiation exposure is differential ascertainment of cases which is correlated with exposure, due to an increased interest in and improved detection of cases in heavily exposed populations. In contrast to thyroid cancer, which can exist for long periods in a latent form, this seems unlikely for childhood leukaemia.

The study will continue data collection for a period of ten years following the accident, so that the further potential of the excess radiation exposure can be studied.

A COMPARATIVE EVALUATION OF THE CONSEQUENCES OF THE CHERNOBYL ACCIDENT BASED ON THE INTERNAL DOSE OF ^{137}Cs TO JAPANESE MALE ADULTS

M. UCHIYAMA, T. ISHIKAWA, M. MATSUMOTO, S. KOBAYASHI
National Institute of Radiological Sciences,
Ibaraki, Japan



XA9745501

1. INTRODUCTION

The Chernobyl accident released a large quantity of radionuclides into the environment. Many measurements were carried out to assess the consequent radiation doses around the world. The health and environmental consequences, however, have not been fully evaluated. The Chernobyl accident reminded us that it is important to establish methodology for the evaluation of measurements obtained with diverse methods when we estimate radiation effect in different countries. Even with limiting the assessment of internal exposure to the whole-body counting of ^{137}Cs , there still remain many unsolved factors related to dose accumulation. These include the calibration of measurements, the timing of measurements, and so on. It will take long time to develop a reliable and generally agreed upon method for the reasonable evaluation of measurements in different countries. As a substitute for such a method, the measurements of subjects from different countries at a given institution can serve for the comparative evaluation of their internal doses when one apparatus is used consistently for the measurements.

We have measured radiocesium body burdens of both Japanese and foreigners since the Chernobyl accident using a whole-body counter. In the occasion of 10th anniversary of the accident, we evaluated the body burdens in order to compare the internal doses among countries.

2. MATERIAL AND METHODS

A whole-body counter at the National Institute of Radiological Sciences (NIRS) was used to measure the radiocesium body burdens of the human subjects under evaluation. The counter is equipped with two identical NaI(Tl) detectors 8" in diameter and 4" in thickness [1]. It was operated in a scanning mode of 5 cm/min in a shielded iron room with walls 20 cm in thickness.

Measurements were carried out on the following four groups. The first group was made up of healthy male researchers from the NIRS who resided in Chiba or Tokyo. This group was measured for ^{137}Cs every 3 months from February 1986 to December 1995. This group was used as the reference for comparative evaluation with the other groups. The subjects of second group were healthy adult individuals who visited the NIRS from various locations within Japan during spring, early summer or autumn of each year. The third group was composed of Japanese returnees from the former USSR and European countries, where they had resided for some duration after the accident. This group included subjects of both genders with a wide spectrum of ages. The fourth group was made of both male and female adult subjects, mainly from European countries that occasionally visited the NIRS.

The internal dose of ^{137}Cs to the whole-body was estimated using the Medical Internal Radiation Dose (MIRD) method. The difference in the specific absorbed

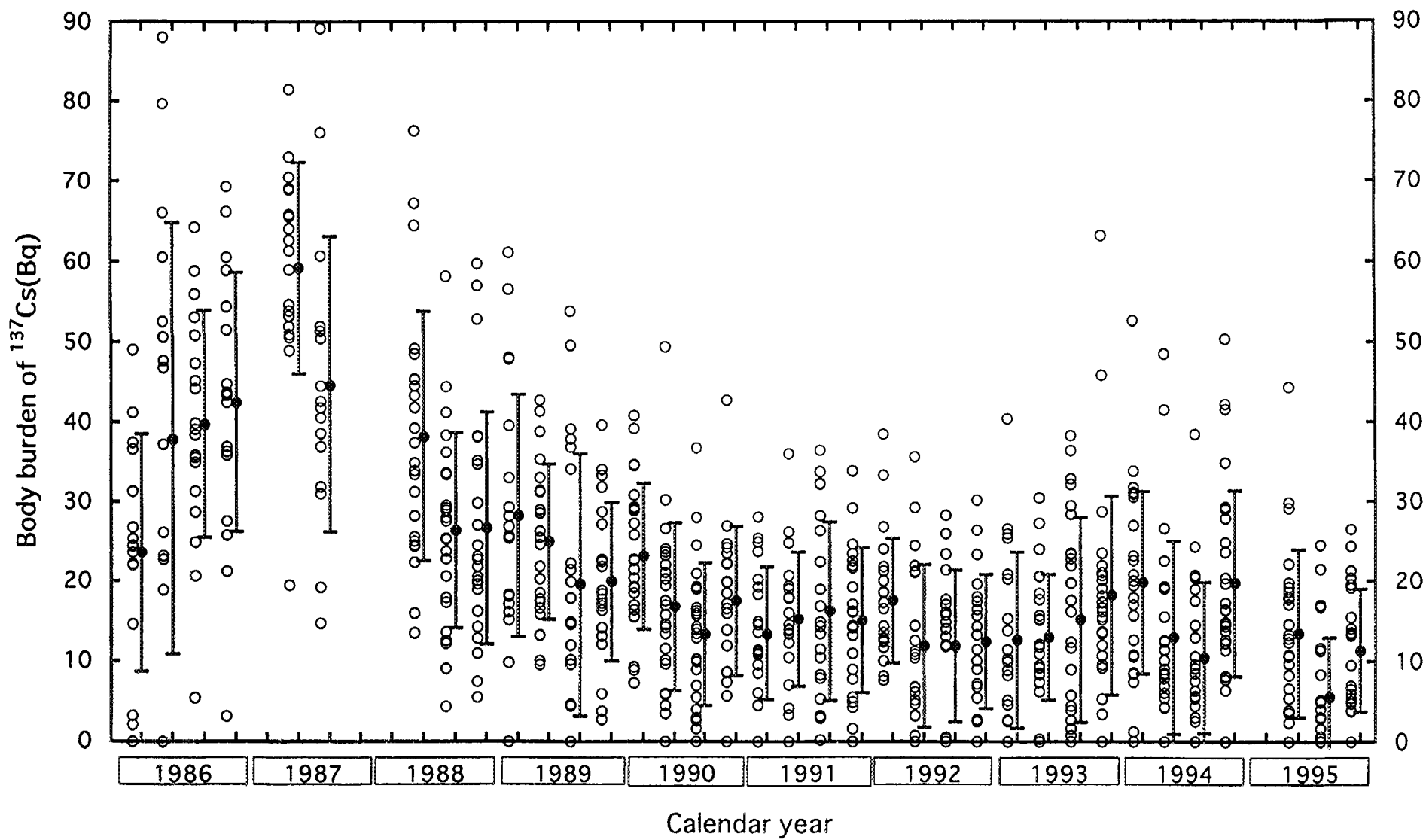


Fig. 1 Temporal changes in ^{137}Cs body burdens for a selected male adult group of Japanese.

fraction to penetrating radiation in weight between the subjects and the standard man of the MIRD was taken into account and the actual absorbed fraction was corrected accordingly [2].

3 RESULTS

3.1 Japanese subjects

For the first group, ^{137}Cs body burdens were indicated as a function of time as shown in Fig. 1. The body burden began to increase in May 1986 and it attained a maximum of 59 Bq in May 1987. This was the estimated maximum consequence of the accident on the radiocesium body burden for the first group. The temporal change in their average body burden can be explained by a single-compartment model. The average individual dose was $1.5 \mu\text{Sv}$ for the first year. Using the above mentioned single compartment model for ^{137}Cs body burden, together with the daily ^{137}Cs intake data for each district in Japan, consequences of the Chernobyl nuclear power plant accident on the Japanese people were assessed. The doses were an average of $1.24 \mu\text{Sv}$ and 148 man Sv for the population of 120 million for the one-year period from May 1986 [3].

The annual change in the body burden decreased with a human radioecological half-time of 1.8 years by May 1991. Five years were sufficient to reduce the effects of the accident to the level before the accident for the first group. The dose from radiocesium was below $2 \mu\text{Sv/year}$ even in the most contaminated period. The cumulative dose for 5 years was estimated to be $5.6 \mu\text{Sv}$. After May 1991, the body burden fluctuated erratically, reaching a small peak of 16 Bq in 1993.

When comparing the human radioecological half-time and the cumulative dose of ^{137}Cs body burden due to the worldwide fallout from the atmospheric nuclear weapons tests carried out during the years 1961 and 1962 on the fifth group of Japanese male subjects [4], the half-time is 0.3 years longer in the first group. The variance in the half-times between the first and the fifth groups can perhaps be explained by the difference in the contribution of imported food to the total food consumption in Japan. The consumption of domestic products decreased rapidly from 91% in 1964 to just 65% in 1991. The cumulative dose is much smaller than the committed dose of $82 \mu\text{Sv}$ to the year 2000 that includes the dose from the atmospheric nuclear explosion tests carried out over approximately 20 years from 1963.

The trends and the levels of ^{137}Cs body burden in the second group were similar to the first group. This suggests that the dose caused by ^{137}Cs intake in Chiba was insignificantly different from that in other areas within Japan, although a larger distribution was observed among individual body burdens in the second group.

No detectable health risk was expected for the two groups or the Japanese population.

3.2. Japanese returnees

A regression line for the biological half-time on the body weight was obtained for 16 individuals in the third group, the Japanese returnees. The half-time (T_b in days) was expressed as $1.14 \text{ times } W \text{ (body weight in kg)} + 9.47$ with a correlation coefficient of 0.72. When a subject could not be measured for the body burden immediately after their return, the body burden on the day of return was estimated using the formula explained above. As for the third group, the relationship

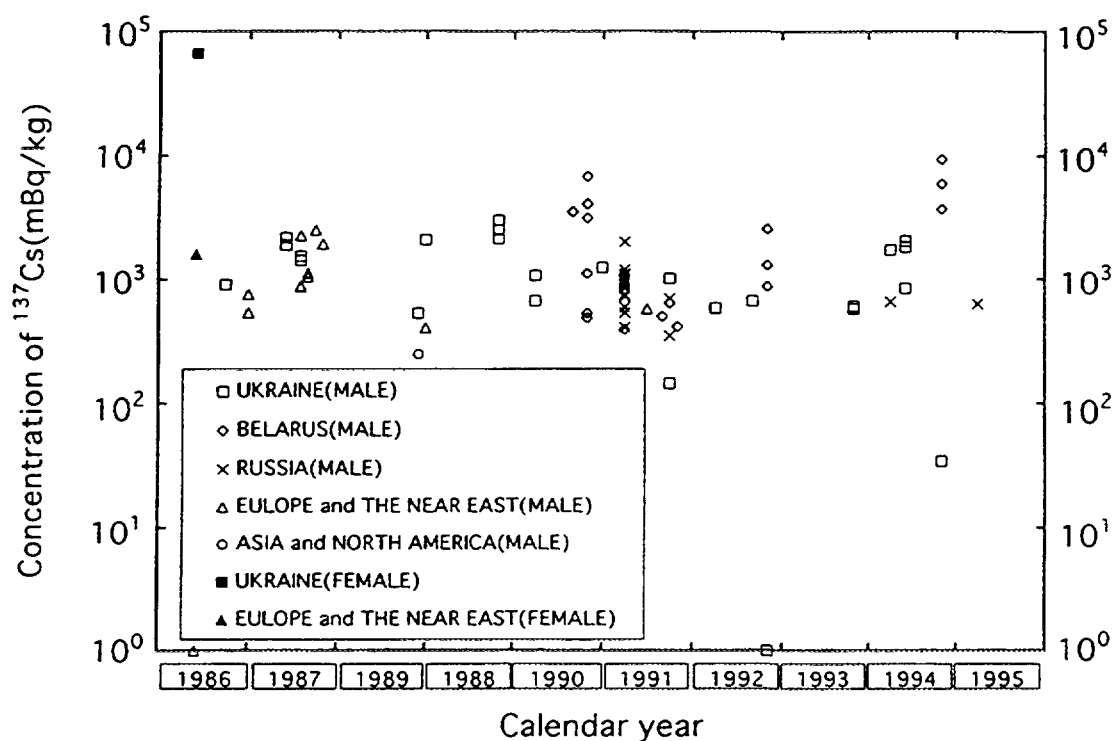


Fig. 2a Temporal changes in ^{137}Cs concentration in whole-body for Japanese returnees. - Period of stay < 1 month -

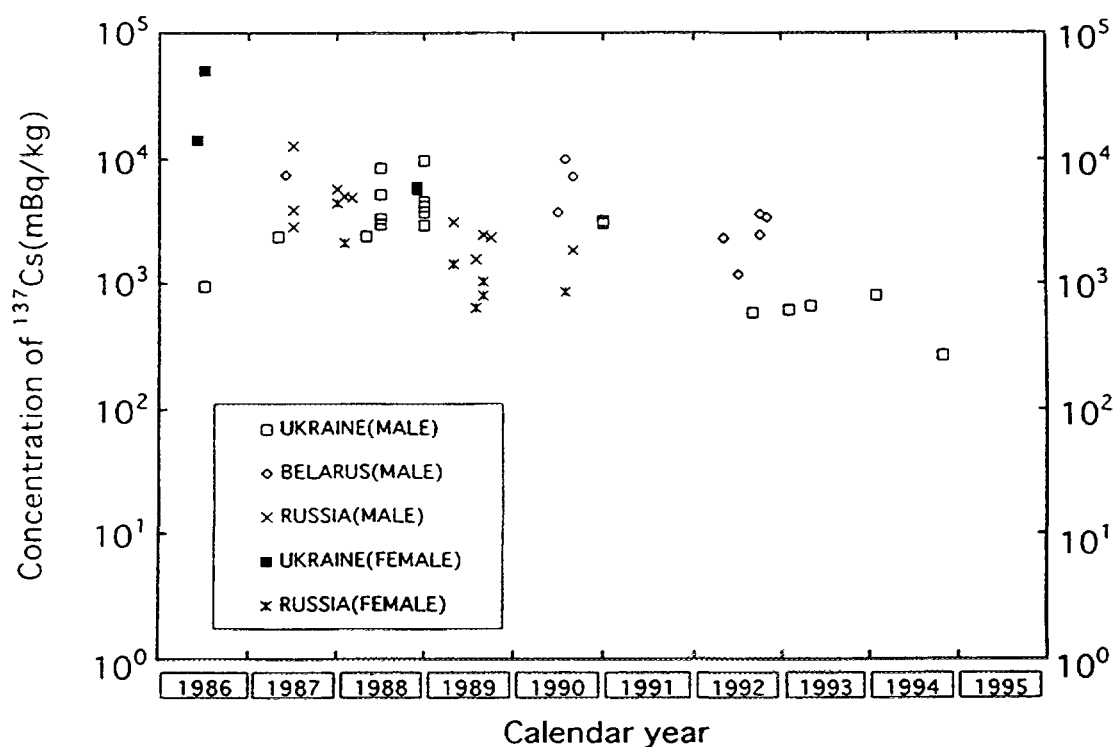


Fig. 2b Temporal changes in ^{137}Cs concentration in whole-body for Japanese returnees. - Period of stay \geq 1 month -

between the time elapsed after the Chernobyl accident and the duration of each individuals' stay according to the length of their stays. less than 1 month and 1 month or greater. The secular changes in the concentration of ^{137}Cs in the body are explained graphically for the subgroup 1 in Fig 2a and for subgroup 2 in Fig 2b. The number of individuals as of December 1995 was 82 for subgroup 1 and 59 for subgroup 2.

3.3. Foreigners

The fourth group was composed of foreigners who visited the NIRS occasionally. It was divided into 5 subgroups according to origin of each subject. They were; (1) Ukraine; (2) Belarus; (3) Russia; (4) the rest of Europe except for just mentioned 3 areas and the Near East; (5) Asia and North America. Only one foreigner was measured before the year 1988, a subject from Hungary in July 1986. Figure 3 represents annual changes in the ^{137}Cs concentration in mBq/kg. The highest concentration of ^{137}Cs including ^{134}Cs was 67,400mBq/kg. It was observed in a male Ukrainian. The subjects from the most affected countries, Ukraine, Belarus and Russia were principally at similar levels to one another by 1992. A slight increasing tendency was observed thereafter with occasional high levels. Foreigners from Europe and the Near East had larger concentrations than the first group. The concentration in subjects from Asia and North America did not exceed the level of the first group. This tendency in the concentration of body burden primarily coincided with the order of areas contaminated with fallout radiocesium of the Chernobyl accident that had been analyzed by the UNSCEAR in 1988 [5].

In Kiev, the concentration had decreased considerably by 1991. The trend was complicated from then on. The circumstances in Belarus and Russia were similar to Ukraine as described above. It must be emphasized that in all the former USSR regions under study, there were individuals who showed ^{137}Cs concentrations at extreme levels, sometimes as much as two orders higher than that for the first group.

The consequences of the Chernobyl accident on the citizens in Kiev in Ukraine, Minsk in Belarus and Moscow in Russia were evaluated according to the ratio of ^{137}Cs concentration for the third and fourth groups to that in the first group. The ratio of ^{137}Cs concentration in the whole-body to the first group was about one-twentieth for the third and fourth groups. In Minsk, an increasing trend in the ^{137}Cs concentration was observed from 1992. The ratio to the first group was approximately at the same level as Kiev. A fairly large distribution in the concentration existed in individuals from these cities. In Moscow, the concentration decreased to one-seventh in 1990. Thereafter it seems to show an increasing trend. The ratio to the first group was rather large, one-sixth to one-eighth for Moscow. The doses of the groups mentioned above were evaluated relative to the dose in the first group. The risk can be estimated to be not larger than 2 orders greater than the first group. These dose evaluations led us to conclude that there may not be any serious consequences expected for the health of individuals in the third and fourth groups except for some extreme cases.

3.4 Estimate of ^{137}Cs ingestion by citizens in Kiev and Moscow

A model was used to describe the temporal change in radiocesium body burden following the continuous ingestion of radiocesium. The daily amount of radiocesium intake in mBq per kg of body weight was estimated for the returnees. The regression of the estimated concentration of radiocesium resulting from the

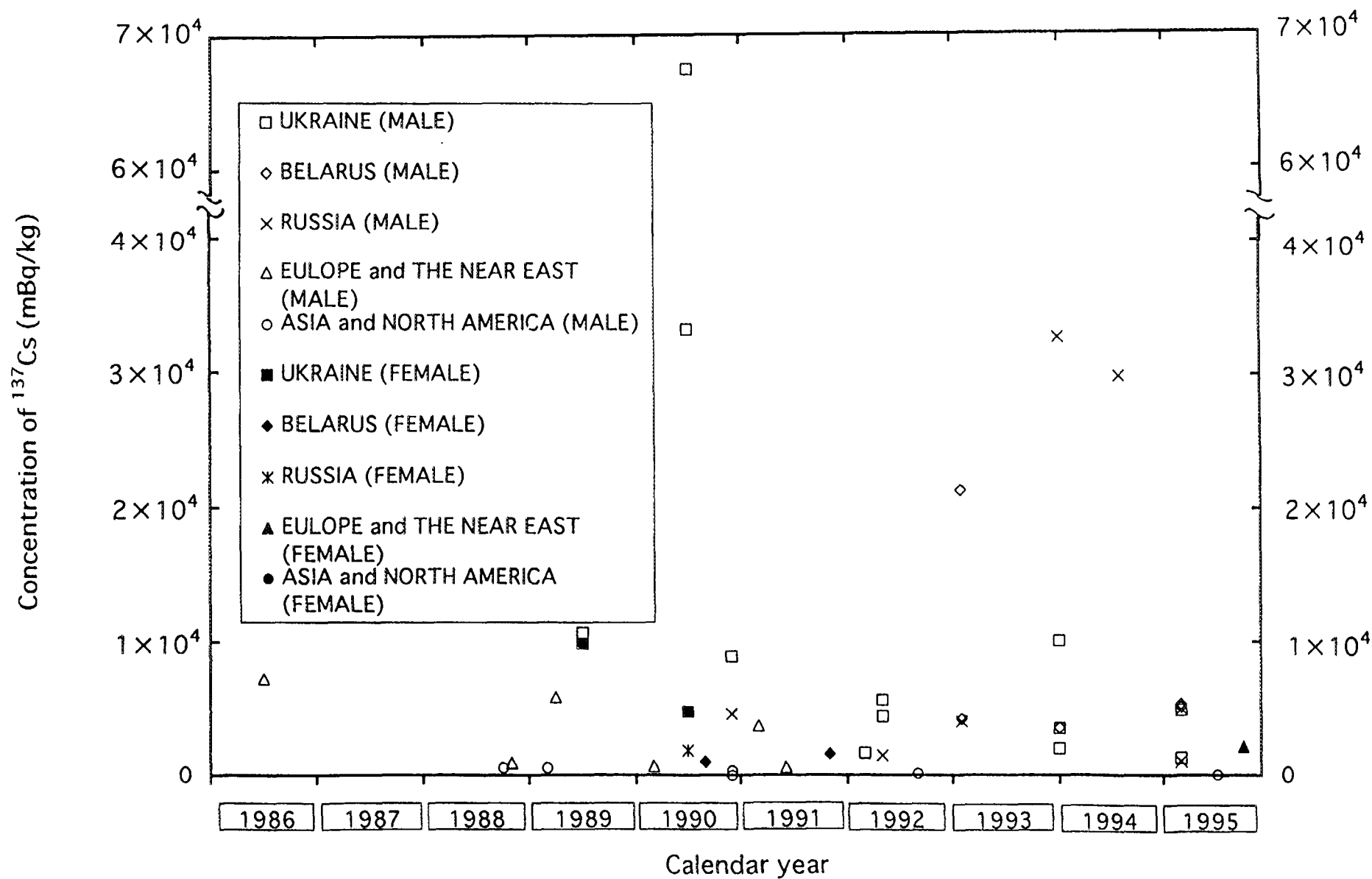


Fig. 3 Temporal changes in ^{137}Cs concentration in foreigners that occasionally visited the NIRS.

daily intake of ^{137}Cs against the elapsed time after the Chernobyl accident varied according to the period of the analysis. For the people that returned from Kiev, an apparent half-time of 460 days was estimated for adults for the period from 1986 to 1992. It varied from 391 to 920 days when changing the period or the number of individuals included in the analysis. For the returnees from Moscow, the apparent half-time was estimated to be 358 days for the period from 1987 to 1990. Recent measurements indicate trends in ^{137}Cs body burden that can not be explained by the current methods of estimation. However, a decreasing trend in the body burden was observed in returnees who consumed strictly controlled foodstuffs. This indicates that the regulation of the food distribution systems might have loosened up in the former USSR countries. The prognosis of dose estimation should be changed with regard to this situation

4. Conclusion

The internal dose from radiocesium due to the Chernobyl accident was estimated to be $5.6 \mu\text{Sv}$ for 5 years for the body burden of Japanese male adult group. The highest average recorded level was 59 Bq in May 1987. No detectable health risk was expected for the Japanese population. In Kiev, the concentration had decreased considerably by 1991. The trend was complicated from then on. The circumstances in Belarus and Russia were similar to that in Ukraine. The ratio of ^{137}Cs concentration in the whole-body to the first group ranged from about one-twentieth for Kiev to one-seventh in 1990 for Moscow. A fairly large distribution in the concentration existed in individuals. It must be emphasized that in all the former USSR regions under study, there were individuals who had ^{137}Cs concentrations at extreme levels. The risk can be estimated as being not larger than 2 orders greater than the first group. These dose evaluations led us to conclude that there may not be any substantial consequences to the health of individuals expected in the third and fourth groups, except for some extreme cases.

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HEALTH CONSEQUENCES OF THE CHERNOBYL ACCIDENT IN EUROPE OUTSIDE THE FORMER USSR: A REVIEW

E. CARDIS, D. SALI
International Agency for Research on Cancer,
Lyon, France



XA9745502

The accident which occurred in the night of 25 to 26 April 1986 in reactor 4 of the Chernobyl nuclear power plant in the Ukraine released considerable amounts of radioactive substances in the environment. Outside of the former USSR, the highest levels of contamination were recorded in Austria, Greece and Romania, followed by other countries of Central and Southeast Europe.

Studies of the health consequences of the accident have been carried out in these countries as well as in other countries in Europe. This paper presents the results of a systematic and critical review of studies of the general population in Europe, carried out on the occasion of the tenth anniversary of the Chernobyl accident. The primary focus of this paper is cancer, the major long term consequence of radiation exposure expected, although studies of pregnancy outcome in these countries are briefly outlined. Overall, there is little evidence of a major public health impact of the accident in countries of Europe outside the former USSR.

LEUCOCYTE MARKERS IN THE CHILDREN OF UKRAINE AFFECTED BY THE ACCIDENT AT CHERNOBYL

G. LÓPEZ PUMAR

Instituto de Medicina de Trabajo,
La Habana, Cuba

J. CÁRDENAS HERRERA

Centro de Protección e Higiene de las Radiaciones,
La Habana, Cuba

Los leucocitos son las células sanguíneas que más rápidamente reflejan los efectos inducidos por las radiaciones ionizantes. En la medida que son mayores las dosis los cambios inespecíficos se traducen en alteraciones funcionales y orgánicas que afectan la vida media de las células, el desempeño de sus funciones y de los órganos de la hematopoyesis. Con el propósito de estudiar el comportamiento de los índices leucocitarios y su relación con el estado somático general, se estudió un grupo de 100 niños ucranianos atendidos en Cuba en el período 90/94. Los resultados preliminares arrojan que las cifras relativas de leucocitos neutrófilos segmentados es muy similar al de linfocitos, encontrándose los números absolutos de ambos, así como del total de leucocitos por debajo de la media por edades en un rango que oscila entre el 20 - 35 % de los casos. El conteo de eosinófilos se mantuvo en un gran número de casos por encima de 2,5% asociado a patologías no radiogénicas. Es de señalar que se encontraron alteraciones del sistema hemolinfopoyético, entre las más frecuentes adenopatías e hiperplasia de tejido linfoide en orofaringe.

SESSION 4

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PSYCHOLOGICAL CONSEQUENCES OF THE CHERNOBYL ACCIDENT IN BELARUS

A.P. GELDA, F.M. GAJDUK, I.M. SHELDAK, A.Eh. KACHALKO, V.D. KOROLEV
Minsk Institute of Medicine,
Minsk, Belarus



XA9745504

ПСИХИЧЕСКИЕ ПОСЛЕДСТВИЯ В БЕЛАРУСИ ЧЕРНОВЫЛЬСКОЙ КАТАСТРОФЫ.

Ф.М.Гайдук, В.Д.Королев, А.П.Гелда, И.М.Желдак, А.Э.Качалко.

Беларусь, Минский медицинский институт.

В четырех районах с общим заражением свыше 1 Кюри на километр и в двух чистых районах изучалось влияние Чернобыльской катастрофы на частоту возникновения шизофрении, врожденной умственной отсталости и неврастении. Сравнивались периоды времени за 5 лет до катастрофы и 5 лет после катастрофы. В послеаварийном периоде частота заболевания шизофренией и врожденной умственной отсталостью не изменилась, неврастения стала встречаться чаще и изменилась клиническая ее структура за счет увеличения астенического радикала.

У детей, подростков и взрослых при клинко-психологическом обследовании в зараженных районах было отмечено увеличение примерно в 2 раза уровня тревожности и эмоциональной лабильности, а также повсеместное снижение удовлетворенности качеством жизни по сравнению с чистыми районами.

Было обследовано 1868 детей, получивших радиоактивное поражение внутриутробно, а также их матерей и воспитателей по программе ВОЗ "Айфика". Была выявлена в пораженных районах более частая встречаемость IQ ниже 70 согласно цвет-

ным матрицам "Равена" и Британскому рисуночному тесту мужчины.

Динамическое наблюдение за взрослыми показывают, что в структуре психической патологии на I этапе после катастрофы преобладали невротические и соматоформные расстройства. В настоящее время происходит их трансформация в посттравматическое стрессовое расстройство, нарушение психологического развития личности и органическое поражение головного мозга сосудистого генеза.

SOCIO-PSYCHOLOGICAL EFFECTS OF THE CHERNOBYL ACCIDENT ON THE POPULATION OF BELARUS AND MITIGATION OF THOSE EFFECTS

L.A. AGEEVA

Institute of Sociology, Belarus Academy of Sciences,
Minsk, Belarus



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Р Е Ф Е Р А Т

научного доклада на Международную конференцию
"Десятилетие после Чернобыля: оценка последствий аварии"

АГЕЕВА Л.А.

СОЦИАЛЬНО-ПСИХОЛОГИЧЕСКИЕ ПОСЛЕДСТВИЯ ЧЕРНОБЫЛЬСКОЙ КАТАСТРОФЫ ДЛЯ НАСЕЛЕНИЯ БЕЛАРУСИ И ИХ СМЯГЧЕНИЕ

После второй мировой войны, в которой в Беларуси погиб каждый четвертый ее житель, Чернобыльская катастрофа является национальной трагедией ничуть не меньшего масштаба. На загрязненных территориях, на которые выпало около 70 процентов радиоактивных выбросов, оказались два миллиона сто тысяч человек. О радиации жители республики знали мало. Своих атомных станций у Беларуси нет. О чужих авариях средства массовой информации сообщали очень скупо. Считалось, что ничего подобного в нашей стране произойти не может. Все дружно прославляли "мирный атом" и проклинали атомную бомбу.

Происшедшая на Чернобыльской АЭС авария застала всех врасплох. Она каснулась не только тех, кто проживал вблизи Чернобыльской станции и попал, в так называемую тридцатикилометровую зону, но и тех, кто находился от нее на значительном расстоянии. Страх радиации прочно обосновался в республике и вызвал существенные изменения в сознании населения в отношении к "мирному атому" и всему, что с ним связано.

По данным социологических исследований, выполненных в рамках Международного проекта JSP-2 в 1993-1995 гг. (было опрошено 1015 человек в различных регионах республики) Чернобыльскую аварию как "довольно значительную" и "очень большую" причину своего психологического стресса назвали 55,2 % респондентов. Причем так высоко свой стресс оценили не только жители территорий с высоким уровнем загрязнений (15-40 Ки/км²), но и чистых территорий. Так, на близ расположенных к загрязненным зонам (пограничных) территориях стресс оценивался по максимуму 51,8 % населения, а на чистых, удаленных значительно от зон загрязнения - 46,9 %. Связана такая реакция на происшедшую аварию, на наш взгляд, с тем, что большинство жителей республики до сих пор не верят, что проживают на чистых территориях. Это произошло потому, что в первое время после аварии республика не обладала достаточным числом специалистов-дозиметристов и наличием должного количества приборов для измерения уровня радиации, о чем населению было известно, и, вместе с тем, отсутствовала правдивая информация о масштабах катастрофы, которая была бы доступна населению. По полученным нами данным, процент, считающих свои территории радиоактивно сильно загрязненными, довольно высок и составляет 22,4 % в чистой зоне, 64,0 % в чистых приграничных зонах и 88,2 % в действительно загрязненных. Однако 17,3 % переселенных в чистые зоны уверены, что все равно проживают на загрязненных радионуклидами территориях. Проводимые же правительством мероприятия в зонах с повышенным уровнем загрязнения (эвакуация, переселение, изымание скота, дезактивация, обязательная диспансеризация и другие), приводили к возникновению повышенной тревожности у населения за своё здоровье и здоровье своих близких. Эта тревожность осталась на достаточно высоком уровне и спустя ряд лет после аварии. Так, в наших исследованиях 7,1 % респондентов сообщили, что у них и 18,6 % у членов их семей появились серьёзные заболевания вследс-

твие Чернобыльской аварии, при этом они сообщили, что документа об этом у них нет. 50,4 % утверждали, что лично знают серьёзно заболевших вследствие аварии.

Налицо тенденция со стороны населения все заболевания, которые оказывались у респондентов, связывать с аварией на ЧАЭС. На наш взгляд, это происходило потому, что пострадавшим от аварии полагалась определенная социальная защита, что в условиях ухудшающегося экономического положения Республики, было немаловажно, а отсюда и стремление получить полагающиеся пострадавшему населению льготы. Поскольку установление связи заболеваний с аварией на ЧАЭС проблематично, то появилась тенденция не верить своим специалистам. Это подтверждают данные социологического исследования. Так, в загрязненной зоне не верят компетенции людей, изучающих влияние Чернобыльской катастрофы на здоровье 22,8 % респондентов, в пограничной зоне 12,5 %, в чистой зоне 13,8 %, а "очень немного" доверяют соответственно 29,5 %, 27,4 % и 27,1 %. В то же время обеспокоенность за последствия от аварии на ЧАЭС у населения Республики была очень высокой и составляла в загрязненных районах 62,5 %, в пограничных 68,0 %, у переселенных 74,4 %, у жителей чистых зон 67,8 %. В то же время поведение местных властей, которые призваны были заботиться о людях, попавших в беду оценивается населением очень низко. Только 4,8 % респондентов оценили эту заботу как "довольно достаточную", 59,6 % посчитали, что она была "в какой-то степени" и 34 % полностью её отрицали.

Ощущение безысходности, покинутости в беде, появились у пострадавшего населения спустя несколько лет после аварии, когда резко стало меняться социально-политическое положение Республики в связи с распадом Союза, изменением её статуса и невозможностью в полной мере теперь оказывать помощь пострадавшим. Уверенность, что именно государство, официальные структуры прежде всего должны заботиться

о людях, оказавшихся в трудных условиях, прослеживается в ответах респондентов. Так, на заботу от центральных властей рассчитывали 81,3 %, от врачей - 51,3 %, от местных властей - 47,9 %, от служб радиационного контроля - 32,7 %. Вместе с тем на себя, свои семьи, друзей рассчитывает сравнительно небольшой процент опрошенных (12,1 % - семья, друзья и 26,3 % - сам на себя). Здесь мы имеем ситуацию, свойственную большинству населения бывшего Союза - иждивенчество, неспособность и часто нежелание помогать самим себе. Населению выгоднее занять позицию "жертвы" и требовать к себе внимания, заботы со стороны, чем самому активно преодолевать возникшие сложности в своей жизни. Позиция ожидания, неумение бороться индивидуально со своими бедами - наследие более чем семидесятилетнего коммунистического прошлого, когда все действия населения при любых ослаблениях строго регламентировались. В данной ситуации подобное выжидание для многих оборачивается серьёзными трудностями. Так, неспособность перестроить свой уклад жизни, заняться новым делом, сменить место жительства, переориентировать себя и своих близких на новые жизненные ценности, неумение общаться, защищать свои права, добиваться намеченных целей привели и продолжают приводить многих жителей из пострадавших, и не только, районов в отчаянное положение, порождая пессимизм, ощущение безысходности. Так, своим будущим "очень сильно" и "довольно сильно" обеспокоены 70,7 % респондентов в загрязнённых районах, 77,5 % - в приграничных, 76,7 % в чистых и 84,7 % переселённых. При этом 46,2 % опрошенных ждут ухудшения ситуации в стране в ближайшем будущем, сохраняя уверенность, что лично они, а процент таких 39,7, никак не способны повлиять на свою жизнь. "Немного" и "очень незначительно" считают, что могут влиять на свою сегодняшнюю жизнь 47,7 %. Подобное восприятие своего состояния связано не только с аварией на Чернобыльской АЭС, но и действительным ухудшением положения населения в посткоммунистичес-

ком обществе в связи с кризисом экономики и резким падением жизненного уровня населения в прошлом благополучной республики. Поэтому сегодняшние стрессовые состояния населения должны рассматриваться в комплексе всех факторов их вызывающих и также комплексно необходимо проводить профилактику этих состояний.

К мероприятиям, призванным снизить тревожность населения, помочь преодолеть депрессию, страх радиации, смягчить последствия от аварии на ЧАЭС, на наш взгляд, следует отнести не только чисто медицинские, направленные на сохранение здоровья пострадавших, но и продуманную политику государства, допустившего в первый период поставарийной ситуации много ошибок (непродуманное поспешное переселение, спешка со строительством типового жилья, недобровольность переселения, неподготовленность рабочих мест в местах отселения, неспособность обеспечить чистыми продуктами, квалифицированной медицинской помощью, и другие), которая должна включать, на наш взгляд, большую работу с населением всей республики, а не только с пострадавшим населением по повышению уровня радиационных знаний; полную открытость информации об аварии и ее последствиях; создание по всей республике реабилитационных центров социально-психологического профиля с одновременным повышением психологической культуры населения; отмена льгот пострадавшему населению при одновременном улучшении медицинского адресного обслуживания этой категории населения в поликлиниках и стационарах и несоздания противопоставления между потерпевшим и непотерпевшим населением Республики; принятие правительством законов, которые должны быть исполнимыми, а не декларируемыми, на основе мирового опыта борьбы с атомными авариями.

ROLE OF RADIOECOLOGICAL EDUCATION IN THE SOCIO- PSYCHOLOGICAL REHABILITATION OF THE POPULATION OF BELARUS AFFECTED BY THE CHERNOBYL ACCIDENT



XA9745506

A.I. STAVROV

Training, Research and Information Centre, Academy of Management,
Minsk, Belarus

The accident on Chernobyl NPP was the largest radiation accident in a history of mankind. It touched millions people in Russia, Ukraine and Belarus and has become one of the most significant phenomena, which have affected influencing a course of development of political and economic processes in these states. The accident in the special degree had an effect and will an effect hereafter in Belarus, which has assumed main radiation impact.

The consequences of Chernobyl accident represent a complex radiation, socio-psychological, economic and political effects. Each of such effects results in changes of conditions of life of the population of republic, influences a condition of his health and requires the special measures on its minimization.

As experience has shown, one of the most significant consequences of accident were in socio-psychological sphere. It is connected first of all to inadequate perception of these consequences by all layers of the population, including, authorities, accepting the decisions, executive authorities of all levels, experts, mass media and etc. An existing situation largely was strengthened by all history as of period before accident, and first years after. Characteristic attribute of this time was practical complete absence of the authentic information not only for the population, but also for a wide range of the chiefs of a various level in the most various fields of human activity.

The process beginning simultaneously with announced "perestroyka" and "glasnost" to a moment of accident has not typed complete force and first years after accident a real radioecological situation, condition of a health of the population and liquidators, economic damage and etc. down to a beginnings of 90's were actually closed for access as the population, and many experts.

Opening of the information in the above mentioned fields along side with positive effect has resulted and negative - strengthening of socio-psychological consequences and formation of certain mistrust in the home specialists and state structures, engaged in work on overcoming of consequences of accident. Besides in result of desintegration USSR practically main sources of the information, educational centers, experts in the field of radiation and nuclear safety and uses of nuclear energy have appeared outside of Belarus in Russia and on Ukraine.

As experience accumulated to the present time shows, the fulfillment of the whole complex of measures on providing of radiation protection of the population depends not only on quality of the accepted programs and laws, but on a level of competence, qualification and education of the experts and chiefs of a various level, responsible for realization of these measures or connected to work in this field. Or else, in which degree a system of education in field of radioecology and radiation protection is advanced. On the other hand, the maintenance of ability to live in conditions of radiation contamination largely depends on a level of education in this field of whole population, on knowledge of the rules and norms of radiation protection and on a degree of their fulfillment.

In connection with change of state policy to the rehabilitation of contaminated territories and maintenance of normal ability to live in formed conditions, one of the main roles begin to play education and information of the experts, engaged in work on realization of measures on overcoming of consequences of accident, and with the population of republic in, first of all, regions, subjected to radiation contamination.

Despite distinction, these two problem in contemporary conditions can and should be solved in complex, with use of all opportunities available in republic, with attraction of the leading scientists and experts, with orientation on all groups of the population.

At the same time, the traditional measures and actions on formation of adequate perception of accident on ChNPP as of one of main ways of socio-psychological rehabilitation of the population in republics have appeared not quite effective. In many respects it is connected to a problem of trust of the population to various sources of the information on problems of radiation protection. Some results of sociological survey of the population on study of the attitude of the citizens to an opportunity of development in Belarus of NPP, conducted in republic in 1995 can by way of illustration serve. Was straightened out, that more than 89 % of the population considers that information in this field is absolutely insufficient (Pic. 1). At the same time, as it is clear from Pic.2, population prefer to believe international organizations (IAEA), foreign experts, and almost do not believe authorities (state and local) and mass media.

In this connection search of new ways in the decision of a delivered problem was required. In conditions of Belarus such way has become general radioecological education of all layers of the population, including informing of all categories of the population on problems, connected not only with consequences of accident, but also with general problems of radiativity and use of nuclear energy in the peace purposes.

Radioecological education is based on introduction in all steps of common education from school up to high educational establishments, specialized training of the workers of a network of the radiation control, chiefs of all branches of a national economy, representatives of an executive authority of all levels and other, wide knowledge in the field of radioactivity, consequences of accident and maintenance of ability to live in hard radioecological conditions. It is directed on creation educational base, formation of adequate perception of specific information and of certain skills in maintenance of own radiation protection, of the decisions in all spheres of life and activity, directly or indirectly connected to consequences of accident. As experience has shown, in conditions of Belarus without such education usual information activity by virtue of the mentioned above reasons would be not effective.

At the same time radioecological education permits to generate adequate perception of consequences of accident among the persons, whom the population trust first of all. To these persons, besides well-known categories (medicine doctors, teachers and other) belong the workers of a network of the radiation control, providing the control of an environment, food-stuffs, industrial goods and etc. Just they, working on contaminated, in the heaviest degree can render influence to public opinion and perception the population of consequences of accident, thus largely intensify socio-psychological rehabilitation of the population. On the other hand, through them the most effective distribution of the information in the specified areas is possible.

Understanding gravity of a delivered problem, in republic was created Training, Research and Information Center (BelTRIC) on problems of radiation protection, power

engineering and radioecological education of Academy of management at the President of Belarus.

The purposes of activity of Center were:

- 3.1. Training and education of the specialists, authorities and workers of ministries on problems of the prevention and overcoming of emergencies.
- 3.2. Development of the educational program, maintenance of constant scientific and informational-methodical support of educational process, coordination of such activity in republic.
- 3.3. Development and distribution of information materials on the specified problems, intended for governmental establishments, management bodies of a various level, ministries and departments, but also for the population.
- 3.4. Scientific-analytical support of the decisions and valuation of their efficiency in the field of radiation protection, overcoming of consequences of accident on ChNPP, actions under the prevention and overcoming of emergencies.
- 3.5. Organization of information exchange on the above-stated problems with international scientific organizations and centers and distribution in republic of the arriving information.
- 3.6. Creation and maintenance of serviceability of specialized computer banks of data for educational process, information and scientific-analytical support of the decision on the above-stated problems.
- 3.7. Coordination of development of the normative-legal documentation in the field of radiation, nuclear and industrial safety.
- 3.8. Maintenance of methodical support of activity of a state and departmental network of the radiation control on territories of republic, contaminated in result of accident on ChNPP.

BelTRIC is appointed as head organization in republic of a radioecological education and training of the specialists of a network of the radiation control and workers of ministries, departments and authorities engaged in realization of measures on overcoming of consequences of accident on ChnPP, providing of radiation protection of the population.

Experience of BelTRIC has shown:

1. The main purpose now is informational and educational activity on radioecological education of the specialists of an specific infrastructure created in republic (network of the radiating control, organizations and establishments, scientific institutes and other, oriented on fulfillment of State Programme of overcoming of consequences of accident on ChNPP).

In turn, these specialists become the personnel basis for general radioecological education of the population, as in the heaviest degree cause trust at the general public of republic and are able to render significant influence to process of socio-psychological rehabilitation of the population.

2. The significant role plays wide use of world experience in the field of providing of radiation protection. According to existing situation in republic, the population prefer in a greater degree to trust foreign, instead of home scientific and experts. In this connection is necessary to establish effective information exchange first of all in sphere of radioecological education and training of the experts and specialists, engaged in this activity.
3. Creation of the concept of radioecological education and the begun work on its realization creates conditions of wide distribution of main knowledge in field of radioecology in a system of national education. In turn it will allow to begin formation of adequate perception of the mentioned above problems of young generation, that is in essence important from the point of view of development of a situation in republic in foreseeable future.

The realization of the mentioned above approaches within the framework of work BelTRIC has demonstrated appreciable results. Past through a system radioecological education in Center more than 3000 experts largely render now influence to formation of adequate perception of consequences of accident on ChNPP different layers of the population and management bodies of republic. It has in turn allowed largely to decrease socio-psychological stress among the population, first of all that part, which lives on contaminated territories.

STUDY OF THE ART AS A NEW WAY TO MEASURE NUCLEAR PUBLIC OPINION



M. OBERHOFER
ISPRA Establishment, JRC.,
Ispra, Italy

F. ABDEL-HAY
National Center for Nuclear Safety and Radiation Control,
Cairo, Egypt

1. INTRODUCTION :

In the recent last years, it became increasingly evident that people must learn more about the atom and radiation , in order to be able to live with it without fear. More efforts are needed to make them familiar with the benefits of its applications in the modern live. The recent accidents of Chernobyl and Goinea in Brazil, created an immense negative public reaction against nuclear energy. It is therefore important to consider using art as an approach to make people listen more and understand better. Such objective is not so easy because it requires that the artists themselves should be familiar with related science and technology aspects of the subject and its various consequences on human beings. Then they can try to find ways of expressing themselves with their artistic tools and skills.

In this context, it is important for scientists to seek for an appropriate way of communication with artists. The different types of art which could be engaged are either the spoken word ; such as novels, poetry and drama, fine arts ; paintings, illustrations or even cartoons or a combination of both ; such as theater and movies.

2. PSYCHOLOGICAL IMPACTS OF NUCLEAR ACCIDENTS :

Soon after the discovery of ionizing radiation, it was realized that radiation could harmfully affect skin tissues, body organs and the human body as a whole beside the genetic effects. Lately after the drop of the first atomic bombs in Hiroshima and Nagasaki and also after Three-Miles-Island and Chernobyl accidents a new phenomenon described as RADIOPHOBIA have become apparent and widely spread..

After Chernobyl , radiophobia manifested itself among the population on an international level. As a consequence , some people consumed only canned food over months and even over years, other people did not leave their homes or move around using masks. Also numerous abortions have been performed in order to save newly born from a miserable life in the future(1).

Citizens do not know the behavior during radiological accidents and emergencies . Even though ionizing radiation are continuing to be used in research, medicine, agriculture, and industry with all the problems connected with its use and radiophobia of people. Thus radiological accident will contribute again to fear with its consequent uncertainties with regard to the "Monster" called ionizing radiation.

The psychological symptoms estimates have been found in association with more serious psychological health indices. The relationship between the people believes about negative health effects of pollutants shows their behavior during pollution episodes (2) The role of human behavior in the environmental health science with emphasis on the study of pollution has not yet been completely investigated

Surveys among different countries such as Germany, England, U.S.A, Australia and other countries in order to analyze the long-term impacts of Chernobyl disaster on public opinions, attitudes and behavior showed that uncertainty about the health consequences was a major response of increasing the hurted (and/or injured) population in the event. The information given to the public by different sources after the accident were insufficient, (3,4) . The assessment of danger was not well estimated after the following 3 years. This explains the increase of the political opposition to the future uses of nuclear power.

3. THE ROLE OF ART :

Art reflects culture development, knowledge and interaction of people with new technologies. Art sums up the life of the whole people and casts light ahead. Each person in the center of his own being has a reservoir of spiritual energy (5) keeping all land and time memories. The art with all its tools, is a human being self expressing and it is a spiritual dialogue between land and time. So, the art in the old stone ages is different from the art now.

The industrial revolution with its economic systems contributed an enormous share towards the radiation quality in life. So any accident is not a machine's mistake. It was a human mistake(5) Profits and explorations little care is given to art . In the nuclear age, The concern is the use of atom in peace; health and prosperity, electrical power, agriculture, hydrology, medicine, industry and regulatory activities. The atomic culture ignored both the public psychology and artists feelings.

The effect of Chernobyl accident on children drawings were studied at southeast England. The analysis of complete drawings after Chernobyl from 3 schools seemed to contain chimneys smoke, pipes and cooling towers which were expressed to some extent as bombs or rockets (6). The study of attitude towards nuclear power plants could be made as questionnaire consisting of sociodemographic questions with a drawing paper in order to be analysed (6).

The aim of this study is to measure the nuclear public opinion and their reflections after the nuclear accidents.

3.1.The Effect of Chernobyl Accident On Egyptian Artists:

The Chernobyl accident affected deeply the public opinion in Egypt. A research was made in two famous daily journals AL-Ahram &AL-Akhabar and two popular weekly magazines Rose Elyossef and Sabah EL-Kheir during April to December 1986, after the accident the artist drawings and cartoon published expressing the reactions of Chernobyl accident on their feelings influences the public opinion that had stopped the Egyptian nuclear program after this accident directly. The Egyptian artists were affected clearly through their art works reflecting their fear against nuclear technology and the radiological accidents.

This was shown in the Egyptian journals and magazines. Some of them were reflecting their fear in their drawings, the other joined the accident time by the festivals Sham-El-Nassim which occurred at the same period of time of the year in Egypt, the third group used the Arabic language derivatives making jokes reflecting their fear from the accident of Chernobyl.

Fig. (1) shows the thoughts of the artist Salim from Rose Elyossef magazine. It was clearly a negative effect where he drew the skull (head bone) and the dried leaves and roses reflecting his pessimism.



Fig. (1) Expression of Feelings of Fear Due to Chernobyl Accident Giving Warning to The Universe. (Reproduced from Rose Elyossef magazine. at 9/6/1986 by Artist Salim).

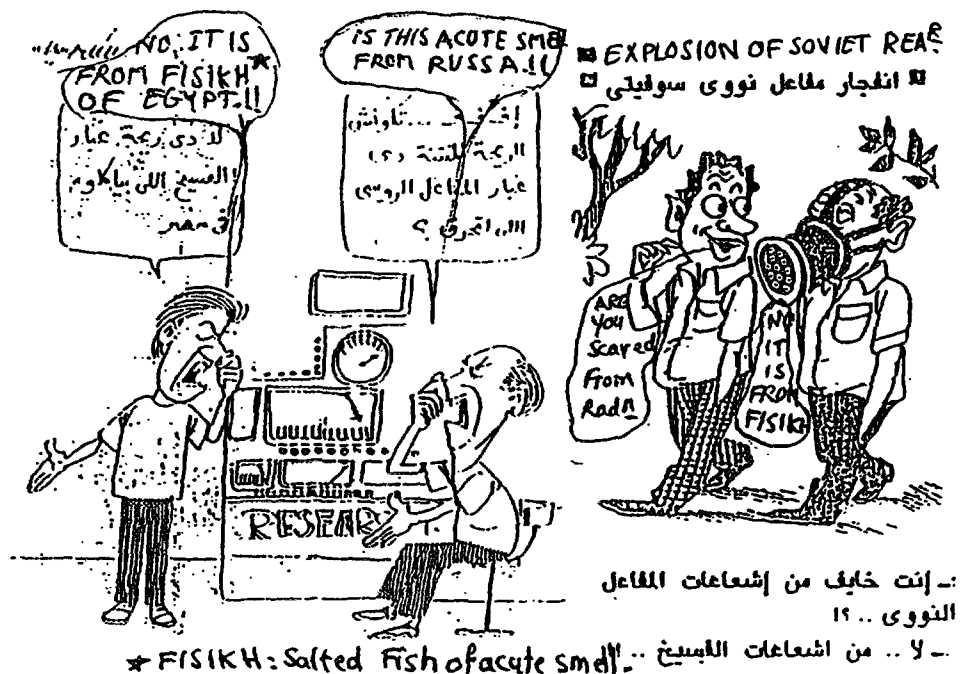
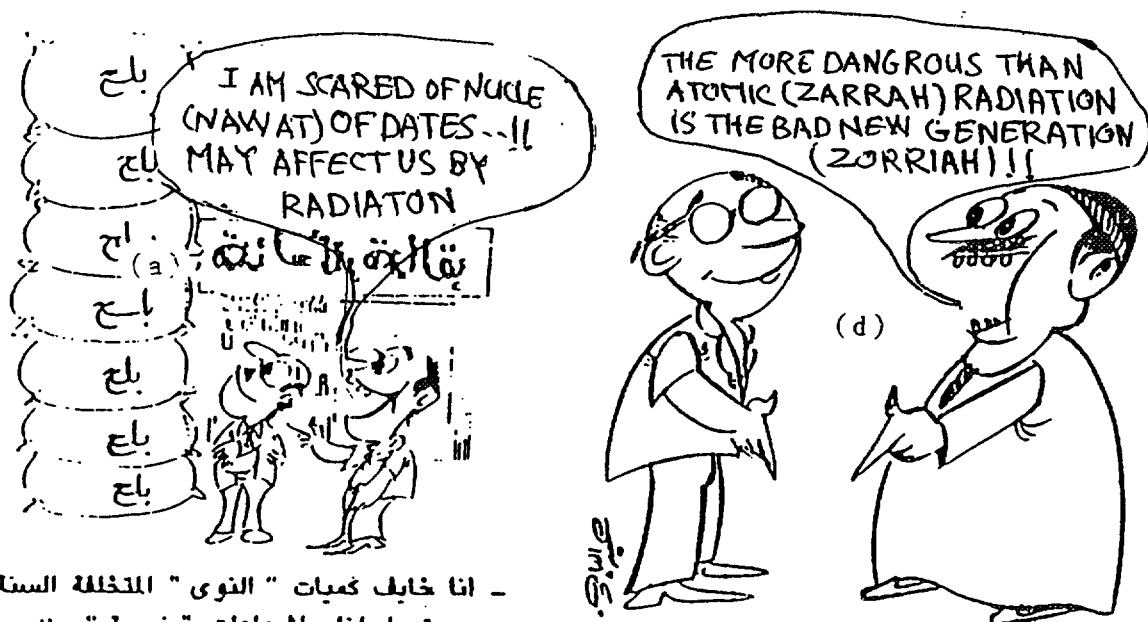
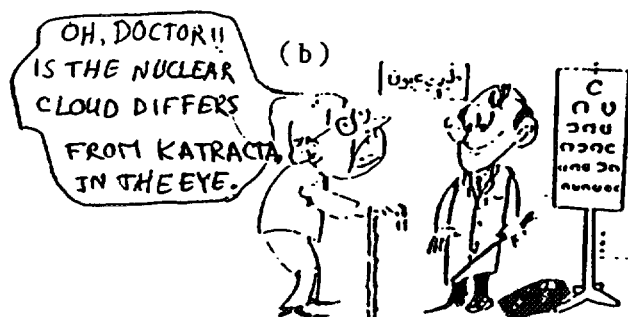


Fig.(2) Expression of Radiohobia After Chernobyl Accident .
(a) Reproduced from 'ALAKhbar Journal at 5/5/1986.by Mostafa Hussien.
(b) Reproduced from ALAhram Journal at 4/5/1986. by Nagy.



- انا خايف كميات " النوى " المتخللة السنة
 بى .. تعمل لنا إشعاعات " نووية " ..!!

- واللى اخطر من الإشعاعات . الذرية .
 . الذرية . اللي مش صالحة !!



- والسحابة النووية .. تفرق كثير عن
 السحابة اللي على العين .. يادكتور !!



- لازم لخرج من هنا .. لان السحابة الذرية
 حصلت بروضه ن منطقة " كيبف " ..

Fig.(3) Expression and Reflections of Chernobyl Accident and its effects on Human Body (Reproduced from 'Rose Elyossef, magazine at 19/5/1986 for a, b and c and for d at 9/6/1968 by Artist Abdel-Baky).



Fig.(4) Expression of the Effect on Nuclear Cloud on Some Body to get rid of him (Reproduced from Rose Elyossef magazine at 23/6/1986 by Artist Kamal).



Fig.(5) Expression of Ignorance of Two Thieves Had Stolen a Radioactive Source (Reproduced from Sabah EL-Kheir Magazine at 5/6/1986 by Artist Mohamed Hakim).

Chernobyl accident occurred in April, 26, 1986 that was the spring time "Sham El-Nassim". The feast day in May, the Egyptians are accustomed to eat salted fish with a characteristic smell.

Fig.(2,a,b) by Mostofa Hussein, from AL-Akhbar, and Nagy, from AL-Aharm, represents their thoughts about the effects of the accident and they joined it with the smell of salted fish.

Fig.(3,a,b,c and d) drawn by Abdel-Baky from Rose Elyossef, he used Arabic language derivatives creating both negative and joke effects, the derivative from the nucleus of the dates and that of the atom in (a). The cloud of the accident and the cloud on the sick eye in (b). The accident site "Kiev" and smoking drugs in (c). The new generation and the atom in (d).

Fig.(4) that drawn by Kamal from Rose Elyossef magazine represents the death effects of the nuclear cloud on someone waiting under its effect.

Fig.(5) drawn by Mohammed Hakem from Sabah- EL-Kheir magazine showing two thieves that had stolen radioactive source from faculty of science giving their wishes to move to the nuclear countries to transport their activities there.

These figures show the poor nuclear culture for the Egyptian artists that results in a negative effect on the nuclear public opinion producing antinuclear opinion against the nuclear program in Egypt.

3.2. The Effect of Goinea Accident On the Artwork :

The examples shown in figures (6) to (13) were drawn by Barzilian artists, some of them were unknown and spontaneous. they painted it directly on the building walls. The others were professional and working in the local magazines. The artworks are given for demonstrating to what extent that art is already used in connection with the atomic radiation and nuclear energy. They give an idea about nuclear public opinion locally. In general most of the artworks presented regarded as negative effects on human life. It is observed that all the artists used symbols that directly and indirectly reflect their opinion and awareness. They used radiation symbol, atom orbits, sexual fear, children awareness, tears, headache, wounds, cracks and pessimistic effectiveness.

Figures (6) through (8) - which are wall paintings were made by unknown spontaneous artists at Goinea in Brazil. They expressed their awareness towards the accident. Figure (6) shows the atom with its orbits located inside the brain in a man's head, a naked human body resembling the awareness towards the human race destruction and the symbol of radiation awareness. Also it is clearly noticed from Fig. (7) the crying announcement to survive the children from hazards effects. This is clear from the children faces drawn inside the arms of the radiation symbol, with the eyes full of tears and a frog throwing its tongue out to swallow the radiation symbol.

Figure (8) shows an atom with its orbits having legs and moved around as an unknown monster worm to eat all green lands and spreading radiation every where through its walking ways.

Figure (9) was published in Journal De Brazil in 19.10.78 created by a professional artist named "IQUE". He drew the radiation hazardous effects revealing at a wounded face and head covered with plasters, a swelling eye and headache with atomic radiation symbols resulted from the radioactive accident.

Figures (10) and (11) by another artist "SIRON" in black and white forms. Fig.(10) represents the human sickness resulted from radiation while Fig. (11) shows the terror of a poor man against shooting with gun towards him. It reflects the effects of radiation with all its distorting tools on the poor human.

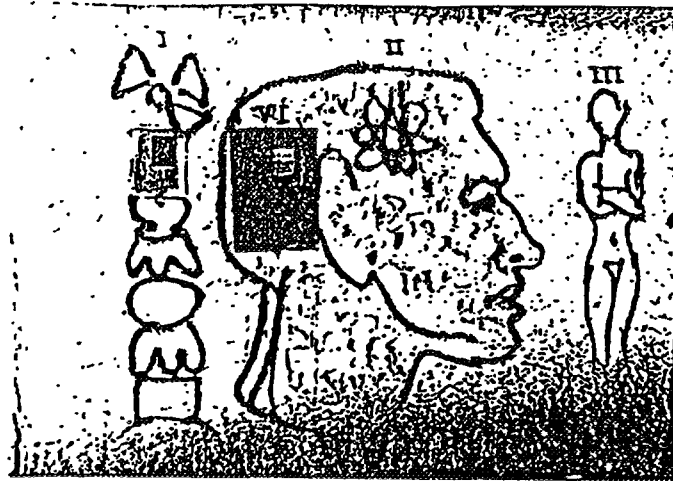


Fig.(6) Expression of Fear and Pessimism Were Illustrated by The Atom Orbits Inside The Brain in Human Head, Naked Human Body And Radiation Symbol Awareness (Reproduced from a Wall Painting Goinea by Unknown Spontaneous Artist).

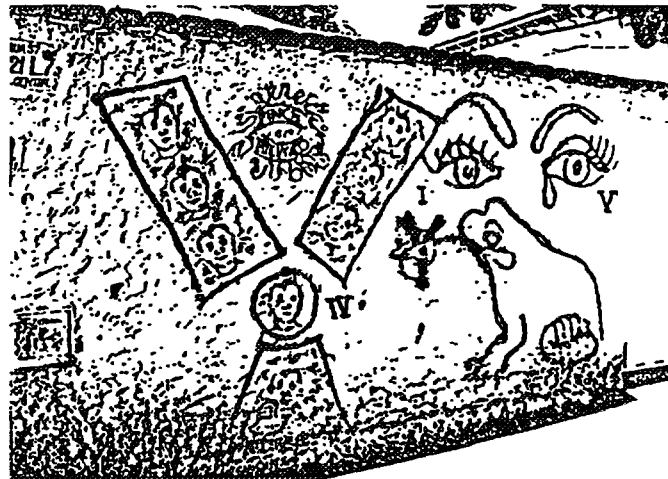


Fig.(7) Expression of Sadness After The Radioactive Accident Illustrated by Eyes With Tears, Radiation Symbol and Frog Throwing its Tongue on. (Reproduced from a Wall Painting Goinea by Unknown Spontaneous Artist).

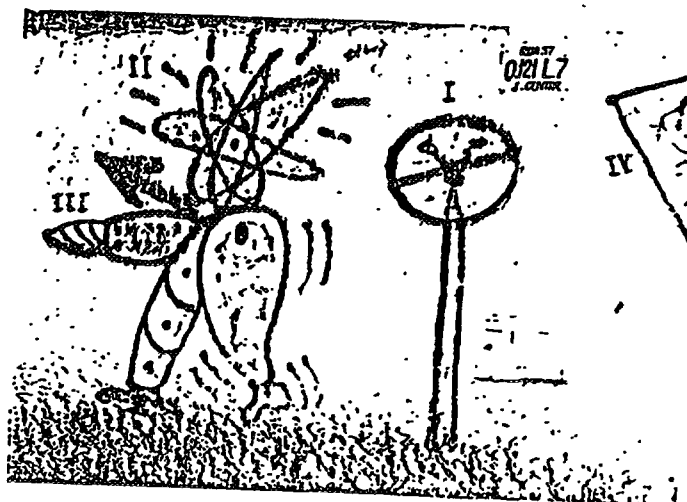


Fig.(8) Expression of Fear Illustrated by the Atom Orbits Having Legs Moving Around Eating All Green Lands and Spreading Around .(Reproduced from a Wall Painting Goinea by Unknown Spontaneous Artist)

Ique

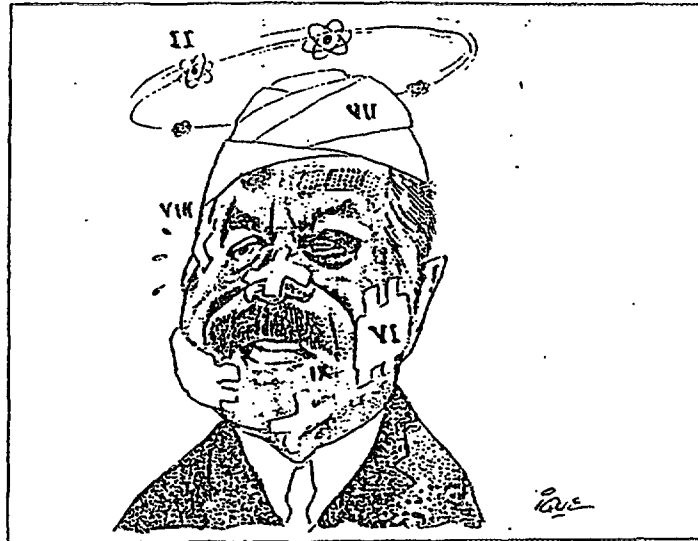


Fig.(9) Expression of Negative Effect on Human Body . (Reproduced from Journal of Brasil by the Artist Ique at 19/10/1987).



Fig.(10) Expression of Sickness of a Man Due to the Effect of Radiation by the Artist Siron.



Fig.(11) Expression of Terror of a Man With a Gun Frieghting a Poor One by the Artist Siron.



Fig (12) Expression of Painfull Effect of Headache due to Radiation by the Artist Luis Triman.

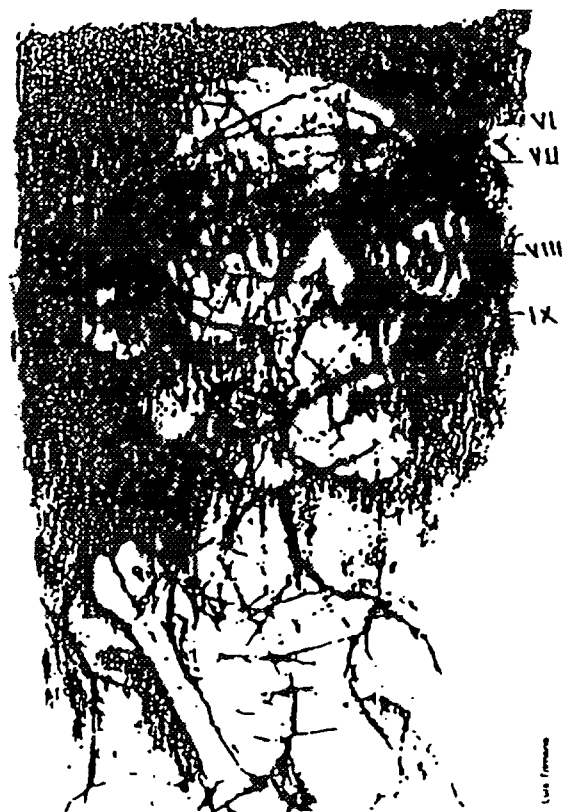


Fig (13) Expression of Mesrableness of Human Due to Radiation by Artist Luis Triman.

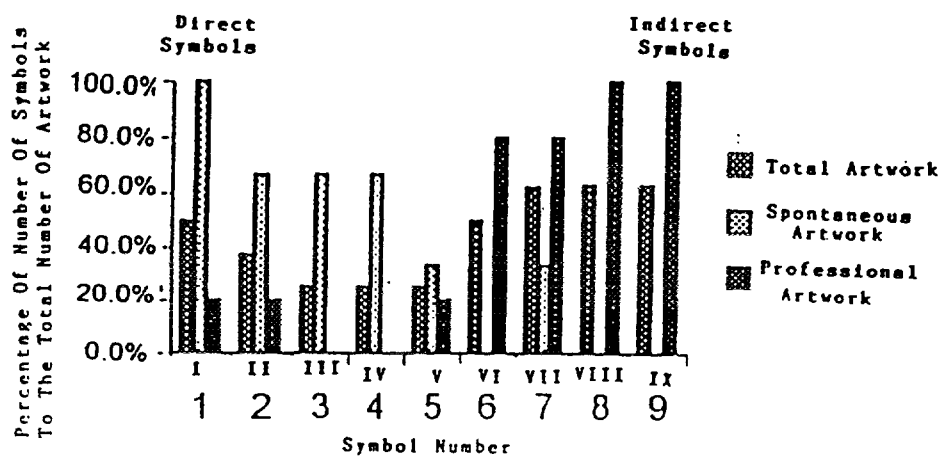


Fig (14) Shows the Percentage in the Use of Artistic Symbols by Both Spontaneous and Professional Artists, From the Direct and Indirect Point of View

Table (1): Number of Symbols Found in the Artwork Used to Express Feelings in Both Spontaneous and Professional Artwork.

Symbol No.	Symbol Subject	Spontaneous Artwork			Professional Artwork					Total No of Symbol
		Fig.(6)	Fig.(7)	Fig.(8)	Fig.(9)	Fig.(10)	Fig.(11)	Fig.(12)	Fig.(13)	
I	Radiation Symbol	1	1	1	—	1	—	—	—	4
II	Atomic Orbits	1	—	1	1	—	—	—	—	3
III	Sexual Fear	1	—	1	—	—	—	—	—	2
IV	Children Awareness	—	1	1	—	—	—	—	—	2
V	Tears	—	1	—	—	—	—	1	—	2
VI	Wounds (Cracks)	—	—	—	1	1	—	1	1	4
VII	Headache (Sickness)	1	—	—	1	1	—	1	1	5
VIII	Terror	—	—	—	1	1	1	1	1	5
IX	Pessimism	—	—	—	1	1	1	1	1	5

Table (2) Percent age of Number of symbols (S) to the Total Number of art work (N)

Symbol No.	Symbol Subject	% of S / N
I	radiation Symbol	50%
II	Atomic Orbits	37.5%
III	Sexual fear	25%
IV	Children awareness	25%
V	Tears	25%
VI	Wounds (Cracks)	50%
VII	Headach (Sickness)	62%
VIII	Terror	62.5%
IX	Pessimism	62.5%

Table (3) Percent age of Number of symbols (S) to the Total Number of art work (N)

Symbol No.	Symbol Subject	% -S / N
I	Radiation Symbol	100%
II	Atomic Orbits	66.6%
III	Sexual Fear	66.6%
IV	Children awareness	66.6%
V	Tears	33.3%
VII	Headach (Sickness)	33.3%

Table (4) Percentage of Number of symbols (S) to the Total Number of art work (N)

Symbol No.	Symbol Subject	% S / N
I	Radiation Symbol	20%
II	Atomic Orbits	20%
V	Tears	20%
VI	Wounds (Cracks)	80%
VII	Headach	80%
VIII	Terror	100%
IX	Pessi-mism	100%

Figures (12) and (13) were drawn by "LUIS TRIMAN" in black and white forms expressing a cracked body representing the damaging effects of radiation on human face in two different expressions.

Table (1) gives the number and the distribution of symbols used to express the feelings of different artists for both spontaneous and professional artworks. [The symbols are located on the figures in roman numbers]. As illustrated in Figs. (6) to (13), these symbols ranged from direct symbols [symbols (I) to (V)] to indirect ones [(VI) to (IX)].

Radiation symbol (I) that is normally drawn on the different sources of radiation to warn people to take care of handling and using of the objects. The atomic orbits (II) which is a scientific symbol were used to show the nucleus and electrons in their orbits, sexual fears (III) as a naked female or arrows. Children awareness (IV) which is symbolized by a face of a child drawn between the arms of radiation symbol. Tears (V) is drawn directly on the crying eyes. Wounds and cracks (VI), headache (or sickness) (VII), terror (VIII), expressed in the eyes or wolves and finally gun attack and the pessimism (IX) expressed by the black background and on the drawn mouth.

Table (2) presents the percentage of number of symbols (S) to the total number of art work (N). It is clearly indicated from table (2) that the percentage of indirect symbols showing terror, pessimism and headache have higher values (62.5%) than other direct symbols (which range from 25 to 50%) and express directly the artists fear from radiation.

Table (3) gives the percentage of number of symbols to the total number of artwork of the spontaneous artists. As indicated from the table, the spontaneous artists have used radiation symbols in all their artwork as a direct symbol of awareness, also atom orbits and sexual fear, which is of great importance where it reflects their fear from the human destruction.

Table (4) gives the percentage number of symbols to the total number of artwork of the professional artists. It illustrates their higher interest to express the indirect feelings of pessimism and terror and lesser interest in expressing headache and wound. The minimum interest was in using radiation symbols, atomic orbits and tears.

Figure (14) shows the percentage in the use of artistic symbols by both spontaneous and professionals. It is clearly observed from the figure that the spontaneous artists expressed themselves more using direct symbols while the professionals were more expressive using the indirect symbols.

This means that they were expressing themselves in different ways according to their culture and their background knowledge about the atom. The appropriate creation of artists may lead to a better understanding and fearless living of public opinion with peaceful uses of nuclear energy.

4. DISCUSSIONS

Up to recent time it was very rare that artists tried to forward their understandings, impressions and feelings in connection with the atomic radiation and nuclear energy in the form of paintings, sculptures and spoken word. If they did so, they did it in order to express their grieves or fears which is negatively affecting people. Some examples may demonstrate this; paintings which were created in connection and after the radiological accidents at Chernobyl and Goinea in Brazil, some of them also were presented as murals. Such paintings definitely are suitable to influence people, as experience shows and if this in a negative sense it should be possible to achieve also the opposite.

Artists should demonstrate this fact in the future by introducing appropriate creations.

Stage plays or theaters are another way for artist to express himself in front of a larger number of audients. So, he has the vocation to forward a message to the public and affect directly their opinion. Indeed after the radiological accident in Goinea, some artists wrote stage plays on this accident to demonstrate its socioeconomic and psychological impacts on the general public.

5. CONCLUSIONS:

From the analysis of the collected art work, paints, written words about the radiophobia, The following conclusions can be drawn:

1: It was clearly found that the fear from the unknown was extremely exaggerated. It could be used as a measure of the negative effect on public opinion.

2: Due to the fear from the exaggerated danger the opposition of population against nuclear actions increased. It leads to the antinuclear opinion which directly affects establishment of new nuclear facilities in some countries all over the world.

3: The public opinion could be a controlled and oriented or directed towards the benefits of the peaceful uses of nuclear energy.

4: It is important to realize that the art plays a great role on the public opinion. So it is important to upgrade the artists culture on atomic radiation with simplified information written by scientific writers.

5: The artists having atomic and nuclear culture and knowledge could then be used against this unknown with respect to people, by making art have a positive effect and high lighting the benefits of the peaceful uses of nuclear radiation to mankind.

6: After positively art work orientation to population feelings; reconsideration to its effect on the public opinion should be evaluated and measured.

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SOCIO-PSYCHOLOGICAL CONSEQUENCES OF RADIATION ACCIDENTS FOR THOSE LIVING IN RADIOACTIVELY CONTAMINATED AREAS

A.N. LIBERMAN, N.K. STRELNIKOVA, V.N. MURALOV, M.V. KISLOV,
E.V. KHRAMTSOV, M.A. BAZJUKINA, M.V. KISLOV

Institute of Radiation Hygiene,
St. Petersburg, Russian Federation



XA9745508

A complex of radiation-hygienic and socio-psychological studies was carried out in western areas of Bryansk region contaminated due to the radiation accident at the Chernobyl nuclear power station and population living in the areas of the Chelyabinsk region radioactively contaminated after release of liquid wastes into the basin of the Techa river, and accident at the "Mayak" enterprise. In all 1256 persons were examined, including those of control groups.

In Bryansk district the following population groups of Zhukovsk and Pochep areas have been studied:

- permanent residents of "clean" settlements;
- relocated in 1991-1992 years from contaminated areas in these "clean" settlements;
- residents of contaminated territories (Yablonevka, Baturovka, Doubenets, Udobnoe, Selets, Medvedi, Myrny).

Total number under observation - 525 persons. The level of anxiety has been studied by Spielberg and Hanin method and by interview on factors affecting the health and on measures to protect and improve the health status.

In all groups of Zhukovsk and Pochep areas (place of relocation) the level of anxiety was similar (Table I) with exception of group of relocated by whole families population in Zhukovsk, with higher level of anxiety in comparison with permanent residents. The level of anxiety in relocated persons was significantly higher than in residents of contaminated territories. In assessment of factors affecting the state of health respondents mentioned "effect of radiation and hard work" (Table II).

The effect of radiation has been mostly blamed by relocated persons than by residents of contaminated areas. In assessment of remedial actions population gave priority to improvement of work conditions, increase of pensions and salaries (Table III). The effect of anxiety persisted for a long time and did not decrease with time of living in the new place of residence, as well as in the contaminated areas.

Table I
Anxiety in population of Bryansk district

Area for relocation	Interviewed group	Level of anxiety in units (1)
Zhukovskiy	Relocated persons	50,4 7+ 0 0,76*
	Residents of contaminated territories	48,0 7+ 0 0,62
	Permanent residents (Clean area)	49,8 7+ 0 0,78
Pochepskiy	Relocated persons	49,9 7+ 0 1,57
	Residents of contaminated territories	50,9 7+ 0 1,83
	Permanent residents (Clean area)	49,6 7+ 0 2,02

Table II
Opinion on factors affecting their health (proportion in % of respondents mentioned 2-3 basic factors; Bryansk district)

Factors	Relocated	Residents of contaminated areas	Permanent residents (clean area)
Age	2	6	7
Hard work	20	14	25
Poor nutrition	7	11	0
Radiation effects	35	27	2
Environmental and food pollution	8	12	13
Neurotic environment	20	12	25
Family problems	7	14	17
Alcohol, smoking	2	4	10

Table III
Public opinion on measures to improve health (proportion in % of respondents mentioned 2-3 basic factors; Bryansk district)

Factors	Relocated	Residents of contaminated areas	Permanent residents (clean area)
Improvement of work conditions	38	18	35
Increase of pensions and salaries	23	18	35
Improvement of health care	13		6
Quality improvement of water, air and food	5		3
Cessation of alcohol drinking, smoking	0		2
Provision of compensations and privileges	0	1	0
Relocation to clear areas	3	11	0
Radioactivity-free food supply	13	40	5

The long-term anxiety phenomenon has been observed also in the Urals accident area in 1992-1993, when 727 persons have been interviewed, more than 30 years after the accident, in 1949, river Techa, and in 1957, East Urals accident. The study has been carried out on 460 persons from contaminated area (more than 50 mSv) in comparison with control group (267 persons with the effective dose less than 50 mSv) (Table IV).

The level of anxiety increased with age and in general was significantly higher in the affected group. The similar to the Bryansk region public assessment of health status was observed in Chelyabinsk (Table V, VI), with prevalence of radiation and hard work effect on health.

Table IV
Level of personal anxiety (in unite) depending on age (Chelabinsk area)

All cohorts. age	Affected group (> 50 mSv)	Control group (<50 mSv)
20-29	47,3 7+ 0 1,1	46,9 7+ 0 0,7
30-39	50,1 7+ 0 0,7	48,0 7+ 0 0,9
40-49	50,1 7+ 0 0,8	49,0 7+ 0 1,0
50-59	53,2 7+ 0 0,9	48,6 7+ 0 1,6
60<	53,8 7+ 0 0,9	50,9 7+ 0 1,2
All ages	51,3 7+ 0 0,4	48,2 7+ 0 0,4

Table V
Opinion on factors affecting their health
(proportion in % of respondents mentioned
2-3 basic factors; Chelabinsk district)

Factors	Affected group (>50 mSv)	Control group (<50 mSv)
Age	24	16
Hard work	48	30
Poor nutritions	13	7
Radiation effects	69	39
Environmental and food pollution	28	28
Neurotic environment	28	37
Family problems	11	17
Alcohol. smoking	6	5

Table VI
Public opinion on measures to improve health (proportion in % of
respondents mentioned 2-3 basic factors; Chelabinsk district)

Factors	Affected group (>50 mSv)	Control group (<50 mSv)
Improvement of work conditions	23	23
Increase of pensions and salaries	60	57
Improvement of health care	52	50
Quality improvement of water. air and food	16	30
Cessation of alcohol drinking. smoking	4	7
Provision of compensa- tions and privileges	72	26
Relocation to clear areas	8	1

The lowest rate was given to alcohol and smoking and their cessation as a measure to improve health. The main way to health improvement was considered in all groups as the increase of salaries and pensions and provision of better health care.

Comparative studies of psychological status of population in Bryansk and Chelyabinsk districts definitely indicate to long-term anxiety effects that practically do not depend on time after accident. These phenomena could be explained by some kind of collective stress conditions or so-called collective traumatic neurotization, leading to the increase of stress-dependent chronic diseases rate and possibly related to the increase of morbidity and mortality from cardiovascular diseases in Bryansk district with high incidence of hypertension and myocardial infarction, with 2-3 times increase during first years after accidents.

Similar increase of chronic morbidity from the so-called stress-dependent diseases (neurologic and mental disorders, hypertonic disease, ischemic heart disease, stomach and duodenal ulcer, some endocrine and other diseases) has been observed in the Chelyabinsk case (Table VII). Some relation between stress-dependent diseases frequency and self-estimation of health status has been established.

Table VII
Chronic diseases depending on age
(Number of persons with chronic diseases %)

All cohorts, age	Affected group (>50 mSv)			Control group (<50 mSv)		
	0*	1	2	0	1	2
20-29	61	11	28	72	16	12
30-39	50	17	33	43	23	34
40-49	24	36	40	29	26	45
50-59	11	56	33	31	46	23
60<	11	62	27	3	59	38

0* - no chronic diseases

1 - chronic diseases related to stress-factor

2 - chronic diseases not related to stress-factor

CONCLUSION

No significant correlation between radiation dose and psychological tension level was found. It is suggested that the spread of psychological tension depends not on radiation factor itself, but on the perception by population of the situation in contaminated areas after the accident. The results of the study show that main reasons of psychological tension in residents of the contaminated areas are relocation of population, prohibition of local food and water consumption, and other limitations, resulting in the disturbance of usual mode of life, diet and social activity. Less than 10% of all persons examined in the Bryansk and Chelyabinsk regions agreed to move to noncontaminated regions.

On the basis of the obtained results a complex of recommendations was worked out to decrease the level of anxiety in population living (or having lived before) in contaminated areas. It is recommended to provide a timely, complete and objective information on radiation situation and degree of risk, and measures taken by authorities for the improvement of socio-economical conditions.

THE PSYCHOLOGICAL EFFECTS OF CHERNOBYL ON THE VICTIMS

Yu. SAENKO
Institute of Sociology,
Kiev, Ukraine



XA9745509

Introduction. Social and psychological post-effects of Chernobyl disaster have turned out one of the most unpredicted unexpectednesses by scale and extent in the post-catastrophe period. Certainly, it was necessary to start to study this phenomenon from the very beginning in the monitoring comparative mode. However, the lack of understanding the urgency of this problem, from one side, and the lack of funds, from the other side, have led to the fact that beginning only from 1992 thru 1994 there have been carried out in Ukraine three systematic studies of socio-psychological post-effects of the disaster funded from the state budget. All the studies performed further by Western researchers were of episodic nature. If Western funds intend to continue to allocate the funds for such studies, it would be better to do it, involving the Institute of Sociology of the National Academy of Sciences, Kiev, Ukraine that functions as the National Coordinator on this problem, possessing of proper experience and system results.

Method. Mass socio-psychological interviewing of all categories of suffered population has been conducted by questionnaire. Survey method is the interview. Representative quota sampling is according to the criteria of place of residence (city, village), type of settlement, sex, age and level of education. Reliability of results is equal to 3-5%.

Results. The disaster has made a tremendous destructive impact upon socio-psychological state and socio-cultural orientations of the population. Apathy, passivity, paternalism, lack of initiative, loss of future, fear of suffered environment, loss of belief in support from the side of authorities, syndrome of doomed, fear for health and future of children is the uncomplete list of typical characteristics of the suffered people. The migrants adapt very hardly to natural-climatic and socio-cultural conditions of new place of residence, they have quite a high level of nostalgia, almost all adults want to return to old places. There have been fixed a number of paradoxes in orientations of the suffered people. The radius of socio-psychological impact of disaster was found to be much more greater than the radius of radioactive hitting. There have been detected radioactively "clean" areas in Zhytomyr region, residents of which, by the level of socio-psychological impact of disaster, do not differ practically from the residents of radioactively contaminated territories. In some cases the level of their fears even exceeds the level of fears of the suffered. There have been fixed in the 1994-1995 studies that general and political crisis in Ukraine has "covered" the Chernobyl factor, the people have reconciled themselves to their destiny, and their low living standard and absence of clear perspective to pass through the crisis frighten them out of existence more than the Chernobyl. There has been fixed the "psychological tiredness" due to permanent stress situation. In my view, methods of mass and socio-psychological rehabilitation are of limited effectiveness, without improving political and economical situation in the country.

Conclusions. Socio-psychological studies should be carried out in complex with the other studies in the monitoring mode. Involved Western funds for conducting socio-psychological studies of Chernobyl disaster post-effects should be co-ordinated with the Institute of Sociology of the National Academy of Sciences of Ukraine. These studies must be continued, because the "memory of trauma" remains at the suffered population, and while improving an economic situation, the "Chernobyl factor" again will be valid. Especially as, it is not known, how the small radiation doses will influence upon socio-psychological state and physical health of 130 000 suffered people who remained to reside in radioactively contaminated zones.

The Chernobyl disaster is the global catastrophe of XX century. The deep bases of mankind -- spiritual, social, material -- have shuddered. Chernobyl has appeared as the result of undoubtful priority of engineering and technology and economics thought over ecologic and humanistic expediency. Chernobyl is the planetary multifactor unique hypercomplex event that should be studied and treated, using not elementary linear or mosaic measures, but involving non-ordinary non-traditional and complex methods.

This Chernobyl "explosion" has occurred long before 1986, just in the period of planning, designing and adopting the decisions on the nuclear reactor type and region allotted for the construction of it. This is the spiritual, moral-ethical tragedy, first of all.

Moscow has taken in arbitrary manner the decision on the construction of the Chernobyl Atomic Power Station. Moscow has managed overall work at the Chernobyl construction site. Moscow commanded to start that sadly known experiment resulted in the explosion. Moreover, even today we do not know, for sure, of what nature -- technical or military -- was that experiment at the 4th block?!

Moscow has said no word, it has taken no step to remedy post-Chernobyl situation in Ukraine. Quite the contrary. When Russia fastens the noose of prices on energy carriers, suddenly shot up to the world level, around Ukraine's neck and strangles, by doing so, it compels Ukraine to run even the blocks of the Chernobyl Atomic Power Station.

Chernobyl is the energetic tragedy, no doubt. The myth of "peaceful atom" is undermined. The safety of atomic power engineering raised doubts. Likely, searching for alternative kinds of energy is the only way to salvation.

Chernobyl is also the methodological and organizational tragedy: neither science nor technology do know and do manage to cope with it. We do not cure, but do make it worse by unskilful treatment. This the tragedy of crisis and begging. From one side, it ought to curtail nuclear power engineering, but from the other -- may we allow this to ourselves under the power famine situation that is the result, incidentally, of outdated power consuming technologies.

However, the most striking unexpectedness of Chernobyl has been its socio-psychological strike at the population. Ecological, economical and medical post-effects could be foreseen, to some extent. More than convincing experience of Hiroshima, Chelyabinsk, nuclear test range of Kazakhstan gave some grounds for it. However, it has been Chernobyl that has demonstrated tremendous destroying impact on socio-psychologic sphere of vast masses of population -- up to 6 000 000 of people (including Kiev habitants, suffered, in fact, but not recognized, officially, as such ones).

The first socio-psychological studies have fixed symptoms of different aspects. Break-down, asthenization, headache, memory weakening, sharp health worsening. Alarmedness and fear for children's and own health and fate. Fear of uncertain future. Feeling the total menace and absence of common sense. Feeling keenly the dissonance of the authorities statements: "Everything is okay, there is nothing terrible in the Chernobyl disaster" and great mass resettlement actually and the other large-scale acts of the Chernobyl disaster liquidation. There is no confidence to the authorities. Acute problems of resettled population. The syndrome of doomed.

The first sociologic study of socio-psychologic post-effects of the Chernobyl disaster has been carried out by the Institute of Sociology of the National Academy of Sciences of Ukraine in 1992. Beginning from that time, these studies have assumed the more systematic character. There have been interviewed more than 10 000 of suffered people, resettlers, in particular. 60% of the suffered have testified the dread of foodstuffs, feeling of fear and helplessness, sleeplessness and shortness of temper; 20% noted that they have no appetite. Almost 30%, in general, lost their interest to life. 45%, answering the question "What do you intend to do for finding a way out from this hard situation?!", said "Nothing"! The suffered people fall in the state of to be infatigable socially. There is formed "the community of doomed", who rely, mainly, upon God, sometimes on themselves, the near relations, the state aid for life. 90% of these people are concentrated only on their own health, and health of their children and near people.

The resettlers possess of the crippled socio-cultural and landscape space, they are hardly adapted to new conditions. A half of them wants to come back to native places, even radioactively contaminated. Moreover, "the Soviet model of life" -- irresponsibility, helplessness, absence of initiative -- has stuck fast in quite a great number of people. So, for example, only 7% want to have their own property, and it does not matter for 40% who will possess of the property; 30% are for the state or kolkhoz property, and more than 20% have not formed their own opinion of it.

The people are inclined to hyperbolize the Chernobyl disaster post-effects: whatever happens with them they put down to "the Chernobyl factor".

Carrying out the resettlement too chaotically has shown what the irreversible influence on the state of mind, social and socio-cultural status of the resettled population, especially, of elder age is made by such unreasoned actions. Due to prolonged hushing up by the USSR government the Chernobyl disaster scales and post-effects, the suffered population as well as population of Ukraine, in general, has experienced hardly the double stress, "two Chernobyls". The first is objective, the second is of informational nature when mass media has received, at last, an opportunity to open the truth about the Chernobyl Atomic power Station Disaster. The Chernobyl has marked the beginning of searching for the new post-Chernobyl models of survival for the whole mankind, not only for Ukraine itself. It has dictated the requirement to change cardinal value-normative space of life and complex analysis and synthesis of all factors of the survival.

The interviewing in December 1994 has covered 1 200 respondents, who belonged to such categories of Zhytomyr region population: II zone, obligatory settling out - 300 persons; III zone, free-will settling out - 300 persons; IV zone, high radiation - 300 persons; "clean zone", control zone - 300 persons. The sample is representative by age, sex, education, place of residence (city, village) and family structure.

Due to the lack of funds, researchers selected, as a "clean" zone, the Zhytomyr region areas, not listed in the register of radioactively contaminated zones,

where the people from the II and III zones have been resettled to. Unexpectedly, we registered such a fact. The residents of "clean" areas do not differ in the least, in their socio-psychological self-appraisals, from the residents of radioactively contaminated territories. This fact indicates that the radius of socio-psychologic impact is vastly larger than the radius of radioactively suffered territory.

For example, the life plans of residents of territories under comparison are practically the same:

	<i>Clean Areas</i>	<i>Disaster Zones</i>
Life Plans:		
- To search for additional earnings	55	42
- To do nothing, only to survive	28	24
- To rent or buy a plot	8	14
- To be retrained	6	11
- To be engaged in making business	11	21

Perception of the Chernobyl disaster:

- We are living as before	14	19
- We are overcoming everything	36	47
- Irreparable fatal thing came about	15	10
- We have no future	4	6
- Children have no future	22	14

The population, irrespective of residence area and degree of its radioactive contamination, is fully concentrated on the problems of elementary survival. The most pressing needs are money aid, medicines, food products, clothes. In the interim, such active orientations of activity as a retraining, setting up a business or acquiring a plot for farming remain in the background. In settling the problems of survival, the people rely, mainly, upon themselves, their families and near persons. They rely a little in this matter on public organizations and do not trust the authorities' structures. It is the Ministry of Affairs on Protection of the Population from Chernobyl Disaster Post-effects with which the suffered people connect bigger hopes, comparatively to the other organizations, to improve the situation that has arisen after the disaster. 30% of the suffered people and 46% of "clean" area residents did know practically nothing of the Law On Status and Social Protection of Citizens Suffered from the Chernobyl Disaster, or could say nothing of it. And only 1% of both the suffered people and "control" respondents consider this Law as the just, complete and effective law.

This is too alarming symptom. It testifies the apathy, distrust, utmostly lowest level of legal consciousness of the population, and spiritual emptiness, information deafness, law-making and organizational insolvency from the side of the state and civil society. It may search for explanations in paternalistic stereotypes of the population that has been weaned from independent thinking and initiative actions by centuries, in the youth and poverty of the state and immaturity of civil society, in absence of experience from the side of world community for large-scale actions of support that Chernobyl needs, though they themselves only will not mend matters.

**Self-appraisals of socio-psychological state and orientations
(in % to the interviewed people) of
residents of the II and III radioactively contaminated zones, resettlers and residents of
comparatively clean zone.**

**June 1992. The Institute of Sociology of
the National Academy of Sciences of Ukraine**

	<i>Disaster Zones</i>	<i>Resettlers</i>	<i>Clean Zones</i>
Chernobyl Disaster Post-Effects of Worsening:			
- health	81	85	20
- material conditions	45	65	35
- attitude to the authorities	43	45	32
- standing at the work	38	40	6
- relations at the family	42	30	6
- attitude to religion	4	3	1
Forecast of the future:			
- all things will settle one way or another, it is not terrible	5	9	17
- we must seek the way out from this situation	11	20	28
- it is better not to think of it	18	28	18
- the worst is still ahead	38	26	21
- we are doomed	22	15	6
What do they hope for?			
- for themselves	38	45	57
- for the authorities	10	13	5
- for science	6	4	10
- for foreign aid	2	1	4

**Self-appraisals of socio-psychological state and orientations
(in % to the interviewed people) of
residents of the I, II and III radioactively contaminated zones, resettlers and residents
of comparatively clean zone.**

**December 1995. The Institute of Sociology of
the National Academy of Sciences of Ukraine.**

The number of interviewed persons is 700.

	<i>Clean Areas</i>	<i>Resettlers</i>	<i>II and III Zones Residents</i>	<i>30 km Zone Residents</i>
1. The Chernobyl disaster is perceived as follows:				
- Irreparable fatal thing came about, we have no future	9	37	48	70
- We live, as if nothing came about	37	0.5	6	3
2. Residing in radioactively contaminated environment (air, earth, water, plants)	52	54	90	98
3. Wishing to resettle to the other territory of Ukraine	1	2	36	5

4. Having the bad or terrible state:				
- Material conditions	57	51	50	99
- Adults' health	33	42	53	91
- Children's health	15	13	41	-
- Psychologically feeling themselves	27	25	26	- 70
- Housing conditions	7	8	12	21
- Food	19	7	11	91
- Relations in family	1	2	3	8
- Relations with other people	2	2	5	8
- Conditions for treatment	44	21	66	99
5. Lack of incomes for a living	40	77	65	95
6. It does not matter what food to eat, if only to have something	56	60	60	98
7. Adults have chronic diseases	26	55	52	100
8. Success factors in life:				
- Of will origin: initiative, dodgeness	38	48	16	8
- Intellect: education and qualification	27	54	12	8
- Efficiency: persistent work	34	26	45	4
- Of myth nature: lucky chance, lucky way of life	27	16	32	10

**Self-appraisals of socio-psychological state and orientations of
"samoseles" -- the residents of the dead 30 km alienation and astrangement zone
(in % to the interviewed people)
December 1995. The Institute of Sociology of
the National Academy of Sciences of Ukraine.
The number of interviewed persons is 100.**

1. Residing in the zone more than 5 years	93
2. Out of them those who has resettled never from the zone	52
3. Residing here, because here everything is native	98
4. As far as possible from the society, politics and authorities	80
5. Residing here, because we want to be independent people	72
6. We want to remain in the zone for ever	99
7. We have suffered strongly and seriously from the disaster	100
8. The disaster has broken our life, we do not have the future	70
9. Residing there where all is radioactively contaminated -- air, earth, water, plants	97
10. Having the bad housing conditions	20
11. Having the bad material conditions	99
12. Having the chronic diseases	90
13. We feel ourselves psychologically bad	70
14. Do not have medical servicing	99
15. Observing the strange changes in the people, animals and plants	98

It is seen from the above that the population of disaster zones, in absence of the proper support and advice, has accustomed to all of this for long ten years after the disaster, and directed thoughts and efforts to getting the living and daily bread, safeguarding children, and then -- higgledy-piggledy.

The studies of December 1995. There have been interviewed 700 persons, including the II zone residents -- obligatory settling out, the III zone residents -- free-will settling out, as well as the resettlers and the "clean" zone residents from the Poltava region territories. It is the results of studying "samosels" -- the residents of the dead 30 km alienation and astrangement zone, the persons who took their old residence again (or new ones) independently, without authorities permission, the number of which exceeds 1 000 persons that deserve a special attention. This is the particular phenomenon of post-Chernobyl situation. The results of the study given below are so significant that they require no comments, taking into account the limited size of this paper.

PSYCHOLOGICAL STUDIES OF CHILDREN AFFECTED BY THE CHERNOBYL ACCIDENT MADE DURING THEIR STAY IN CUBA

A. LORENZO RUIZ, R. PÉREZ LOVELLE, B. PÉREZ IBARRURI,
M. VASILEVA ANGUELOVA, L. BECQUER GORDON
Hospital Pediátrico Tarará,
La Habana, Cuba



XA9745510

G. AMARGOS GONZÁLEZ
Hospital Psiquiátrico de La Habana,
La Habana, Cuba

ESTUDIO PSICOLOGICO EN NIÑOS DAMNIFICADOS

DE CHERNOBIL DURANTE SU ESTANCIA EN CUBA

INTRODUCCION

El accidente de la Central Electronuclear (CEN) de Chernobil, constituye una catástrofe por su magnitud, pérdidas ecológicas, que muy directamente afectaron los intereses vitales de algo más de 4 millones de personas.

En función de sobreponerse a sus consecuencias, muchas veces se ha prestado mayor atención a los aspectos económicos y materiales, olvidando su innegable naturaleza también psicosocial. Desde los estudios comenzados durante los bombardeos atómicos a Hiroshima y Nagasaki en Japón, han sido demostradas las reacciones humanas durante este tipo de desastres, su esencia y contradicciones (1).

El accidente de Chernobil, como cualquier desastre, pasa una serie de estadios. Partiendo de los criterios establecidos por Cohen et. al. (2), actualmente estamos ante la fase post-traumática, la más compleja en sus aspectos psicosociales, inclusive en el caso de lograrse una exitosa solución de muchas interrogantes técnicas y económicas, dado que no todos los individuos perciben por igual estas situaciones.

En Psicología se reconoce que la psiquis en todas sus manifestaciones actúa como un producto activo de la interacción del individuo con su medio circundante. Sin embargo, se mantiene abierta la interrogante en relación al rol del sujeto mismo en dicha interacción. En tanto, de gran interés resulta abordar la problemática de la actividad del niño,

en particular sus posibilidades de readaptación en condiciones desagradables o difíciles de interacción con la naturaleza y el medio social. Ejemplo vivo de ello lo constituye el accidente de la CEN de Chernobil.

A partir de la primavera de 1990 en Cuba se ha organizado un programa médico-sanatorial especializado, el cual ya abarca cerca de los 15000 niños y adultos acompañantes, todos procedentes de áreas afectadas por el accidente de Chernobil. El programa se caracteriza tanto por la organización de una precisa atención médico-especializada con el sistema cubano del Médico de la Familia, como por la calidad en la organización de actividades culturales-recreativas, todas basadas en las características psicosociales de esta población damnificada.

En esta dirección fue organizado especialmente un servicio de atención psicológica, interrelacionado con todas las estructuras médicas y de los servicios. El mismo lo integran especialistas de Psicología rusoparlantes y conocedores de la cultura ex-soviética, lo cual les permite diseñar y ejecutar diferentes programas de acciones psicosociales.

Para la ejecución de este programa fue seleccionado el Campamento Nacional de los Pioneros, ubicado en Tarará a orillas de las playas del este de la Habana, centro sanatorial donde los damnificados descansan 45 días como promedio.

OBJETIVOS

OBJETIVO GENERAL:

Evaluar el sistema de acciones psicológicas a que se someten los damnificados de Chernobil, que reciben tratamiento en Tarará, teniendo en cuenta, tanto las variables referidas al desastre en sí, como las que dimanen de características personales que influyen en la adaptación psicosocial de esta población.

OBJETIVOS ESPECIFICOS:

1.- Estimar la mejoría en Salud Mental en el transcurso de la estancia en Cuba, así como la satisfacción con los diversos servicios recibidos.

2.- Determinar algunas características del Cuadro Interno de la Enfermedades (CIE) en damnificados con padecimientos crónicos.

3.- Identificar y cuantificar los principales factores influyentes en la adaptación psicosocial de esta población damnificada, tanto referidas a las características del desastre tal y como han sido percibidas por los damnificados, como los dependientes de características de personalidad.

4.- Diseñar y ejecutar un sistema de acciones psicológicas, basado en las investigaciones realizadas al efecto, para facilitar la adaptación psicosocial.

En este trabajo pretendemos integrar los diferentes estudios realizados por nuestro equipo de trabajo.

MATERIAL Y METODOLOGIA

Se seleccionó una muestra de 404 niños damnificados de Chernobil, en edades comprendidas entre 11 y 17 años de ambos sexos, de los cuales 140 (34.65 %) corresponden a pacientes con enfermedades crónicas (Vitiligo, Alopecia, Psoriasis). Donde los niños sanos se considerarán el grupo control en relación a los enfermos crónicos.

La investigación se realizó teniendo en cuenta las características biomédicas generales y especializadas agrupadas en la base de datos computarizada Quest Tree de nuestro centro, la observación clínica y los siguientes test y cuestionarios:

1.- Cuestionarios de satisfacción con los servicios recibidos. Se aplican al final de la estancia en Cuba. (Variable - Satisfacción de los servicios).

2.- Inventario de Autoevaluación Ansiedad Rasgo / Estado Infantil IDAREN (STAIC) de Ch. D. Spielberger. Se aplica al principio y al final de la estancia en Cuba. (Variable - Ansiedad).

3.- Cuestionario de Depresión, confeccionado sobre la base del Test de Depresión IDERE de J. Grau y M. Martín, elaborado a los efectos de esta investigación. Se aplica al principio y al final de la estancia en Cuba. (Variable - Depresión).

4.- Escalas de Autovaloración de Dembo-Rubinstein. modificación de T. M. Gabriyal. (Variable - Autovaloración).

5.- Inventario de Personalidad de Eysenck, modificación del Instituto de Psicodiagnóstico de Kiev, Ucrania. (Variable - Personalidad).

6.- Test de Thomas, el cual evalúa las formas de reacción ante situaciones de conflicto. (Variable - Afrontamiento).

7.- Cuestionarios de magnitud de las pérdidas; incluye las siguientes variables:

- a) pérdidas materiales,
- b) pérdidas en el sistema de relaciones,
- c) pérdidas del bienestar subjetivo.

8.- Escala de credibilidad del individuo de la magnitud de las pérdidas. (Variable - Credibilidad).

9.- Cuestionario Valoración del individuo de la información recibida acerca del desastre. (Variable - Grado de Información).

10.- Cuestionario de eventos vitales previos al desastre. (Variable - Eventos Vitales).

11.- Cuestionario Control del destino. (Variable - Control del Destino).

Para el análisis estadístico, toda la información fue almacenada en una base de datos computarizada. Las correlaciones y comparaciones fueron hechas con ayuda del software Stadgraf, tomándose un coeficiente $\alpha = 0.05$, así como su coeficiente K para comparación de parámetros idénticos entre dos muestras de una población. Es decir, a continuación las significaciones estadísticas las abordaremos siempre tomando en cuenta los dos grupos de sujetos, los sanos y los enfermos crónicos.

ANÁLISIS DE LOS RESULTADOS

La valoración de la estancia en Cuba es de muy satisfactoria. Prácticamente el 92 % valoraron su estancia en Cuba de **MUY BUENA** a **BUENA**, con una tendencia más marcada en los niños con enfermedades crónicas. Es decir, todo ello independientemente de lo novedoso de una cultura y condiciones de vida diferentes, observándose una buena adaptación al medio.

Ello está en igual dirección que los resultados de la evaluación de Ansiedad y Depresión

La Personalidad en formación de estos infantes refiere en el 45.79 % de los casos aumento de los elementos neuróticos y manifestaciones de labilidad emocional. un 32.18 % refleja introversión y el 22.03 % extraversión

La Autovaloración por su parte no tiene un carácter diferenciado (por todas las escalas), ni patrones medios, lo cual indica hacia sus inadecuaciones, donde tanto los rasgos neurotizantes, como las inadecuaciones de la Autovaloración se manifiestan como tendencia predominante en los enfermos crónicos. Ello posiblemente manifiesta la subjetividad de la personalidad como mediador para contrarrestar las situaciones estresantes y como una especie de defensa psicosocial

En esta dirección, es importante señalar como al finalizar de la estancia en Cuba los estilos de afrontamiento a situaciones de conflicto y/o generadoras de estrés tienden a formas más adecuadas y estructuradas de reacción y manejo. Resaltando una vez más los mayores aprendizajes en los enfermos crónicos.

En su conjunto todas las variables reactivas en relación al accidente de Chernobil consideramos pueden ser agrupadas dentro del conocido síndrome de estrés post-traumático (5,6), pues resulta llamativo la pobreza de la unión lógica entre los objetivos y los medios para lograr su alcance, considerándose la falta de posibilidades reales y experiencias para la solución de situaciones de esta índole de complejidad y novedad

Por ejemplo, la preparación psicosocial previa al desastre en esta población se manifiesta de forma insuficiente. En tanto, las informaciones de carácter científico acerca del accidente en la CEN de Chernobil para estos infantes resulta poco convincente y creíble.

Igualmente encontramos como la mayoría de los niños se consideran afectados en el plano material, muy insatisfechos con los cambios ocurridos en los sistemas de apoyo psicosocial (familia, escuela, amigos , etc) Inclusive negativamente valoraron las repetidas evacuaciones y sus mecanismos, la continuidad de la vida en zonas contaminadas por radioactividad sin olvidar ni un instante sus posibles repercusiones sobre la vida humana.

Pudiera abordarse como con frecuencia los niños refieren un variado grupo de situaciones estresantes tales como: enfermedades y muerte de seres queridos, conflictos individuales-grupales-familiares, las posibilidades de situaciones similares al accidente de Chernobil, etc, donde todo ello deja sus huellas en la insuficiente preparación para su autoreafirmación y análisis de la vida futura.

El carácter amplio de estas informaciones nos lleva a meditar en relación a todos estos parámetros psicosociales, sin dejar de considerar las emociones como reacciones organísmicas que juegan un papel importante en la determinación de la salud, ... , una excitación emocional puede producir cambios patológicos en el organismo (3). En tanto las reacciones emocionales crónicas pueden conducir a patologías crónicas, apareciendo las personalidades con una estrategia determinada de enfrentar la vida (4).

Tal parece ser el caso de las diferencias sustanciales que detectamos en los enfermos crónicos, donde estas reacciones emocionales negativas (incluyendo las consecuencias psicosociales del desastre en sí) guardan cierta interrelación con la etiopatogenia, curso, evolución y tratamientos especializados de sus enfermedades de base, según los propios pacientes refieren. De ahí las alteraciones detectadas en el cuadro interno (subjetivo) de la enfermedad. No obstante, sus mejorías en salud mental con la estancia en Cuba, son muy superiores a los niños sanos. Resultados que explicamos como posibles factores asociados a la efectividad y satisfacción con los tratamientos médicos especializados recibidos, particularmente la Histoterapia Placentaria que reciben estos enfermos crónicos, según la metodología del científico cubano Dr. Carlos Miyares Cao (11), en el Centro de Histoterapia Placentaria de Tarará.

Las experiencias acumuladas en la atención integral a los damnificados de Chernobil fue aplicada con igual efectividad en la rehabilitación psicosocial de un grupo de familias radioaccidentadas brasileñas (12), en ambos casos poblaciones damnificadas por desastres asociados a la radioactividad.

CONCLUSIONES

- 1.- Presencia de valores llamativos de Ansiedad y Depresión, con tendencia a disminuir al finalizar la estancia en Cuba.
- 2.- Alteraciones en la personalidad en formación con predominio de rasgos neurotizantes, inadecuada autovaloración u insuficiencias de afrontamiento.

- 3.- Vivencias de pérdidas significativas, destacándose las propias del sistema de relaciones sociales.
- 4.- Percepción en grado significativo de etiquetamiento y estigmatización por el desastre.
- 5.- Tendencia a sobrevaloración de los efectos reales de la contaminación radioactiva sobre la salud, hasta considerarla causa generadora de enfermedades.
- 6.- Impresionan insuficientes la preparación psicológica previa de la población y la información recibida en relación al desastre.
- 7.- El cuadro interno (subjetivo) de la enfermedad manifiesta inadecuaciones en relación a las realidades de cada patología, dado las notables influencias que tienen las valoraciones cognitivas y psicopatologías detectadas.
- 8.- Superiores en los enfermos crónicos los matices negativos relativos al desastre y las mejorías de salud alcanzadas durante la estancia en Cuba.
- 9.- La situación social de esta población actúa sobre el desarrollo de la Personalidad Infantil en formación como un conjunto de situaciones estresantes.
- 10.- Tendencia hacia la deformación del Cuadro Vital del adolescente actual y futuro.
- 11.- El desastre de Chernobyl en general se considera una situación extrema, novedosa y compleja por sus repercusiones.
- 12.- Valoración positiva de la estancia en Cuba, resaltando la satisfacción con los servicios médico-especializados recibidos.
- 13.- Finalmente, la constatación de mejoras en la salud (de la mental en lo particular) durante la estancia en Cuba, nos inclina a evaluar el sistema de acciones psicológicas-médico-especializadas como propias de una favorable readaptación psicosocial para una población damnificada por desastre.

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