in the eight years since Chernobyl, yet it is unclear when the problems related to living on contaminated soil will be alleviated. Post-disaster medical and public health planning must evaluate specific disease outcomes and the impact of alterations of the physical environment on human health, and must assess the deleterious effects of societal and economic changes on the well-being of populations.

This report focused on the current weaknesses in medical planning and response to nuclear disasters in the period after an acute emergency (i.e., the mid- and long-term health consequences). These are critical times in dealing with many problems related to chemical, biological, and other human-made disasters, as well as natural disasters. The medical and social sciences are least developed in dealing with post-disaster health concerns in the mid- and long-term. Major deficiencies include the need for adequate testing methods that can be applied to large groups for monitoring their physical and psychological health.

The creation of mobile units to evaluate mid- and long-term health risks among populations exposed to releases of nuclear radiation at Chernobyl, in the Ural mountains, and following other disasters is described. The findings indicate substantial, long-term physical and psychological health effects, and illustrate the importance of regular screening in assessing disaster impacts on health.

MONITORING AND ASSESSMENT: DIFFERENT PERSPECTIVES

Medical Monitoring

The Health of the Chernobyl Patients During the Late Consequences Period of the Acute Radiation Syndrome

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The Clinical Department of the Institute of Biophysics admitted 129 victims who were acutely exposed during the Chernobyl radiation accident in April 1986. Acute radiation syndrome (ARS) of different degrees of severity were diagnosed in 108 patients. Of this group, 27 patients died during the acute period (26 in Moscow and one in Kiev). The ARS diagnosis was verified in a total of 134 persons (including patients in Kiev). The number of patients under the dynamic observation of the Clinic gradually decreased during the 8 years following the accident. In 1993–1994, the number patients being observed was 14.

During the later period, other serious problems occurred in some individuals who had sustained severe local radiation injuries (third degree); these included the development of radiation ulcers on the background of the severe scarring and trophic changes in the skin which required repeated plastic surgery. Nine patients developed radiation cataracts; eight patients from this group had *beta* radiation burns of the eyelids during the acute period, which documents the contribution of high-penetrative *beta* radiation to the etiology of radiation cataracts in the Chernobyl patients.

The oncological consequences in patients continuing to be followed in our Clinic are hypernephroma that developed in the seventh year in a patient who survived ARS of a moderate degree of severity.

The most frequently observed consequences of ARS during the latent period include: 1) astheno-neurotic syndrome; 2) vegetative vascular dystonia; and 3) transient moderate leukopenia and thrombocytopenia.

Somatic diseases frequently observed during the late period in ARS survivors include: 1) Gastrointestinal disease; 2) Different neurological diseases and syndromes; and 3) Upper pulmonary tract diseases.

Thus, the similarity of the morbidity structure for nosological forms of somatic disease at the pre-accident time (anamnesis data) and at the late consequences of ARS (without dependence from the severity, i.e., from the dose of exposure) testifies to the absence of radiation factors contributing to the development of chronic somatic diseases.

Immunobiology and Psychosocial Aspects of the Health of Children After the Chernobyl Disaster

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Immunobiology

Various population groups who have suffered after the Chernobyl accident showed marked differences in irradiation levels that were combinations of external irradiation and radionuclide incorporation. Acute radiation syndrome patients, clean-up workers who were exposed to doses under the 1 Gy limit in 1986 and in subsequent years, those evacuated to Prypjat and those within a 30 km zone, and those who are still living in the territories contaminated with radionuclides comprise the

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main groups for this investigation. The problems associated with the biological effects of these levels of irradiation and medical consequences of this exposure are the main points of this presentation.

Scientific data about long periods of low levels of irradiation are controversial. Clonal selection and proliferation of radio-resistant cells may result in decreased radiosensitivity.[1–3] On the other hand, it is assumed that the cumulative dose has a negative effect even in the 0.35 Sv per life exposure level. If one believes that the integral functional reaction of the immune system to nonlethal irradiation is not the result of parallel cell changes, but instead, is the result of the combination of heterogenic activation and suppression subset reactions (i.e., the CD4+ cell activation), the limit is considered to be 0.01 Gy, and CD8+ cell inhibition occurs at 0.2 Gy.[4,5] Estimation of normal ranges of the immunologic parameters in this new situation is related closely to immunologic deficiencies and onco-hematological pathology diagnosis, especially when the question of treatment with thymic derivatives or growth factors is considered to have a beneficial effect.

A prospective study of children who lived in Zhitomir (Ovruch, Narodichi) and Kiev (Gornostajpol) was performed at the Institute of Clinical Radiology, Scientific Centre for Radiation Medicine (SCRM) between 1989 and 1994. Clinical investigation and laboratory data analysis were conducted with the use of standardized criteria. Radionuclide contamination levels in 407 patients were 1,120 Gbq per sq km within the regions investigated, and 20.5–50 Gbq per sq km limits in the control patients.

Surface phenotype changes, as defined in this study, were characteristic for all groups of children exposed, especially in the Ovruch and Gornostajpol districts. Marked changes observed in T-cells included not only CD3+ expression, which was associated with pan-mitogen function and TCR, but also CD4 and CD8 clusters. Deviation in T-cell subsets were identified: a low CD4+8-/4–8+ ratio was characteristic for 26%. This percentage is outside the normal range. In children at ages 1 to 5 years, the frequency of lower ratios was two-fold higher (44.5%); these lower figures were associated with the high CD8+ values.

A slow tendency for normalization was identified in cytoxic and NK cells. These data did not correlate with the results of B-cell surface immunoglobulins. The CD10+ (CALLA) cell count in investigated groups varied, but an increase in the mean values was present in 1989. At first, these patients were considered a group at high risk for the development of leukemia, and sophisticated diagnostic assays were performed in the Department of Pediatric Haematology, SCRM. Signs of non-specific activation of the haemopoetic and immune systems were detected, but none were identified for leukemia. The CD10+ positive cells showed a low intensity of fluorescence. During 1990–1992, a decrease of CD10+ cell count was identified in this group. The positive interleukin-2 receptor PMMC count varied. The transferrin-receptor positive cell count decreased. Also, the CD1+ cell content was increased in the exposed group, as well as the double-stained CD4+8+ cell percentage.

In the children from Kiev who comprised the control group, a low CD3+ cell count was detected beginning at the age of 6 years. In children who were born in 1985, a significant decrease of CD3 antigen fluorescence intensity was present on CD4+ and CD8+ cells; those born after 1987 had lesser degrees of deviation.

Certain immune system changes which were reported previously, indicated that E-receptor positive cells with serum immunoglobulin content deviations decrease.[6,7] Tendencies of partial normalization of E-rossette forming cells percentages were present in 100 Prypjat children evacuated to the city of Belaya Cerkov (Kiev region) following sanitary rehabilitation. Minimal T-cell figures associated with normal EAC-forming cell content were present in the older boys who were evacuated to Harkov.[8] Some believe that prominent T-cell changes with T-suppressor inhibition are related with immune complex pathology.[8] A significant decrease of CD2+, CD3+, CD4+ cell content and CD4+/CD8+ ratios associated with HLADr+ and alpha-chain of LFA positive cells content occurred in 26 children from Brjansk (1987) and 30 children from Zhitomir (1989), but all values were within normal ranges.[8]

Difficulties encountered in data acquisition and summation in order to gain a comprehensive picture of the effects of ionizing radiation on the immune system in children were enhanced by aspects of the methodologic assays and control group differences. Prospective studies are the only way to gain valuable information, for example, the study of the immune status of 56 exposed children from Luga and 43 from Radomishl (control group) districts of the Zhitomir region. In 1989, the evaluations showed that the T- and B-cell content in the exposed group decreased not only in comparison with the control group, but in comparison to the levels defined in a previous study in 1988. The formation of stable immunologic deficiencies were reported in children who had shown only transitory changes in 1988. Similar changes were seen during this investigation.

Various speculations can be made about the nature of cellular changes after continuous low level irradiation. Peripheral PMNC changes seem to be related with age at the moment of the accident. Deviations in cell activation and differentiation were the most frequent event. The percentage of PMNC with cortical thymocyte phenotype (CD1+, CD4+8+) was elevated, and, according to Beverly[9], was considered to be of a compensatory origin.

Most of the patients in this study showed a two-fold increase of TCR aberrant CD3-4+ cell content, suggesting some stem cell alterations. Other flow cytometric assays could help in supporting this suggestion.[10] A thorough investigation is needed in cases with elevations of TrR, IL-2R, and CALLA-expression. These findings seem to be signs of T-cell activation and indicate functional possibilities. This suggestion was confirmed by 3H-TdR uptake studies in this laboratory. The prognostic value of these data will be the topic of future study and estimation.

Psychosocial Aspects

The Chernobyl Power Plant accident was an example of an external situation with several stages of development of different health effects on large populations, including children. The threat to life and health which was characteristic during the first stage after the accident, changed with the prolonged life-threatening situation that was associated with the addition of other distress factors.

Parameters of Psychological Investigation	Patients with Deviations (%)	
	1987–1988	1994
Adjustment responses	48	41
Situational anxiety	39	32
Accident-related anxiety	97	20
Evacuation-related anxiety	97	2
Family conflict	63	
Feelings of doom	72	12
Fixed interest in Chernobyl victims health effects	100	82

Table 1—Psychoemotional characteristics of children evacuated from Prypjat

A study of psychoemotional peculiarities of children evacuated from the town of Prypjat was performed in two stages. During the first stage (1987–1988), the following psychoemotional problems were found: 1) a high level of adjustment responses; 2) increase of situational anxiety connected with the accident and the evacuation; and 3) possible health effects for the evaluated persons and their relatives, clearly expressed as family conflict (Table 1). Adaptation was disturbed: persons did not see any way to exit from the conflict situations. In many cases, there was a need for psychotherapeutic intervention. Conflicts were between the mother and the family due to the loss of occupational status of women with high educational levels. After the evacuation, the mother could not find a job consistent with her education and professional orientation. Fathers, who were nuclear industry professionals but worked as watchmen, were considered a family stabilizing force. Among age-matched children living in Kiev, such conflict relations were not found. In 1994, among those adolescents evacuated from Prypjat, family conflict also was not found. This fact makes it possible to speculate about the improvement of the family conflict situation related to an alleviation of the occupational difficulties of women professionals.

Preoccupations about the accident and the evacuation dominated among the adolescents studied in 1987. Children described their own feelings in detail, and reconstructed the actions of adults after the declaration of radiation danger and during the evacuation. Family discussions about acquaintances, analysis of their morbidity, and rumors about their grave state significantly influenced the psychoemotional state of the children. They exhibited fixed ideas about inevitable diseases that would occur in the future, and feelings of doom.

Negative emotional reactions associated with the accident and evacuation from the area were characteristic in the patients studied in 1987, but not in those studied in 1994. This may be explained both by the age of those studied (5–6 years of age at the time of the accident and evacuation), and the above-mentioned stages of psychoemotional responses of the population.

Ideas about the inevitable development of diseases in the future and feelings of doom were quite rare in the 1994 study. However, the psychoemotional state of the adolescents was influenced, as before, by discussions about the health state of acquaintances evacuated from Prypjat. Children talked about the possible irradiation effects and even made a prognosis about these effects. Many of them knew the medical scientific publications concerning the Chernobyl problem. Evacuated adolescents studied in 1994 differed from native inhabitants of Kiev by more overt adjustment responses including situational anxiety and fear of possible irradiation effects.

It must be stressed that in both the 1987 and 1994 studies, a high percentage of adjustment responses and situational anxiety was identified among the adolescents from Prypjat (approximately two-times higher than among same-age adolescents from Kiev). But, the psychoemotional motives of falsification for "good" results were quite different. In 1987, patients paid intense attention to everything connected with the collection of data about the accident and evacuation, trying to stress their state of victimization. In the majority of families, a rent adjustment took place; possible victim privileges were foreseen. In the 1994 study, adolescents also exhibited situational anxiety, but they spoke about their being victims without enthusiasm, and were interested in the rules of victim registration. Patients felt that job, education and other discrimination could occur in the future. Victims' privileges seemed insufficient, they may be neglected, there was a desire to merge into the native population of Kiev, and to be like others. Many adolescents wanted to hide their exposure to the accident.

In summary, several main tendencies can be highlighted in terms of the findings of the psychosocial study:

1) The psychoemotional state of adolescents evacuated from Prypjat significantly differed between the 1994 and the 1987 study by the absence of emotional reactions connected with the accident evacuation and changes in family positions;
2) Adjustment responses and situational anxiety had different motives: the 1994 study adolescents had the desire to hide their belonging to the victim population;
3) Fixed attention to the health state of Prypjat inhabitants remained stable as defined in the scientific literature on this topic in 1994; and
4) In 1994, there was a lack of difference between the psychoemotional portrait of evacuated and Kiev adolescents. However, a high level of adjustment responses, situational anxiety, and emotional experiences connected with possible irradiation effects remained.

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Medical-Evacuation Characteristics of Persons Affected During Earthquakes

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The notion of medical-evacuation characteristics (MEC) of people affected by earthquakes is a broad one that includes estimating the needs of the affected people with regard to different medical measures. The data needed include dates, results, places of treatment, and evacuation features. In spite of the general acknowledgment of the importance of such estimations in determining, not only the situation in the seismic center, but also the organization of the medical-evacuation ensurance (MEE), this problem has not been studied scientifically in a comprehensive manner.

Even the volumes of material about the earthquakes in Armenia (1988) and Loma Prieta (1989) do not provide an integration of the MEC of the affected people. This can be explained not only by the severe medical after-effects of each earthquake and problems with the established organization of medical-evacuation ensurance, but also by some subjective reasons. These include imperfect methods of studying earthquake consequences and the accounting systems used.

In accordance with the organization of the MEE adopted by the All-Russia Disaster Medicine Service, the MEC investigation is grounded in assessing the needs of the affected person for the most labor-intensive measures in the acute response period and for later more skilled medical aid. These include complex anti-shock therapy; surgical interventions, including urgent hospitalization of untransportable patients; immobilization; Novocain block, etc. The MEE also examines the distribution according to the medical institutions where the patients are treated (head-neck-spine; thoracoabdominal, trauma, etc.).

These results are of scientific and practical importance.

Psychological Monitoring

Strategies for Comprehensive Monitoring of Mid- and Long-Term Effects of Disasters

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A conceptual model is presented of radiation exposure effects on psychological and physical health. This model illustrates the breadth of impact of a technological disaster, and the various pathways through which the disaster affects health. In addition to radiation-induced physical health effects, radiation exposure also can result in significant psychological stress. Over time and through a series of steps, this stress may cause clinical symptoms and physical diseases.

Psychological stress is proposed to have a direct effect on personal, family, and community disruption, as well as perceived uncontrollability over one's life and distrust of government. These disruptive influences, in turn, cause family dysfunction, poor social support, other traumatic stresses, economic problems, and accident-proneness. Psychological stress also is proposed to have a direct influence on concerns about the effects of radiation on health, resulting in sensitivity to physical symptoms and complaints. Both family and social consequences of stress and symptom sensitivity may lead to psychological dysfunction, including post-traumatic stress disorder, anxiety, depression, and maladaptive coping strategies. These manifestations of psychological dysfunction can result in increased alcohol and cigarette use, with a direct effect on clinical symptoms such as elevated blood pressure and other cardiovascular problems. Clinical symptoms, in turn, have a direct effect on physical disease, including stress-related disorders and exacerbation of chronic diseases.

Suggested assessment tools and criteria for monitoring psychosocial and gen-