NATO/CCMS Pilot Study Meeting "Risk assessment of Chernobyl accident consequences: Lessons learned for the future", October 19-21 2006, Kyiv
Summary Report

"We didn't know then how dangerous it was. They had no equipment, nothing to protect them from radiation, not even masks or special clothing. We didn't know at the time that many of them would become ill and some will die. They were all military and policeman who were sent to help. There was not a single person who refused. It was our duty to defend the people…." (from an interview to a leader of first emergency workers, at care of A. Speckhard) (the Pilot Study is dedicated to the many people over the world who have lost their lives for saving other lives)

Introduction The Pilot Study Meeting has been held in Kiev, at the Research Center for Radiation Medicine (RCRM) on October 19^{th}-21^{st}, 2006. Prof. D. Bazyka, Deputy Director of the RCRM, had a major role in the organization e coordination. The participants were 42 (39 from Ukraine, 2 from US and 1 from Italy) (Annex). 28 papers were presented. Hereafter a brief summary of most of them is reported.

Doses and risk, an updating Based on the data of the National Report of Ukraine (2006), the following average total (internal and external) cumulative doses may be estimated for 1,446,000 residents in the >37 kBq/m^2 ^{137}Cs original deposition Ukrainian areas over the 1986-2055 period:

Period	Total Average Cumulative Dose	Contributions of the single periods
1986	~ 5.4 mSv (30%)	~ 5.4 mSv (30%) (1986)
1986-2005	~ 13 mSv (72%)	~ 7.6 mSv (42%) (1987-2005)
1986-2055	~ 18 mSv (100%)	~ 5.0 mSv (28%) (2005-2055)

A non-negligible further exposure may be expected in future years. The dose distribution is uneven in the various areas. The higher assessed exposures for Ukrainian population (small groups) are:

1986-2005	~ 100-200 mSv	(600 people, 0.04% of the whole 1,446,000)
1986-2055	~ 100-200 mSv	(5,100 people, 0.35% of the whole 1,446,000)

A high dose variability results also within some very small areas. For example, in Christinovka village, individual total doses in the range of 0.58- 20.9 mSv/year in a sample of 14 people were measured, with extreme values in large part related to personal behaviours and dietary habits and not easily predictable based on the other value statistical distribution (data from Handl et al., 2003).

The liquidator dose reconstruction also indicates a considerably high dose variability.

Taking into account the IARC estimation criteria of cancer burden from the Chernobyl accident fallout (Cardis et al., 2006), an assessment of solid cancer incidence risk in the significantly contaminated areas of Belarus, Russia and Ukraine has been carried out for residents in progressively smaller areas with progressively increasing total doses accumulated in the 1986/2005 period. The lifetime risk parameter for solid cancer (7.28 x 10^{-5}/mSv) proposed by Bennet et al. (2004) was adopted.

Dose and solid cancer risk estimates for Belarus, Russia and Ukraine contaminated areas

Population	1986/2005 Av.Dose (mSv)	Lifetime Risk	Attributable Cases	AF
- 11.2 million people	~ 6.1	~ 4.4 x 10^{-4}	~ 5,000	~ 0.2 %
Within it:				
- 6 million people	~ 2.7	~ 2 x 10^{-4}	~ 1,200	~ 0.1%
- 5.2 million people$_{(1)}$	~10	~ 7.3 x 10^{-4}	~ 3,800	~ 0.4%
Within this latter$_{(1)}$:				
- 4.93 million people	~7.8	~ 5.7 x 10^{-4}	~ 2,800	~ 0.3%
- 270,000 people $_{(2)}$	~50	~ 3.64 x 10^{-3}	~ 980	~ 2%
Specifically for Ukraine:				
- 600 people $_{(3)}$	~150	~ 1.1 x 10^{-2}	~ 7	~ 6 %

[AF= radiation attributable fraction of expected cases with respect to background; (1) Areas with deposition density of ^{137}Cs >37 kBq/m^2; (2) Areas with deposition density of ^{137}Cs >555 kBq/m^2, (3) Areas with deposition density of ^{137}Cs >555 kBq/m^2, highest exposure group identified in Ukraine. The background incidence is estimated based on IARC statistics].

Except for the population resident in the areas with average doses of 50 mSv or more, the estimated radiation attributable fractions of cases is rather low (0.1%-0.4%), with a small risk increase over the background, difficult to be ascertained by epidemiological studies. The risk variability underlines the need of giving great attention to the most exposed sub-populations (a considerably high case percentage is estimated for considerably small population percentages). Assuming that the 1986-2005 cumulative average doses are in the order of about the 72% of the whole average cumulative doses up to 2055 (as above reported), a further corresponding risk increase in the future may be estimated. Taking into account the time evolution of the exposure, the residents in the contaminated areas, born around 1986, may be expected to be comparatively most exposed (whole 1986-2055 period cumulative dose), while the ones born (or immigrant in these areas) after 2005 will be considerably less exposed (only 2005-2055 period cumulated dose or less) (at care of D. Bazyka, RCRM and G.A. Zapponi, ISS).

Some recent epidemiological and clinical data A significant increased incidence of all cancers in the 1990-2004 period has been assessed in recovery workers active in 1986-1987 (SIR: 117.2, 95%CI 114-120, Prysyasniuk, RCRM, 2006). A breast cancer increase has been found in women of the liquidator cohort (1990-2004 SIR: 190.6, 95% CI 164-218, Prysyasniuk, 2006) and in women resident in the most contaminated districts of Belarus and Ukraine (about two-fold increase, reported in the 2005 meeting by A. Kesminiene, IARC participant to the Pilot Study). It has been underlined that due to the latency periods of solid cancers, more time (at least ~ 10 year) is necessary for an adequate epidemiological assessment. In the future, special attention should be paid also to lung, stomach, colon, ovary, bladder, kidney cancers and multiple myelomas (all radiation-associated). An increasing evidence of leukaemia in liquidators is also resulting (e.g., ERR/Gy = 2.41, p=0.03, significant excess for 100-250 mSv; NCI/RCRM Study 2005, -USA/Ukraine-, Gudzenko, Romanenko, Bebeshko, Bazyka et al; SIR: 2.24 for ~150 mSv dose, Prysyasniuk, 2002). An analysis of expressed immunoglobulin heavy chain genes in radiation-exposed patients with chronic lymphocytic leukaemia (CLL) has confirmed the influence of a limited set of antigens in the disease development and of some specific genetic polymorphisms (e.g., DNA repair genes) with higher cancer risk (Bilous, Bazyka, Bebeshko et al., RCRM, 2006). Peculiarities in the clinical course were identified in the haematological effects in radiation-exposed patients (10-30 cSv) with Chronic Myeloid Leukaemia (CML) and Myelodysplasia (MDS), with multiple qualitative damages in hematopoietic cells, and peculiarities in clinical course of radiation-exposed (10-25 cSv) CLL patients were also found (Dyagil, Bebeshko et al., RCRM, 2006). Various cytogenetic effects of the radiation exposure have been found in ARS cases, in liquidators and in exposed children; among them, chromosome instability, increased sensitivity to mutagenic exposure *in vivo* and *in vitro*, transmissible chromosome instability to progeny through irradiated germ cells of parents (Pilinskaya et al., RCM, 2006). The State Registry of Ukraine reports, over 207,486 Recovery Operation Workers, 21,742 deaths due to non-cancer diseases, 2,480 of them attributed to radiation exposure (2,323 for circulatory diseases). A study on the effects on broncho-pulmonary system in the male Ukrainian liquidators active in 1986-1987 has indicated a relative risk increase of 3.32 (95%CI: 1.57-7.02) for Chronic Obstructive Pulmonary Diseases (COPD). The main bronchopulmonary effects also included chronic non-obstructive bronchitis (Susko, Buzunov et al., RCRM, 2005-2006).

A re-examination of the emergency response The emergency evacuation of the Pripyat town (sited at 3 km from the ChNPP) and close areas (49,360 and 254 people as a whole, including about 17,000 children and 80-bed patients), decided by the USSR Ministry of Public Health at 10 pm of April 26th, was carried out on April 27th, between 2 pm and 5 pm. In this period the dose rate in some parts of the town reached several mSv/hour. The city buses used for the evacuation were contaminated. Other neighbouring zones were evacuated in May 2nd – 7th. The information about sheltering needs was diffused with some delay in Pripyat, and with a higher delay in other populations, including Kyiv (recommendations diffused on May 10th, 1986). The iodine prophylaxis (KI) started in Prypiat at 10 hours after the accident (morning of April 26th 1986), but it was significantly delayed in other residential areas, were it was dispensed to 5 million people, including 1.6 million children (as is known, the KI treatment efficiency for the radioactive iodine intake prevention, substantially full when adopted before the exposure, when later adopted very rapidly decreases to very low levels). The emergency remedial actions included the replacement of local milk (shown to reduce by more than 50% of the internal exposure in the Ukrainian contaminated areas) and of other local food products with "clean" products led to a significant decrease of internal exposure doses (e.g., up to 11-fold in the Dubrvitsky Region of Rivne Oblast). External exposure in the most contaminated areas was reduced with the top soil layer removal, the daily washing of roads and pavements, the removal of and burial of dead leaves (about 320,000 m^3 in Kiev city), the clean-up of buildings, the replacement of contaminated roofs and constructions, other. Similar actions carried out in rural settlements did not lead to significant results. At the early emergency period, the clean-up of school areas led to an average drop of 30% of the external exposure dose of children, which was the most effective result. The implemented countermeasures resulted highly effective in reducing public anxiety. The obtained internal dose reduction was considerably easier than the one of external doses. The whole review of the emergency response may provide essential information for emergency response planning (at care of D. Bazyka).

Psychological impact of the accident and need of appropriate risk communication Basic principles: Scared people need concrete facts and not false assurances; Better to be empathetic and admit what in known and not known; Clear and authoritative information campaigns need to be planned ahead; Comprehensible assessment of risks is necessary; Clearly out line of roles that citizens can take on for civil responsibility are important, "Truth, clarity and calm in communication" is essential. (at care of A. Speckhard, Georgetown University, US, 2006).

Chernobyl experience in retrospective dosimetry, Lesson learned Thermally Stimulated Luminescence (TL), Optically Stimulated Luminescence (OSL), Electron Paramagnetic Resonance (EPR) or Electro Spin Resonance (ESR) methods were experimented. The X-band EPR dosimetry on tooth enamel was successful. 7,637 teeth were collected up to March 2006; 4,635 liquidators donated teeth; 3,511 teeth were appropriate for a high precision EPR retrospective dosimetry. The individual instrumental dosimetry had advantages over bio-dosimetry, consenting "area monitoring" indications (at care of V. Chumak and S. Sholon, RCRM, 2006)

Neuropsychiatric effects in clean-up workers Dose-related neuropsychiatric, neurophysiological, neuropsychological, and neuroimaging abnormalities are revealed after >0.3 Sv exposure. Neocortex, cortical-limbic system, and dominant hemisphere appeared most vulnerable. The mental health impact included psychological disorders, organic brain damage, suicides, Chronic Fatigue Syndrome (CFS), schizophrenia disorders, accelerated aging process and neurodegeneration. Mental health care of victims needs to be taken into account in radiation accidents. (at care of K. Loganovsky et al., RCRM, 2006).

Neuropsychiatric effects in prenatally exposed children Effects in children were caused by stress, mother's mental health problems, social and economical problems, other. The dose-related cognitive and neurophysiological effects indicate a disrupted dominant brain development following prenatal radiation exposure. Potential radiation cerebral effects may arise after foetal doses > 20 mSv and *in utero* thyroid dose > 300 mSv at the 8th gestation week and later gestation. (at care of Loganovsky et al., RCRM, 2006).

Some conclusions and lessons learned

- Based on Ukrainian dose estimates, the total cumulative dose up to 2005 may be assumed to represent about the 72% of the whole expected up to 2055.
- The Chernobyl accident attributable fraction of estimated solid cancer cases is generally small in comparison with the background. This does not hold for some highly contaminated areas, relatively limited, for which also the further exposure after 2005 may be significant. The distributions of environmental contamination, exposure and risk are considerably uneven. Individual behaviours may significantly modulate the exposure. Extreme exposure conditions are not easily identifiable through large scale statistics and need specific investigations, measurements, evaluations and care.
- Cancer and non-cancer radiation-related effects have been identified, together with social and psychological disruption. All of them need attention.
- Some more time is necessary for an appropriate evaluation of long latency effects.
- The critical review of remedial actions adopted in the emergency period may provide useful information for an adequate emergency response planning. For instance, an immediate evacuation of critical areas may be essential (in Prypiat town, this decision could have prevented exposures up to several tens of mSv and more). Local food replacement with adequately large amounts of uncontaminated food is necessary in contaminated areas for internal exposure reduction (this means availability and efficient distribution). Prophylactic and sheltering resources systems need to be immediately available and immediately distributed even in large zones. An adequate risk communication, also aimed at the diffusion of individual exposure reduction criteria, is essential.

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