

**SUMMARY REPORT OF “RISK ASSESSMENT OF CHERNOBYL ACCIDENT
CONSEQUENCES: LESSONS LEARNED FOR THE FUTURE” CCMS PILOT STUDY
MEETING, KIEV, JUNE 1ST – 3RD, 2005**

Background: The Pilot Study represents the continuation of a collaborative scientific activity started with the international workshop: “Risk assessment of Chernobyl accident consequences”, held in Kiev, Ukraine on April 8th-12th, 2003, and with 37 participants from Ukraine, Belarus, Russian Federation and Lithuania and 14 participants from western Europe and USA attended to the workshop (Austria, Germany, Greece, Italy, Portugal, Spain, US), respectively presenting 29 and 10 papers.

NATO/CCMS Planning Committee Meeting was performed at Istituto Superiore di Sanità, (Rome) on December 2nd - 4th, 2004). The Scope of Preparatory Meeting was the discussion of the Pilot Study program. preliminary collection of synthetic data, evaluations, assessments on the above listed points, provided by participants, in order to produce a document to be submitted to a larger meeting and organization of the first extended Pilot Study meeting to be held in 2005 in Kiev.

The context of the CCMS Pilot Study meeting:

This meeting is a part of the CCMS Pilot study “Risk Assessment of Chernobyl Accident Consequences: Lessons Learned for the Future” (Co-Directors - Dr. G.A. Zapponi, Italy and Dr. C.C. Travis, United States).

The Chernobyl accident triggered a considerable improvement of national and international procedures for nuclear emergency management and preparedness, especially in the areas of international communication and information exchange. However, there still remains room for improvement, for example in the field of coordinating the response to nuclear accidents, as well as in the area of decision making in the initial and later phases after an accident. The purpose of this study group is to focus on lessons learned from the Chernobyl accident.

The CCMS Pilot Study Meeting structure

For each of the five first items, the working groups were defined. The available relevant documentation was distributed in advance to participants. Working groups included both experts who have dealt with the management of the accident consequences and their evaluation, and experts of risk assessment procedures.

The Workshop program included:

Scientific Program

Dates: June 1-3rd, 2005

Day 1- (Plenary session):

- Welcome address: Ukrainian Authorities, NATO office in Ukraine, CCMS Direction, WHO, IARC, Pilot Study co-directors, other.

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International Organizations (1 hour each)

- WHO representative (general evaluation of the event, conclusions by WHO)
- IARC representative (general evaluation of the event, conclusions by IARC)

Section 1

Summary of national experiences and evaluations of the event and its consequences, still existing problems, other, in the mostly involved Eastern Europe (about 45 min. - 1 hour each)

- Ukraine (Prof. D.A.Bazyka, Deputy Director General, Research center for Radiation Medicine - “Health Effects of the Chernobyl NPP Accident in Ukraine”).
- Prof. A.Zapponi (Istituto Superiore di Sanita, Italy)
 - Dr. Timothy Mousseau

United States National Cancer Institute

- Dr. Ihor Masnyk

United States Environmental Protection Agency

- Dr. Neal Nelson
- Dr. I.Turai (Hungary)
- Dr. H Kitsos (Greece)
- Dr.Kurtinaitis (Liethunia)
- Dr.Kesminiene (IARC, France)
- Dr.Atciuous (Liethunia)

Partner country participants included prof. I.Vasilenko (Institute of Biophysics, Russian Federation), Dr. S.Krivenko (Institute of Hematology, Belarus), Dr. L.Shuvaeva (Institute of Hematology, Belarus). Organizational support was provided by Ms. L.Schoolfield (EPA, USA).

Plenary session

By Key speakers: Introduction to the main topics:

- Dosimetry
- Carcinogenic effects
- Non-Cancer Endpoints
- Psychological Effects
- Integration of the above items and Lessons for future.
- Formation of the workgroups

Session 3 – Dosimetry

P.B. Aryasov, V.V. Chumak (Ukraine) Problem of retrospective assessment of beta doses to lenses of Chernobyl clean-up workers

Pikta V. A. (Ukraine) Expert whole body counter-assisted in vivo methods of radionuclides distribution assessment in human body

I.Ya. Vasilenko, O.I.Vasilenko (Russian Federation) Combined radiation damages.

Shestopalov V.M., Naboka M.V., Kravez A.P. (Ukraine) Landscape –geochemical condition of the radioactive polluted territories as a risk factor of the children morbidity.

J.E.Kruk (Belarus) Radioecological peculiarity of the dose formation in Belarus due Chernobyl accident

Day 2

Session 4 - Health Effects. Cancer and Effects in Children

Gudzenko N.A., Romanenko A.Yu., Ledoshchuk B.O., Belyaev Yu., Trozyuk N., Babkina N. (Ukraine) Role of the specialized population registries of Ukraine for the health risk assessment after the Chernobyl Catastrophe

A.Ye.Prysyazhnyuk, V.G.Gristchenko, M.M.Fuzik, K.M.Slipenyuk (Ukraine)
Risks of cancer due in critical groups of the Ukrainian population affected by the Chernobyl accident

Korol Natalia (Ukraine) Mental conditions as a risk factor for somatick outcomes among Chernobyl children.

Kovalenko Alexander N. , Muraviova I.N., Tuguchov V.A. (Ukraine) Osteopenic syndrom and osteoporosis in ChNPP liquidators in remote period – conditions, risks and prognosis.

S.I.Krivenko (Belarus) The leukemia incidence among Belarussian clean-up workers

L.P.Shuvaeva (Belarus) The tendencies of adult leukemia morbidity and mortality in Belarus after Chernobyl accident

Stepanova Evgeniya I, E.A. Skvarska (Ukraine) Formation of a phenomenon of genetical instability in children born in the families of the Chernobyl accident clean-up workers

I.V.Drozd (Institute of the Problems of National security of the Council of the National Security and Defense of Ukraine). Health effects of Chernobyl

Session 4 - Health Effects. Non-cancer end-points

Buzunov Vladimir A. , L.I. Krasnikova, V.M. Tereschenko, P.A. Fedirko, N.I. Striy, Yu.S. Voychulene (Ukraine) EPIDEMIOLOGICAL ANALYSIS OF NONTUMOUR PATHOLOGY RISK FACTORS IN CHERNOBYL RECOVERY OPERATION WORKERS

Pirogova Yelena A., V.A. Buzunov, G.I. Kartushin, T.Ye. Domashevskaya (Ukraine)
EPIDEMIOLOGICAL ANALYSIS OF NONTUMOUR MORTALITY OF ADULT
EVACUEES FROM PRIPYAT AND CHERNOBYL 30-KM AREA

S.M.Polyakov (Belarus) Non-thyroid cancer incidence among Belarussian clean-up
workers

Sushko V. (Ukraine) Bronchopulmonary pathology in clean-up workers of Chernobyl
catastrophe who undergone inhalation effects of radionuclides (long term study)

Anatoliy Chumak (Ukraine) Persisting infections and genome non-stability at the remote
postirradiational period

Talko Viktoriya V , L.O.Chebanenko (Ukraine)

Vegetative, endocrine, immune status and non-specific resistance in children and adolescents
resident from radioactively contaminated regions

Pilinskaya Maria A., S.S.Dybskyj (Ukraine) Ecogenetic aspects of the Chernobyl accident

V.V.Talko, V.M.Bulavitskaya (Ukraine). Biotechnologic aspects of spermatozoa radiation
damade.

S.V.Andreychenko, D.V.Vatlitsov, K.S.Andreychenko, N.E.Nurichenko (Ukraine).
Spermatozoon as an indicator of organism irradiation consequences.

N.E.Nurichenko S.V.Andreychenko, V.M.Pushkarenko (Ukraine). Radiation induced
suppression of reproductive function.

Session 5 - Health Effects. Psychological effects

N.I. Omelyanets, Dubovaya N. (Ukraine) Demographic losses of the population of Ukraine in
connection with the Chernobyl catastrophe

**Konstantin N. Loganovsky, Sergij V. Volovik, Dimitry A. Bazyka (Ukraine), Pierre Flor-
Henry (Canada)** Risk for Schizophrenia Spectrum Disorders following Radiation Exposure:
Current State and Future Prospects"

V. Varetsky, A. Rakochy, E. Tukalenko (Ukraine). Effects of γ -exposure at 0.5 Gy and
additional stress upon rat's behavior modification with blueberry (*Vaccinium myrtillus*)).

Prilipko Valentyna A. (Ukraine) The factors of social-psychological risks from the population
who lived on radioactive contaminated territories

Perchuk I.V. (Ukraine) Current aspects of the problem - mental disorders in children after surgery for radiation-induced thyroid cancer

V. Atkocius (Lithuania)

Day 3:

- Work in groups and preparation of the Workshop summary
- Plenary session (afternoon)
- Integration of the above items and Lessons for future.

SUMMARY ON THE MAIN WORKSHOP TOPICS

This report presents a synthesis of the contributions by Pilot Study participants. In the first part (at care of Prof. G.A. Zapponi), some items concerning health effects are discussed, that provide some relatively new information. In the second part (at care of Prof. D. Bazyka) other aspects, equally important, are summarized concerning neurological and psychological effects, managed in the medical response to the accident, and other related topics.

Part 1: Some main health effects

1) Chernobyl accident effects (Ukraine): an update (Prof. D. Bazyka)

Three main points were underlined for population protection from Chernobyl accident consequences: i.) Radiation Protection, ii.) Social Support and iii.) Health Care. Moreover, updated data concerning some main points were summarized:

Over 237 patients with ARS (Acute Radiation Syndrome) diagnosed in 1986, 137 of whose were confirmed in 1989, 28 died in 1986 and other 29 in the follow up 1987-2004 period (8 due to sudden cardiac death, 11 due to oncologic and oncohematologic diseases, 4 to traumas and accidents, and 6 to somatic or nervous diseases or to infections).

The cancer incidence (SIR) update has shown thyroid cancer rates 8- and 6-fold higher than national data (control) respectively in radiation rehabilitation workers and in the evacuees from Pripjat and 30-kilometer exclusion zones (highly contaminated). For other solid cancers and leukemia some uncertainty level remains in the expert opinions (however, in part reduced by recent studies presented in the workshop). The number of solid cancers in the population of the contaminated areas of Belarus, Russia and Ukraine increased more than 3-fold in the 1979-2000 analyzed period (13872, 10257 and 7202 cases respectively for the three countries observed in 1979-2000 period).

The cardiovascular disease mortality risk resulted in an ERR (Excess Relative Risk) of 0.54 per Gy (5.4×10^{-4} per mGy) based on the 60,910 cohort of Russian emergency workers (Ivanov et al., 2000). This EER is higher than the one estimated from the atomic bomb survivor cohort (ABS), which is in the order of 0.17 per Gy; however 95% confidence intervals overlap. Over 4995 deaths, 1728 were due to cardiovascular diseases, proportion much higher than the normal one. The conclusion is that low-dose whole body irradiation (≥ 0.05 Gy) may represent a risk factor for ischemic heart diseases, cardiomyopathy, cerebrovascular diseases.

The relative risk of cerebrovascular diseases results higher in the over 500 mSv exposure group, in comparison with the less than 100 mSv exposure group.

The highly exposed “liquidators” recovered for the acute radiation syndrome (ARS) are considered as likely at increased cardiovascular disease risk.

In conclusion, the Chernobyl accident data indicate an excess of cardiovascular disease deaths consistent with the one assessed for ABS. Further investigations are however considered important.

2) Risk of malignant tumours occurrence in critical groups of the Ukrainian population affected after the Chernobyl accident (Prof. A. Prysazhnyuk, Dr. V. Gristchenko, Dr. M. Fuzik and Dr. K. Slipenyuk)

The examined population in this descriptive study includes the Chernobyl accident recovery workers operating in the 1986-1987 (1990-2002 observation period, 1107298 person-years), the evacuees from Prypyat town and from the 30 km zone (from the nuclear plant) (1990-2002 observation period, 678725 person-years) and the residents in most contaminated Ukraine territories (5 districts, 1980-2003 observation period, 4863074 person-years). As a whole, 14285, 4282 and 1754 cancers were respectively diagnosed in residents of contaminated territories (1980-2003), in the recovery worker sub-cohort (1990-2002) and in the evacuees (1990-2002).

General exposure

For the recovery workers, the average individual dose equivalent fluctuated between 100 and 200 mSv in 1986 and from 50 to 100 mSv in 1987.

For the evacuees from Prypyat town, the average external dose was evaluated as 10-12 mSv; for this category, the average external dose estimates should be doubled for accounting the internal dose component.

According to general dosimetric “passportisation”, residents of the most contaminated areas received an individual effective equivalent average dose of 17.4 mSv.

Thyroid exposure

A comprehensive information on thyroid doses for recovery workers is not available.

The high thyroid dose (0.98 Sv – 1.4 Sv), in children resident in contaminated territories is remarkable in particular if compared with the one of adults (0.187 Sv – 0.221 Sv).

The total collective dose in evacuees was 2996 person-Sv and the average individual dose was 0.33 Sv.

The average dose was clearly depending on the age at the accident time: 0.86 Sv and 0.18 Sv, respectively in the 0-15 and in >16 year groups.

All Cancers

The whole data cancer incidence in the 1980-2003 period in the most contaminated territories is characterized by a smooth increase with time. It is worthwhile noticing that the incidences in the initial period are considerably different. The regression coefficients ($b \pm SE(b)$) of cancer incidence time evolution are:

Ukraine: 1.45 ± 0.30

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Kiev region: 2.22 ± 0.17

Zhytomir region: 2.03 ± 0.40

Contaminated territories: 1.23 ± 0.55

These tendencies were similar for male and female sub-populations.

All Cancers

Observed Groups (observation period)	Observed cases	Expected cases	SIR (%)	95% C.L.
Contaminated areas Residents (1990-2003)	7487	9249.8	80.94	79.1 - 82.8
Recovery operation Workers (1990-2002)	4282	3436.3	124.6	120.9 – 128. 3
Evacuees from 30 km Zone (1990-2002)	1754	2175.2	80.6	76.9 – 84.1

These data indicate that only in the recovery workers the all cancer incidence was significantly higher than the national one, while in the other two groups it was significantly lower.

Thyroid cancer

As is known, thyroid cancer represented the most evident and important effect among the various categories of malignant tumors related with radiation exposure. Some increase of this pathology was noted since 1987-1990, possibly in part also due to a screening effect; since 1992, a dramatic increase of thyroid cancer was observed. The estimated regression coefficients ($b \pm SE(b)$) of the incidence increase with time are:

Ukraine: 0.12 ± 0.01

Kiev region: 0.49 ± 0.05

Kiev city: 0.50 ± 0.05

Contaminated territories: 0.44 ± 0.08

Zhytomir region: 0.19 ± 0.03

The time increases for “contaminated regions”, and for the Kiev region and the Kiev city (in the areas where about 80% of former residents were evacuated) are similar, and considerably higher than the other ones and , in particular, than the one of whole Ukraine.

Thyroid Cancer

Observed Groups (observation period)	Observed cases	Expected cases	SIR (%)	95% C.L.
Contaminated areas Residents (1990-2003)	156	102.0	152.9	128.9 – 176.9
Recovery operation Workers (1990-2002)	121	16.2	746.2	613.3 – 879.6
Evacuees from 30 km Zone (1990-2002)	136	28.3	480.3	399.6 – 561.1

These data indicate thyroid cancer incidences higher than the national ones for residents in the contaminated areas (~1.5 folds), for recovery operation workers (~7.5 folds) and for the evacuees from the contaminated areas (~4.8 folds).

Quantitative estimates of radiation risks of thyroid cancer

In the residents of contaminated territories, the only statistically significant risk was assessed in children (0 – 15 year aged at the accident time), in terms of an Excess Absolute Risk (EAR) of 1.7×10^{-4} Py-Sv, of an Excess Relative Risk (ERR) of 15/Sv, and of an Attributable Risk (ATR) of 89.0%.

In the recovery workers, the calculations made on the external dose basis indicated an EAR of 6.1×10^{-4} Py-Sv, an ERR of 23.3/Sv (CI 18.0-28.7) and an ATR of 77.8%. In the evacuees somewhat controversial results were obtained (higher risks for the higher age group, > 16 year).

Breast cancer

Female Breast Cancer

Observed Groups (observation period)	Observed cases	Expected cases	SIR (%)	95% C.L.
Contaminated areas				
Residents (1990-2003)	404	251	160.8	145.1 – 176.5
Female recovery operation Workers (1990-2002)	145	75.1	193.1	161.7 – 224.5
Evacuees from 30 km Zone (1990-2002)	150	95.8	156.6	131.5 – 181.7

These data indicate a significant incidence of breast cancer in both female recovery workers and contaminated territory residents. The case of evacuees is controversial, because its significance is not confirmed if the 1998 local standard is used as reference.

3) IARC Studies of cancer risk following Chernobyl accident: progress and results. (Dr. A. Kesminiene)

The cooperation with the International Agency for Research on Cancer (Lyon) is very important for the Pilot Study. As a general observation, analytical epidemiological studies, as the one here discussed, are essential to assess the effects and risks and are more powerful than the geographical studies, which however, are much less costly and time requiring.

The first results of the case-control studies by IARC, Belarus and Russia of thyroid cancer among the young people in Belarus and Russia have allowed to establish a causal relationship between the exposure to radioactive iodines and increased risk of thyroid cancer in those exposed as children or young people. The studied population included all the people in Gomel and Mogilev “oblasts”, who were children (<15 year) at the accident time, as well as the people in Bryansk, Kaluga and Tula oblasts in Russia who were children or adolescents (up to 18 year) at the accident time. The dose reconstruction included inhalation and ingestion exposure to ^{131}I during the first weeks after the accident, the internal doses from the inhalation and ingestion intake of short living iodine (^{132}I , ^{133}I and ^{135}I) and tellurium ($^{131\text{m}}\text{Te}$, ^{132}Te) in the first days after

the accident, and, for a much more extended time period (until the diagnosis), from Cesium (^{134}Cs and ^{137}Cs).

The assessed dose distribution, used for the study, indicated, respectively, median and maximum levels of about 356 mGy and 9528 mGy for Belarus and about 39.4 mGy and 5257 mGy for Russia, while for the short lived Iodine and Tellurium median and maximum indicated levels are 1.6 mGy and 534 mGy (Belarus) and 0.1 mGy and 26 mGy (Russia).

For external exposure, the levels indicated are 2.4 mGy and 98 mGy (Belarus) and 0.9 mGy and 31 mGy (Russia), and, for short-lived radio-nuclides, 1.2 mGy and 42 v (Belarus) and 0.4 mGy and 12 mGy (Russia). The estimated total doses are 365 mGy and 10163 mGy (Belarus) and 40.4 mGy and 5314 mGy (Russia). The statistical distribution of these doses is log-normal-like, with maximum levels much higher than the median ones.

The presented summary of dose-response relationships indicated a shape substantially compatible with the linear hypothesis, and the use of logistic regression (excess relative models and log-linear models) led to substantially compatible estimates (whenever the overlapping confidence limits are considered) of the OR at 1 Gy:

- For excess relative risk models, ORs from 4.9 (95%CI: 2.2 to 75.) to 6.6 (95%CI: 2.0 to 11.1)
- For log-linear risk models ORs from 5.5 (95%CI: 3 to 9.5) to 8.4 (95%CI: 4.1 to 17.3);

The higher OR values are obtained by linear models (excess relative risk and log-linear risk). The estimated OR at 1 Gy for different radiation types range from 5.2 (95%CI: 2.2 to 8.2) for ^{131}I to 5.9 (95%CI: 1.6 to 10.2), for all iodine isotopes, adjusting for external and long-lived nuclides.

Moreover, the influence of iodine in soil (reflecting the iodine bio-availability at the time of the accident) and of stable iodine supplementation has been analyzed. This has allowed to estimate the OR at 1 Gy in relation to soil iodine level and iodine supplementation:

In the absence of potassium iodine consumption:

- At the highest two tertiles of soil iodine: OR = 3.5 (95%CI: 1.8 to 7.0)
- At the lowest tertile of soil iodine: OR = 10.8 (95%CI: 5.6 to 20.8)

In the presence of sodium iodine consumption:

- At the highest two tertiles of soil iodine: OR = 1.1 (95%CI: 0.3 to 3.6)
- At the lowest tertile of soil iodine: OR = 3.3 (95%CI: 1.0 to 10.6)

As underlined by the authors, this is the largest case-control study of thyroid cancer in young people.

The conclusions of the presentation include the presence of a significant dose-related increase in thyroid cancer, mainly attributed to ^{131}I ; moreover, the risk from ^{131}I is slightly smaller than, but

similar to, the risks from external exposures, and, lastly, a significant modification of the risk by ^{131}I is induced by iodine deficiency and iodine supplementation.

The preliminary results of a descriptive study of spatial and temporal trends in breast cancer incidence in contaminated regions of Belarus and Ukraine have been also presented. This study makes part of a large project aimed at exploring if the observed increase in pre-menopausal breast cancer is related to radiation exposure and at assessing the possible interaction between radiation exposure and possible modifying factors, including genetic susceptibility. As stated by Dr. Kesminiene, the presented data have to be considered preliminary and the topic needs further study.

The time trend of breast cancer Relative Risk (RR) by categories of cumulated exposure in the most contaminated territory of Belarus and Ukraine has been estimated, that indicate a significant relative risk increase at exposure levels ≥ 40 mSv, doses lagged by 5 years for women aged less than 45 years in 1986.

These data, suggest, as a preliminary hypothesis, that women residing in the most contaminated districts could have a 2 –3 fold increased risk at exposure levels ≥ 40 mSv, doses lagged by 5 years for women aged less than 45 years in 1986.

Moreover, this study has been important for establishing a protocol and procedures for a formal analytical epidemiological study on breast cancer risk in young women in Belarus and Ukraine, aimed at studying the interaction among radiation, genetic predisposition and other factors.

4) Study on leukemia and other hematological diseases in the recovery workers in Ukraine after the Chernobyl accident (Prof. A.E. Romanenko et al.; Ukraine and US (NIH) cooperation)

This research has used a case-control design to investigate leukemia incidence in rehabilitation workers in Ukraine, based on cancer registry data. The study also investigated the dose-response relationships in recovery workers, the possible confounding factors, the influence of the time periods of exposure and of the age at exposure, and different relevant hematological effects. The exposure was assessed using the available official dose registers, retrospective methods (EPR, FISH) and other related procedures. The medical data and, consequently, the incidences, were revised and confirmed by international expert commissions. At the moment of the presentation of this study, the exposure dose were reconstructed for 462 individuals.

- For the cases, the exposure assessment indicated an average level of 181.5 mGy (standard deviation 519 mGy) and a geometric mean of 20 mGy (geometric standard deviation 12.4), dose range: 0.003 – 3187 mGy.
- For the controls, it is reported an average level of 78 mGy (standard deviation 217 mGy) and a geometric mean of 11.5 mGy (geometric standard deviation 10.5), dose range: 0.005 – 3256 mGy.

The results at the moment available on the effects in recovery workers indicate:

For CLL leukemia:

- For an exposure range $\geq 100\text{mGy}$, OR = 2.15 (95%CI: 1.00 to 4.58)
- For an exposure range $\geq 200\text{mGy}$, OR = 2.04 (95%CI: 0.76 to 5.28.)
- For an exposure range $\geq 100\text{mGy}$, OR = 1.81 (95%CI: 0.57 to 5.35)

For the other leukemias:

- For an exposure range $\geq 100\text{mGy}$, OR = 2.04 (95%CI: 0.86 to 4.77)
- For an exposure range $\geq 200\text{mGy}$, OR = 2.14 (95%CI: 0.73 to 5.98)
- For an exposure range $\geq 100\text{mGy}$, OR = 2.39 (95%CI: 0.74 to 7.28)

As stated by the authors, the preliminary analysis of the obtained data demonstrates some increase of leukemia risk in the recovery workers who have been irradiated at doses over 100mGy. Moreover, an increase of the statistical potency of the study and more closely examined statistical analysis are necessary for a more detailed evaluation.

5) Demographic losses of the population of Ukraine in connection with the Chernobyl catastrophe (N. Omelyanets)

This study was aimed at the quantitative definition of the direct and latent losses of the population on territories of Ukraine affected by the accident consequences. The populations living in the most contaminated districts (Zhitomir, Kiev) and close territories (Ludiny, Narodichy, Ovruch, Ivankov, Poleskoe), the populations living in non-contaminated territories (Poltava and Lockchvitsya territories), and the Ukrainian population as a whole.

- As a whole, the reported whole number of people in Ukraine is about 50 millions in 1979, about 52 millions in 1994 and about 48 millions in 2003.
- A considerable progressive reduction in the birth rate in the most contaminated areas has been observed. In 1985-1986, the birth rate was something more than 13 -15 births/year per 1000 women in fertility age; in 2002-2003, this rate was reduced to about 7-10 births/year per 1000 women in fertility age, in particular due to a decrease taking place after 1988.
- A considerable progressive increase of population mortality was also observed in the most contaminated areas in the same period, with a rate of less than 13-15 deaths per 1000 per year in 1985 and of about 17-20 per 1000 per year, in particular due to an increase mostly taking place after 1989.
- Cancer diseases accounted for a limited fraction (21%) of the population loss after the accident.
- In all the investigated territories, the highest fraction of mortality increase was at expenses of the age group of 60 years and more.

These data highlight a critical social condition following the accident, possibly leading women to reduce births and affecting the health of elder people.

6) Implications of the variability of the contamination levels and of exposure and dose levels relevant to epidemiological assessment (Giovanni A. Zapponi)

A very high variability of the measured levels of soil and other substrata contamination, as well as of the assessed exposures and doses of the general population, has been pointed out by many studies on the territories mostly affected by the Chernobyl accident consequences. In the large majority of cases, the statistical distribution of the measured or assessed levels appears to be a log-normal-like one. As well known, this kind of distribution is asymmetrical, with an extended tail towards high values, and the coexistence of a limited number of these latter with a high number of considerably lower values. This emerges from exposure and dosimetric data presented in the UNSCEAR (2000) document, and from some fundamental studies on the population exposure (e.g., Golikov et al., 2002; Likhtarev et al., 2002).

These aspects are important in the evaluation of epidemiological study results concerning the Chernobyl accident related risks.

The UNSCEAR document of the year 2000 presents a table (8) of the estimated ^{137}Cs deposition from the accident over a global area of about one million of Km^2 , with average levels varying from 12 kBq/m^2 (over a sub-area 654200 km^2) to 2200 kBq/m^2 (over a sub-area of 3110 km^2). The area with the highest level of contamination (2200 kBq/m^2 as an average) was about the 0.3% of the whole, while the mean deposition was $\leq 83 \text{ kBq/m}^2$ on the 97% of the whole territory. It is immediately evident that, in the presence of a distribution like this, a random and numerically limited sampling would not have a statistical power sufficient for the identification of the most critical levels. This observation holds for practically all the available data on environmental levels and exposure, also including the exposure data above presented.

The suggestion by Likhtarev et al. (2002), based on the extremely high variability of exposure levels, that the “critical” group (highest exposure group) deserves particular social and medical attention, also hold for epidemiological evaluation.

In fact, if the monotonic increasing exposure–effect trend assessed for radiation risk (e.g., linear or linear-quadratic model) is assumed, this exposure variability will hold also for the related risk, and, in the case of linear-quadratic trend, the risk variability will be higher.

This suggests that geographical or descriptive studies not appropriately considering this statistical distribution will have a limited, or very limited, statistical power for detecting a possible risk increase taking place in a very small percentage of highly territory, or in a very small percentage of highly population. As already mentioned, the “critical groups” need a particular attention, and their condition should not be “diluted” in larger groups. What is commonly defined as β or II type error (probability of accepting the “Null Hypothesis” when it is not “true”, i.e., of attributing to chance an effective result) could be considerably high. Computer simulations clearly show this.

As a consequence, analytical epidemiological studies are of main importance for better analyzing the Chernobyl accident consequences. This is confirmed by the new evaluations emerging from case-control studies recently carried out, which have indicated risk conditions not well identified in the past. Lastly, a conservative approach will be appropriate in the data evaluation, taking also into account the level of the possible β error.

7) A review of Ukrainian data: Lessons learned and a model of radiation contamination event and of related problems (Prof. D. Bazyka)

The history of Chernobyl accident emergency response indicates that 237 people were heavily exposed, about 600,000 people (“liquidators”) were exposed at a medium-high level, and up to 15,000,000 people were exposed at low level, while tens of millions of people, exposed to ultra low levels were affected by psycho-emotional stress. For each of these groups specific treatments and support was necessary. In particular, this experience indicates that in analogous conditions (and also for an improvised nuclear device) appropriate evaluations, cares and treatments are needed.

Together with health care, monitoring of environment and food products, restriction of access in the most contaminated areas, countermeasures in agricultural production, etc., were necessary. For instance, the lessons learned from the first stage after the accident indicate the need of timely affording the case of hundreds of heavily exposed people with significant acute radiation injuries, requiring immediate care. Moreover, the possibility of more than 100,000 people, less exposed and requiring in any case evaluation and treatment should be considered.

The Chernobyl event has also indicated the inability or difficulty of an immediate estimation of the whole radiation situation, even if a timely evacuation of highly exposed people and their immediate transport to the Moscow and Kiev hospitals enabled specialized effective treatments.

The initial protective action decisions included the immediate evacuation of people at significant risk (which implies appropriate decision criteria) and the interdiction of access to specific identified territories. The use of potassium iodide was necessary, in order to prevent thyroid uptake of radioactive iodine in contaminated areas. It is worthwhile noticing that the efficiency of this treatment sharply decreases after exposure (available experience indicates that the protection efficiency is only about a 7% after 24 hours from exposure). Therefore, whenever necessary, this treatment needs to be immediate; this has to be considered in emergency planning (KI availability, immediate distribution, people information, etc.).

Official data on Chernobyl accident indicate that iodine prophylaxis started in the highly contaminated Pripjat town (at less than 3 km from the nuclear plant) on April 26th 1986, 10 hours after the accident, and that it was significantly delayed in the large number of other residential areas. The difficulties encountered may be easily understood, if it is considered that iodine prophylaxis was provided as a whole to 5 millions people, including 1.6 million children.

Moreover, at the very beginning no radio-protective drugs were used before entering in the contaminated areas (treatments included hemosorbition, enterosorbents, immuno-modulators). The availability of adequate amounts and of procedures of rapid distribution of these and other drugs is an other essential point

As far as the sheltering procedures and levels are concerned, it results that the information distribution of sheltering needs was distributed with some delay in the Pripjat town, and that for other involved populations groups, including Kyiv town, recommendations on sheltering were distributed on May 10th 1986 (two weeks after the accident). Lastly, the sheltering efficacy could not be appropriately assessed.

The first population evacuation decisions for the Pripjat town were taken in the accident day (April 26th 1986), based on measurements effected in some parts of the town, indicating dose rates up to several mSv/hour. After 9 p.m. of the same day, 1,350 city buses, 2 railway trains and 3 motor ships were brought into the Chernobyl district. At 10 p.m., the USSR Ministry of Public Health decided the evacuation of the town. The evacuation of 49,360 and 254 people, respectively from the Pripjat town (including 17,000 children and 80 bed-bound patients) and

from Yanow railway station was carried out in the following day (April 27th 1986) between 2 pm and 5 p.m.. It is worthwhile mentioning that the city buses were contaminated during their presence in the evacuation areas, and consequently caused some contamination in the Kyiv town after their return.

Before the beginning of May (i.e., 4-5 days after the accident) the radiation contamination conditions were assessed up to a 1000 km distance from nuclear plant, based on aerial surveys, mobile radiological laboratory measurements and radiometric prospecting. During the first phase, 50,000 cesium, 2000 radio-iodine and 600 “hot particles” measurements were carried out, together with 152,000 direct thyroid gland radioactivity, 200,000 total body monitor and 56,000 dose measurements for evacuees, and dosimetry passports for 1200 settlements.

The evacuation from the other neighboring areas was carried out between May 2nd and May 7th 1986. The evacuation decision criteria were based on the 0.05 mSv/hour limit for the isopleth of residential areas, where the estimated exposure doses could exceed 0.1 Sv during the first year after the accident (USSR Ministry of Public Health). The recommended intervention levels for temporary relocation and permanent resettlement respectively were 30 mSv in one month and 1 Sv in lifetime. In some cases, the selection of population relocation areas was not optimal, and led to some exposure increment because of additional exposure due to natural radioactivity (e.g., high radon release).

The countermeasures for the external exposure reduction, adopted in the first period after the accident, with many short-lived gamma emitters still active, included the removal of soil top-layer in the most frequented places of the most contaminated areas, the cleanup of buildings, the replacement of contaminated roofs and constructions, the asphaltting of roads, and other analogous actions. It is worthwhile noticing that the clean-up of school areas was the most effective action, leading to a measured 30% reduction of the external exposure. In 1986 a daily washing of roads, pavements and yard was effected in urban areas (25 km² in Kyiv) and dead leaves were removed and buried (in Kyiv, 323,000 m³). When carried out in rural settlements, analogous actions did not produce significant results. Lastly, it has been estimated that total effectiveness of these countermeasures led to a limited external dose reduction. However, these countermeasures were highly effective in reducing population anxiety (but not in all cases), even in areas with low exposure doses. The Chernobyl experience indicates that the planning and the efficiency of these activities might be improved.

The countermeasures for internal exposure dose reduction resulted significantly more efficient. In fact, more than 50% of internal dose in the Ukrainian contaminated areas was due to radioactive cesium in milk, so that the substitution of local milk and other food items with external and “clean” ones led to a considerable internal dose reduction. As an example, evaluations carried out on the Dubrivitsky region of the Rivne oblast indicate an internal dose 11-fold reduction as consequence of local food consumption restrictions, in comparison with expected level in the absence of countermeasures.

The workplace risk of Shelter personnel, including the radiation workers of Chernobyl, the nuclear industry staff and volunteers with no previous exposure (about 14,000 people during the 2004-2008 period) operate in workplaces that cannot be brought into compliance with the international safety standards and the Ukrainian national regulation. In particular, many workplaces were under “hot cell” conditions (presence of open sources), there is a permanent external exposure, a high risk of radionuclide inhalation and of their incorporation through cuts or wounds, a severe psychological stress may affect workers, and synergism of radiological and general industrial risk may take place. These points need attention.

The possible conclusions are:

- Chernobyl experience in radiation protection has to be reassessed and implemented in emergency planning. The most important effects include:
- Late effects after acute radiation syndrome.
- Leukemia, thyroid, breast, colon, lung, and bladder cancers in radiation workers.

- Analysis of integrated cancer databases on general population.
- Mortality from cardiovascular diseases in radiation workers.
- Follow-up studies of Shelter workers.

Part 2. Neurological and psychological effects, lessons learned in the medical emergency response, improved retrospective dosimetry

Neurological and psychological effects

Frequency of mental retardation cases among children exposed in utero is the subject of several studies in Ukraine and Russia. A study performed in the frame of IPHECA project was criticized for inappropriate control groups and usage of non-standard psychological scales. At present a registry is elaborated of children irradiated in utero in Prypjat. Neuropsychological disorders of children, who received acute pre-natal exposure with doses of 10,7-92,5 mSv on the fetus and 0,2-2,0 Gy on the thyroid gland of the fetus, are heterogeneous. Preliminary results of exposed in utero have demonstrated tendencies of increased behavioral and emotional disorders. The frequency of neuropsychological disorders among parents of children exposed in utero is higher than in a control group. The impact of Chernobyl accident factors other than irradiation has to be determined.

A number of radiation related non-cancer endpoints are of concern following the Chernobyl accident. It is anticipated that information on the development of cataracts in clean-up workers and others who may have received significant exposures will soon be available as well. There are indications that the incidence of cardiovascular, cerebrovascular and thyroid diseases in clean-up workers and possibly other non-cancer conditions may be increased; radiation exposure or other factors may play a role in this increase. Further investigations are needed. During 18 years after the accident other types of health effects seem to have emerged. These are primarily neuropsychiatric and cardiovascular diseases, but also include deteriorating health of liquidators; increasing invalidity among liquidators and decreased birth rate.

Very little is known concerning the community, ecosystem or evolutionary effects of broad scale chronic exposure to radioactive contaminants in non-human systems. Most studies in the past have focused on characterizing the transfer of contaminants (i.e. received dose), morphological correlates (e.g. asymmetry), or genetic consequences of contaminants, which are valuable and necessary prerequisites for further research. Recent studies of natural populations suggest that there are significant reproductive and population level effects in some species that could influence community (i.e. biodiversity) and ecosystem (i.e. energy flow) dynamics. Dr. Timothy A. Mousseau (University of South Carolina) has presented data on chronic exposure to radionuclides in non-human species. In some of recent work he examines reproduction, survival, and other effects in natural populations of animals and will propose future directions for research in this area.

The mental health impact of Chernobyl accident is a main public health problem unleashed by the accident to date. The magnitude and scope of the disaster, the size of the

affected population, and the long-term sequelae make it, by far, the worst industrial disaster on record. Chernobyl accident caused a complex web of events and long-term difficulties, such as massive relocation, loss of economic stability, and long-term threats to health in current and possibly future generations, that resulted in an increased sense of anomie and diminished sense of physical and emotional balance. While it may never be possible to disentangle the multiple Chernobyl stressors from those that followed in its wake, including the dissolution of the Soviet Union, the high levels of anxiety and medically unexplained physical symptoms continue to the present. The studies also reveal the importance of eliminating reporting bias in epidemiological studies of health effects.

The main areas of concern after this disaster involve stress-related symptoms, effects on the developing brain, organic brain disorders in highly exposed clean-up workers, and suicide.

With respect to stress symptoms, increased levels of depression, anxiety (including post-traumatic stress symptoms), and medically unexplained physical symptoms have been found in Chernobyl-exposed populations compared to controls. Compared to controls, three studies found that exposed populations had anxiety symptom levels that were twice as high and were 3-4 times more likely to report multiple unexplained physical symptoms and subjective poor health. Interestingly, in one study, 31% of the mothers of evacuee children reported that their child had memory problems compared to 7% of controls. This is consistent with possible reporting bias.

These mental health consequences in the general population were mostly sub-clinical and did not reach the level of criteria for a psychiatric disorder. Nevertheless these sub-clinical symptoms had important consequences for health behavior, specifically medical care utilization and adherence to safety advisories. To some extent, these symptoms were driven by the belief that their health was adversely affected by the disaster and the fact that they were diagnosed by a physician as a “Chernobyl-related health problem.” These studies point to the importance of eliminating reporting biases that may occur in other epidemiological studies of health status and potential radiation effect.

A great deal of concern has been expressed about the developing brain of children who were *in utero* when the accident occurred. On the one hand, the lowest level of exposure in which mental retardation was found in the offspring of survivors of Hiroshima and Nagasaki was higher than the highest level of exposure reported for most Chernobyl populations. Moreover, there is a general belief that the brains of Chernobyl exposed children may have been in some way damaged. Thus, the World Health Organization conducted the Pilot Project on Brain Damage *In-Utero* at the frame of the International Program on the Health Effects of the Chernobyl Accident (IPHECA). Analysis of the results in the three countries has shown the following:

- a) prevalence of mild mental retardation in prenatally irradiated children is higher when compared with the control group;
- b) an upward trend was detected in cases of behavioral disorders and in changes in the emotional problems in children exposed *in utero*;
- c) prevalence of borderline nervous and psychological disorders in the parents of prenatally irradiated children is higher than that of controls.

The IPHECA study had several crucial limitations from, of which the most important was the impossibility to link the results to individual doses. The definition of an exposed and

unexposed child was based only on the contamination level of the soil of the district of residence, without reference to individual doses (World Health Organization 1995).

Two recent well-designed studies using standard batteries of neuropsychological tests failed to find systematic differences in children exposed *in utero*. However, no dosimetric data were available, and there were no normative data in Ukraine for the measures used in the study. Moreover, the IQ tests were applied selectively

On account of the contradictory results of the mental health assessments of the *in utero* exposed children and the etiology of the observed neuropsychiatric disorders in the literature, a thorough study of the potential radiation effects on the mental health of the *in utero* exposed children was performed within the framework of the Project 3 «Health Effects on the Chernobyl Accident» of the French-German Initiative for Chernobyl. The prenatally exposed children show significantly more neuropsychiatric disorders, lower full-scale IQ due to lower verbal IQ and therefore an increased frequency of performance/verbal intelligence discrepancies. When IQ discrepancies of the prenatally irradiated children exceeded 25 points, there appeared to be a correlation with the fetal dose (Nyagu et al., 2004a,b,c). Moreover, the neurophysiological markers of prenatal exposure were revealed. The most critical period of cerebrogenesis at the radiation accident on the nuclear reactor are the later terms of gestation (16–25 weeks) than that at uniform external exposure (Loganovskaja & Nechayev 2004; Loganovskaja, 2004, 2005).

Current state of art on evidence concerning mental health and brain effects following the Chernobyl accident is as follows:

- The preliminary results the Franco-German Chernobyl Initiative sub-project 3.8.1 «Data base on psychological disorders in the Ukrainian liquidators of the Chernobyl accident» testify to two-fold increase of the prevalence of any mental disorders and depression in liquidators in comparison with Ukrainian general population — 36% vs 20.5% and 24.5% vs 9.1% (Romanenko et al., 2004a,b; Demyttenaere et al., 2004).
- Evacuees have significantly more health problems and rate their health more poorly overall (Adams et al., 2002; Bromet et al., 2002).
- In the liquidators radiation risks on non-cancer effects has been revealed (Biriukov et al., 2001; Buzunov et al., 2001, 2003). The highest radiation was found for cerebrovascular diseases (Ivanov et al., 2000).
- Organic brain damage with inhibition of the cortical-limbic system was revealed in patients who had acute radiation sickness (ARS) and in liquidators of 1986 (Loganovsky & Yuryev, 2001). The neurophysiological markers of ionizing radiation (1–5 Gy) were found (Loganovsky & Yuryev, 2004).
- Dysfunction of subcortical limbic-reticular and mediobasal brain structures and the white matter damage including corpus callosum in remote terms after exposure to radiation were observed (Zavoronkova et al., 2000, 2003).
- Impairment of cognitive function, especially in liquidators, resulting from both acute and chronic exposure to ionizing radiation were revealed (Gamache et al., 2005). The neural diathesis-stressor hypothesis of schizophrenia is considered as a model of the effects of exposure to ionizing radiation (Loganovsky et al., 2004a, 2005a).

- The organic brain damage in remote period of ARS has been verified by clinical neuropsychiatric, neurophysiological, neuropsychological, and neuroimaging methods (Loganovsky et al., 2003; 2005b).
- There are the neuropsychological dose-effects relationships at 0.5–5 Sv dose range (Antipchuk, 2004, 2005).
- There is the «dose–effect» relationship between the dose and the characteristic morphometric neuroimaging features of organic brain damage, starting with 0.3 Sv and increasing in proportion to the dose (Bomko, 2004a).

The structural-functional pattern of radiation organic brain damage in Chernobyl accident clean-up workers consists in the pathology of cerebral cortex, subcortical structures, neuronal pathways and cortical-limbic system of the left (predominantly) cerebral hemisphere (Loganovsky & Bomko, 2004). Exposure to low-dose ionizing radiation could be a risk factor for accelerated aging processes and neurodegeneration. (Bazyka et al., 2004).

- At exposure lower than 0.3 Sv Chronic Fatigue Syndrome (CFS) was diagnosed in 26% liquidators (Loganovsky, 2003). CFS and Metabolic Syndrome X (MSX) are considered to be the stages of another neuropsychiatric and physical pathology development, and CFS can transform towards MSX (Kovalenko & Loganovsky 2001). CFS can be considered as environmentally induced predisposition and vestige of forthcoming neurodegeneration, cognitive impairment, and neuropsychiatric disorders (Volovik et al., 2005).
- Further well-designed neuropsychiatric epidemiological studies in Chernobyl accident survivors have a priority, particularly concerning schizophrenia spectrum disorders, suicides, and CFS. Neuropsychiatric follow up survey of the ARS-patients has to be continued for a life time. In vivo morpho-functional (fMRI; qEEG, EP) and neurochemical studies (SPET) are of the greatest priority (Loganovsky et al., 2005b).

The accident has had a serious impact on mental health and well-being in the general population. Importantly, however, it appears that this impact is demonstrable mainly at a sub-clinical level. Although the empirical studies do not support the view that the public anxiety bears a resemblance to clinical psychiatric disorders, such as phobia or psychosis, the disaster did have a psychological effect that is not limited to mental health outcomes. It also has ramifications for other areas of subjective health and health-related behavior, especially reproductive health and medical service utilization. It furthermore may influence people’s willingness to adopt safety guidelines issued by the authorities.

According to current knowledge, the evidence-based radiation cerebral effects could be outlined as follows:

- Non-cancer effects, especially cerebrovascular, at doses >0.5 Sv;
- Dose-related cognitive decline following radiotherapy in childhood with the possible dose thresholds of delayed radiation brain damage at the doses as low as 0.25–1.3 Gy on the brain;
- Dose-related cognitive and neurophysiological abnormalities in prenatally exposed children;
- Postradiation organic brain syndrome in ARS-patients and dose-related neuropsychiatric, neurophysiological, neuropsychological, and neuroimaging abnormalities following exposure to >0.3 Sv;

The CNS effects that could be studied are as follows:

- Schizophrenia spectrum disorders;
- Chronic Fatigue Syndrome;
- Accelerated aging processes and neurodegeneration.

What the Chernobyl disaster has clearly demonstrated is the central role of information and how it is communicated in the aftermath of radiation or toxicological incidents. Nuclear activities even in Western countries have also tended to be shrouded by secrecy. The Chernobyl experience has raised the awareness among disaster planners and health authorities that the dissemination of timely and accurate information by trusted leaders is of the greatest importance.

Medical lessons learnt from Chernobyl

Dr. Bazyka has made presentation “Chornobyl accident as a model for health effects management after radiological attack”. Main goal has to be an integration and generalization of the Chornobyl accident experience by upgrading the all available in Ukraine medical-biological and dosimetric registers and databases for the strategy elaboration of the operational health effects management of the most vulnerable groups of population and organism’s systems and specific organs and decision making for interventions after radiological attack. Information will be gained on the health state of population depending on the use of radioprotectants. This will be of special interest for stable iodine, data on which are controversial (DHS working group, 2003). Specific aims are as follows:

- Generalization of epidemiological analysis and risk assessment of health effects of the Chornobyl accident;
- Retrospective assessment of medical countermeasures and social protection efficacy for different categories of the Chornobyl accident victims and affected population (including also evacuation criteria, psychological support, contamination analysis/mapping, water/food decontamination and supply, radionuclide transfer via nutrition chains, etc.);
- Lessons and mistakes to be learn from the Chornobyl accident experience analysis; Retrospective assessment of efficacy of the protectors decreasing or blocking of internal exposure to radioiodine, cesium-137 and strontium-90 at the early stage after Chornobyl accident (stable iodine, Prussian blue, radionuclide decorporation, biological response modifiers); Improvement of the guidelines for decision making on medical countermeasures and intervention levels after radiological accidents:
 - i) Establishing protective action guidelines for A-team;*
 - ii) Making evacuation and relocation decisions for A-team;*
 - iii) Evaluating health and medical impact on the public and emergency personnel*
 - iv) Communicating with the public, policy makers, and the media*

The significance of such study is a development of effective medical countermeasures against radiation for clinical use following radiation accident at nuclear reactor: guidelines for decision making on medical countermeasures and interventions after radiological accidents;

- Recommendations on the use of stable iodine;

- Regimens that mitigate and/or treat radiation injury post-exposure, with emphasis on broad activity, ease of administration, and safety;
- Low-dose radiation effects and prevention of long-term disease, such as fibrosis, organ dysfunction, and cancer; including models of accelerated disease that will facilitate research;
- Mechanisms of radiation protection, injury, or repair in the hematological, gastrointestinal, pulmonary, renal, cardiovascular, and central nervous systems, as well as the skin, soft tissue, and liver. Such could be based on the comprehensive epidemiological analysis of health effects of the Chernobyl accident on the basis of the all available in Ukraine registers with their quality control.

Dosimetry and dose reconstruction

During a radiological post-emergency response, public health officials will be required to advise members of the public on the possible health consequences resulting from their exposure to radionuclides. Providing this advice will require knowledge of the radiological doses received by persons during the event. Such doses will likely need to be reconstructed from environmental and other types of measurements made during the emergency event. The Centers for Disease Control and Prevention is currently conducting environmental dose reconstructions at many nuclear weapons production and testing sites in the United States. These projects involve reconstructing potential radiation exposures and doses from past releases of radionuclides to people who lived near nuclear facilities where these releases occurred. The results of dose reconstructions can be used as the basis for deciding if epidemiologic studies or other public health activities should be undertaken around these sites. In addition, the results of dose reconstruction can be used in other site-specific risk assessment activities, such as those associated with environmental restoration and radioactive waste management. All of the environmental dosimetry methods developed for dose reconstruction purposes are potentially applicable to post-emergency response environmental risk assessments, too. The most important application of CDC’s experience, however, may be in the area of public involvement. CDC has learned that the success of any dose reconstruction depends as much on public involvement in the project as on the scientific and technical credibility of the methods used to estimate doses and exposures.

Some preliminary conclusions

- The updated epidemiological result indicate that the risks caused by the Chernobyl accident include more than thyroid cancer. Leukemia and women breast cancer should be considered in this framework, even if more study is necessary. Moreover, other cancer categories (colon, lung, and bladder) should be also taken into account.
- Whole body irradiation, even at not very high doses, may represent a risk factor for ischemic heart diseases, cardiomyopathy, cerebrovascular diseases. The estimated risk for

cardiovascular diseases is higher than but compatible with, the one observed in the Atomic Bomb Survivors (ABS).

- Neurological and cerebrovascular diseases increases have been detected.
- Psychological and social effects are clearly evident, including depression, impact on mental health and well-being, anxiety, decisions of reducing births, some suicide increase, other.
- The cause of psychological disorders is not only attributable to a lack of an appropriate risk communication. Population relocation, loss of home and lifestyle, loss of work, poverty and other related conditions evidently are important factors.
- Moreover, taking into account the high risk perception by the involved people, it seems important to adopt an appropriate form for the diffusion of risk estimates. For instance, the recently diffused information, that about 3,900 radiation-induced deaths of thyroid cancer or leukemia are expected, may evidently have a serious psychological impact on the involved people. Provided that the involved population is of around 600,000 people, the same information might be also expressed in terms of a radiation-induced mortality risk of about 6 cases per 1000, which corresponds to a very low fraction of the independently existing background risk. Some experience in risk communication suggests that this latter form (avoiding the crude indication of the number of expected deaths) has a much lower negative effect on the risk perception of involved subjects.
- The history of the emergency response to the accident is particularly interesting and allows to identify problems possibly arising in the practical management of the event consequences. The lessons learned in this field are very important, also because, generally, are scarcely treated in the scientific literature. The above summarized points are only a limited part of the information available from the personnel that was directly involved.
- The above mentioned evaluations in the IARC and Prof. Bazyka presentations, concerning the efficiency in thyroid cancer risk reduction of iodine administration to people at risk and of the normal iodine dietary intake of the same people, are important for the evaluation of possible residual risks, that presumably may not be excluded at all.
- The uneven distribution of environmental contamination and of population exposure implies a difficulty in detecting possible effects in most exposed sub-groups, whenever their “critical conditions” are not separately and specifically considered. The importance of epidemiological analytic studies is confirmed by recent results.
- The recently published study “Risk of cancer after low doses of ionising radiation: retrospective cohort study”, coordinated by the IARC (Cardis et al., 2005), that indicates a significant cancer risk at very low doses (even at the level of the current occupational exposure limit and also below it) is of main importance for the Pilot Study here discussed.
- Finally, an important information, in terms of lessons learned, is represented by the positive impact, in terms of risk reduction, of the countermeasures adopted (e.g., the Prypyat town evacuation in a low number of hours, etc.). These aspects are under study. However, it may be reasonably assumed that if the Chernobyl accident consequences were not so high as initially predicted, this is also due to the emergency response. It is worthwhile remembering that many people have lost their lives for this purpose.

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**NATO/CCMS Pilot Study: “Risk assessment of Chernobyl accident consequences:
Lessons learned for the future”**

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