

Presented at the  
Armed Forces Radiobiology Research Institute  
Scientific Medical Effects of Ionizing Radiation Course  
July 28 through August 1, 2008  
Bethesda, Maryland

Distributed via the AFRRRI Web site  
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# **Radiation Injuries after the Chernobyl Accident: Management, Outcome, and Lessons Learned**

## **Scientific Medical Effects of Ionizing Radiation (MEIR) Course**

**July 30, 2008**

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# Presentation Outline

**I. What could have been done at Chernobyl to lessen the effects of radiation damage?**

**II. Health consequences**

- Thyroid gland and radiation exposure
- Acute Radiation Syndrome (ARS) and its outcome
- Neuro-psychological impact
- Chernobyl experience of Cutaneous Radiation Syndrome (CRS)
- Other medical problems caused by the accident

**III. Conclusions**

# What if....



# Basic Information on the Radionuclide Releases and the Types of Exposure at Chernobyl

- 100% of gaseous fraction of the noble gases and nuclides may have escaped from the plant
- Cesium, Iodine and Tellurium isotopes accounted for up to 10-20% of the nuclides inventory
- Transuranic elements (Plutonium, Curium and Americium) were found **only** in the lungs
- Neutron irradiation was not significant
- ARS was caused by  $\alpha$ - and gamma-irradiation of the whole body and by beta-irradiation of the skin surface

*Ref: International Atomic Agency. Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident, Vienna, 1986.*

# Sheltering

- Sheltering is an effective preventive action in the area within a radius of **3-10 km** from the point of the accident even in the case of absence of confirming radiation measurements
- At Pripyat information about the need for sheltering was delayed
- For other populations including Kyiv recommendations on sheltering were distributed on **May 10**, 1986 after the spread of radioiodine
- The efficiency of sheltering could not be assessed

# Relocation from the site

- **The preliminary decision to evacuate the town of Pripyat, which is located less than 3 km from the ChNPP, was taken on the afternoon of 26 April 1986, when the dose rate in some parts of the town reached several mSv/hour**
- **By 9 pm on 26 April 1986, 1,350 buses, 2 railway trains and 3 motor ships were brought into the Chernobyl district (12 km from the town of Pripyat)**
- **At 10 pm the USSR Ministry of Public Health decided that the emergency evacuation of the town was necessary**

# Relocation from the site (continued)

- **The organized evacuation of the town of Pripyat (49,360 including about 17,000 children and 80 bed-bound patients), was carried out on 27 April 1986, between 2 pm and 5 pm**



# Iodine Prophylaxis

## Official information from 1986

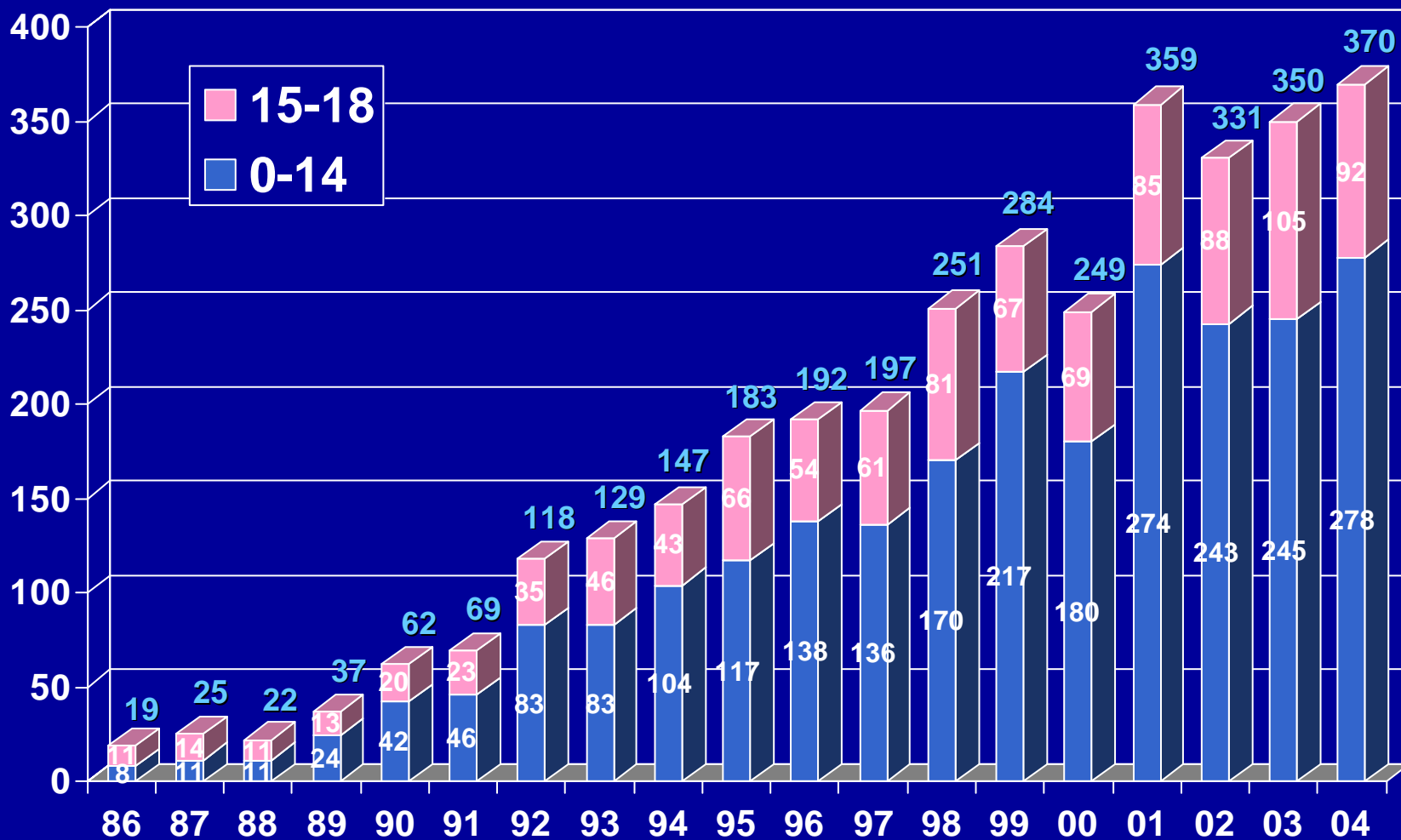
**Total:** It was administered to about 5 million people, including 1.6 million children

**Pripyat town:** It was administered to about 70% of the total population, including 60% on April 26

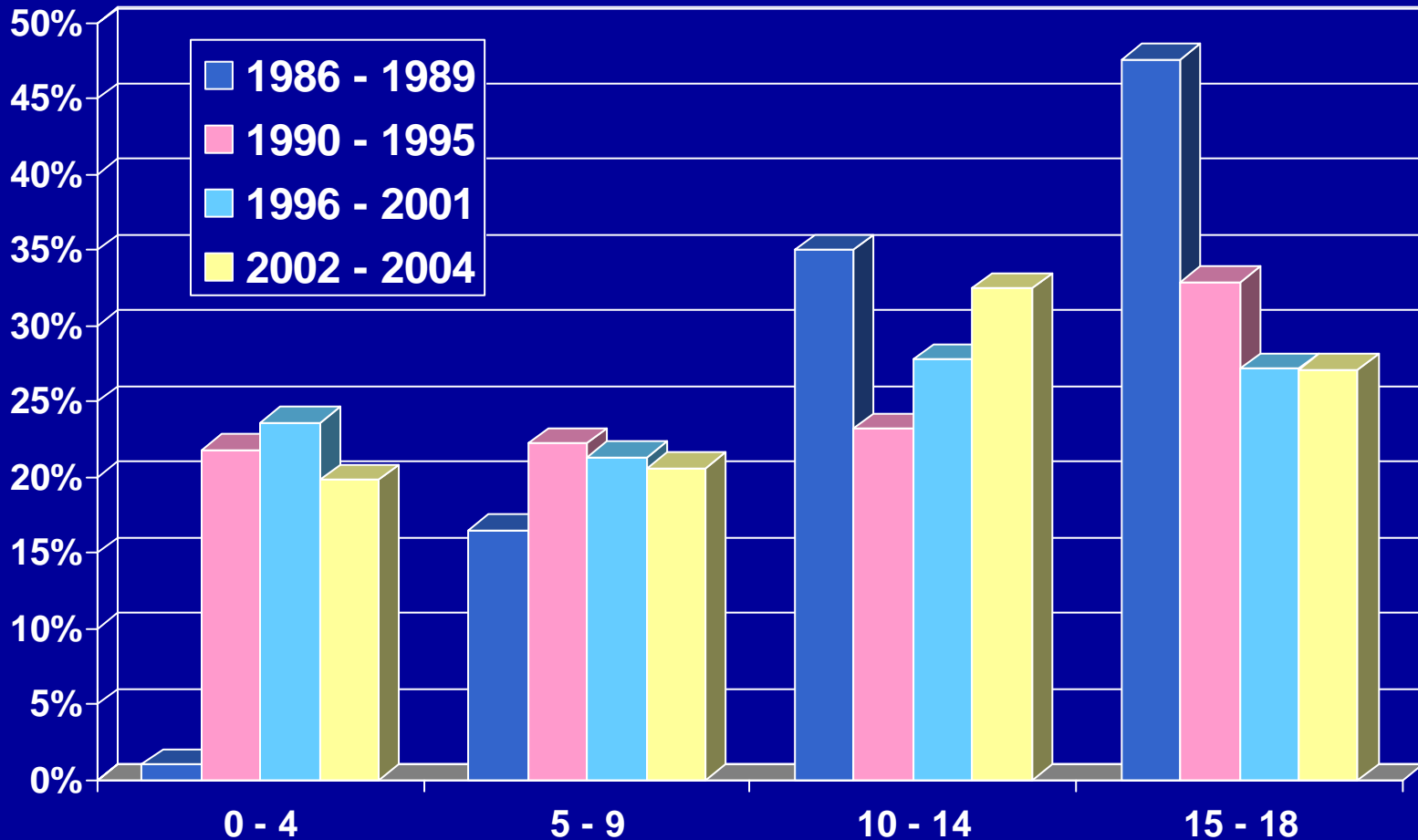
**Kiev Oblast:** Department of the Ministry of Health made a decision on iodine prophylaxis on May 6, **10 days after the accident**

**The Russian Federation:** It was administered to 71,930 people, including 25,060 children, **from June** to the middle of August 1986

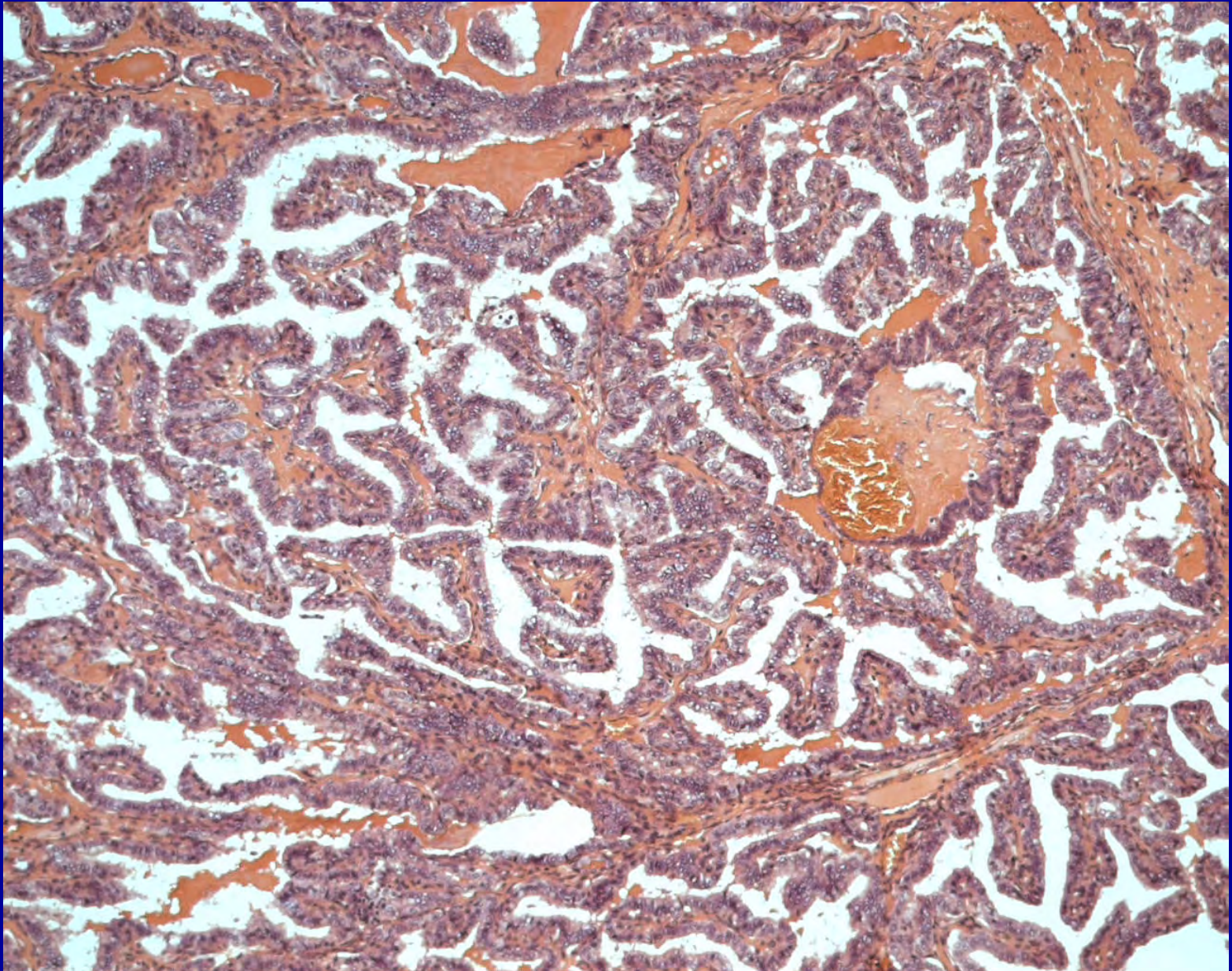
# Number of thyroid cancer cases in children and adolescents of Ukraine (aged 0-18 yrs) at the time of the Chernobyl accident



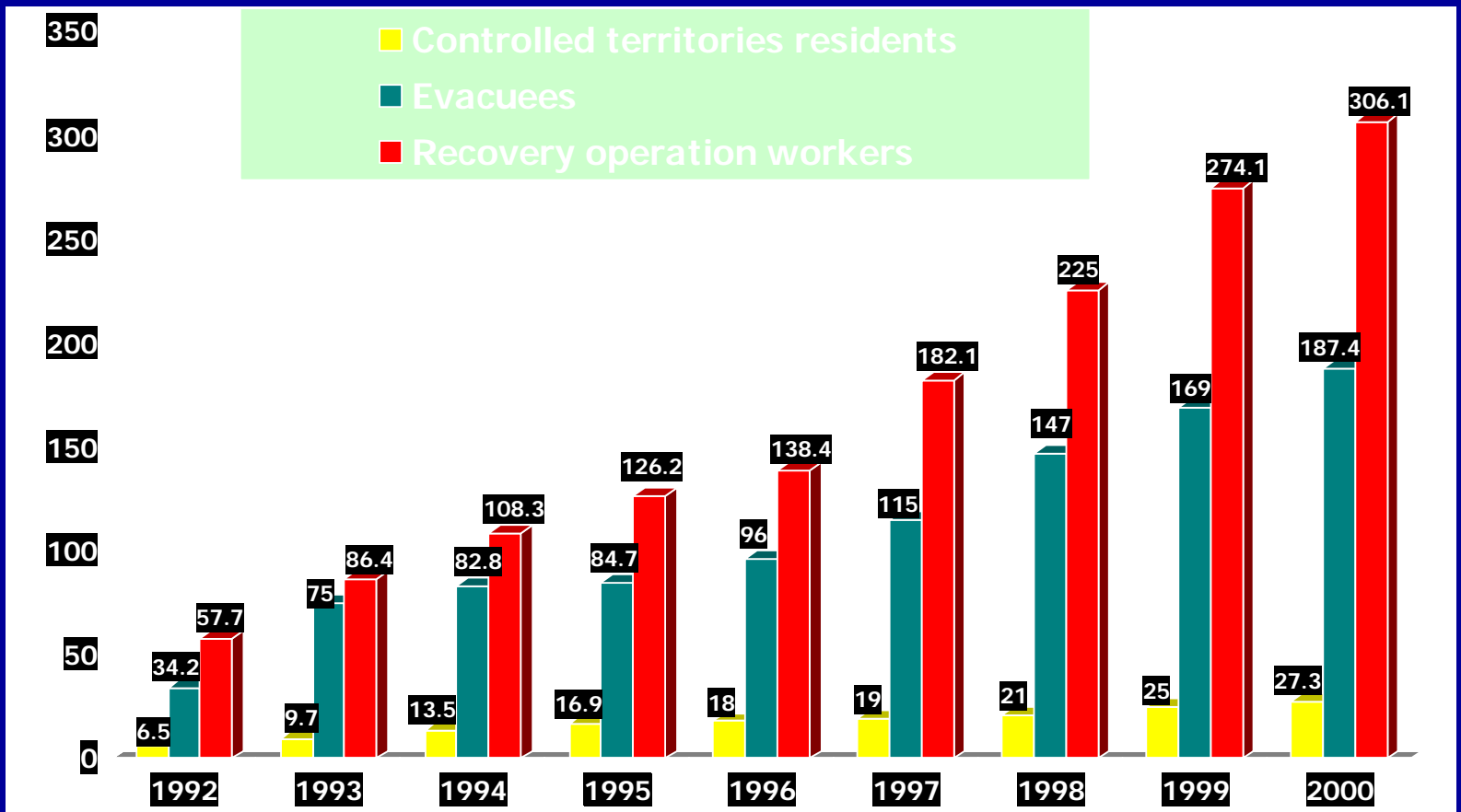
## Distribution of thyroid cancer cases depending on patients' age at the time of the accident



# Papillary Carcinoma



# Chronic Thyroiditis



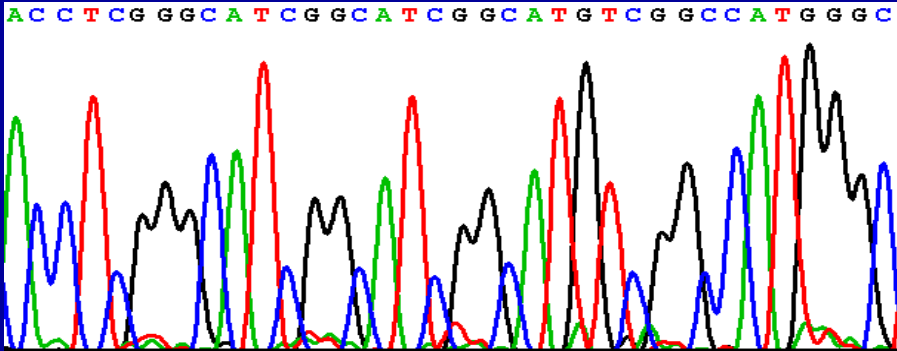
Data of Ministry of Health of Ukraine

# Leukemia

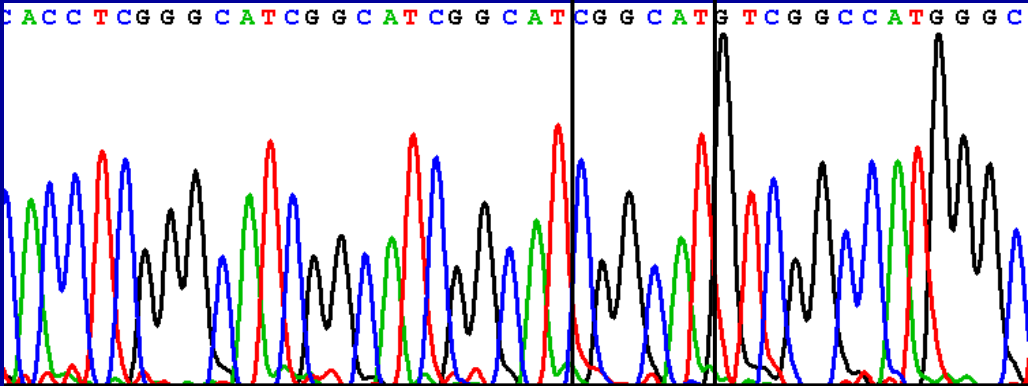
- Consensus exists on the absence of leukemia excess in inhabitants of the contaminated territories (*French-German Initiative study*)
- There is a controversy in data on the leukemia incidence in children exposed *in utero*
- Preliminary data from 2003 - 2005 demonstrate dose-effect relationship in operation recovery workers irradiated over 100 mGy (*US Natl. Cancer Institute-RCRM joint study of leukemia among clean-up workers of Chernobyl in Ukraine*)

# Mutation *AML1* in ARS Survivors with Myelodysplastic Syndrome

During *AML1* gene sequencing in ARS survivor, who had suffered MDS, it was revealed punctuated mutation as repeating of 6 nucleotides



Patient No 24 / *AML1* wt



Patient No 263 / *appel* with ins 1502 (CGGCAT)

T S G I G I G I G M S A M

AK consecution with mutation

# Conclusions

Studies in Ukraine have shown:

- an **excess of thyroid cancer and non-cancer thyroid disease** in children & other exposed groups (recovery operation workers, evacuees, adult population)
- a controversy in data on the leukemia incidence in children exposed in utero
- a **dose-effect relationship on the leukemia incidence** in recovery operation workers exposed to over 100 mSv

# Conclusions (continued)

- an increase in the **breast cancer** incidence rate in females participating in recovery operation works in 1986/87 and female subpopulation still living in the most contaminated areas
- an increase in **all forms of cancer** incidence rate **only among recovery operation workers of 1986-1987** in comparison with national level

# Liquidators in Action



# Chernobyl, April 26, 1986: Sequence of the Initial Intervention

Time	Intervention	Treatment/Disposition
<b>30 min – 3-4 hours</b>	Initial treatment on the site	<ul style="list-style-type: none"><li>• evacuation from the site, antiemetics, sedative, cardiotoxic</li></ul>
<b>4 hours - 12 hours</b>	Evaluation and treatment at the nuclear plant medical facility	<ul style="list-style-type: none"><li>• discharged if condition is OK</li><li>• remained hospitalized</li></ul>
<b>12 hours - 36 hours</b>	Specialized team arrived	<ul style="list-style-type: none"><li>• Assessment, blood tests, administration of KI, priority for hospitalization established</li></ul>

*Guskova et al, 1986. Acute radiation effects in exposed persons at the Chernobyl Atomic Power Station Accident. Medical Radiology, (477), pp.3-18*

## Sequence of the Initial Intervention (continued)

- Within the first three days, **299 persons** were sent to the specialized treatment center in Moscow and to hospitals in Kiev
- Over the subsequent days **hundreds** of additional persons were admitted for examination
- Criteria for hospitalization included for patients with the suspected ARS
  - » Presence, time of onset and intensity of nausea and vomiting
  - » Primary erythema of the skin
  - » Decrease of the lymphocyte count in the peripheral blood  $<1 \times 10^9/L$  in first 24 hours after the exposure

**Thousands of concerned citizens were admitted to the hospitals for examination and blood work**

# Primary Diagnostic Criteria of ARS: Diagnostic Coefficient (DC)

## Assessment of irreversible myelosuppression according to DC in cases of ARS

<i>Time to the onset of vomiting</i>	<i>Hours</i>	<i>Diagnostic Score</i>
	<b>0-0.4</b>	<b>+8</b>
	<b>0.41-0.8</b>	<b>+4</b>
	<b>0.81- 1.2</b>	<b>+2</b>
	<b>1.21 – 1.6</b>	<b>-2</b>
	<b>&gt;2.0</b>	<b>-10</b>
<i>Lymphocyte count</i>	<i>10<sup>9</sup>x1-1</i>	<i>Diagnostic Score</i>
Lymphocyte count on Day 2	<b>0-0.2</b>	<b>+6</b>
Lymphocyte count on Day 2	<b>0.61- 0.8</b>	<b>-15</b>
Lymphocyte count Days 4 – 7	<b>0.01</b>	<b>+5</b>
Lymphocyte count Days 4 – 7	<b>&gt;0.15</b>	<b>-15</b>

A sum of **+10** is the basis for the prognosis of irreversible myelosuppression; a sum of **-10** is a prognosis for **NO** irreversible myelosuppression.

# The Severity and Outcome of ARS in Chernobyl Victims

ARS Grade	Dose (Gy)	Number of Patients			
		Total	Alive	Died ( <b>days to death</b> )	
<b>I</b>	0.8 -2.1	31	31	0	
<b>II</b>	2.0 - 4.0	43	42	1	<b>96</b>
<b>III</b>	4.2 - 6.3	21	14	7	<b>16 - 48</b>
<b>IV</b>	6.0 –16.0	20	1	19	<b>14 - 91</b>
<b>TOTAL</b>		<b>115</b>	<b>88</b>	<b>27</b>	

*Baranov et al, Antibiotics and Chemotherapy, 1989, 34, 7, 555-558; Guskova et al, "Acute Radiation Effects in Exposed Persons at the Chernobyl Atomic Power Station Accident" Medical Radiology, 1986, pp. 3-18.*

# The Bone Marrow Syndrome and its Treatment in Chernobyl Victims (1)

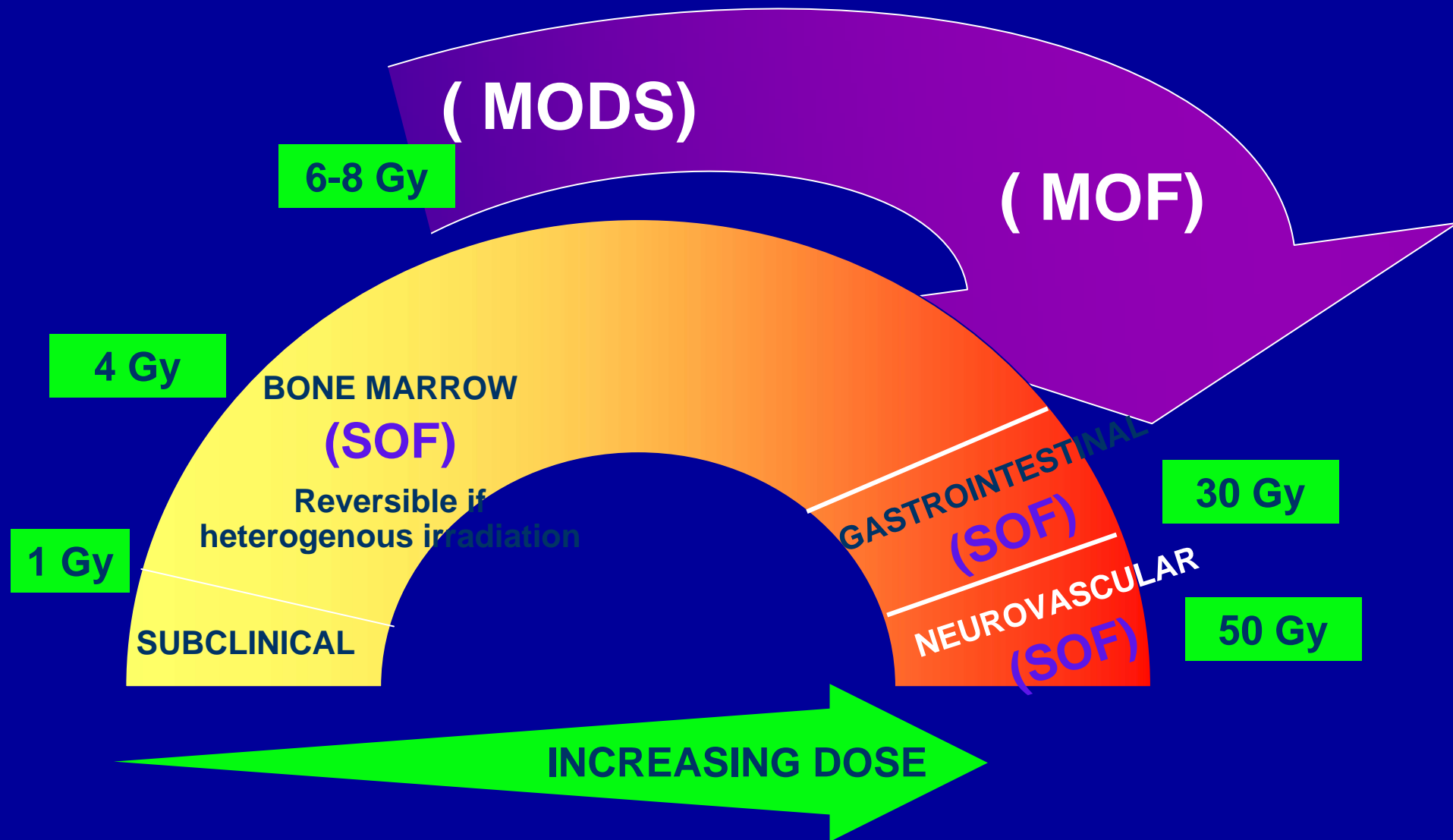
- **Antiseptic regimen**
  - » Isolation
  - » Air sterilization
  - » Changes of underclothing for patients at least once/day
  - » Maintaining the micro-organism population at less than 500/mm<sup>3</sup> in the room air
- **Supportive therapy**
  - » Antimicrobial decontamination of the intestine
  - » Administration of systemic antibiotics
  - » Acyclovir
  - » Transfusions of blood cells (e.g. fresh donor platelets and RBC)

*Ref: UNSCEAR Report, 1986; Robert Gale et al, The Lancet, April 23, 1988. Guskova A. et al, 1986.*

# Supportive Therapy for Neutropenia

- Oral quinolones, fluconazole, acyclovir prophylactically
- Standard care for hemopoietic failure
- All blood products irradiated at 25 Gy
- Other supportive measures ad libitum

# The New Concept of the ARS



# Bone Marrow Syndrome and its Treatment in Chernobyl Victims (2)

- HLA-matched unrelated bone marrow donors from large HLA-typed volunteer donor pools – **13 patients**
- Fetal liver cells – **6 patients**
- Bone marrow syndrome combined with other Injuries
  - Skin
  - GI
  - Oropharyngeal
  - Radiation pneumonitis

## Number of Deaths from Direct Radiation Effects in first 3 months

Number of patients died ( <b>TOTAL = 27</b> )	Days of death after the exposure	Comments
<b>22</b>	14 - 34	In 20/22 patients $\beta$ -burns were the main cause of death
<b>5</b>	48 – 99*	Died after the bone marrow recovery stage  * Patient on Day #96 died from ischemic stroke

*Baranov et al, Antibiotics and Chemotherapy, 1989, 34, 7, 555-558; Guskova et al, "Acute Radiation Effects in Exposed Persons at the Chernobyl Atomic Power Station Accident" Medical Radiology, 1986, pp. 3-18.*

# Indications for an Allogenic BMT or an Embryonic Live Cell Transplantation

- Whole body  $\gamma$ -irradiation dose **6.0 Gy -16.0 Gy**
- Irreversible degree of myelosuppression using a Diagnostic Coefficient **(DC)**  
*plus additional criteria*
- Vomiting during the first **30 minutes**
- Diarrhea during **1-2 hours** after the exposure
- Swelling of the parotid glands during the first **24-36 hours**

*Ref: UNSCEAR 1988 Report*

# Outcome (Survival or Cause of Death) in Patients Receiving BMT

Dose range (Gy)	Bone marrow transplant patients			
	Number of patients	Deaths*	Deaths**	Number of survivors
< 6.5	4	0	3	1
6.5 – 9.0	3	2	1	1
> 9.0	6	5	0	0
<b>TOTAL</b>	<b>13</b>	<b>7</b>	<b>4</b>	<b>2</b>
		*skin and GI injuries	**GVHD + infection	

*Gale et al, 1988; UNSCEAR report, 1988; Baranov et al, 1989; Guskova et al, 1989;*

# Hemopoetic Stem Cell Transplants ???

- Never an emergency!
- Not if MODS!
- Always consider heterogeneity of irradiation and possibility of autologous hemopoietic recovery
- HLA typing immediate
- Transplant never before day 14-21
- Low immunosuppression: fludarabine  $\pm$  ATG
- High cell dose  $2 \times 10^6$  CD34/kg (*peripheral blood*),  $2 \times 10^8$  nucleated cells/kg (*bone marrow*) and  $3 \times 10^7$  nucleated cells (*cord blood*)

# Problems that Complicated the Use of BMT for Chernobyl Victims

- Determination of the radiation dose
- Several kinds of irradiation (external  $\gamma$ - and  $\beta$ , and inhaled and ingested isotopes)
- Partial shielding of body parts by physical structures
- Rapid onset of lymphocytopenia made HLA typing difficult. Donor-recipient histocompatibility was not accurately determined
- Most individuals who received a sufficiently high dose of irradiation had thermal burns as well as injuries to the GI tract and other tissues

# Causes of Death among ARS Survivors (1986 through 2006)

Cause of death	Grade I ARS	Grade II ARS	Grade III ARS	Total
Oncological and oncohematological pathology	1	2	2	5
Sudden cardiac death	2	2	2	6
Internal organ systems and neurological diseases	1	3	1	5
Traumas and accidents	2	-	-	2
<b>TOTAL</b>	<b>6</b>	<b>7</b>	<b>5</b>	<b>18</b>

# Oncological Diseases in ARS Survivors and non-ARS Patients

No	Group	Diagnosis	First revealed	Outcome
1	non-ARS	Sarcoma of hip soft tissues	1992	Died in 1993
2	non-ARS	Leiomyosarcoma of shin	1998	Operated in 1998
		Cancer of colon	1999	Operated in 1999
3	non-ARS	Cancer of colon	2001	Died in 2005
4	non-ARS	Cancer of kidney	2000	Operated in 2001
5	non-ARS	Cancer of stomach	2004	Died in 2004
6	non-ARS	Cancer of stomach	2004	Died in 2005
7	non-ARS	Cancer of lung	2001	Operated in 2003
8	non-ARS	Cancer of prostate	2001	Died in 2003
9	non-ARS	Cancer of throat	2000	Died in 2001
10	ARS 1 d.	Cancer of colon	1997	Operated in 1997
11	ARS 2 d.	Cancer of thyroid gland	2000	Operated in 2000
12	ARS 2 d.	Cancer of thyroid gland	2000	Operated in 2001
13	ARS 2 d.	Neurinoma of lower jaw	2003	Died in 2004

# Non-bone Marrow Syndromes Caused by Radiation Exposure

Acute Radiation Syndrome	Skin burns (%)	Oropharyngeal Syndrome (%)	Gastro-intestinal (%)	Radiation Pneumonitis (%)
<b>115</b>	<b>56 (48.6)</b>	<b>80 (69.5)</b>	<b>17 (14.7)</b>	<b>7 (6.1)</b>

*Barabanova A., Vojnosanit Pregl. 2006 May;63(5):477-80*

*Ministry of Health, Clinical Department of the Institute of Biophysics, Moscow, Russia. abarabanova@rambler.ru*

# Stages of CRS

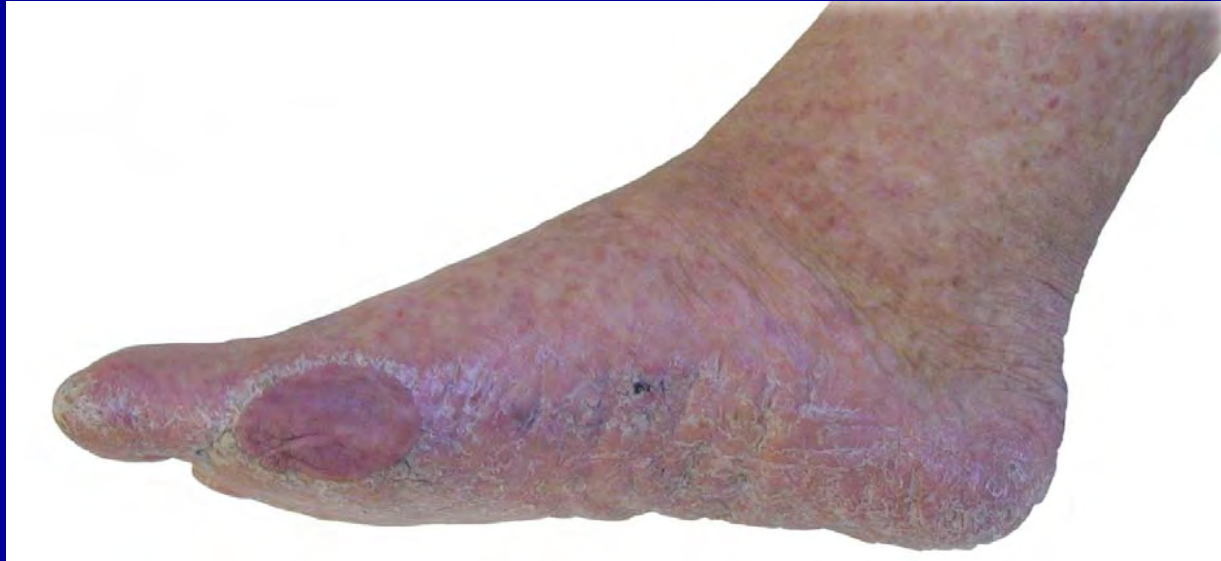
Stage	Onset	Symptoms
<b>Prodromal</b>	24-72 hours	Transient erythema, pruritis
<b>Manifestation</b>	Days – 4 weeks	Intense erythema, edema, pruritis, pain, blisters, erosions, ulcerative necrosis
<b>Subacute</b>	4-6 weeks	Erythema, edema, ulcers
<b>Chronic</b>	3 months-2 years	Keratosis, fibrosis, ulcer, atrophy, pigment alteration, subcutaneous vasculitis, ulceration
<b>Late</b>	Decades	Ulcers, angioma, fibrosis, keratosis, basal cell carcinoma

*Stages of the CRS according to Second Consensus Development Conference on the Management of Radiation Injuries, Bethesda, MD, 1993*

## Early and Late Skin Lesions in Radiation-exposed Patients after the Chernobyl Accident

ARS (Grade)	Number of patients	Body area	Early skin lesions (1986)	Late skin lesions	Basal Cell Carcinoma (BCC)
<b>I</b>	<b>5</b>	feet, LE, trunk, hands	Erythema, edema	Atrophy, pigment alteration, xerosis	
<b>II</b>	<b>6</b>	LE, UE, trunk + LE	Erythema, edema	Atrophy, pigment alteration, xerosis, keratosis, ulcers	
<b>III</b>	<b>9</b>	Combinations of the above	Erythema, edema, blisters, ulcers	Atrophy, pigment alteration, fibrosis keratosis, ulcers	
<b>IV</b>	<b>1</b>	trunk + extremities	Blisters, ulcers	Same as Grade III plus carcinomas	2 BCC lesions
<b>Non-confirmed group</b>	<b>1</b>				
<b>TOTAL</b>	<b>22</b>				

# Chronic Cutaneous Radiation Syndrome (CRS)



Patient N. In 1986 suffered from severe ARS (3rd degree) and moderate-severe acute skin damage (2nd - 3rd degree) of right foot. Essential keratosis and fibrosis. Nail bone of 1 finger was amputated in 1986, the focus with transplanted skin are well visible.

*Courtesy of Drs Belyi and Bebashko, Kiev, Ukraine*

# Chronic Cutaneous Radiation Syndrome (CRS)



Patient K. In 1986 suffered from severe ARS (3rd degree) and severe acute radiation skin damage of both shins (3rd degree). On the frontal surface foci of hyperpigmentation and telangiectasis are visible (15 years had passed)

*Courtesy of Drs Belyi and Bebeshko, Kiev, Ukraine*

# Chronic Cutaneous Radiation Syndrome (CRS)



Patient N. In 1986 suffered from severe ARS (3rd degree) and moderate acute skin damage (2nd degree) of right leg. After 15 years following skin changes dominate: telangiectasis, hyperpigmentation, keratosis, fibrosis.  
*Courtesy of Drs Belyi and Bebeshko, Kiev, Ukraine*

# Treatment Experience of Skin Injuries in Chernobyl victims

- **Systemic treatment**

*Hemoperfusion, plasmapheresis, continuous heparinization and administration of freshly frozen plasma*

- **Local treatment**

*Use of Combutec-2 for local treatment of skin injuries  
Aerosol Lioxanol  
Solution Balis-2*

- **Pain management**

*was challenging and not effective due to an absence of the local anesthetics in the treatment arsenal*

- **Necessity of surgical operations at an early stage**

*Guskova et al, 1988, Baranov et al, 1991, Selezneva, 1990, Barabanova, 2006*

# Non-radiological Health Effects

- Psychological effects
  - Can overwhelm radiological physical effects
  - Symptoms are similar for different radiation emergencies (different scales)
  - Need for comprehensive strategy directed to different population groups before/during/after an emergency

04.06.2005 14:27

Жвания: Слухи об изменении радиационного фона на ЧАЭС - не случайность



Министр по вопросам чрезвычайных ситуаций и по делам защиты населения от последствий Чернобыльской катастрофы Давид Жвания считает преднамеренным распространение слухов об изменении радиационного фона на Чернобыльской АЭС и объекте "Укрытие". "Это целенаправленная кампания. Я в этом убежден, но настаивать не могу, потому что не уполномочен", - сказал он.

Отвечая на вопрос, кому могли быть выгодны такие слухи, Жвания сказал, что он не хотел бы обвинять в этом Беларусь, но первая информация о возможных неполадках на ЧАЭС поступила из Гидрометеорологического центра Беларуси.

"...о том, что теплый воздух идет с территории Украины, и вероятнее всего, какие-то неполадки или как саркоф

Жвания для той какой-т

09.07.2005 | 12:39

## КОМСОМЛЬСКАЯ ПРАВДА в Белоруссии

Политика Мисс "КП" Форум Гостевая книга  
Экономика Проверка слуха  
Культура  
Жизнь  
Спорт

Выберите рубрику  
Выберите клуб  
Толстушка  
Страна "КП"

### Радиационный фон в норме!



В один голос ответили специалисты четырех ведомств на вопросы журналистов «Комсомолки». Но из-за чего тогда началась паника?

Звонки в редакции раздаются второй день: «Правда ли, что произошел выброс на одной из атомных электростанций, то ли в Чернобыле, то ли в России?»

Почему детей в детских садах запретили выводить на прогулки?»

Генеральный директор Объединенного института энергетики и ядерных исследований Вячеслав Кувшинов:

«Радиоактивные аэрозоли в воздухе не обнаружены. Уровень излучения 0,006-0,6 микрозиверта в час, это гораздо ниже нормы».

Главный санитарный врач Беларуси Михаил Римжа:

**“The largest public health problem unleashed by the accident is the mental health impact”**

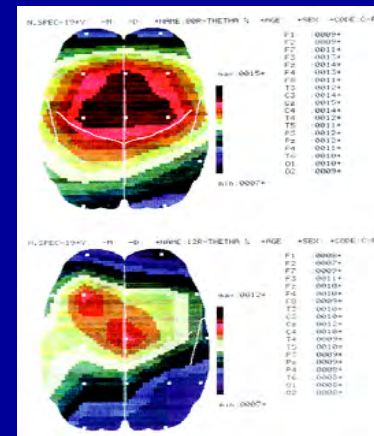
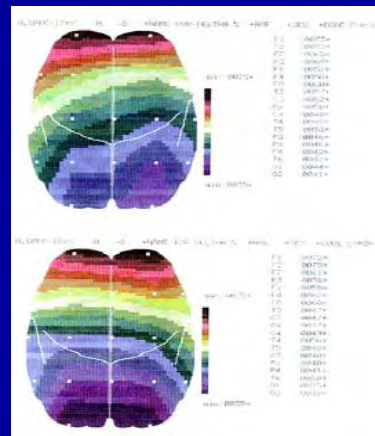
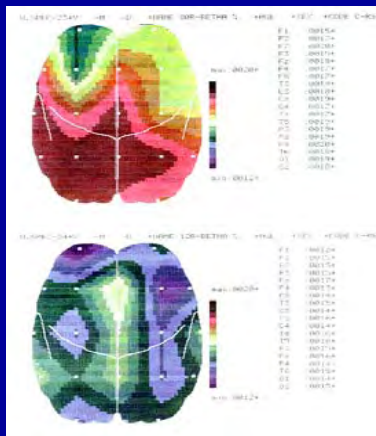
**(WHO report of the UN Chernobyl expert group, August 2005)**

- Stress-related symptoms
- Chronic Fatigue Syndrome
- Effects on the developing brain
- Organic brain disorders in highly exposed clean-up workers
- Suicide



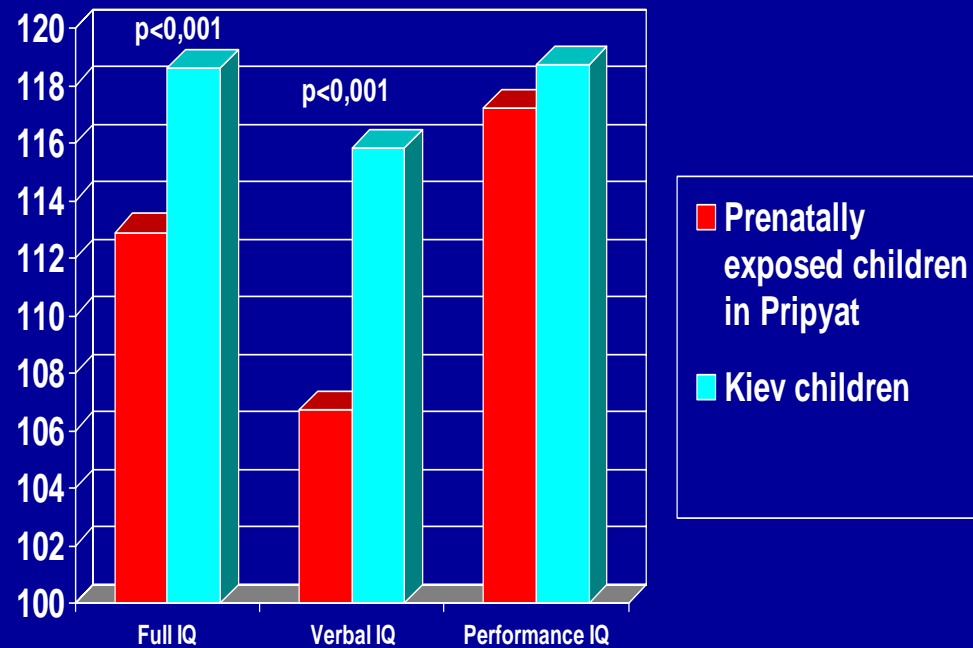
# Brain Damage in Clean-up Workers

“Today it is recognized that the Central Nervous System (CNS) is a radiosensitive organ whose degree of dysfunction can be quantified by electrophysiological, biochemical and/or behavior parameters. Abnormalities in CNS function defined by these parameters may occur at a low dose of whole body radiation”

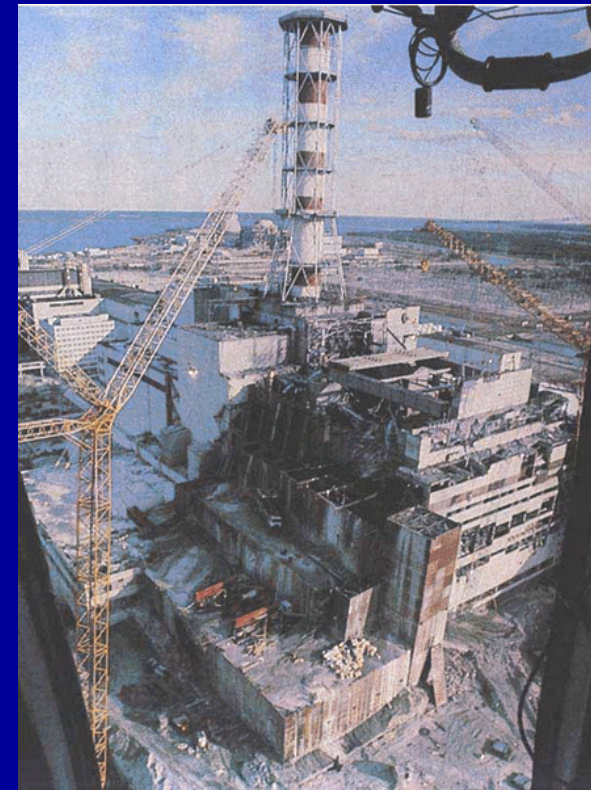
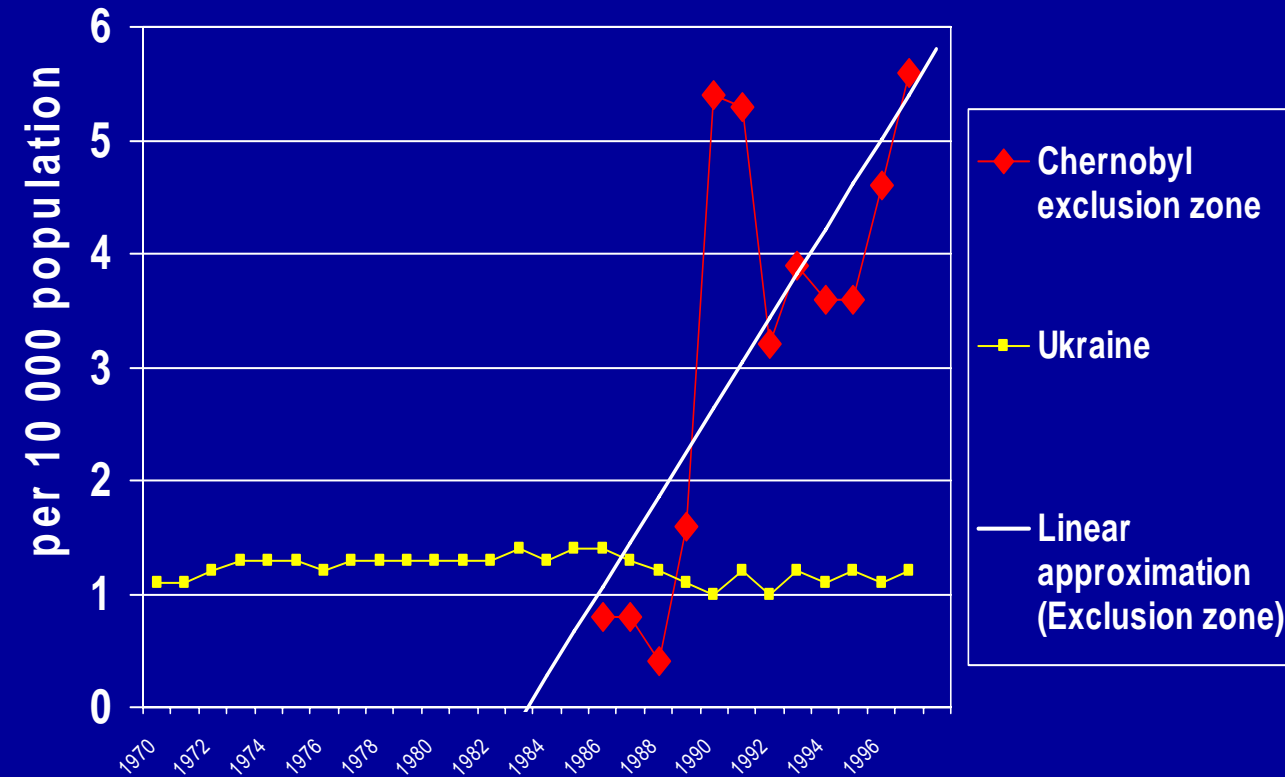


# Impact of Low Level Radiation on Brain Development

1. Children irradiated *in utero* in the first 4-5 months of gestation have:
  - reduced verbal IQ at age 11
  - ECG changes in the left hemisphere
2. Treatment with low dose radiation in infancy leads to neuropsychological disorders later in life



# Schizophrenia Incidence Excess in Chernobyl Exclusion Zone Personnel



At Issue: Schizophrenia Spectrum Disorders in Persons Exposed to Ionizing Radiation as a Result of the Chernobyl Accident by Konstantin N. Loganovsky and Tatiana K. Loganovskaja *Schizophrenia Bulletin*, 26(4):751–773, 2000.

# Neuro-Psychological Consequences: Summary

- Genetic predisposition to schizophrenia can be provoked by environmental stressors including effects of exposure to ionizing radiation

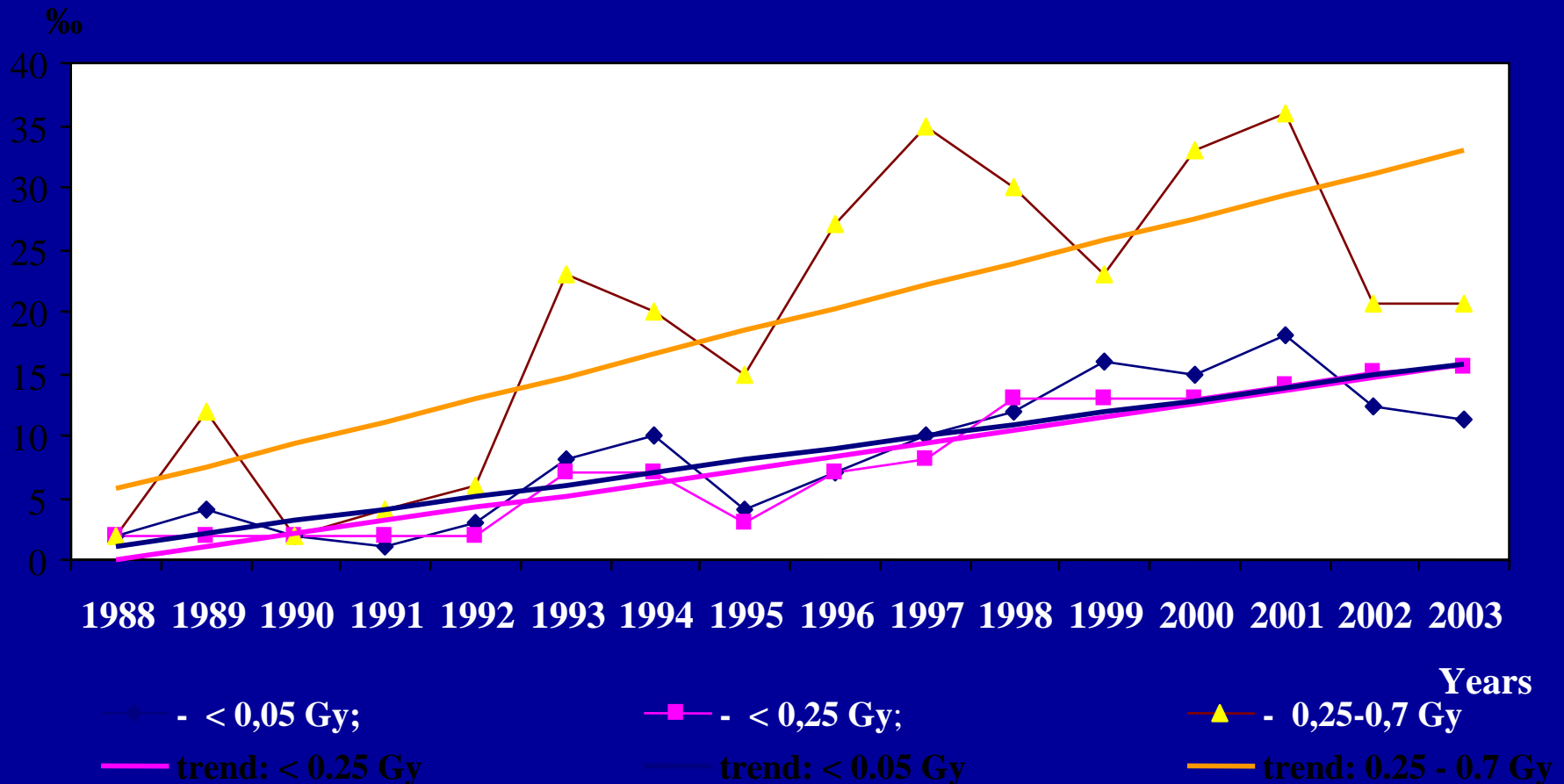
- Left hemisphere is the most radiovulnerable

- Neuroimaging abnormalities are revealed following exposure to **>0.3 Sv**



- The CNS effects that could be attributed to exposure to ionizing radiation are as follows: **schizophrenia spectrum disorders; Chronic Fatigue Syndrome; accelerated aging processes and neurodegeneration; and suicide**

# The risk of development of cerebrovascular diseases is higher in recovery operation workers with doses of 0.25 Gy and higher as compared to those with an exposure of less than 0.1 Gy



# Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (1)

- Cutaneous component of the ARS had significantly complicated the clinical prognosis and contributed to or caused death in patients
- Severe beta-burns of the skin remain an unsolved problem as a result of their spreading
- The severity of the skin damage could have been avoided by removing the contaminated clothing
- The prevention of late skin effects depends upon the effective management of acute lesions

# Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (2)

- Communications: who/how to contact, how to verify and confirm information
- Confidentiality: different understanding of what was classified and what was not, limited information available for International professional community
- Public health implications of the radiological accident: International significance was not as well understood as for communicable diseases incidents

## Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (3)

- The outcomes and late effects of the skin lesions depended on the depth-dose distribution and on the size of the area affected
- Radiation-induced fibrosis is a predominant clinical problem
- Appearance of secondary ulcerations presents treatment challenges
- No malignant melanoma or squamous cell carcinoma have been detected so far



"An accident has occurred at Chernobyl nuclear power station. One of the atomic reactors has been damaged. Measures are being taken to eliminate the consequences of the accident. Aid is being given to the victims. A government commission has been set up."

# Be clear of what you are trying to say!



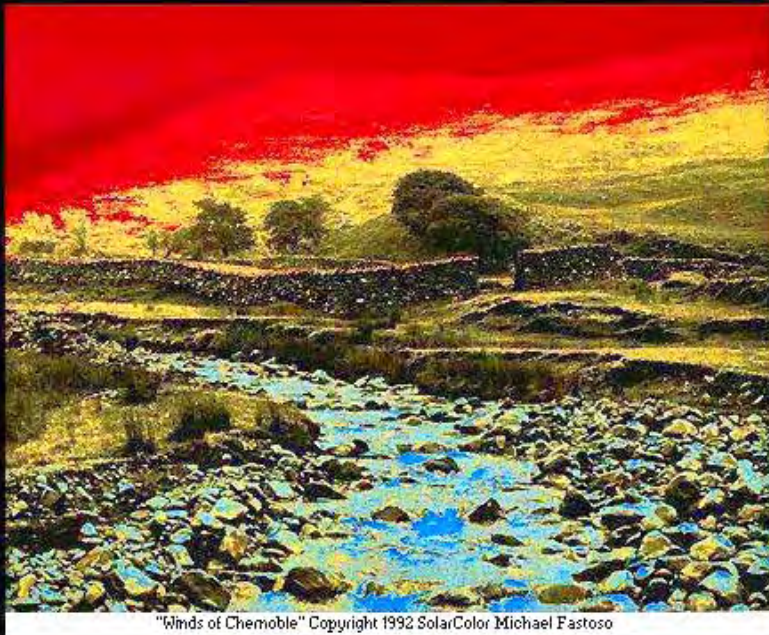
## Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (4)

- Effective medical care is generally **not possible** for accident victims with high-dose TBI
- Most individuals will not receive a sufficiently high dose to make a bone marrow transplant necessary for hematological recovery
- Only a small number of patients will have bone marrow syndrome **without** other life-threatening non-bone marrow related complication
- Transplants should probably be considered for victims receiving more than **7 to 8 Gy** of external radiation

# Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (5)

- Maximize the education of physicians
- Provide medical community with practical tools how to identify and assess radiation victims
- Explain situation in plain language and avoid conflicting information
- Stay in touch with collaborating centers in European and other countries experienced in managing radiation emergencies

# Invisible danger still exists



"Winds of Chernobyl" Copyright 1992 SolarColor Michael Fastoso



## What was the most unexpected for us?

- Diversity of clinical manifestations of skin lesions
- Unaccustomed course of clinical phases of a radiation injury to skin
- Significant severity of injuries
- Serious influence of skin burns on the general state of a patient
- Need for surgical interventions at an early stage



**LUCK FAVORS THE PREPARED!**

**Thank You!**

# Acknowledgements:

- M.Tronko, T.Bogdanova et al, G. Thomas et al, Institute of Endocrinology and Metabolism, Acad. Med. Sc., Ukraine; Swansea University, UK; University, Japan; Institute of Oncology and Radiology, Acad. Med. Sc., Ukraine”.
- D.A.Bazyka, V.G.Bebeshko, D. Belyi, A.E.Romanenko, V.A.Buzunov, A.E.Prysyazhniuk, K.M.Loganovsky, M.I.Omelyanets  
Research Centre for Radiation Medicine (Kyiv)
- Ihor J. Masnyk, Ph.D., NCI, Epidemiology Branch U.S. Director Chernobyl Research Projects
- M.N.
- Savkin, L.A. Ilyin, A.K. Guskova
- State Research Center – Institute of Biophysics, Moscow, Russia
- Albert L. Wiley, MD, PhD, Director, Radiation Emergency Assistance Center Training Site (REAC/TS)
- Patrick Gourmelon, T.M.Fliedner and V. Meineke, Institute for Radiation and Nuclear Safety (France), University of ULM (Germany)
- Pierre Flor-Henry, Konstantin Loganovsky, Alberta Hospital Edmonton, Canada, Research Centre for Radiation Medicine, AMS of Ukraine, Kyiv



# **Radioprotectants Currently Approved in Russian Federation**

## **ANTI-RADIATION FIRST- AID KIT CREATED**

### **Includes:**

- **INDRALIN – neutralizes Cesium and Strontium**
- **LIOXAZOL (spray) – for early treatment of radiation sickness and spray for skin burns**
- **ZASHITA (PROTECTION) – deactivation and protection of skin**

# Radioprotectants approved in Russian Federation (continued)

- **DEZOXYNATUM** stimulates the proliferation of hemopoetic cells
- **Chemical structure:** Sodium salt of DNA extracted from the milt of sturgeon species
- **Mechanism of Action:** stimulates proliferation of hemopoetic cells
- **Indication:** ARS, hypo-and aplastic anemia secondary to chemo or radiation therapy
- **Contraindications:** none
- **Side effects:** low grade fever (infrequent)

