

Late cancer and non-cancer effects of chronic radiation exposure of bone marrow

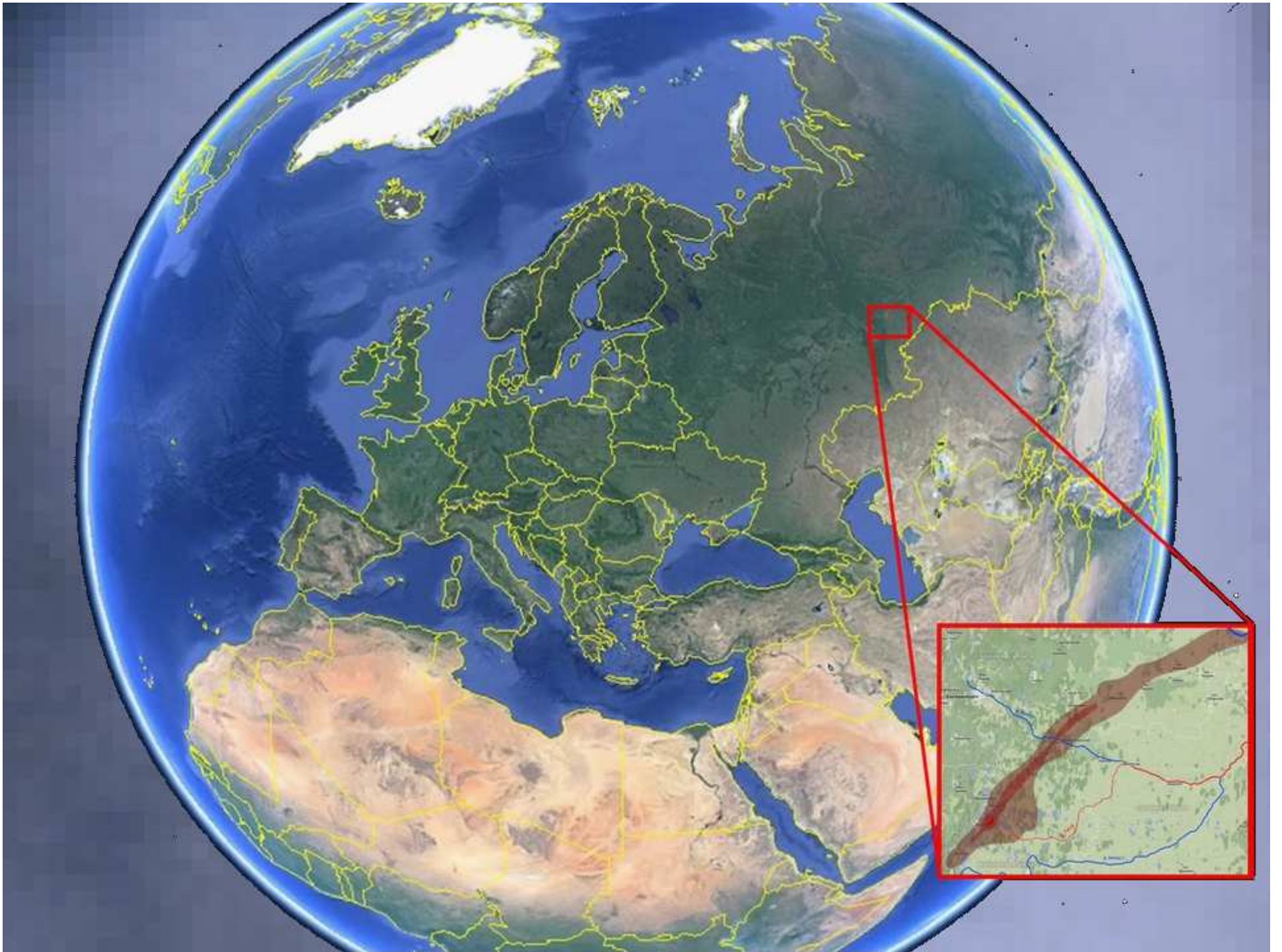
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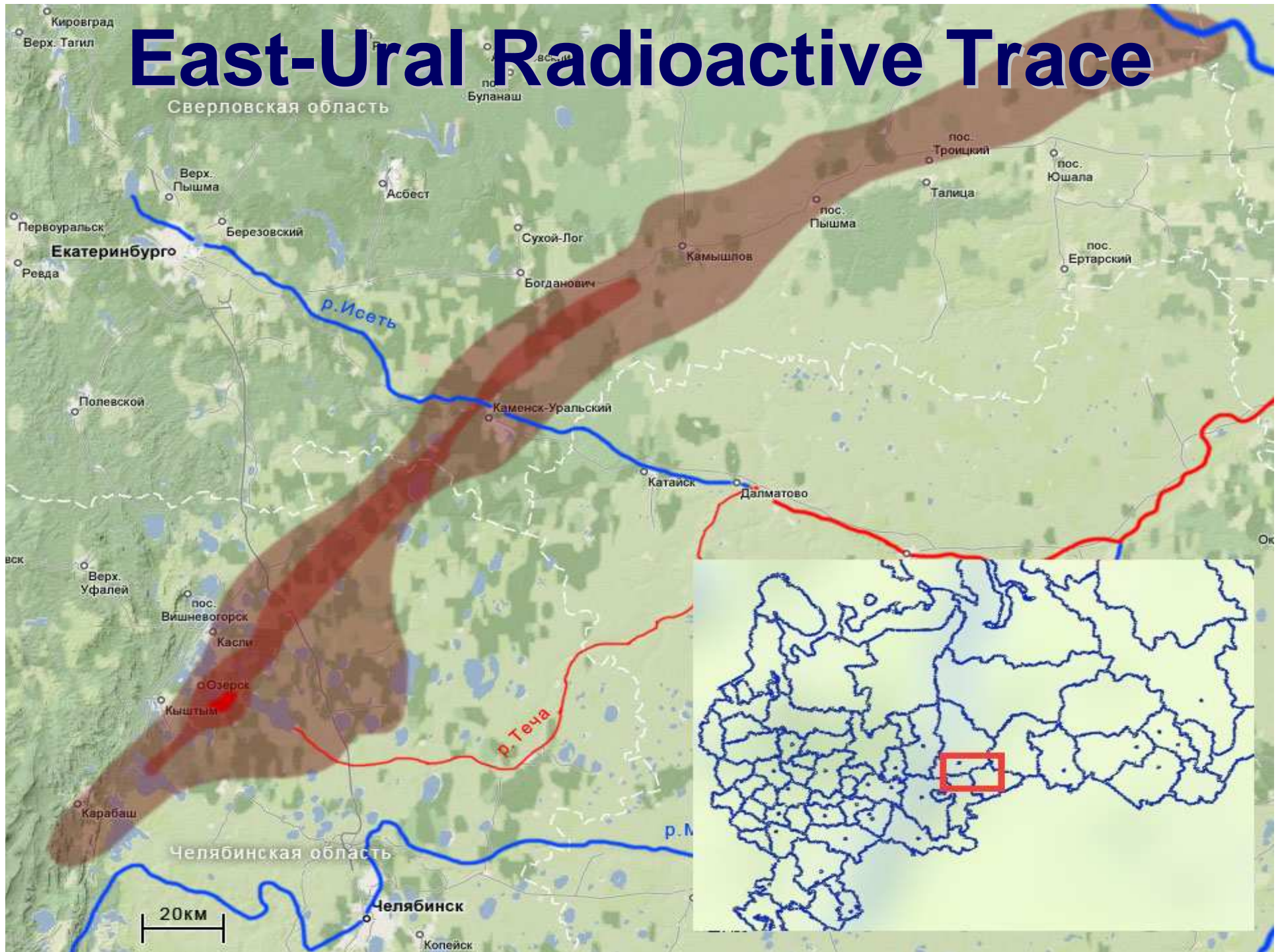
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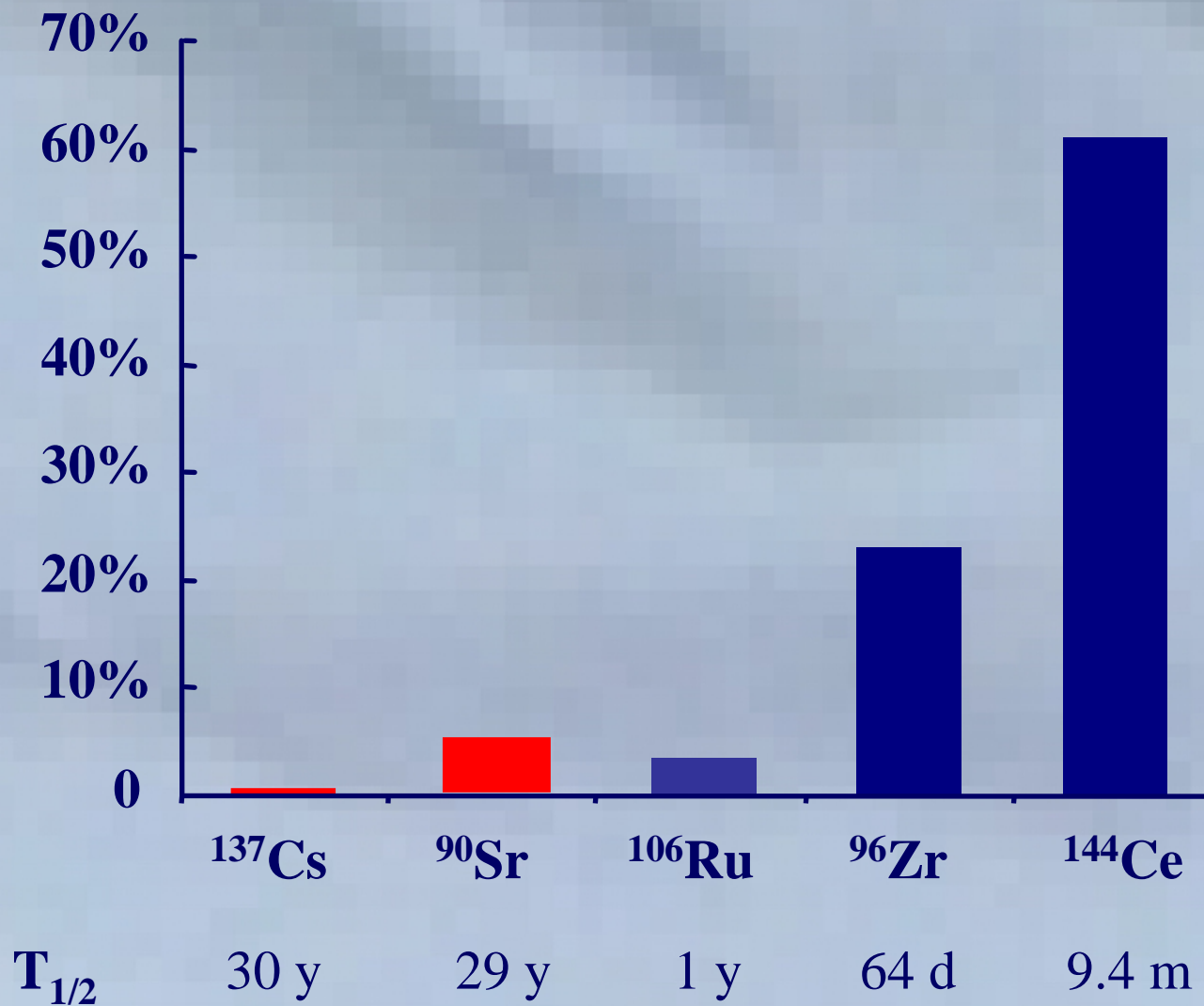
Ekaterinburg, Russia

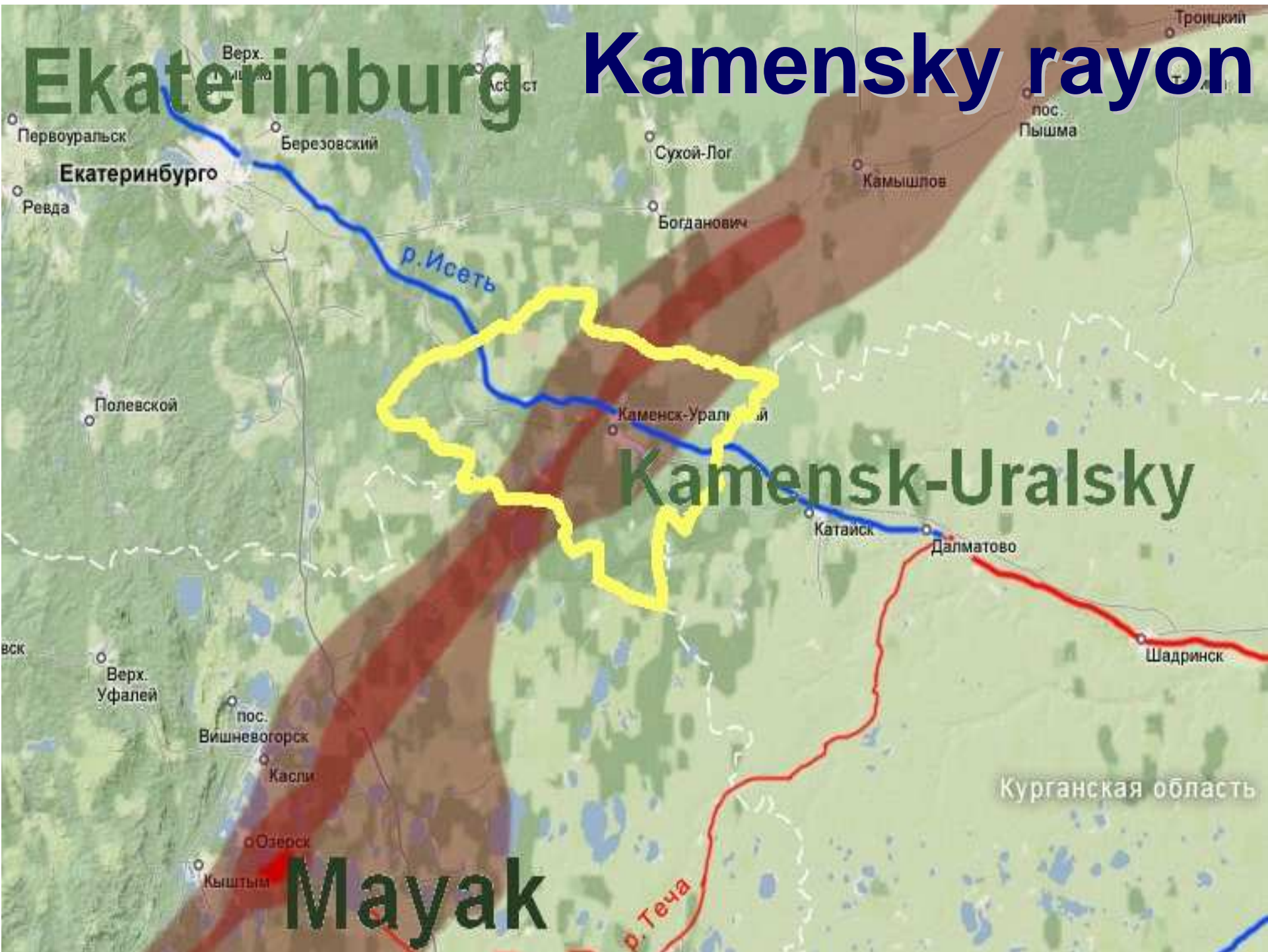


East-Ural Radioactive Trace



Composition of radioactive release





Kamensky rayon

Ekaterinburg

Kamensk-Uralsky

Mayak

Курганская область

р. Исеть

р. Теча

Kamensky rayon of Sverdlovsk oblast

- Rural population 30,000 (in 1957).
- Distance from epicenter of accident 80-130 km.
- Initial ^{90}Sr surface contamination 0.1-5 Ci/km² (3.7-185 kBq/m²).
- 50% of rural population turned out to live on contaminated territory.
- 3 rural settlements were evacuated.

Average doses and range of doses accumulated in organs and tissues, mGy

Organ	Age in 1957 > 20	Age in 1957 < 20
Bone surface	84 (9-290)	170 (4-850)
Colon	71 (11-230)	88 (11-390)
Red bone marrow	40 (5-140)	62 (3-250)
Lung	25 (2-105)	27 (3-99)
Stomach	10 (1-33)	10 (1-36)
Liver	10 (1-33)	8 (1-31)
Esophagus	6 (1-22)	5 (0.3-20)
Breast	6 (1-20)	5 (0.3-19)
Genitals (F)	7 (1-26)	6 (0.4-24)

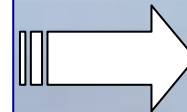
Archive data on mortality (death certificates)



Archive of Civilian
Registry Office.
> 60 rural settlements
of Kamensky rayon



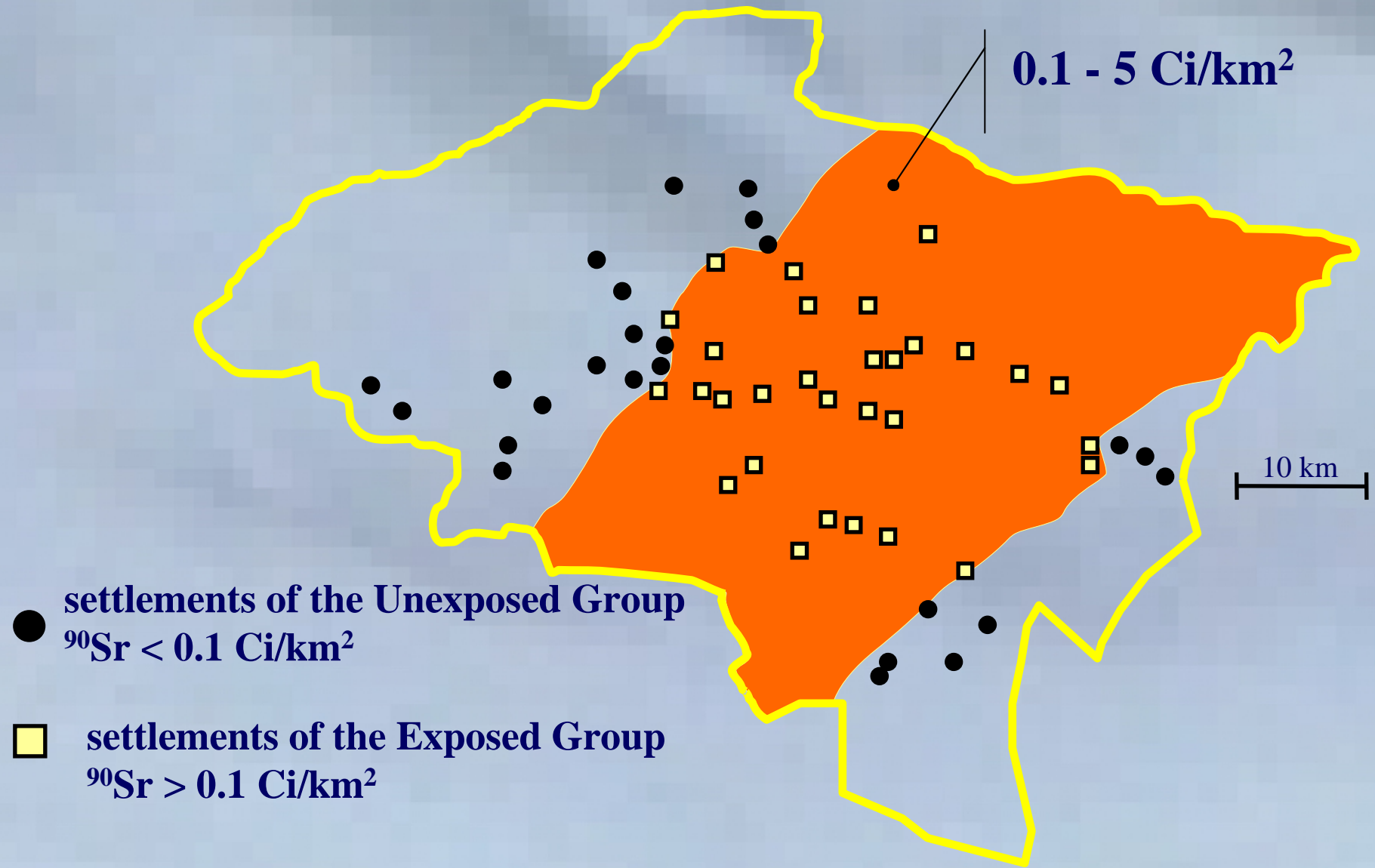
Identification
Sex
Year of death
Year of birth
Place of birth
Last place of
residence
Duration of
residence at
the last place
Cause of death



15 685
records
1954-2000

Register of causes of deaths

Radioactive contamination of Kamensky rayon by ^{90}Sr in 1957



Characteristics of exposed and unexposed groups

Characteristic	Exposed	Unexposed
Number of records male/female	5630 2716 / 2914	4606 2211 / 2395
Mean colon dose, mGy	73	4.6
Mean age in 1957	44.5	42.5
Percentage of age < 20 in 1957	10.3	11.3

Methods of analysis.

Proportionate mortality ratio (PMR)

$$PMR_i = \frac{n1_i / N1}{n2_i / N2}$$

where $n1_i$ and $n2_i$ are the numbers of deaths due to i -th cause in the exposed and unexposed groups respectively;
 $N1$ and $N2$ are the total numbers of deaths from all causes in exposed and unexposed group respectively

Methods of analysis.

Relative life lost (RLL)

$$RLL_i = \frac{\sum_i L(A1_i) / N1}{\sum_i L(A2_i) / N2}$$

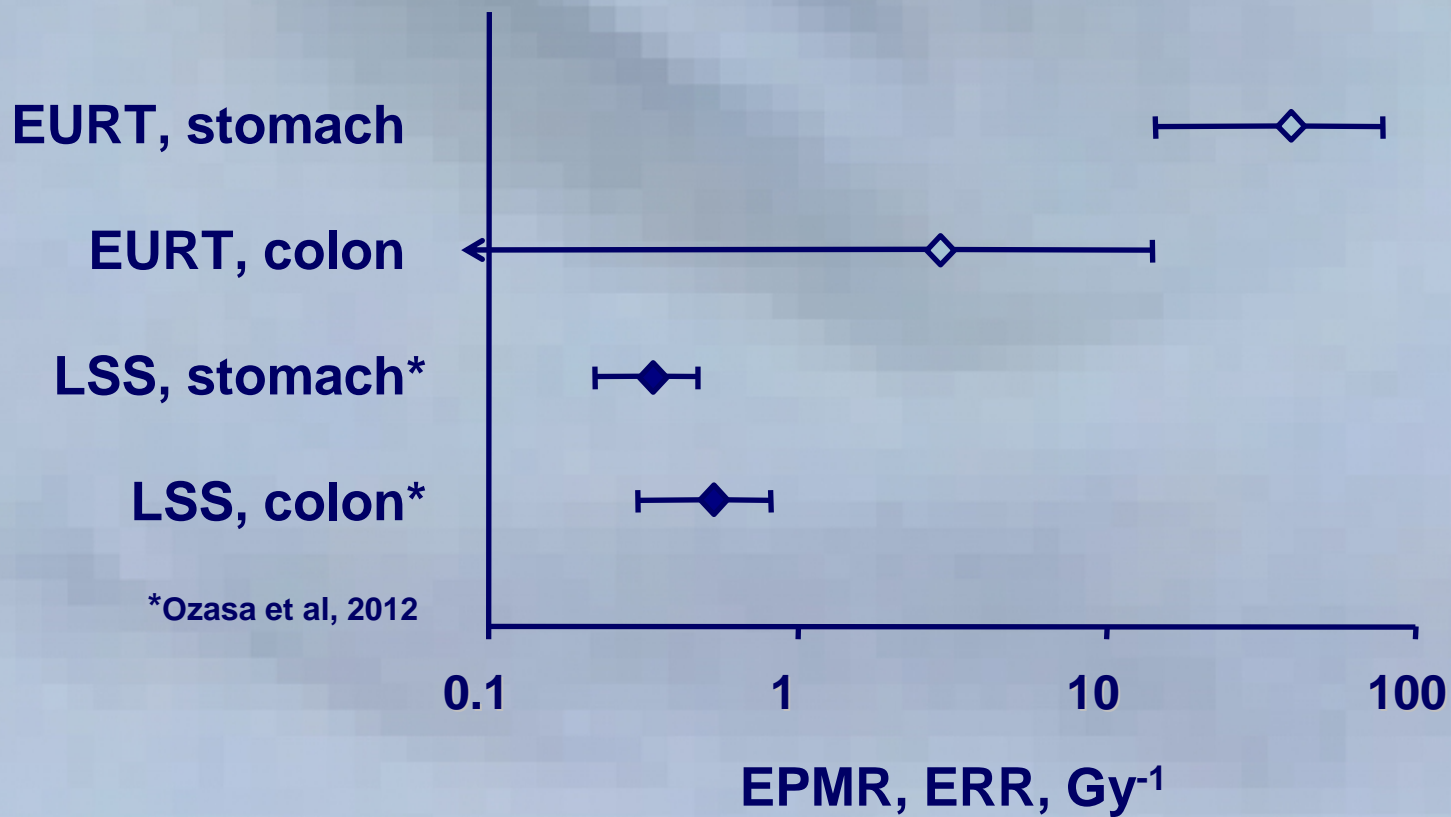
where $\sum_i L(A1_i)$ and $\sum_i L(A2_i)$ are total years of life lost from i -th cause of death in exposed and unexposed group respectively.

Results of estimation of PMR and RLL

Cause of death	$n1_i$	PMR (90% CI)	RLL (90% CI)
Stomach cancer	251	1.38 (1.14-1.75)*	1.50 (1.21-1.97)*
Lung cancer	209	1.17 (0.97-1.46)	1.20 (0.99-1.52)
Liver cancer	69	1.19 (0.86-1.9)	1.17 (0.88-1.72)
Colon cancer	56	1.21 (0.86-2.00)	1.35 (0.97-2.23)
Cervix cancer	50	1.04 (0.77-1.63)	1.06 (0.77-1.7)
Esophagus	33	0.93 (0.64-1.69)	0.98 (0.71-1.57)
Leukemia	25	0.73 (0.52-1.21)	0.92 (>0.68)
Bone cancer	16	1.30 (0.71-8.64)	1.63 (-)
Other cancers	152	0.91 (0.76-1.12)	0.83 (0.69-1.03)

*significant value (p<0.05)

Excess PMR (EURT) vs Excess RR (LSS)



Discussion

- 1) non-significant risk of colon cancer corresponds to the dose accumulated in the colon,
 - 2) significant risk of stomach cancer could not be associated with the dose accumulated in the stomach.
- Is the excess risk associated with EURT radiation exposure?

Some considerations

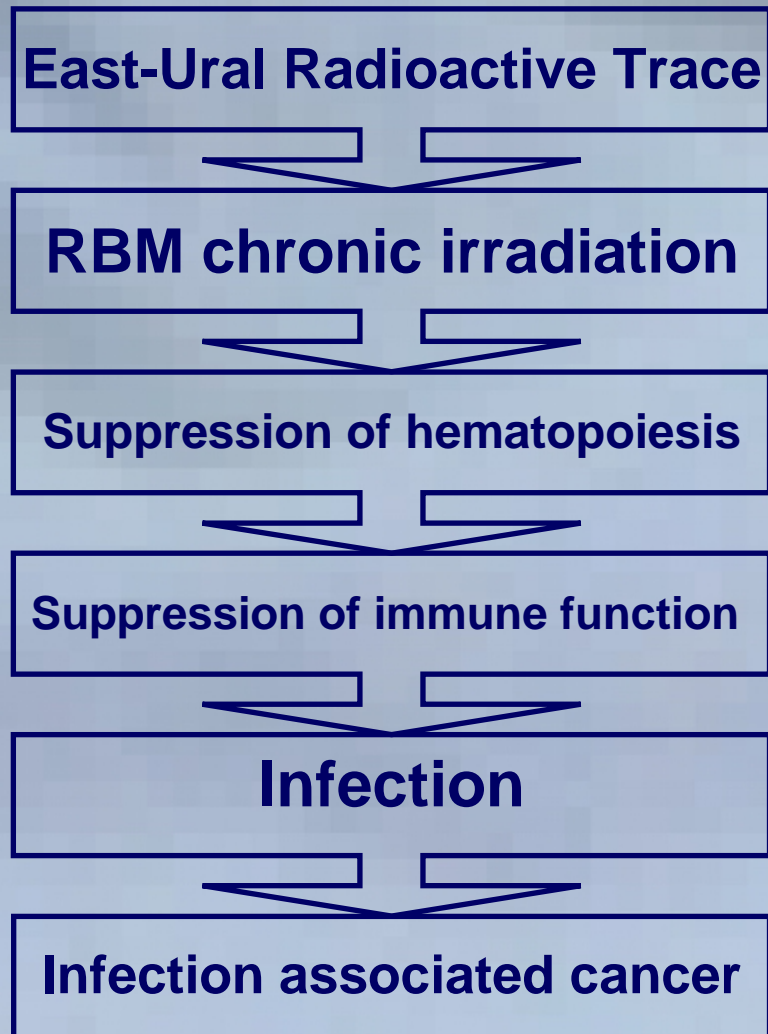
Risk factors	Cancer effects
Primary immunodeficiency	Stomach cancer, lymphoma.
Secondary immunodeficiency	Stomach cancer, liver cancer, sarcoma Kaposi, lymphoma.
Helicobacter Pilloiry	Stomach cancer (IARC: RR= 5.6).
Hepatitis B and C virus	Liver cancer (IARC: RR=23 and 17 respectively).
Human Papillomavirus	Cervix cancer (IARC: RR >100).

Discussion

Excess mortality due to the stomach cancer, liver cancer and cervix cancer can be associated with radiation induced immune suppression and increased susceptibility to infection.

Radiation induced suppression of immune function could be complicated due to low immune status of rural population in 1957.

Is there excess risk of non-cancer deceases of infectious etiology?



Non-cancer deceases of infectious etiology

The group include diseases from the following classes according to ICD 10:

- **certain infectious and parasitic diseases;**
- **diseases of the digestive system** (gastric and duodenal ulcer, appendicitis, cholelithiasis with cholecystitis and cholangitis, acute pancreatitis etc.);
- **diseases of the respiratory system** (pneumonia, acute respiratory infections, chronic bronchitis, emphysema, influenza etc.);
- **diseases of the ear and mastoid process** (purulent otitis);
- **diseases of the genitourinary system** (Pyelonephritis including uremia);
- **diseases of the musculoskeletal system and connective tissue** (osteomyelitis).

Results of estimation of PMR and RLL

Cause of death	$n1_i$	PMR (90% CI)	RLL (90% CI)
Non-cancer deceases of infectious etiology	401	1.32 (1.13-1.58)*	1.39 (1.17-1.71)*
Infection associated cancer	370	1.29 (1.10-1.54)*	1.33 (1.13-1.63)*

*significant value (p<0.05)

– infection associated cancer

Total years of life lost = $(1.31 \pm 0.72) \times 10^3$ years

Life lost per excess death = 16 years

– non-cancer deceases of infectious etiology

Total years of life lost = $(1.98 \pm 0.94) \times 10^3$ years.

Life lost per excess death = 21 years

Summary on health effect of chronic irradiation of EURT population (all cancer and non-cancer effects)

Period of time, age in 1957	Number of deceased	Excess deaths	Total years of life lost
1958-2000, all ages	810	171±71*	(3.33±1.25)×10 ³ *
1968-2000, all ages	463	98±51*	(1.56±0.81)×10 ³ *
1981-2000, all ages	223	5±37	(0.08±0.52)×10 ³
1958-2000, younger 20	116	25±27	(1.00±0.75)×10 ³ *

*significant value (p<0.05)

Conclusions

Excess mortality of EURT rural population due to infection related cancer and non-cancer diseases can be associated with chronic radiation exposure.

Possible biological mechanism comprises chronic irradiation of bone marrow due to incorporated ^{90}Sr and alteration of anti-infection immunity.