

## Study of malignant neoplasms of the genitourinary system among Chernobyl accident emergency workers over Russian Federation in 1987-1996

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Data of Russian National Medical and Dosimetric Registry (RNMDR) on morbidity of malignant neoplasms of the genitourinary (GU) system among males taken part in clean-up work in the 30-km zone around the Chernobyl NPP were used in the paper. Malignant neoplasms (213 cases) of the GU system detected among clean-up workers (liquidators) were included in the study. The purpose of the work is to study the effect of radiation on disease rates, incidence ratio, time-trends for morbidity and mortality of the diseases of interest. We tried to examine relationship between risk factors (external radiation dose, age at arrival in the zone, duration of stay in the zone, age at diagnosis, time interval between the work and the diagnosis) and morbidity, disability and mortality due to malignant neoplasms of the GU system among liquidators. Cumulative morbidity rates for GU malignant neoplasms among liquidators, standardized rates for neoplasms of specific site for the period 1987-1996 were computed. The rates were compared to data on males of Russia developed malignant neoplasms of the GU system of 1995. Relationship between radiation dose and cancer incidence was not evident. Morbidity rate among liquidators with the highest radiation dose was not the highest, however it exceeded magnitudes of rates for 4 of 6 dose groups of lower radiation doses. The Mean dose to liquidators who developed GU cancer is equivalent to one dose to liquidators of 1986-1987 (122.7 mGy and 123 mGy respectively). More than 70% of GU cancer cases are under 50 years of age. The layout number of cases are in the age group of 40-49 years. The mean age of the cases at diagnosis is 45.2 years. They are 13.6 years younger than Russian males with GU cancer. Kidney cancer was detected in 48.4% of GU cancer cases. Standardized rates for incidence and mortality due to malignant neoplasms of the GU system among liquidators is reliably higher compared to Russian males with GU cancer in age groups under 50 years.

### Introduction

To minimize the consequences of the Chernobyl accident, a large number of professionals were involved in clean-up work. Most of them were exposed to harmful factors such as ionizing radiation, hard and intensive labor and permanent stress. The radiation doses to clean-up workers are up to 250 mGy (the average dose is 105 mGy) [1, 2]. That is why the cohort of emergency accident workers (liquidators) can be considered as optimal group for study of possible health effects of low radiation doses to a human body at the population level.

Malignant neoplasms of the genitourinary (GU) system were selected for the study because the radiation dose to the organs of the system can be higher than to other tissues because the most number of substances including radionuclides that are eliminated from a body are accumulated in kidneys. They form additional radiation dose to tissues of the urinary tract. Gonads are radiosensitive glands; therefore radiation can be considered a carcinogenic agent for the GU system.

### Purposes of the study

The purpose of the work is to examine incidence of malignant neoplasms of the GU system among liquidators, as well as the effect of radiation on disease rates, incidence ratio, time-trends for morbidity and mortality of the diseases of interest.

Objectives of the study are as follows:

1. Descriptive analysis of the cases with regard to possible risk factors for the development of a tumor (dose received, date of arrival in the area of the accident, duration of stay in the area).

2. Study of special features of prevalence of malignant neoplasms of the GU system among liquidators: age-specific distribution of cases, annual incidence rates, and circumstances of detection of a tumor, opportune detection of a tumor, effect of screening.

3. Analysis of standardized incidence and mortality rates for malignant neoplasms of the GU system among liquidators for the period from 1987 through 1996 compared to Russian males with GU cancer.

### Materials and methods

The source of information is the data of Russian National Medical and Dosimetric Registry (RNMDR) on 162658 males who performed clean-up work following the Chernobyl accident and have been followed for about ten years at the hospitals at their places of residence. More than 81% of them worked at the Chernobyl NPP in 1986-1987. Data on received

External radiation doses have been taken from records of dosimetric measurements performed in the course of clean-up work.

A case is defined as a person who has developed a cancer in the gastro-urinary system (GU). Each case was especially examined. The sources of information are databases of RNMDR and cancer-registry of RNMDR as well as extracts from files of local health care institutions. The extracts consist of the conclusion of the urologist (oncologist), records of the case history, full pathology reports, the protocols of autopsy, the registration of death at Registration offices, etc.

Intensive incidence rates for dose and age-specific groups of cases were used to make comparative analysis. The frequency of occurrence of tumors of specific site and mortality rates was analyzed with the use of annual coefficients. Age-specific incidence coefficients are expressed as the ratio of the integrated number of cases detected in an age group for 10 years to the sum of person-years (PYs) of the group members. Standardization of calculated rates was performed by the direct method in accordance with the age-specific distribution of males of Russia of 1995. Calculation, standardization and comparison of mortality rates from disease under study were made by direct method as well.

### Results of the study

A case is defined as a person in an inspection of each case allowed us to recognize 213 GU cancer

cases among liquidators of 1987-1996, which were included in the study. We considered the following risk factors: the dose received due to the work at the Chernobyl NPP, date of arrival in the 30-km zone, the duration of stay at the Chernobyl NPP, the age of liquidators at the time of arrival in the zone. All cases were grouped in accordance with the criteria. The cases with well-known external dose are attributed to a dose-specific group. These groups ranged to 250 mGy. In 81 cases (57.9%) the dose is less than 100 mGy (Fig. 1).

The layout number of cases (48 persons or 34.3%) are in a dose group less than 50 mGy, 33 persons (23.6%) are attributed to dose group of 50-99 mGy. Approximately equal numbers of cases are in the following dose groups: 100-149 mGy, 150-199 mGy, 200-249 mGy (18, 17 and 21 cases respectively). Three cases had a dose higher than 250 mGy (250, 289, 617 mGy respectively). In 73 persons (35.3%) doses are not conclusively established. The mean dose in the cohort of liquidators with established dose is 122.7 mGy.

Figure 2 shows one-incidence rates of malignant neoplasms of the GU system in a dose-specific group. The fewer incidences are in a dose group ranged between 50 mGy and 99 mGy. The highest incidence is in the group of 100-149 mGy. There is no evident relationship between the dose and the incidence rate.

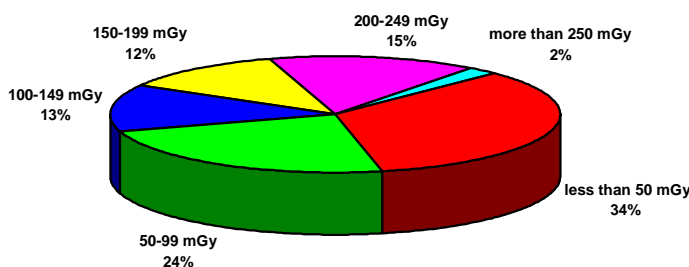
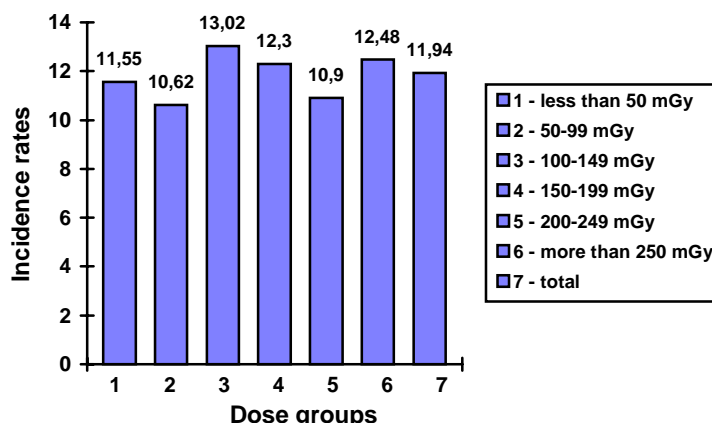


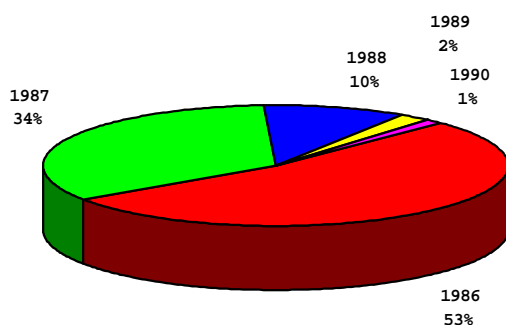
Fig. 1. Distribution of liquidators with established diagnosis malignant neoplasms of the GU system by dose groups.



**Fig. 2.** Incidence rates (per 100,000 PYs) of malignant neoplasms of the GU system among liquidators in dose-specific groups.

The layout number of cases worked in the zone around the Chernobyl NPP in 1986, (107 persons). One third of them, 36.44% worked in the first month after the accident (April-May, 1986) (Fig. 3). About 32% of cases (62 persons) worked at the Chernobyl

NPP in 1987, about 9% - in 1988, seven cases (about 3%) made clean-up work in the following two years. So, 82.2% of cases worked at the Chernobyl NPP in 1986 and 1987, 12.6% of cases worked in the following three years.



**Fig. 3.** Distribution of liquidators with malignant neoplasms of the GU system by date of arrival in the 30-km zone of the Chernobyl NPP.

The duration of stay within the zone varied from 3 to 314 days in 1986, from 13 to 265 days in 1987, from 44 to 335 days in 1988, from 60 to 134 days in 1989, from 9 to 90 days in 1990. 22.7% of cases stayed at the zone less than one month, 25.7% - 1-2 months, 28.2% - 2-3 months. About 77% of the cases worked less than 90 days. Only 11 persons (5%) worked at the Chernobyl NPP more than 6 months.

The distribution of liquidators with cancer detected after their work at the Chernobyl NPP by age at arrival is given in Figure 4. In 70.4% of cases the age at arrival was 30-49 years, of them 103 individuals (48.37%) were less than 40 years of age. The average age of the cases is 39.47 years.

The layout numbers of cases (55 or 26.75%) were at the age of 40-44 years at diagnosis and at the age of 45-49 years (50 cases or 24.3%) (Fig. 5). Average age at diagnosis is 45.2 years.

Although there is a latent period, which is characteristic for the development of the disease, 8 cases were detected in 1 year after their arrival in the zone (Fig. 6). Sharp increase in number of detected GU cancer cases (from 5 to 31 cases per year) was observed within the period of 2-6 years after arrival at the zone. Within the period from 7 to 9 years after beginning of the clean-up work the number of detected cases was stable and high. After that period it declined to 13 cases per year.

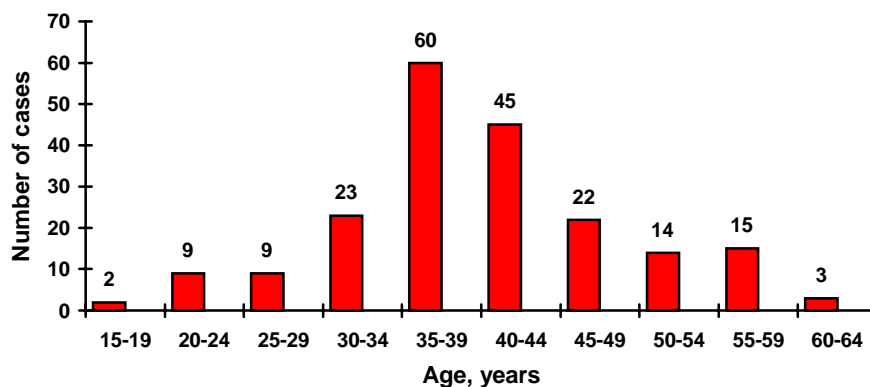


Fig. 4. Age of the cases at the time of arrival in the zone of Chernobyl NPP.

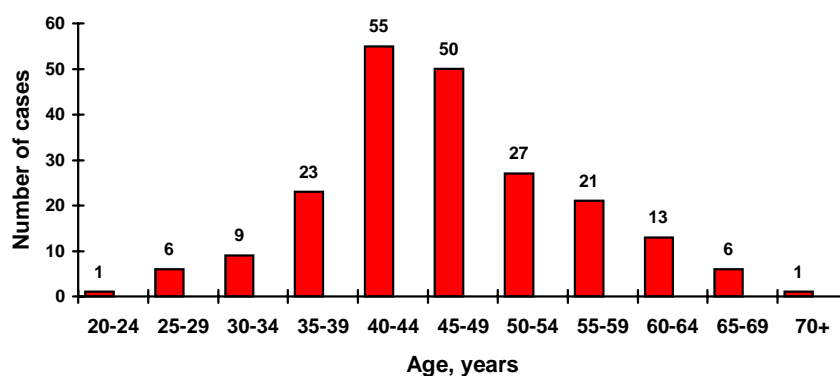


Fig. 5. Age of the cases at the time of diagnosis.

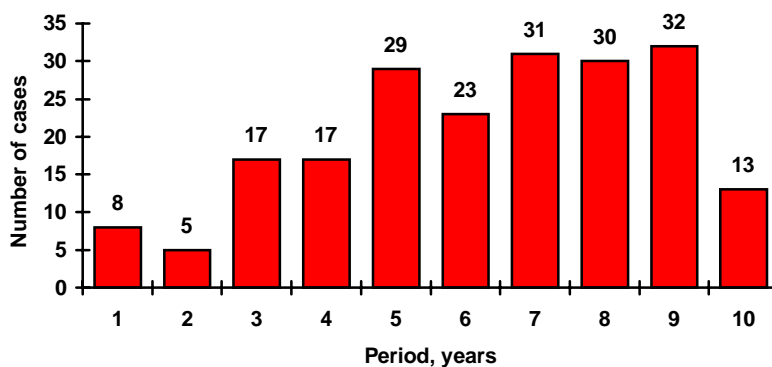
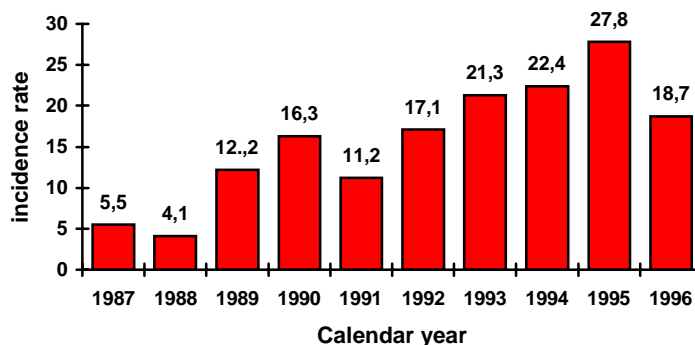


Fig. 6. Distribution of the cases by the time passed from their arrival in the zone of Chernobyl NPP to the diagnosis.

In the first five years after the clean-up work at the Chernobyl NPP, a GU cancer was detected in 76 liquidators; it was 37% of the studied cohort. In 7 cases the interval between work and diagnosis is not conclusively established. The average interval is 6.3 years.

Annual incidence rates began to grow in 1991 and continued until 1995. From 1991, (Fig. 7). For that period the incidence rate increased by 2.5 times. In 1996 the rate declined.

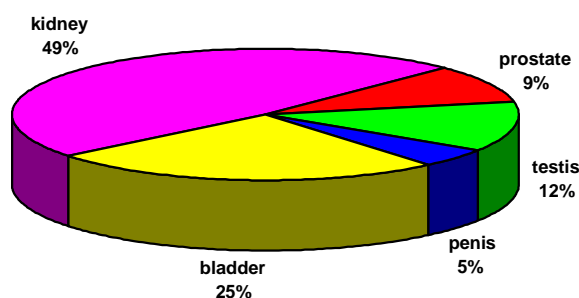


**Fig. 7.** Incidence rates of malignant neoplasms of GU system (per 100 thousand persons) by calendar years.

Figure 8 gives information fraction of malignant neoplasms of GU system that occur in each site. The most cases develop kidney cancer (103 cases, 48.4%), bladder cancer was diagnosed in 54 cases (25.35%), testis cancer was detected in 26 cases (12.2%), and prostate cancer and penis cancer was detected in 9.4% and 4.7% of cases respectively.

The study of mortality rates due to GU malignant neoplasms is a key problem. As seen in Table 1, 72

cases (33.8% of cohort causes) have died. Among them 4 deaths were due to other than GU cancer was the causes. Malignant neoplasm was the main cause of death in 68 cases (32.2%). The highest mortality (60%) was among prostate cancer cases, 39.8% of deaths were caused by kidney cancer, 38.5% of cases died from testis cancer. The lowest mortality was from bladder cancer (16.7%). Penis cancer was not fatal.



**Fig. 8.** Fraction of malignant neoplasms of GU system among liquidators in each site.

**Mortality due to GU malignant neoplasms among liquidators**

**Table 1**

Specific cancer site	Number of cases	Number of deceased cases
Malignant neoplasms of GU system	213	72 (33,8%)
Prostate cancer	20	12 (60%)
Testis cancer	26	10* (38,5%)
Penis cancer	10	0
Bladder cancer	54	9 (16,7%)
Kidney cancer	103	41**(39,8%)

\* - 1 case died from other cause; \*\* - 3 cases died from other causes.

We compared standardized incidence rates in the cohort with those for males of Russia in the year 1995 [3]. We compared rates for cancer of a specific site and of the GU system as a whole.

We compared all the standardized incidence rates for liquidators male with the rates for males of Russia of relevant age groups of 1995, (Fig. 9). In age groups under 45 years the standardized incidence rate for cancer among liquidators is higher than the Russians in the same age group. However, standardized rate among liquidators of 50-54 years of age and those over 60 years is lower than the Russian males with the same disease. Exception is liquidators of 55-59 years of age.

We have compared the rate for the mean age of cases at diagnosis for the whole period of study and males of Russia of 1995 with the GU cancer. On average, cases are 13.6 years younger than GU cancer male-patients in Russia of 1995 (Fig. 10). The difference between ages is as follows: 3.7 years for testis cancer patients, 19.2 years for penis cancer patients, and 19.7 for bladder cancer cases.

Comparative age-specific data on mortality caused by GU cancer are given in Figure 11. Mortality rates for cases under 50 years of age are higher compared to male-patients of Russia in the same age groups. In older groups mortality rate is less in liquidators than in GU cancer male-patients of Russia.

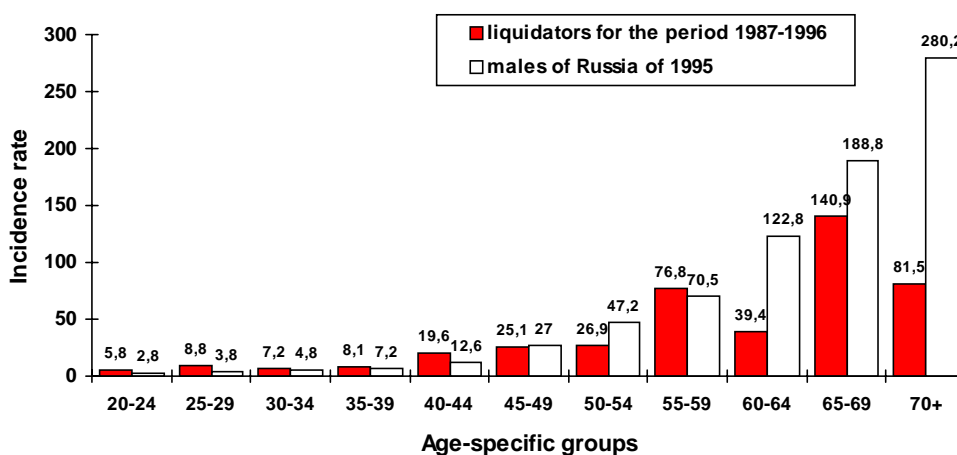


Fig. 9. Standardized incidence rates (per 100,000) of malignant neoplasms among liquidators for the period 1987-1996 and males of Russia of 1995.

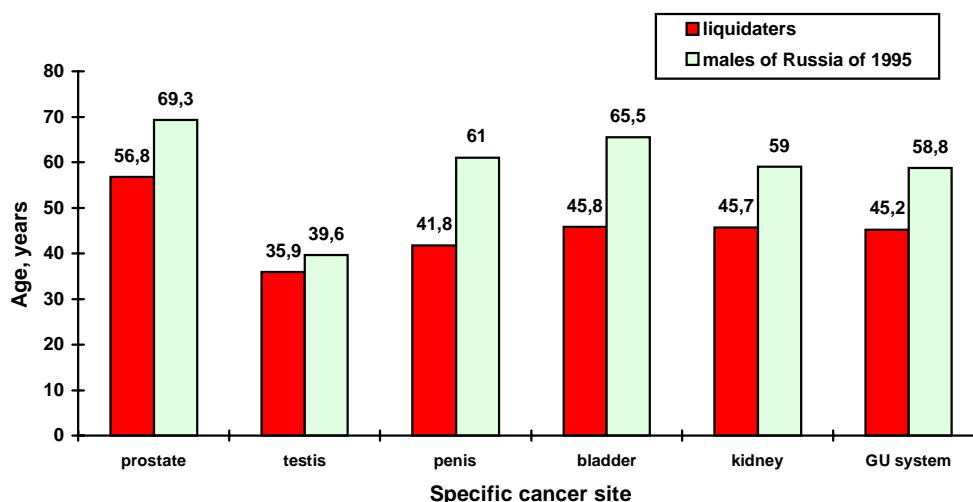
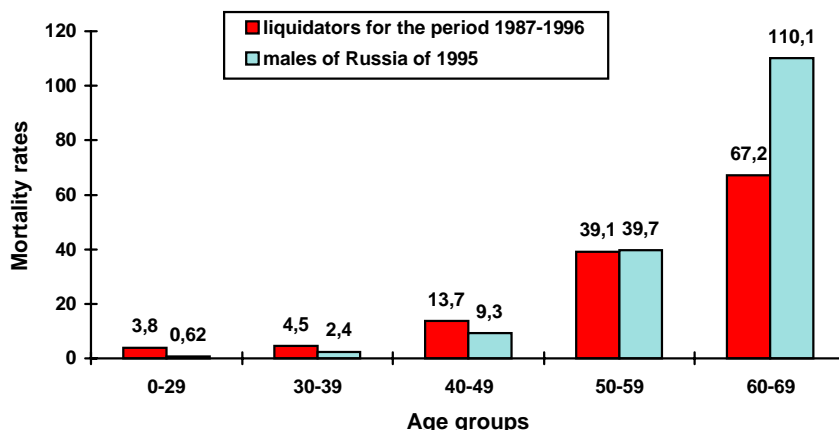


Fig. 10. Mean age of cases at diagnosis for the whole period of study and males of Russia of 1995 with GU cancer.



**Fig. 11.** Standardized rates (per 100000 persons) of mortality from malignant neoplasms of GU system among liquidators for the period from 1987 to 1996 and males of Russia of 1995.

## Discussion

In this paper all cases of malignant neoplasms of the GU system among liquidators detected for decade after the Chernobyl accident are analyzed. We have found that the incidence rate among clean-up workers with radiation dose less than 100 mGy is lower than that among liquidators with higher doses. It might be explained by the re-distribution of radionuclides particularly  $^{137}\text{Cs}$  entered a body. Caesium eliminates from a body with urine (90%) and faeces (10%) [4]. Thus the genitourinary system gets an especially large radiation dose.

The higher incidence rate among liquidators in comparison with Russian male-patients who developed GU cancer can be partially caused by the extent and the quality of clinical examination of liquidators. It was stated that liquidators at the time of diagnosis are 13.6 years younger than males of Russia with GU cancer. It should be stressed that there is some difference in age distribution of examined liquidators and males of Russia. Moreover, in Russia the number of newly detected prostate and bladder cancer cases of grade I and II was 32.5% and 39.2% respectively in 1996 [5]. In the cohort the number of prostate and bladder cancer cases detected was 16.6% and 33.3% respectively. The average time interval between the beginning of the work in the 30-km zone and the diagnosis is 6.3 years.

The average age of liquidators at diagnosis is 45.2 years. In about 70% of cases the age at diagnosis was under 50 years. This fact allows us to say that because occurrence of GU cancer is more frequent among liquidators than males of Russia of the same age special actions towards earlier detection of malignant neoplasms of the GU system in liquidators older than 35 years of age should be undertaken. As it was said previously [6], special attention should be paid to liquidators of 40-49 years of age.

Liquidators develop kidney cancer (48%), testis cancer (12%), penis cancer, (5%) more frequently than males of Russia (26%, 4% and 2% respectively). Specific diagnostic methods, which allow detection of

neoplasms at the above sites, should be used. Testis cancer and penis cancer can be detected by palpation and visual examination.

In conclusion it should be said that the decreased incidence rates of malignant neoplasms of the GU system in 1996 could be caused by a phenomenon of delaying or due to inertia, which is characteristic to any large-scale registration system.

Though the findings of the study are preliminary, we have traced "rejuvenation" of GU cancer among liquidators compared to males of Russia. Standardized incidence rates for malignant neoplasms of the GU system among liquidators are higher than that among males of Russia. Prostate cancer is an exception. However, it is impossible to say conclusively that detected GU neoplasms in liquidators are associated with radiation. Further studies and new data will be helpful for clarification of existence of the radiation risk for GU malignant neoplasms among liquidators.

## Conclusions

1. An association of GU malignant neoplasms in liquidators with radiation is not shown the Incidence rate per 100,000 PYs is higher in the dose group of 100-149 mGy, 13.2, the least incidence rate is 10.6, in the group of 50-99 mGy.

2. The mean external dose to cases exceeds the mean dose to liquidators (122.7 mGy and 109 mGy respectively).

3. Liquidators develop kidney cancer (48%), testis cancer (12%), penis cancer, (5%) more frequently than males of Russia (26%, 4% and 2% respectively).

4. Liquidators at the time of diagnosis of malignant neoplasms are 13.6 years younger compared to males of Russia. This suggests one possibility for improvement of screening and rehabilitation of this group of the population.

5. The standardized GU cancer incidence and mortality rates among liquidators of 1986-1987 are higher than those among males of Russia of 1995. 33.8% of cases died, GU cancer was the first cause of death in 32% of cases.

6. "Rejuvenation" of GU cancer among liquidators (on average the cases were 13.6 years younger compared to Russian males) is a problem of great concern. In this connection the system of screening for GU cancer and rehabilitation of liquidators should be improved.

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