



BY0000308

Health Status and follow-up of the liquidators in Belarus

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Abstract. This paper presents information on the organisation of the follow-up of Chernobyl liquidators in Belarus. The characteristics of the liquidators cohort and results of preliminary analyses of their health status, including cancer incidence and general morbidity, are presented.

1. Introduction

The data presented in this paper were obtained from two health registries functioning in Belarus: the State Registry of Individuals Exposed to Radiation as a Result of the Chernobyl Accident (which is referred to as the "Chernobyl Registry") and the Belarus Cancer Registry.

The Chernobyl Registry has functioned in Belarus since 1987. It was established by a directive of the Ministry of Public Health of the USSR as a comprehensive registration and follow-up system for the persons most affected by the Chernobyl accident. The directive identified four groups of subjects - the groups of "primary registration" - for whom registration and follow-up was mandatory. Group 1 consists of participants in the "liquidation" of the consequences of the Chernobyl accident, the so-called "liquidators" or clean-up workers. Information contained in the Chernobyl Registry includes demographic ("passport") variables, including the group of primary registration, information on location and behaviour (food and milk consumption, time spent in contaminated zones) around the time of the accident and work in the Chernobyl area, dosimetric information (when available) and medical information, updated periodically to include the results of the obligatory annual medical examination and all diagnoses and treatments made at the raion (district) and oblast (region) levels (from local dispensaries and clinics), as well as at the state level (from republican clinics and institutes).

The central Cancer Registry began functioning in Belarus in 1973. Data are available on magnetic tapes since 1978. Until 1985, however, the information stored in the computer files did not include the names and addresses of the cancer patients. In 1985, a computer

Table 1 Distribution of Belarus liquidators by place of work, sex and duration of stay in contaminated area

| Place of work | Duration (days) | Men | Women |
|---|-----------------|--------|-------|
| 30 km zone | less than 30 | 15 541 | 2 117 |
| | more than 30 | 12 424 | 1 119 |
| | Total | 27 965 | 3 236 |
| Area with Cs ¹³⁷ contamination level greater than 555 kBq/m ² | less than 30 | 3 953 | 1 182 |
| | more than 30 | 8 110 | 1 228 |
| | Total | 12 063 | 2 410 |

system of dispensary control for cancer patients was set up in the oncological dispensaries of Belarus. This system facilitated long-term prospective data collection on, and follow-up of cancer patients. Since 1991, this system has functioned on personal computers in all the oncological dispensaries in the country. The Belarus Cancer Registry registers all cases of malignant neoplasms, including diseases of lymphatic and hematopoietic tissues, and carcinoma in situ.

2. Characteristics of the Belarus Liquidator Cohort

At the beginning of 1995, more than 63 thousand liquidators were registered in the Belarus Chernobyl Registry. Place of work in the Chernobyl region was known for 45 674 of them (the results presented in this paper are restricted to this sub-cohort). Among these, 31 201 liquidators worked in the evacuation area around the Chernobyl power station (30 km zone), 14 473 worked in the areas of primary or further relocation (with ¹³⁷Cs contamination levels higher than 15 Ci/km², i.e. 555 kBq/m²). Fifteen percent were women (10 284). Table 1 shows the distribution of liquidators by place of work, sex and duration of stay in the contaminated area. The distribution of liquidators by age in 1994 is shown in Table 2.

3. Follow-Up

3.1 Test of Passive Follow-up in the Framework of ECP-7

In 1993-1994, a liquidator follow-up study was carried out in the framework of Experimental Collaboration Project 7 (ECP-7) - "Epidemiological Investigations Including Dose Assessment and Dose Reconstruction"- between CIS States and the European Union [1]. The objectives of this study were to assess the feasibility of long-term passive mortality and incidence follow-up of liquidators, and to examine available mechanisms for tracing individual subjects and collecting relevant data pertaining to these subjects.

The study covered 500 liquidators, selected at random from the population of 1986-87 liquidators having worked in the 30 km zone and included in the Chernobyl Registry.

Table 2 Distribution of Belarus liquidators by age in 1994

| Age range in 1994 | Men | Women |
|-------------------|--------|-------|
| <30 | 2 010 | 549 |
| 30-40 | 17 964 | 1 539 |
| 40-50 | 11 816 | 1601 |
| 50-60 | 5 737 | 1 413 |
| 60+ | 1 903 | 468 |
| Total | 39 430 | 5 570 |

A step by step approach was used to ascertain vital status on 1 October 1993:

- a subject was assumed alive on 1 October 1993 if a recent (within the last 3 months) medical visit had been recorded in the Chernobyl Registry;
- where a recent medical visit was not registered, the address bureau of the area of last known place of residence (based on last address in Chernobyl Registry) was contacted in order to confirm the address; if the person had moved, a visit was made to the address bureau of that locality to ascertain the subject's new address; if the person had moved outside Belarus, the date and country of emigration were obtained;
- if the subject's current vital status could not be ascertained through the relevant address bureaus, the records of the local Chernobyl Registries and hospitals and polyclinics were consulted. If no information could be obtained from these sources, the records of the population registry (ZAGS - buro zapicii akta grazhdanskovo sostoyania) at the last known place of residence were to be consulted to determine whether the person had died; if so, a copy of the death certificate was to be obtained;
- for subjects who could not be traced at all, the date of last known vital status (and the source of this information) was to be noted.

Follow-up was virtually complete (99.2%). One hundred and thirty eight (27.6%) subjects had had a recent medical examination registered in the Chernobyl Registry; vital status of 253 subjects (i.e. 69.9% of those who had not had a recent medical visit registered in the Chernobyl Registry) was ascertained through the address bureaus and the remainder through the local registries (100 subjects) and hospitals and polyclinics.

Among subjects who were traced successfully, five (1%) were found to have died - and cause of death was obtained from the Chernobyl Registry and the ZAGS- and two (0.4%) emigrated (place unknown). The cohort was also linked to the Cancer Registry and one case of cancer was identified. The diagnosis was Hodgkin's disease (ICD 9 code 201) and morphological confirmation was obtained.

An analysis of data contained in the Chernobyl Registry for this cohort was carried out. The mean age at the time of the Chernobyl accident was 31.3 years (53% of the liquidators were below the age of 30; 31.5% between 30 and 39 and 15.5% were 40 or above). Information on social group was available for all study subjects: most were employees (68.8%) or industrial workers (27.4%). The overwhelming majority were sent to the 30 km zone around the Chernobyl reactor on mission, following the accident (97.6%); five subjects were actually residing in the area at the time of the accident and three were employed there.

Most liquidators worked in the 30 km zone in 1986 (82.6%); 46% first entered the 30 km zone between April 26 and 30 June of that year; 41.8% of liquidators were in the 30 km zone for less than one month. Thirty-one liquidators were sent to the 30 km zone a second time.

Dose estimates were missing in the Chernobyl Registry for 73.8% of subjects. The mean registered dose of external radiation among those for whom estimates were available was 56.6 mSv (median 48 mSv); registered doses ranged between 1.4 and 185 mSv.

The results of this pilot study confirmed the feasibility of carrying out a passive long-term follow-up of liquidators in Belarus. As there are plans to centralise the passport department information at the Republican level, follow-up for vital status ascertainment based on passport department information appears to be feasible. For subjects identified as dead, cause of death information would be obtained from local ZAGS and verified using data from hospitals and, in the case of cancer, from the Cancer Registry.

3.2 Active Follow-up of Liquidators in Outpatient Clinics

As a consequence of the 1987 directive of the Ministry of Public Health of the USSR, all liquidators must undergo an obligatory annual medical examination in which he or she is seen by a general practitioner, an endocrinologist, an ophthalmologist, a neuro-pathologist, an otorhinolaryngologist and a gynaecologist (for women). The liquidator is also directed, as appropriate, for additional examinations to oncologists and other specialists.

All data on diseases diagnosed during the annual medical examination, as well as at any other time during the year, is entered in the personal outpatient card at the regional outpatient clinic from which the liquidator depends and is also sent to the Chernobyl Registry for inclusion in the registry data base. As mentioned above, the Chernobyl Registry includes information on place of residence, social group and on internal and external radiation exposure, in addition to data on medical conditions. This information is also updated, as appropriate, at the time of the annual examination.

In Belarus, several official directives regulate the activities of groups which are in charge of controlling the special dispensary examinations and the local registries. According to them, if a person does not present him or herself for the obligatory annual examination, the cause must be ascertained: personal refusal, emigration outside of the area covered by the health institution activities or outside of Belarus, or death. For this purpose, a nurse from the outpatient clinic visits the subject at home; if he or she has moved, a query is sent to the passport department where all population is registered to confirm the move and information is entered into the database of the Chernobyl Registry. In case of death, a nurse visits the district ZAGS bureau and ascertains the date and cause of death, which are also entered into the registry data base.

4. Preliminary Results on the Health Status of the Liquidators

4.1 General Morbidity

In Belarus, regional outpatient clinics systematically collect information on disease diagnoses on all the residents of the region they cover (not only on those included in the Chernobyl Registry). This information is summarised locally and is sent on special statistical reporting forms at yearly intervals to the Ministry of Health. These forms contain information about the number of cases of acute and chronic diseases diagnosed in a given year in the population in all areas of Belarus. This information is not broken down by age or sex. The number of acute and chronic diseases thus reported to the Ministry of Health has

been increasing in recent years in the population of Belarus as a whole. This passive system of collection of morbidity data on the population contrasts with the active follow-up carried out, as described above, for the liquidators.

In this section, we present preliminary analyses of the morbidity of liquidators both over time and in comparison to the general population of Belarus. It should be noted that comparisons to the general population may not be appropriate and should be interpreted with caution, as no age-adjustment could be made and as the method for ascertainment of disease differs.

Preliminary analyses of the morbidity of liquidators, as registered in the Belarus Chernobyl Registry indicate an increase in the crude (i.e. not age-adjusted) incidence of diseases over time between 1990 and 1994. This finding may at least partly be explained by the ageing of the population (as indicated above, nearly half the liquidators are now over the age of 40 and close to 20% is above the age of 50) and needs to be investigated in more detail. The increase in morbidity is seen for many disease classes, in particular diseases of the endocrine and digestive system and of metabolism and immunity (2 508 diagnoses per 100 000 in 1990 compared to 4 787 per 100 000 in 1994), mental disorders and diseases of the blood and circulatory system. Morbidity for these disease classes tends to be higher among the liquidators than among the adult population of Belarus (Table 3). By the beginning of 1995, the cumulative prevalence of chronic diseases registered in the Chernobyl Registry since the accident was greater than 50%.

The greatest apparent differences in morbidity between liquidators and the general population are registered for endocrine diseases, and disorders of the digestive system, metabolism and immunity (Table 3). The ratio of morbidity from thyroid diseases in liquidators to that of the entire adult population is particularly high. These results must be interpreted with caution as these ratios are not adjusted for age or sex and the intensity of screening of liquidators resulting from the annual medical examinations may have artificially increased the number of disorders diagnosed.

Table 3 Crude incidence of disease diagnosed among liquidators and the general Belarus population in 1993 and 1994

| Class of diseases (ICD 9 codes) | Year | Rates per 10 ⁵ | |
|--|------|---------------------------|---------|
| | | Liquidators | Belarus |
| Diseases of the endocrine system, disorders of the digestive system, metabolism and immunity (240-279) | 1993 | 2 560.6 | 630.9 |
| | 1994 | 2 862.0 | 667.6 |
| Diseases of the thyroid gland (240-246) | 1993 | 329.8 | 329.8 |
| | 1994 | 391.4 | 391.4 |
| Diabetes mellitus (250) | 1993 | 316.7 | 101.1 |
| | 1994 | 313.1 | 94.5 |
| Mental disorders | 1993 | 1 466.2 | 1 014.0 |
| | 1994 | 2 438.7 | 1 098.6 |
| Diseases of the circulatory system | 1993 | 4 960.2 | 1 626.2 |
| | 1994 | 5 974.6 | 1 646.1 |
| Diseases of the digestive system | 1993 | 5 318.6 | 1 937.6 |
| | 1994 | 6 411.2 | 1 889.1 |
| Cataracts | 1993 | 281.4 | 136.2 |
| | 1994 | 420.0 | 146.1 |

An apparent difference in morbidity from nervous and perception organs diseases including cataract is also observed (morbidity ratio 2.6), as well as an increase in digestive system disorders and benign tumours (morbidity ratio 1.7). Again, the depth of medical examination of liquidators may account for at least part of this difference.

Among liquidators, an apparent increase over time in the frequency of non-specific diseases of the vegetative nervous system (ICD-9 code 337.9) – 997.9 per 100,000 in 1994 compared to 599.8 in 1991 – and of chronic respiratory diseases is also noted. Morbidity from a number of diseases associated with older age has also been registered in younger individuals (diabetes mellitus, ischemic heart disease, hypertension, atherosclerosis etc.).

Differences in the morbidity of 1986-1987 liquidators and 1988-1989 liquidators have been observed recently. In particular, morbidity from thyroid diseases, diabetes mellitus, diseases of blood and hematopoietic tissues, circulation system, respiratory organs, digestive, urinary and genital systems, skin and subcutis appear to be higher in the first group. The rate of disease and trauma related disability and mortality appears to be approximately 1.5 times higher among those who worked in 1986-1987 than among those who worked later. The possibility that these differences may at least be partly explained by a different distribution of age and of participation in the annual medical examination between these two groups needs to be studied further.

The preliminary observations reported here may reflect a real increase in morbidity following the Chernobyl accident. On the other hand, they may at least be partly explained by a bias introduced by the active follow-up of liquidators and by failure to take into account the effects of age and sex in the analyses. They must therefore be interpreted with caution.

4.2 Cancer Incidence in Liquidators in 1993-1994

The Belarus Cancer Registry which, as described above, was already functioning before the Chernobyl accident, is an important tool for the study of cancer incidence among liquidators. Cancer diagnoses among liquidators can be systematically identified by linkage of the Chernobyl Registry and the Cancer Registry using full name (last, first, patronymic), year of birth and current (last known) address [2]. Age and sex-specific cancer incidence rates among liquidators can then be calculated and compared with the incidence in the general population of same sex and age.

Dosimetric data reported to date in scientific papers show that, in general, the liquidators received the highest doses among the populations exposed to radiation from the Chernobyl accident (with the exception of smaller groups of populations residing in the most contaminated areas, particularly Pripyat, and evacuated in the days following the accident). It has been estimated that 15% of the Belarus liquidators have received whole body radiation doses below 50 mSv, 30% between 50 and 100 mSv, 48% in the range 100-250 mSv and 7% in the range 250-500 mSv [3]. In principle, therefore, studies of liquidators should be more informative for estimating radiation risks than studies of comparable populations having been exposed environmentally [4]. For studies to be informative radiation risk estimation, however, it is important that individual radiation dose estimates be available; at present, dose estimates are available for less than half of all liquidators in the cohort.

Table 4 Distribution of observed and expected numbers of cancers in 1993-94 among liquidators, by sex and cancer type.

| ICD-9 | Site | Men | | | | Women | | | |
|---------|-----------------|-----|----------------|-----|---------|-------|------|-----|---------|
| | | O | E | SIR | 95% CI | O | E | SIR | 95% CI |
| 151 | Stomach | 19 | 12.1 | 157 | 94-244 | 1 | 2.5 | 39 | 98-218 |
| 153 | Colon | 11 | 6.8 | 161 | 80-288 | 1 | 1.2 | 81 | 2-453 |
| 162 | Lung | 33 | 51.0 | 65 | 45-91 | 0 | 0.7 | 0 | 0-502 |
| 173 | Skin | 5 | 10.5 | 48 | 15-111 | 3 | 2.3 | 128 | 27-375 |
| 174 | Female breast | 0 | - ¹ | - | | 4 | 7.4 | 54 | 15-139 |
| 188 | Urinary bladder | 15 | 6.9 | 219 | 123-361 | 0 | 0.2 | 0 | 0-2165 |
| 189 | Kidney | 8 | 8.2 | 98 | 42-192 | 2 | 0.9 | 226 | 27-817 |
| 193 | Thyroid | 4 | 1.7 | 241 | 66-617 | 5 | 1.33 | 376 | 122-878 |
| 204-208 | Leukaemia | 12 | 6.5 | 184 | 95-321 | 1 | 0.8 | 124 | 3-692 |
| 140-208 | All sites | 155 | 202 | 77 | 65-90 | 27 | 30.0 | 90 | 59-131 |

Table 5 Distribution of observed and expected numbers of cancers in 1993-94 among male liquidators by duration of work in the 30 km zone.

| ICD-9 | Site | Duration of work in the 30 km zone | | | | | | | |
|---------|-----------------|------------------------------------|------|-----|--------|------------|------|-----|----------|
| | | Less than 30 days | | | | 1-6 months | | | |
| | | O | E | SIR | 95% CI | O | E | SIR | 95% CI |
| 151 | Stomach | 7 | 12.1 | 58 | 23-119 | 5 | 7.3 | 69 | 22-160 |
| 153 | Colon | 7 | 2.9 | 241 | 97-497 | 2 | 1.7 | 117 | 14-423 |
| 162 | Lung | 14 | 22.1 | 63 | 35-106 | 9 | 12.0 | 75 | 34-143 |
| 173 | Skin | 2 | 4.4 | 45 | 5-163 | 0 | 2.7 | 0 | 0-139 |
| 188 | Urinary bladder | 5 | 3.0 | 167 | 54-390 | 4 | 1.6 | 245 | 67-628 |
| 189 | Kidney | 3 | 3.4 | 88 | 18-257 | 4 | 2.1 | 189 | 52-485 |
| 193 | Thyroid gland | 1 | 0.7 | 151 | 4-844 | 3 | 0.5 | 625 | 129-1826 |
| 204-208 | Leukaemia | 3 | 2.7 | 111 | 23-325 | 6 | 1.8 | 342 | 126-746 |
| 140-208 | All sites | 61 | 85.2 | 72 | 55-92 | 41 | 50.4 | 81 | 58-110 |

The following analyses are based on age standardised cancer incidence rates in the period 1993-94. The standardisation was carried out according to the age and sex distribution of the liquidators population. Expected numbers are based on the incidence in the general population of Belarus of same age and sex. It is noted that, for cancer types with small number of cases, the rates are very unstable and are thus difficult to interpret.

Table 4 shows the distribution of observed (O) and expected (E) numbers of cases and the standardised incidence ratio (SIR) and its 95% confidence interval (CI) for 9 cancer types by sex. The incidence of cancer in general appears to be lower in liquidators, both in men - SIR: 77 - and in women - SIR: 90 -; only for the former is this difference statistically significant. Among men, a significant increase in the incidence of urinary bladder cancers is seen among liquidators (SIR: 219, 95% CI 123-361) compared to the general population. Non significant increases are also seen for cancers of the colon and thyroid and for leukaemia; the number of cases on which these comparisons are based, however, are small, particularly for thyroid cancer (Table 4). Among women, an increased incidence of cancers of the skin, kidney and thyroid gland was observed on the basis of even smaller numbers of cases.

¹ not applicable

Table 5 presents the distribution of observed and expected numbers of cases and SIR's for the same cancer types among male liquidators by duration of work in the 30 km zone: less than a month (30 days) and 1-6 months. The SIR for all cancers together is slightly higher among those who worked in the 30 km zone over 30 days (SIR: 81, 95% CI 58-110) than among those who worked for shorter times (SIR 72, 95% CI 55-92). In particular, a higher incidence of tumours of the bladder, kidney, thyroid and of leukaemia is observed among those who worked in the 30 km zone more than 30 days. None of these SIR's is significantly elevated compared to the general population, however, apart from thyroid cancer among those who worked more than 30 days. The number of cases in these categories is, moreover, quite small and these comparisons must be interpreted with caution.

5. Discussion

It is difficult at present to evaluate with certainty the health of the liquidators. Results of analyses of the general morbidity of the liquidators appear to indicate an increase in the prevalence of a number of acute and chronic diseases, both over time and compared to the general population. These results, however, are preliminary and must be interpreted with caution. Analyses were not adjusted for age or sex. Moreover, the observed increases may at least partially be explained by the different approaches for ascertaining diseases in the general population and the liquidators. Among the liquidators themselves, although participation in the annual medical examination is obligatory, only about 80% of liquidators actually participate in it in any given year. The possibility that participation rates vary with the age and health status of the liquidators - and may, in addition, vary over time - cannot be rejected.

The results of cancer incidence analyses are less subject to these biases, except for some cancer types such as thyroid cancer and chronic leukaemia where the depth of screening may greatly influence the observed incidence. Overall, in 1993-4, the liquidators appeared to have a lower incidence of cancer than the general population of Belarus. Among male liquidators, the incidence of cancer of the urinary bladder was significantly increased compared to the general population and non-significant increases in cancers of the colon, thyroid and leukaemia were observed. These results are, however, based on relatively small number of cases and on active follow-up of the liquidators. Further studies of this population is needed to confirm or reject this observation.

The population of liquidators in Belarus, because of the level and type of radiation exposure they received, is an important population to study the health consequences of radiation exposure, in particular the effects of relatively low doses (compared to atomic bomb survivors, for example) and the effects of exposure protraction.

We have shown that a passive mortality follow-up of liquidators is possible in Belarus using existing population registration structures. Furthermore, the existence of a long-established cancer registry, and the ongoing work aimed at improving the registry and the possibility of linking [5] it to other sources of data - in particular the Chernobyl Registry - ensures the feasibility of systematic cancer morbidity follow-up.

The population of 1986-87 liquidators having worked in the 30 km zone, although large, is still relatively small for studying directly the effects of low doses of radiation. It is therefore important that studies of liquidators be carried out in parallel in other countries,

using similar and compatible protocols, in order to maximise their informativeness for radiation risk estimation.

Many of the liquidators were young at the time of the accident; today, 10 years later, the mean age among the Belarus cohort is approximately 40 and 15% of the liquidators are over the age of 50. As the population ages, and enters the age range where cancer incidence increases rapidly, the informativeness of the follow-up for cancer risk is increasing.

6. Conclusions

The population of Belarus liquidators is important for the epidemiologic study of the health consequences of the Chernobyl accident. The distribution of doses and exposure patterns in this population and the demonstrated feasibility of carrying out passive follow-up for mortality and cancer morbidity make this a particularly important population for the study of radiation effects. Although the total number of subjects in the cohort is large (over 45 000), this is still a relatively small number of subjects for the study of the effects of low doses. It is therefore important that this population be followed-up over time, and that similar studies be carried out in parallel in other countries with substantial numbers of liquidators, particularly Russia and the Ukraine, but also the Baltic countries, in order to maximise the information which can be obtained about radiation risks.

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