STOCHASTIC EFFECTS OF ENVIRONMENTAL RADIATION EXPOSURE IN POPULATIONS LIVING NEAR THE MAYAK INDUSTRIAL ASSOCIATION

Progress Report
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Executive Summary

The objective of our long-term epidemiologic collaborative project is to assess stochastic (carcinogenic) effects among populations exposed to offsite releases of radioactive materials from the "Mayak" nuclear facility located in the South Ural Mountains in Russia. Subjects of the present study are those individuals who lived at least one month during the period January 1950 through December 1952 in any of the exposed villages along the Techa River in Chelyabinsk Oblast. This study will focus on cancer morbidity among these subjects. The milestones for the time period covered by this report were to identify the number and composition of the sub-cohort of subjects who lived in Chelyabinsk Oblast (Task #1), assess completeness of information on cancer incidence for exposed subjects in Chelyabinsk Oblast, begin work to enhance the URCRM cancer morbidity registry (Task #2), and begin validation procedures (Task #3). We have successfully characterized the entire Techa River cohort by sex, age at exposure, ethnic background, and estimated radiation dose based on the information that was available at the completion of the reporting period. Our tracing activities during the project period resulted in a substantial reduction in the number of subjects lost to follow-up. Additional activities are planned during the next 2 years of this three-year project to trace the remaining lost to follow-up. Considerable progress was made on Tasks 2 and 3 of our project. Using information obtained from regional oncology dispensaries, the URCRM cancer morbidity file (cancer registry) was updated with cases diagnosed during the period 1991-1996. During the next 2 years of the project we will continue to edit and clean the database and update the morbidity registry with newly diagnosed cancer cases. In order to initiate our proposed series of validation procedures, the mortality registry was updated through 1994. Preliminary work was conducted to compare cancer diagnoses ascertained from cancer registration with those recorded on death certificates.

I. Introduction

The objective of the long-term epidemiologic studies is to assess stochastic (carcinogenic) effects among populations exposed to offsite releases of radioactive materials from the "Mayak" nuclear facility. The unique conditions in the South Urals resulted in chronic exposure of the residents to a wide range of radiation doses. An investigation focusing on health effects observed over the 40-year period since the onset of exposure could become a source of new knowledge about the health risks associated with chronic protracted exposure to ionizing radiation.

A cohort study design will be used to evaluate stochastic health effects among populations exposed to offsite releases from Mayak. The analysis of stochastic effects carried out in previous studies of these populations was based on mortality data from the 33-year follow-up of the Techa Cohort comprising 29,000 individuals: 26,000 exposed in adolescence and adulthood and 3,000 exposed in utero [1]. The rate of leukemia and certain solid cancers was slightly higher among exposed persons [2-4]. A significant disadvantage of those studies was loss to follow-up of 36% of the cohort members due to migration. Only 70% of the known deaths were confirmed by death certificates which led to a considerable uncertainty in the inferences about the significance of exposure effects. In order to obtain more complete data, a decision was made to continue the study along the following two lines:

1. Obtain more complete information on vital status for the entire cohort through 1992, and for all deaths to obtain an official document confirming the fact of death for migrants, and on the basis of the new information to re-assess the cancer mortality rates among the exposed cohort. This project was jointly supported by the Urals Research Center for Radiation Medicine (URCRM), the National Cancer Institute (NCI) of the United States and the Radiation Effects Research Foundation (RERF) and it has been in progress for 2 years [5]. This URCRM/NCI/RERF project will examine only those cancer deaths reported as underlying cause on death certificates for the exposed Techa River population.

2. Assess cancer incidence among the sub-cohort of exposed Chelyabinsk Oblast residents. This study was funded by the Department of Energy in May, 1997 and is a collaborative effort between URCRM, The George Washington University, Uniformed Services University of the Health Sciences, and Oak Ridge Institute for Science and Education since 1997.

These two projects are independent since one will evaluate only ***cancer mortality*** among the entire Techa River Cohort while the other will evaluate ***cancer incidence*** only among the sub-cohort of Chelyabinsk Oblast residents. However, the projects have a common goal of assessing radiation risk from chronic exposure at small and medium doses, and in this respect the projects are well integrated and complement each other. The present project will utilize the comprehensive data base created and maintained by the Urals Research Center for Radiation Medicine (URCRM) to study populations exposed to radiation in the Urals and will update and enhance the registry. The URCRM registry is a relational data base consisting of a series of data files linked together by primary and secondary linkage keys. The principal key that links together all registries is the unique

identification number assigned to each subject. All information (passport data, places of residence, migration history, family history, dosimetry data, information on health status, etc.) is marked by the unique identification number. Files in the data base include demographic data, mortality data, cancer incidence data, and dosimetry data.

II. Background

A. Techa River Cohort Characterization

Discharges of radioactive wastes into the Techa River during the period 1950-1956 resulted in contamination of the Techa-Iset river system, and radiation exposure of the inhabitants of the riverside villages for whom the rivers were the principal source of water. According to official data, a total of about 124,000 people were exposed to radiation. The highest doses were received by 29,000 residents of the Techa riverside. Doses received by the population that lived on the banks of the Iset were much lower and, according to official estimates, they did not exceed 50 mSv. Because of limited resources, a single health center (the Urals Research Center for Radiation Medicine) whose purpose was to render specialized health services to exposed persons was established during the 1950's. A decision was made to focus on the follow-up and medical treatment of the residents of the Techa riverside area, who were the most heavily exposed.

A registry was developed to collect information about the exposed Techa River cohort. It was decided that any person who lived at least 1 month during the period January 1950 through December 1952 in any of the 39 villages located along the length of the Techa river down to the confluence of the Techa and Iset should be included in the registry. The period of residence was defined on the basis of information on the dynamics of radioactive waste discharges into the Techa [4], and, consequently, on the highest rates of exposure received by the population. In the process of compiling the registry, several sources of information were used to identify exposed subjects who met the cohort definition: lists of exposed residents made during door-to-door rounds of the villages and books for registering community members (tax books). Currently, the registry contains data on nearly 26,000 exposed persons born before 1950 (the year of the start of the heaviest exposure), and on about 3,000 persons exposed in-utero, born during the period 1950-1952.

Table 1 shows age (in 1950), sex and ethnic characteristics of the Techa River Cohort. Fifty-eight percent of the subjects are women. A considerable proportion of the cohort (39%) were less than age 20 in 1950. The cohort is composed of subjects from two principal ethnic groups: Slavs (mostly Russians) and Asians (Tartars and Bashkirs).

The Techa Cohort was divided into 2 sub-cohorts: residents of the upper and middle reaches of the river in Chelyabinsk Oblast (15,464 persons, 60%) and residents of the lower reaches in Kurgan Oblast (10,481, 40%). The population of Chelyabinsk and Kurgan Oblasts differed not only in terms of age at exposure and ethnic composition but in terms of accessibility of health services as well. The availability and quality of medical assistance largely depended on the distance of a specific village from cities where medical services were available, e.g., Chelyabinsk city where the URCRM is located. The specialized hematological clinic of the URCRM rendered medical assistance mainly to exposed residents of Chelyabinsk Oblast.

The differences in age and ethnicity between the exposed residents of Kurgan and Chelyabinsk oblasts are shown in Table 1. The age distribution of the Chelyabinsk exposed subjects (42% less than age 20 in 1950) is younger than that of the Kurgan subjects (36% less than age 20 in 1950). The Kurgan exposed subjects were primarily Slavs, whereas 34% of the Chelyabinsk subjects are Tartars and Bashkirs. The numbers in the table are slightly different than those reported in September, because as a part of our verification and follow-up efforts, a number of duplicate entries for the same subjects were found in the database. The table reflects the distribution from the corrected database.

Table 1. Characterization of the Techa River Cohort

	Total Techa River Cohort		Chelyabinsk Oblast		Kurgan Oblast	
	#	%	#	%	#	%
TOTAL	25,945	100.0	15,464	100.0	10,481	100.0
Men	10,933	42.1	6,675	43.2	4,258	40.6
Women	15,012	57.9	8,789	56.8	6,223	59.4
Age in 1950						
<10	4,375	16.9	2,776	18.0	1,599	15.3
10-19	5,806	22.4	3,654	23.6	2,152	20.5
20-29	4,809	18.5	2,884	18.7	1,925	18.4
30-39	3,103	12.0	1,881	12.2	1,222	11.7
40-49	3,128	12.1	1,813	11.7	1,315	12.5
50-59	2,010	7.7	1,104	7.1	906	8.6
60-69	1,554	6.0	783	5.1	771	7.4
70-79	913	3.5	447	2.9	466	4.4
80-89	210	0.8	99	0.6	111	1.1
90+	37	0.1	23	0.1	14	0.1
Ethnicity						
Slavs	20,486	79.0	10,017	64.8	10,469	99.9
Tartar & Bashkir	5,303	20.4	5,291	34.2	12	0.1
Other	156	0.6	156	1.0	0	0.0
Subjects Evacuated						
Total	7,292	28.1	6,771	43.8	521	5.0

Part of the population exposed in Chelyabinsk Oblast (approximately 7,500) was moved from the contaminated riverside area to clean villages located further from the Techa (the so-called villages of mass re-settlements) during the period 1953-1961. In the subsequent years, many of the younger subjects moved from the riverside villages to nearby cities. This migration process considerably hampered URCRM's ability to follow the exposed population.

B. Estimation of radiation doses

Dose reconstruction for populations exposed on the Techa has been carried out by the research staff of the URCRM Biophysics Laboratory and described in several publications [6-8]. The doses accumulated by the population exposed on the Techa were due to both external and internal radiation. External exposure resulted from gamma-radiation in the Techa flood plain, gardens, and homes. Internal exposure resulted from absorption of long-lived radionuclides (mainly Sr^{89}, Sr^{90} and Cs^{137}) through the consumption of river water and food.

External doses were calculated as averages for 3 age-groups (children, adolescents and adults) for each populated area. The calculations were based on the results of gamma-background measurements on the territory of populated areas and lifestyles typical of different population groups [6]. "Lifestyle" implies the average time length (hrs/day) spent by each age group in the exposed areas with different gamma-background characteristics. The highest contribution to external dose resulted from staying at the water edge due to contamination of bottom deposits with long-lived Cs^{137}. It is believed that adolescents spent an average of 2 hours per day on the river while adults only 1 hour. The doses calculated using this approach ranged from 0.01 to 2.13 Gy.

Internal dose reconstruction was based on lifetime (in vivo) measurements of beta-activity in teeth and Sr^{90} whole body counting. Fourteen thousand persons exposed on the Techa have been measured using the URCRM whole-body counter. On the basis of these measurements and an age-specific model for strontium metabolism [9] it was possible to calculate average internal doses for persons for each year of birth and for each village.

The distribution of internal doses by age and distribution of doses from internal and external radiation absorbed in the red bone marrow by 1976 for the Techa Cohort are shown in publication [6]. The highest dose rates were registered in 1950-1951. Table 2 shows the distribution of estimated doses absorbed in the red bone marrow for members of the Chelyabinsk and Kurgan sub-cohorts of the Techa Cohort.

Table 2. Distribution of estimated doses to red bone marrow for exposed members of the Techa River Cohort.

	Total Techa River Cohort		Chelyabinsk Oblast		Kurgan Oblast	
	#	%	#	%	#	%
TOTAL	25,945	100.0	15,464	100.0	10,481	100.0
< 0.1 Gy	4,148	16.0	1,304	8.4	2,844	27.1
0.1-0.29 Gy	10,486	40.4	5,259	34.0	5,227	49.9
0.3-0.49 Gy	4,422	17.0	2,433	15.7	1,989	19.0
0.5-0.99 Gy	4,345	16.8	3,924	25.4	421	4.0
1.0+ Gy	2,499	9.6	2,499	16.2	0	0
Unknown dose	45	0.2	45	0.3	0	0

About 40% of all exposed subjects received doses from 0.1 to 0.29 Gy. The doses accumulated in the red bone marrow were considerably higher for residents of Chelyabinsk Oblast than for residents of Kurgan Oblast. Doses higher than 0.5 Gy were received by 42% of exposed residents of Chelyabinsk Oblast, and by only 4% of the exposed residents of Kurgan Oblast.

C. Catchment area and long-term follow-up of the exposed population

In Russia, there are no national vital status or disease registries useful for follow-up of study cohorts. Due to limited resources, it was decided to conduct active follow-up of exposed residents of a well-defined catchment area. The catchment area was defined as the territory of 2 administrative districts (rayons) in the Chelyabinsk Oblast (Kunashaksky and Krasnoarmeysky), 2 administrative districts in the Kurgan Oblast (Kataisky and Dolmatovsky) through which the Techa flows, and 2 administrative districts in Chelyabinsk Oblast (Argayashsky and Sosnovsky) to which people evacuated from the Techa riverside were moved. The catchment area is part of Mayak's downwind territory. In 1970 the population of the catchment area numbered 181,000 of which about 12% were people exposed on the Techa.

Intense medical observation and active follow-up of the exposed residents in the catchment area was conducted during the period 1969 through 1982. The villages were regularly visited by teams of physicians who examined and treated exposed residents. These teams also collected information on the number, age and sex composition of the population in the catchment area as well as on all death cases and cancer incidence over decades after the exposure. Through 1982, data collected on the last address of exposed residents were regularly entered into the URCRM data base at five-year intervals. In addition, because increased incidence of leukemia was anticipated to be a principal radiation effect among the population exposed on the Techa, a hematologic department was established in 1968 at the URCRM. Its purpose was to render specialized medical assistance to all hematological patients (both exposed and unexposed) residing in the catchment area in Chelyabinsk Oblast. To trace residents of the catchment area who migrated, documents certifying the citizens' residence registration were used. The residence registration system which existed in the USSR and currently exists in Russia requires that each citizen register his/her address at the militia (police) station (village councils in rural areas). The citizen's address is recorded in his/her passport and a special seal is applied. Information on residence is forwarded from the militia stations to Regional Address Bureaus. Information on migration of exposed residents of the catchment area was derived from interviewing patients and/or their next-of-kin during medical examinations, from tax books kept by village councils, and from Regional Address Bureaus.

In 1990 the total number of exposed subjects meeting criteria for inclusion in the Techa River Cohort, including exposed residents of the Chelyabinsk and Kurgan Oblasts, was estimated to be 26,485 persons. Of these 10,233 (39%) were reported to have died, but fact of death was confirmed by death certificates for only 65% at that time. There was a large proportion (38%) of subjects whose vital status was unknown in 1990. There is a great likelihood that many members of the latter group migrated outside the catchment area as there was active migration during that period with many people of younger ages moving to nearby towns.

III. Identification and follow-up of the Techa River cohort subjects living in Chelyabinsk Oblast (Task #1)

The first milestone to be completed during the project period was the following: Identify the number and composition of the Techa sub-cohort living in Chelyabinsk Oblast and assessment of completeness of information on cancer incidence for this sub-cohort.

A. Progress on follow-up activities

This task was to extend the follow-up of exposed persons through 1994 (5 additional years); thus, the overall follow-up period would be 45 years since the start of radiation exposure. A part of this task was to verify residence during the period 1950 to 1952 and to eliminate duplicate records for the same subject from the data base. During this verification process, a number of subjects were identified who were entered into the registry twice under different family names. After elimination of the duplicates, the total number of exposed subjects (Chelyabinsk Oblast and Kurgan Oblast combined) in the registry was 25,945.

The primary focus of our follow-up activities was to determine current vital status for those exposed subjects in the catchment area in Chelyabinsk Oblast who were not known to have migrated but who were lost to follow-up. Subjects whose residence in 1950 to 1952 was in one of the exposed villages in the Chelyabinsk Oblast portion of the catchment area were identified. Of the subjects initially identified as having been residents of exposed villages in the Chelyabinsk Oblast portion of the catchment area 3,335 had a last known address in the catchment area and were lost to follow-up before 1993.

The progress on this task was accomplished in two stages. Intensive tracing efforts were initiated to determine current vital status of the 3,335 study subjects who were lost to follow-up before 1993. Inquiries at the Address Bureaus were made about the current addresses for these subjects. Individual inquiry forms sent to the Address Bureaus included information on the person's name, birth date and last known address. The replies received from the Address Bureaus can be categorized into 3 groups:

- 1 295 persons continuing to live in the catchment area
- 282 died
- 1 758 individuals were listed as "does not appear in the files"

Thus, vital status was verified for 1,577 (47%) of those traced by this method.

The second stage involved follow-up activities aimed at tracing the vital status and residence for exposed persons whose last known date of follow-up was in 1993 and 1994, and for those who, according to information provided by the Address Bureau, "do not appear in the files". To achieve this, entries for the years 1986-1996 in the books for registering community members (tax books) were reviewed for all villages in which the majority of exposed population lived (Brodokalmak, Russkaya Techa, Nizhneye Petropavlovskoye, Muslumovo). As a result of this effort the proportion of subjects with unknown vital status was reduced substantially. As of 31 December 1994, 3,206 subjects were alive and continued to live in the catchment area; 5,575 persons had died in the catchment area (cause of death is confirmed by death certificate for 4,742 (85%) deceased persons);

1,125 individuals whose last known address was in the catchment area were lost to follow-up; and 5,558 were known to have moved out of the 4-rayon catchment area.

Current vital status of the entire sub-cohort of subjects exposed in Chelyabinsk Oblast is shown in Table 3. Because death certificate data is available only through 1994, vital status is shown through the end of 1994, even though follow-up for some subjects is complete through 1996, and cancer morbidity data is available through 1996.

Table 3. Status of Subjects Exposed in Chelyabinsk Oblast on 31 December 1994

	Total		Residents of 4-rayon catchment area		Migrated out of 4-rayon catchment area	
Status	#	%	#	%	#	%
Alive*	5,588	36.1	3,206	32.4	2,382	42.9
Deceased						
Confirmed by Death Certificate	5,391	34.9	4,742	47.9	649	11.7
Unconfirmed	1,492	9.6	833	8.4	659	11.9
Lost to follow-up	2,993	19.4	1,125	11.4	1,868	33.6
TOTAL	15,464	100.0	9,906	100.0	5,558	100.0

*last follow-up 1994 or later

Table 3a. Location of subjects who moved outside of the 4-rayon catchment area.

Location	#	%
Chelyabinsk City	2,871	18.6
Chelyabinsk Oblast**	1,368	8.9
Outside Chelyabinsk Oblast	1,319	8.5
TOTAL	5,558	100

**outside 4-rayon catchment area

We propose to include all 14,145 subjects who remained residents of Chelyabinsk Oblast in our study group. This excludes only the 1,319 subjects who migrated outside Chelyabinsk Oblast. The reason for excluding these subjects is that we will be unable to obtain cancer morbidity information from outside Chelyabinsk and Kurgan Oblasts.

The distribution by year of last follow-up for the subjects lost to follow-up whose last known residence was in the 4-rayon catchment area is shown in Table 4:

Table 4. Distribution of subjects lost to follow-up whose last known residence was in the 4-rayon catchment area by last year of follow-up

Last Year of Follow-up	# of Subjects
1950-59	179
1960-69	170
1970-79	118
1980-89	306
1990-93	352
Total	1,125

B. Improvement of radiation dose estimates

The time period during which each individual continued to live in a riverside village in the early years after the start of exposure is of crucial importance. Late in 1996 the URCRM staff completed the computer file "Place of Residence" which includes data on the number of months or years any member of the Techa Cohort lived in one of the riverside villages. In 1997 this information was used for calculating individual absorbed doses to red bone marrow and bone surfaces for each member of the exposed cohort.

A fraction of the population (1,700) exposed on the Techa received additional radiation doses due to an explosion of a storage tank in the radioactive waste depot in 1957 (the Kyshtym accident). The overlapping exposure resulted from the fact that the villages of "mass evacuations" (i.e., the villages in which most of the evacuees lived) were located on the territory which became contaminated in 1957 due to the blast (the new contaminated area was later named the "East-Urals Radiation Trace"). The additional radiation exposure doses were estimated for each of the 1,700 individuals, and the calculated doses were included in the Techa Cohort dosimetry file. Doses have not yet been estimated for those 45 subjects (0.17%) who were exposed in three villages located in closest vicinity to the site of explosion of 1957, in addition to the exposure they received being residents of the Techa riverside villages.

A project is currently underway (JCCRER Project 1.1) to review and improve these dose estimates and to calculate the dose for each subject in the Techa River cohort. Project 1.1 "Population dose reconstruction" is closely coordinated with this project and will provide further dose refinement for members of the cohort on the basis of thermoluminescence dosimetry (TLD) measurements and electron spin resonance (ESR) dosimetry technique. The results of the dose refinement will be entered into the URCRM data base and used in epidemiologic studies.

New dosimetry files were created in the URCRM registry at the request of the URCRM Epidemiology Laboratory. The epidemiologists in cooperation with dose reconstruction researchers developed a new file structure for the dosimetry files to enable the linkage of doses with data necessary for epidemiologic cohort studies. The newly-created dosimetry files containing data on individual dose estimates have been incorporated in the URCRM's unified data base and serve as a basis for obtaining data on distribution of absorbed doses in the red bone marrow over the 40 years since the start of exposure for the exposed cohort of Chelyabinsk residents. For deceased subjects, absorbed doses were calculated as of the year of death.

The progress achieved in dose reconstruction can be summarized as follows:

- Individual information on doses for each person included in the Techa Cohort;
- Calculation of doses by each of the exposure years, and cumulative doses for any period during the 40 years since onset of exposure;
- Estimation of doses absorbed by critical organs: bone marrow, and bone tissue.

C. Additional work planned on Task #1

Further work will be conducted to verify current vital status for study subjects, particularly those who are currently lost to follow-up. We will continue our efforts to locate the 1,125 persons whose last known address was in the catchment area but are currently lost to follow-up. The most realistic way to achieve this goal is to interview the next-of-kin. The "family unit" computer file created at the URCRM contains the family names and addresses of those family members who could provide information on persons lost to follow-up.

IV. Enhancement of URCRM Cancer Morbidity Registry (Task #2)

A. Background

In Russia, there is a compulsory system of cancer registration. A cancer notification form must be completed each time a cancer case is diagnosed. The forms are filled out by the physicians of the health establishment where diagnosis of cancer was made, and then forwarded to registration sections of specialized establishments: regional (oblast's) oncology dispensaries. The system of oncology registry cards was introduced during the period 1952-1955. Such a unified system of cancer registration is useful for epidemiologic analyses of cancer incidence. At the same time, a limitation of the system adopted in Russia is due to the fact that the registration cards are completed and sent to Oncology Dispensaries by clerks who are not trained in dealing with cancer registration. URCRM has routinely copied the registration cards maintained by the oncology dispensaries since the early 1950's. At the beginning of our joint project, URCRM had already added cancer cases through 1990 to the URCRM registry. Several activities are described in our protocol to assess the completeness and accuracy of the information obtained from the Oncology dispensaries and to update the URCRM registry with cancer incidence data through the most recent year available.

A second source of information on leukemia and cancer cases is the archives of the URCRM's clinical department. The URCRM clinical department is charged with rendering medical assistance to exposed subjects in the catchment area, thus some cancer cases have been diagnosed at URCRM. Complete information on methods of diagnosis ascertainment including cytological and morphological preparations, are available on patients who were examined at the URCRM clinic.

Sources of information on cancer incidence contained in the URCRM Registry are as follows:

- first-diagnosed cancer notification cards which are available at registration divisions of Chelyabinsk and Kurgan Oncology Dispensaries and which are copied by the URCRM staff;

- clinical case histories of patients with leukemia and solid cancer diagnosed at the clinical department of URCRM.

B. Progress on Task #2

The milestone for Task #2 for October 1997 through September 1998 is to continue to update and edit cancer morbidity data for newly reported cases of cancer occurring in the Techa River cohort. Cancer notification cards on cancer cases diagnosed in 1996 among residents of the catchment area (607 cards - 579 unexposed and 28 exposed) and stored at the registration division of the Chelyabinsk Oncology Dispensary have been copied. The cancer morbidity file (cancer registry) has been updated with cases diagnosed during the period 1991-1996. The following steps were followed in accomplishing this update:

- Information from cancer notification forms was matched to the exposed population registry on the basis of last name, first name, patronymic and birth date;

- Identification numbers were recorded on the notification cards for cancer cases diagnosed among exposed cohort members;

- Complete information on the patient, date of cancer diagnosis, specific cancer diagnosis, method of diagnosis (cytological, histological, roentgenological evidence confirming the diagnosis) was entered into the cancer morbidity file;

- Cancer diagnoses were coded using the International Classification of Disease, 9th Revision.

The total number of cases entered into the computer file "cancer registry" using the information derived from the above-listed sources is shown in Table 5.

Table 5. **Cancer cases in the URCRM Cancer Morbidity Registry by year of diagnosis, 1956-1996**

Year of Diagnosis	Unexposed residents of the catchment area # of Cases	Exposed residents in Chelyabinsk Oblast # of Cases
1956-59	988	88
1960-69	3,209	220
1970-79	4,794	240
1980-89	4,396	229
1990-94	3,523	125
1995-96	1,404	43
Total	18,314	945

Cancer morbidity data was collected only for those exposed subjects who remained residents of Chelyabinsk (1956-1996) and Kurgan (1956-1970 and 1982-1996) Oblasts because data were abstracted from the regional oncology dispensaries only in those two Oblasts. Cancer notification forms for Kurgan Oblast were not copied and abstracted during the period 1971 to 1981. These notification forms were not retained by the Kurgan Oblast Oncology Dispensary, and cannot be retrieved.

Cancer diagnosis validation is as a rule based on cytologic and histologic confirmation of the diagnosis established on clinical grounds. Autopsy is performed on only a small percentage of cases; however, most patients with leukemia and cancer whose death occurred at the URCRM in-patient department were autopsied. Work was begun to determine whether cancer diagnoses were properly coded and classified in the cancer morbidity registry, and has resulted in the re-classification of a number of cases.

C. Additional work planned on Task #2

Work will continue on re-classifying cancer registry diagnoses into the appropriate categories. As a result of the initial review of cancer cases, it was noted that several subject were diagnosed with more than one primary cancer. Early analyses indicated an increase in the incidence of simultaneously occurring multiple malignancies among persons exposed on the Techa. Second primary cancers were also observed which may be the result of therapy administered for primary tumors. Cases of multiple cancers will be the subject of a further analysis. In case some of the cancers are identified as radiation therapy-related, appropriate adjustments in doses will be made.

V. Validation Procedures (Task #3)

Task #3 of our project is to conduct a series of validation procedures to determine the completeness of and to enhance the quality of the URCRM cancer morbidity registry. The first procedure in the verification process is to update mortality data for the Techa River cohort, link the cancer morbidity and the mortality registries, and identify and describe the causes of discrepancies between the two registries.

A. Update the mortality registry through 1994 (Task #3a)

Background

The source of information on deaths are death certificates stored in the archives of the ZAGS offices in the localities where the death occurred. In order to obtain a permission to bury the deceased, the next-of-kin have to present to the ZAGS the affidavit of death which is filled out and signed by a physician. On the basis of the information on the affidavit of death, ZAGS clerks complete death certificates which contain the following information: registration number, the deceased person's last name, first name, patronymic, birth date, birth place, occupation, place and date of death, immediate death cause, underlying cause of death, contributing causes, last name of the informant (person who reported the death case). The storage time for these documents is 75 years. Abstracting death certificates stored at the Oblast ZAGS archives has been going on for several decades. As has already been mentioned, death certificates for residents of the catchment area who died in the period 1950-1982 have been abstracted, coded and entered into the computer registry. On the basis of these data cancer mortality and radiation risk assessment was carried out for people exposed on the Techa (publication of 1994 [3]). As a next step death certificates for the subsequent years (1983-1992) were received from the ZAGS archives which were stored at the URCRM on paper.

B. Progress on Task #3a

During the project period, death certificates for persons who died in the catchment area in 1993-1994 were obtained from the archives of the Chelyabinsk Oblast ZAGS. In all, 1,497 death certificates were abstracted for that time period. After that the following tasks were completed: (1) the last name, first name, patronymic, and birth date were key entered; (2) information on deceased individuals was matched with the entire Techa River Cohort Registry to determine who was exposed; (3) for decedents who were exposed, the following information was abstracted and key entered: underlying and contributing causes of death, place of last address, profession, and informant; (4) underlying cause of death was coded using the rubrics of the 9th Revision of the ICD. The same tasks were carried out for entering the information on deaths for the period 1983-1993 into the URCRM data base. The total number of deaths from all causes is shown by year of death in Table 6. The number of deaths among members of the study for whom fact of death was confirmed by a death certificate is 4,742.

Table 6. Distribution of confirmed deaths from all causes by year of death, 1950-1994.

Years of death	Unexposed residents of the catchment area # of Deaths	Deaths among Subjects in Chelyabinsk Oblast as of 1994 # of Confirmed Deaths
1950-55	13,195	709
1956-59	7,925	455
1960-69	20,116	1,107
1970-79	23,852	1,314
1980-89	19,605	1,186
1990-94	6,266	620
Total	90,959	5,391

The distribution of these deaths by cause is shown in Table 7.

Table 7. Distribution of confirmed deaths by cause, 1950-1994

ICD	#	%
Infectious and Parasitic Diseases (001-139)	273	5.1
Neoplasms (140-239)	951	17.6
Endocrine Diseases (240-279)	46	0.9
Diseases of Blood (280-289)	5	0.1
Mental Disorders (290-319)	13	0.2
Diseases of the Nervous System (320-389)	55	1.0
Diseases of the Circulatory System (390-459)	2,554	47.4
Diseases of the Respiratory System (460-519)	523	9.7
Diseases of the Digestive System (520-579)	147	2.7
Diseases of the Genitourinary System (580-629)	56	1.0
Complications of Pregnancy (630-676)	18	0.3
Diseases of the Skin and Subcutaneous Tissue (680-709)	2	0.04
Diseases of the Musculoskeletal System (710-739)	15	0.3
Congenital Anomalies (740-759)	4	0.1
Certain Conditions originating in the Perinatal Period (760-779)	2	0.04
Symptoms, Signs and Ill-defined Conditions (780-799)	132	2.5
Injury and Poisoning (800-999)	595	11.0
All Causes	5,391	100.0

Examination of deaths by cause indicated that over the 45 years of follow-up, the highest proportion of deaths were in the category of circulatory disorders (47%). Malignant neoplasms ranked second (18%), while injuries and poisoning were third (11%).

C. Additional work planned on Task #3a

The data collected on deaths for our validation study will enable us to describe non-cancer mortality in the Techa River cohort by time period since the start of exposure, age, ethnicity, cause of death, and radiation dose. Similar analyses of non-cancer mortality among the A-bomb survivors show increased rates of myocardial infarction, chronic liver diseases, myoma of the uterine body [10]. Non-cancer mortality for the population exposed to chronic radiation on the Techa has not yet been described in the scientific literature. This is a task that will be carried out during the next stages of the current project.

D. Link the data from morbidity and mortality registries (Task #3b)

Background

The issue of whether or not studies of malignant neoplasms should be based on cancer morbidity and/or cancer mortality data has repeatedly been discussed at the meetings of the WHO experts committee [11]. Many researchers are of the opinion that data on cancer morbidity and cancer mortality should complement each other. If studies are based only on mortality, then cases of the non-lethal cancers (e.g., cancer of the skin, thyroid, etc.) will not be included. Also, if cancer is not listed on the death certificate as underlying cause, the use of mortality rates may underestimate cancer risk. On the other hand, mortality data may be sufficient for studying some highly fatal cancers [12]. Linking data on diagnoses derived from different sources of information (death certificates, cancer registration) is one method that is useful in validating cancer diagnoses for epidemiological analysis [13].

E. Progress and additional work planned on Tasks #3b and #3c

One of the tasks in our series of validation procedures is to compare the cancer diagnoses from the cancer morbidity registry with those on the death certificates. Our work on this task has recently begun. The next step in verification of cancer diagnoses will be a detailed investigation to explain the causes of the discrepancies between information recorded in the cancer morbidity registry and the death registry. This task will consist of two parts: (1) a determination of why some cancer deaths are not recorded in the cancer registry and (2) a comparison of specific cancer diagnoses listed in the cancer registry with the underlying cause and contributing causes listed on the death certificate. Additional validation procedures to be conducted include the following: (1) linking data from the cancer morbidity registry with information from the URCRM clinic registers and autopsy records for 1955 to 1996 to verify diagnoses; (2) linking data from the cancer morbidity registry with contributing causes of death in the death registry; and (3) linking data from the cancer morbidity registry with the Techa River general morbidity registry. Diagnoses based on histological and cytological preparations at URCRM will be compared with the diagnoses in the cancer morbidity registry. Most study subjects diagnosed with leukemia were treated at the URCRM clinic, and bone marrow preparations for those patients have been retained in the URCRM tissue bank. Detailed descriptions of the preparations are available.

VI. Issues for discussion at the April 1998 SRG meeting

(1) The present project includes only exposed residents of Chelyabinsk Oblast because of the completeness of cancer registration during the follow-up period. The sub-cohort from Kurgan Oblast was not included in our original cohort definition because of the gap in cancer morbidity data for the time period 1971 to 1981. Adding the sub-cohort from Kurgan Oblast would increase our study size and statistical power. We would like to discuss the following possibilities: (a) conduct a feasibility study to determine whether information can be obtained on cancer cases diagnosed during the missing time period in Kurgan Oblast from sources other than the oncology dispensary (e.g., hospital records); or (b) explore the feasibility of developing a model to estimate the number of missing cancer cases during the period 1971 to 1981.

(2) There are 1,125 subjects lost to follow-up whose last known residence was in the 4-rayon catchment area of Chelyabinsk Oblast. About 70% of these subjects were lost before 1990. We plan to contact next-of-kin to trace these subjects. The issue for discussion is how much further effort should be made to trace these subjects.

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