VILNIUS UNIVERSITY

Vitalija Samerdokiene

RISK OF ONCOLOGICAL DISEASES AMONG MEDICAL RADIATION WORKERS IN LITHUANIA, 1978–2004

Summary of Doctoral Dissertation
Biomedical Sciences, Public Health (10B)

Vilnius, 2009

The study was carried out at the Institute of Oncology, Vilnius University during 1999–2007.
The dissertation is defended by extern.

Scientific consultants:
Dr. Vydmantas Atkočius (Institute of Oncology, Vilnius University, biomedical sciences, biophysics – 02B)
Prof. Dr. Rimantas Stukas (Vilnius University, biomedical sciences, public health – 10B)

The dissertation will be defended in the Public Health Council of Vilnius University:

Chairman:

Prof. Dr. Rimantas Stukas (Vilnius University, biomedical sciences, public health – 10B)

Members:

Prof. Dr. Habil. Stanislava Domarkienė (Kaunas University of Medicine, biomedical sciences, public health – 10B)

Prof. Dr. Janina Didžiapetrienė (Institute of Oncology, Vilnius University, biomedical sciences, medicine – 07B)

Prof. Dr. Habil. Povilas Pipinys (Vilnius Pedagogical University, physical sciences, physics – 02P)

Assoc. Prof. Dr. Kęstutis Žagminas (Vilnius University, biomedical sciences, public health – 10B)

Opponents:

Prof. Dr. Habil. Jadvyga Petrauskienė (Kaunas University of Medicine, biomedical sciences, public health – 10B)

Prof. Dr. Habil. Laima Liudvika Griciūtė (Institute of Oncology, Vilnius University, biomedical sciences, medicine – 07B)

The public defense of the dissertation will be held in the Great Hall at the Faculty of Medicine of Vilnius University at 3 p.m. June 12, 2009.

Address: M.K. Čiurlionio 21, LT-03101 Vilnius, Lithuania.

The summary of the doctoral dissertation has been sent on May 11, 2009.
The dissertation is available at the Lithuanian Library of Medicine, at the libraries of Vilnius University and of the Institute of Oncology, Vilnius University.

VILNIAUS UNIVERSITETAS

Vitalija Samerdokienė

LIETUVOS MEDICINOS DARBUOTOJŲ, DIRBUSIŲ JONIZUOJANČIOSIOS SPINDULIUOTĖS APLINKOJE, ONKOLOGINIŲ LIGŲ RIZIKA 1978–2004 METAIS

Daktaro disertacijos santrauka
Biomedicinos mokslai, visuomenės sveikata (10B)

Vilnius, 2009

Disertacija rengta 1999–2007 metais VU Onkologijos institute.
Disertacija ginama eksternu.

Moksliniai konsultantai:
dr. Vydmantas Atkočius (VU Onkologijos institutas, biomedicinos mokslai, biofizika – 02B)
prof. dr. Rimantas Stukas (Vilniaus universitetas, biomedicinos mokslai, visuomenės sveikata – 10B)

Disertacija ginama Vilniaus universiteto Visuomenės sveikatos mokslo krypties taryboje:

Pirmininkas:

prof. dr. Rimantas Stukas (Vilniaus universitetas, biomedicinos mokslai, visuomenės sveikata – 10B)

Nariai:

prof. habil. dr. Stanislava Domarkienė (Kauno medicinos universitetas, biomedicinos mokslai, visuomenės sveikata – 10B)
prof. dr. Janina Didžiapetrienė (Vilniaus universiteto Onkologijos institutas, biomedicinos mokslai, medicina – 07B)
prof. habil. dr. Povilas Pipinys (Vilniaus Pedagoginis universitetas, fizikos mokslai, fizika – 02P)
doc. dr. Kęstutis Žagminas (Vilniaus universitetas, biomedicinos mokslai, visuomenės sveikata – 10B)

Oponentai:

prof. habil. dr. Jadvyga Petrauskienė (Kauno medicinos universitetas, biomedicinos mokslai, visuomenės sveikata – 10B)
prof. habil. dr. Laima Liudvika Griciūtė (Vilniaus universiteto Onkologijos institutas, biomedicinos mokslai, medicina – 07B)

Disertacija bus ginama viešame Visuomenės sveikatos mokslo krypties tarybos posėdyje 2009 m. birželio mėn. 12 d., 15 val. VU Medicinos fakulteto Didžiojoje auditorijoje.
Adresas: M.K. Čiurlionio 21, LT-03101 Vilnius, Lietuva.

Disertacijos santrauka išsiuntinėta 2009 m. gegužės mėn. 11 d.
Disertaciją galima peržiūrėti Lietuvos Medicinos bibliotekoje, Vilniaus universiteto ir Vilniaus universiteto Onkologijos instituto bibliotekose.

1. INTRODUCTION

Introduction

An excess risk of cancer was first observed among Japanese bomb survivors and patients exposed through radiotherapy – both populations had received relatively high doses (IARC 2000; BEIR 1980; UNSCEAR 2000). X-radiation and γ-radiation were classified by International Agency for Research on Cancer as the agents carcinogenic to humans (1 group) (IARC, 2000). The situation concerning small doses, however, is quite inexplicit.

Medical radiation workers are an occupational group to be exposed to external radiation; their patterns of cancer incidence provide information on the long-term effects of exposure to repeated small doses of radiation. The total cumulative dose among medical radiation workers was substantial, but nowadays is much smaller.

Although high-dose ionizing radiation is acknowledged as a cancer risk factor, there is a lot more to discover about this phenomenon, namely the effects of small doses. No medical radiation worker cohort study had been performed in Lithuania. Consequently, there was no historical data about occupational exposure (average annual effective dose) before year 2004; the cancer risk for medical radiation workers had been assessed neither by occupational categories nor by the length of employment, nor by the range of cumulative dose.

The results of the present study may prove useful for both today's science and health assessment of medical workers exposed to ionizing radiation.

The aim of the study and the objectives

The aim of this study was to evaluate the risk of cancer among Lithuanian medical radiation workers during 1978–2004.

Objectives:

1. To estimate the risk of cancer among Lithuanian medical radiation workers during 1978–2004 in comparison with the general Lithuanian population.
2. To estimate the risk of cancer among Lithuanian medical radiation workers by occupational categories (diagnostic radiology, radiotherapy and nuclear medicine).
3. To estimate the risk of cancer among medical radiation workers in relation to the duration of employment in the environment of ionizing radiation and to the cumulative dose.
4. To evaluate the occupational exposure of medical radiation workers during various historical periods of dosimetry.

The defensive statements:

1. The risk of some sites of cancer among Lithuanian medical radiation workers may be related with occupational exposure to ionizing radiation.
2. The risk of cancer by different occupational categories (diagnostic radiology, radiotherapy and nuclear medicine) was the same as in the general Lithuanian population.
3. The occupational exposure of medical radiation workers consistantly decreased in various historical periods of dosimetry.

Scientific novelty and practical value of the study

This study, based on the retrospective cohort method, was the first cancer risk research among medical radiation workers in Lithuania (107 medical institutions; 2787 medical radiation workers). The occupational exposure (annual average effective dose) of medical radiation workers has been assessed; the dependence of cancer risk on occupational categories, the length of employment and the cumulative dose has been evaluated.

This study is one of the cohort studies of medical radiation workers exposed to small doses of ionizing radiation: two cohort studies were made in Europe (Andersson et al. 1991; Berrington et al. 2001), two in Asia (Wang et al. 1990; Yoshinaga et al. 1999) and four in North America (Miller et al. 1970; Matanoski et al. 1987; Mohan et al. 2003; Sigurdson et al. 2003). The data of our cohort study contribute to extending the current knowledge of related occupational epidemiology: a complex study has been made to discover a relation between the risk of cancer and the exposure to ionizing radiation. Occupational exposure for medical radiation workers in the cohort was assessed from 1950 to 2004, and the cumulative dose was calculated for each worker in the cohort.

MATERIALS AND METHODS

The work was approved by the Bioethics Committee of Lithuania (Protocol № 01-27, 2002).

The dissertation comprises an introduction, literature review, description of study material and methods, results, discussion, conclusions, 98 references, 2 appendixes. The volume contains 114 pages, 31 tables and 3 figures.

The cohort

The data was obtained from 107 medical institutions of Lithuania. The study cohort consisted of 2787 medical workers exposed to sources of ionizing radiation from 1948 to 2004.

The following information was received on all workers: name, surname, date of birth, personal code, place of residence, affiliation, dates of employment and retirement.

The study was confined to workers who were alive at the beginning of the follow-up period on January 01, 1978. 387 (14%) persons were excluded because the duration of their employment was less than one year. Another 150 (5%) persons emigrated, died or had been lost to the follow-up before 1978.

The remaining 2250 persons (301 men and 1949 women), representing 81% of the target population were retained for cancer incidence analysis.

Some characteristics of the cohort of medical radiation workers in Lithuania are shown in Table 1.

Table 1. Characteristics of medical radiation workers in Lithuania, 1950–2004

Characteristics	Men	Women	Total
Year of birth			
≤1930	62	246	308
1931–1959	171	1284	1455
1960–1980	68	419	487
Total	301	1949	2250
Beginning of employment			
1950–1959*	19	96	115
1960–1969	41	194	235
1970–1979	70	489	559
1980–1989	87	596	683
1990–1999	83	531	614
2000–2004	1	43	44
Total	301	1949	2250
Age at the beginning of employment			
20–24	44	418	462
25–29	95	371	466
30–34	50	308	358
35–39	34	256	290
40+	78	596	674
Total	301	1949	2250

* 19 medical radiation workers (4 men, 15 women) were included with the beginning of employment in 1948–1949.

Medical radiation workers deal with one of three occupational categories: diagnostic radiology 1777 persons, of them 243 men and 1534 women, radiotherapy 386, of them 43 men and 343 women, and nuclear medicine 87, of them 15 men and 72 women.

Follow-up of the cohort

The start of the follow-up period was 01 January 1978 and the end 31 December 2004. The beginning of the follow-up was 1978 because of the possibility of a reliable identification of all cancer cases in the Cancer Registry at the Institute of Oncology, Vilnius University. The follow-up period started one year after the date of the beginning of employment in the environment of ionizing radiation for those with the first entry after January 01, 1977. Workers who emigrated or died were followed until the time of these events, while other medical radiation workers were followed to December 31, 2004. For medical radiation workers who were lost to follow-up after 1978, person-years were calculated to the date of discharge.

Vital status at the end of the follow-up

Vital status was ascertained for a total cohort of 2250 medical radiation workers (301 men and 1949 women) at the end of the follow-up (December 31, 2004). Information on vital status, dates of emigration and death was obtained from the main

sources: Lithuanian Archives Department under the Government of the Republic of Lithuania; the Residents' Register Service and Migration Department under the Ministry of Interior.

The vital status of the medical radiation workers is presented in Table 2.

Table 2. Total cohort of medical radiation workers and vital status at the end of the follow-up (December 31, 2004)

Vital status	Diagnostic radiology		Radiotherapy		Nuclear medicine		Total		Total
	Men	Women	Men	Women	Men	Women	Men	Women	
Total	243	1534	43	343	15	72	301	1949	2250
Alive	195	1403	35	292	14	68	244	1763	2007
Dead	38	98	6	41	1	3	45	142	187
Unknown	7	12	1	7	0	0	8	19	27
Emigrated	3	21	1	3	0	1	4	25	29

Identification of cancer cases

The registration of cancer incidence is based on compulsory reporting of all new cancer cases from all hospitals in Lithuania. The systematic information is available in a computerized database of the Lithuanian Cancer Registry since 1978.

New cancer cases in the cohort of medical radiation workers were identified in the Lithuanian Cancer Registry through record linkage procedures by person code, name, surname, father' name, place of residence, gender, and date of birth.

Occupational exposure

The main sources on radiation measurement practice and data on occupational exposure in the former USSR were summarized in manuals. The information on doses for nuclear and medical radiation workers was being collected very precisely in the former USSR, but access to any data pertaining to individual doses was restricted. Systematic radiation-related data collection on medical radiation workers of Lithuania started in 1991.

Three methods of individual dosimetry were most common in the former USSR: ionization chambers, film dosimetry and thermo luminescence dosimetry. All types of dosimeters had been used during the period under consideration, so the value of 0.1 mSv was used as the minimum detectable level, and all doses below this value had been considered as zero doses.

The information on the average effective annual dose was collected and evaluated from 1950 to 2004.

Statistical methods

Cancer risk evaluation analysis was done using the retrospective cohort method. To calculate the expected cancer numbers, an indirect standardization method was used (Breslow, Day 1987).

Standardized incidence ratios (SIRs) were calculated. The person-years at risk for each person were calculated from January 01, 1978 until December 31, 2004 or from one year after the date of the beginning of employment in the period 1978–

2004 until the date of death, emigration or loss to the follow-up. The standardized incidence ratio (SIR) was calculated as the ratio between the numbers of observed and expected site-specific cases of cancer. The expected numbers of cancer cases were based on sex-specific incidence rates in five-year age groups and in five-year periods in Lithuania. The cohort contributed 42479 person-years to the study (5518 for men, 36761 for women).

95% confidence intervals (95%CI) were estimated assuming that the observed number of cancer cases follows the Poisson distribution (Esteve, Benhamou, Raymond 1994). The value of $p < 0.05$ was considered statistically significant.

For dose-response analysis, the risk associated with occupational exposure was estimated by the duration of employment and by the cumulative dose.

RESULTS

Cancer incidence in the main study population

During the follow-up period, 159 cancer cases (29 in men and 130 in women) were identified, among them 13 cases of leukemia (3 in men and 10 in women).

Table 3 shows standardized incidence rates in the study population for cancer incidence. During the follow-up period cancer incidence was not elevated among medical radiation workers of both genders: SIR = 0.92, 95%CI = 0.62–1.33 and SIR = 0.97, 95%CI = 0.81–1.15 for men and women, respectively.

The risk of lung cancer among men (6 cases, SIR = 0.81, 95%CI = 0.30–1.77) was not increased. The number of leukemia among men was insignificantly increased as compared with the expected numbers (SIR = 3.30, 95%CI = 0.68–9.63, based on 3 cases).

Among women, the risk of leukemia was insignificantly elevated (SIR = 2.67, 95%CI = 0.92–4.20, based on 10 cases). The risk of breast cancer among women (25 cases, SIR = 0.90, 95%CI = 0.58–1.33) was not increased. An insignificantly increased risk was found for cancers of rectum (8 cases, SIR = 1.48, 95%CI = 0.64–2.91), uterus (13 cases, SIR = 1.23, 95%CI = 0.66–2.11) and thyroid (5 cases, SIR = 1.63, 95%CI = 0.53–3.80).

Table 3. Observed (Obs) numbers of new cancer cases and standardized incidence ratios (SIRs) among medical radiation workers during the follow-up period 1978–2004

Cancer sites	ICD-9/ICD-10 codes	Men			Women		
		Obs	SIR	95%CI*	Obs	SIR	95%CI*
Lip, mouth and pharynx	141–149/C01–14	0	-	-	2	1.89	0.23–6.82
Esophagus	150/C15	1	1.56	0.04–8.71	1	2.63	0.07–14.07
Stomach	151/C16	2	0.57	0.07–2.08	8	0.90	0.40–1.77
Colon	153/C18	0	-	-	5	0.81	0.30–1.89
Rectum	154/C19–21	1	0.65	0.02–3.64	8	1.48	0.64–2.91
Liver	155/C22	1	2.70	0.07–15.10	1	1.01	0.03–5.63
Gall blader	156/C23–24	1	6.67	0.17–37.10	1	0.71	0.02–3.98
Pancreas	157/C25	1	0.85	0.02–4.72	2	0.61	0.07–2.20
Larynx	161/C32	0	-	-	1	3.85	0.10–21.40
Lung	162/C33-34	6	0.81	0.30–1.77	3	0.68	0.14–2.00
Bone and connect. tissue	170,171/C40–41, 45–47,49	0	-	-	1	1.12	0.03–6.26
Melanoma	172/C43	1	3.57	0.09–19.90	2	0.77	0.09–2.79
Skin	173/C44	3	1.19	0.25–3.47	15	0.90	0.50–1.48
Breast	174/C50	-	-	-	25	0.90	0.58–1.33
Cervix uteri	180/C53	-	-	-	8	0.70	0.30–1.38
Uterus	182/C54–55	-	-	-	13	1.23	0.66–2.11
Ovary	183/C56	-	-	-	9	0.91	0.42–1.73
Prostate	185/C61	7	2.10	0.85–4.33	-	-	-
Bladder	188/C67	1	0.68	0.02–3.76	1	0.68	0.02–3.82
Kidney	189/C64–66,68	0	-	-	4	0.93	0.25–2.37
Brain	191–192/C70–72	1	1.96	0.05–10.90	2	0.83	0.10–3.00
Thyroid	193/C73	0	-	-	5	1.63	0.53–3.80
Non-Hodgkin's lymphoma	200–203/C82–85, 88,90	0	-	-	3	1.31	0.27–3.83
Leukemia	204–208/C91–96	3	3.30	0.68–9.63	10	2.67	0.92–4.20
Other		0	-	-	0	-	-
All sites	140-208/C00-96	29	0.92	0.62–1.33	130	0.97	0.81–1.15

* 95% confidence interval.

Cancer risk by occupational categories

Diagnostic radiology

Table 4. Observed (Obs) numbers of new cancer cases and standardized incidence ratios (SIRs) among medical workers of diagnostic radiology during the follow-up period 1978–2004

Cancer sites	ICD-9/ICD-10 codes	Men			Women		
		Obs	SIR	95%CI*	Obs	SIR	95%CI*
Lip, mouth and pharynx	141–149/C01–14	0	-	-	2	2.44	0.30–8.81
Esophagus	150/C15	0	-	-	1	3.45	0.09–19.20
Stomach	151/C16	2	0.67	0.08–2.41	8	1.19	0.51–2.35
Colon	153/C18	0	-	-	4	0.86	0.23–2.20
Rectum	154/C19–21	1	0.75	0.20–4.19	7	1.72	0.69–3.53
Liver	155/C22	1	3.13	0.08–17.40	1	1.35	0.03–7.53
Gall blader	156/C23–24	1	7.69	0.20–42.90	1	0.97	0.02–5.41
Pancreas	157/C25	1	0.98	0.02–5.46	2	0.82	0.10–2.96
Larynx	161/C32	0	-	-	1	5,00	0.13–27.90
Lung	162/C33–34	2	0.32	0.04–1.15	3	0.91	0.19–2.66
Bone and conn. tissue	170,171/C40–41, 45–47,49	0	-	-	0	-	-
Melanoma	172/C43	1	4.35	0.11–24.20	2	0.99	0.12–3.56
Skin	173/C44	3	1.36	0.28–3.99	14	1.11	0.61–1.86
Breast	174/C50	-	-	-	20	0.91	0.56–1.44
Cervix uteri	180/C53	-	-	-	6	0.67	0.24–1.45
Uterus	182/C54–55	-	-	-	11	1.32	0.66–2.36
Ovary	183/C56	-	-	-	8	1.03	0.45–2.03
Prostate	185/C61	7	2.32	0.93–4.78	-	-	-
Bladder	188/C67	1	0.77	0.02–4.29	1	0.93	0.02–5.21
Kidney	189/C64–6,68	0	-	-	3	0.89	0.18–2.60
Brain	191–192/C70–72	0	-	-	1	0.53	0.01–2.93
Thyroid	193/C73	0	-	-	5	2.05	0.67–4.78
Non-Hodgkin's lymphoma	200–203/C82–85, 88,90	0	-	-	3	1.69	0.35–4.93
Leukemia	204–208/C91–96	2	2.56	0.31–9.26	7	2.43	0.98–5.01
Other		0	-	-	0	-	-
All sites	140–208/C00–96	22	0.81	0.51–1.23	111	1.04	0.85–1.25

* 95% confidence interval.

Medical radiation workers are engaged in one of three occupational categories: diagnostic radiology, radiotherapy and nuclear medicine. The observed and expected numbers of new cancer cases and SIRs among diagnostic radiology workers (both genders) are shown in Table 4.

During the follow-up period, the overall cancer incidence was not increased among men working at departments of diagnostic radiology (22 cases, SIR = 0.81, 95%CI = 0.51–1.23). The observed number of lung cancer cases among men was not increased as compared with the expected numbers (2 cases, SIR = 0.32, 95%CI = 0.04–1.15). However, among men a tendency of an excess of prostate cancer risk (7 cases, SIR = 2.32, 95%CI = 0.93–4.78) was found.

During the follow-up period, cancer incidence was not increased among women working at departments of diagnostic radiology (111 cases, SIR = 1.04, 95%CI = 0.85–1.25). An insignificantly elevated risk was found for cancers of rectum (7 cases, SIR = 1.72, 95%CI = 0.69–3.53), skin (14 cases, SIR = 1.11, 95%CI = 0.61–1.86), uterus (11 cases, SIR = 1.32, 95%CI = 0.66–2.36) and thyroid (5 cases, SIR = 2.05, 95%CI = 0.67–4.78). The risk of leukemia was increased (7 cases, SIR = 2.43, 95%CI = 0.98–5.01).

Radiotherapy and nuclear medicine

The risk of cancer in radiotherapy and nuclear medicine workers was difficult to interpret because of the small numbers of observed cancer cases. SIRs among workers of radiotherapy and nuclear medicine are summarized in Table 5.

Table 5. Observed (Obs) numbers of new cancer cases and standardized incidence ratios (SIRs) among medical radiation workers by occupational categories during 1978–2004

Occupational categories	Obs	SIR	95%CI*
Men			
Radiotherapy (N = 43)	6	1.88	0.69–4.09
Nuclear medicine (N = 15)	1	0.89	0.02–4.93
Women			
Radiotherapy (N = 343)	18	0.79	0.47–1.25
Nuclear medicine (N = 72)	1	0.25	0.01–1.41

* 95% confidence interval

Cancer risk by duration of employment

The duration of employment in the ionizing environment: less than 2 years – 153 persons, of them 19 men and women 134; 2–9 years – 721 persons, of them 72 men and 649 women; 10 years and more – 1376 persons, of them 210 men and 1166 women.

Tables 6, 7 show the observed numbers of new cancer cases and standardized incidence ratios of overall cancer and leukemia among medical radiation workers by duration of employment.

Table 6. Observed (Obs) numbers of new cancer cases and standardized incidence ratios (SIRs) among medical radiation workers by duration of employment in the period 1978–2004

Duration of employment, years	Men			Women		
	Obs	SIR	95%CI*	Obs	SIR	95%CI*
<2	2	1.77	0.21–6.39	8	1.21	0.52–2.38
2–9	5	1.52	0.49–3.55	26	1.00	0.66–1.47
≥10	22	0.82	0.51–1.23	96	0.95	0.77–1.16
Total	29	0.92	0.62–1.33	130	0.97	0.81–1.15

* 95% confidence interval.

Cancer risk among medical radiation workers of either gender did not change statistically significantly (men p = 0.29, women p = 0.75) while the duration of employment in the ionizing radiation environment increased.

Table 7. Observed (Obs) numbers of leukemia and standardized incidence ratios (SIRs) among medical radiation workers by duration of employment during the follow-up period 1978–2004

Duration of employment, years	Men			Women		
	Obs	SIR	95%CI*	Obs	SIR	95%CI*
<2	0	–	–	1	5.56	0.14–31.0
2–9	0	–	–	1	1.43	0.04–7.96
≥10	3	3.85	0.79–11.20	8	2.79	1.20–5.49
Total	3	3.30	0.68–9.63	10	2.67	0.92–4.20

* 95% confidence interval.

An increased risk of leukemia was found significant only among women who had been working in the environment of ionizing radiation for more than 10 years (SIR = 2.79, 95%CI = 1.20–5.49).

Occupational exposure

Changes of monitored medical radiation workers in Lithuania during 1950–2003 are shown in Table 8.

Table 8. The monitored medical radiation workers in Lithuania, 1950–2003

Occupational categories	1950–1959	1960–1969	1970–1990	1991–2003
Diagnostic radiology	865	1018	1200	1737
Radiotherapy	NA	78	112	382
Nuclear medicine	NA	NA	62	84

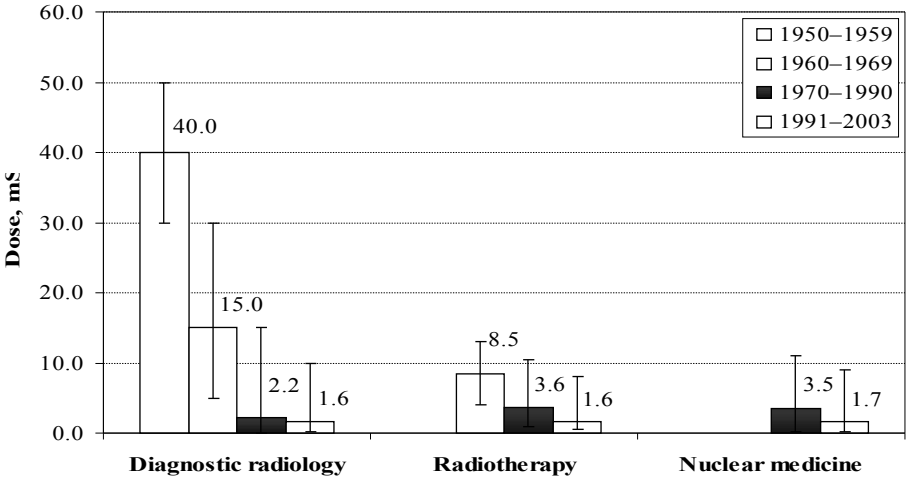
NA – not available.

Data on occupational exposure for the diagnostic radiology group had been traced in all available archives of hospitals since 1950, for radiotherapy since 1960 and for nuclear medicine, since 1970. These periods correspond to the start of extensive application of diagnostic radiology, radiotherapy and nuclear medicine in Lithuania. Because the availability and quality of badge dose record data differ in each period, the data were grouped into periods: 1950–1959, 1960–1969, 1970–1990, 1991–2003. For the earliest periods before 1969, data from publications were used (Sirotka 1973; Sirotka 1972); for the period 1970–1990, data from archives of the largest hospitals (Institute of Oncology, Vilnius University, Kaunas Medical University Clinics), and for the period 1991–2003, data from the Lithuanian Subdivision of Individual Dosimetry of Radiation Protection Center were employed.

The average annual effective dose for medical radiation workers was estimated by correlating the types of dosimeter in all periods and practices applied and compared with the doses of medical radiation workers in other countries.

The occupational exposure among Lithuanian medical radiation workers during 1950–2003 consistently decreased (Fig. 1).

Fig. 1. Annual average effective dose, mSv (min, max), for medical staff at diagnostic radiology, radiotherapy and nuclear medicine departments in Lithuania, 1950–2003



Among medical workers engaged in diagnostic radiology, from the period 1950–1959 to 1991–2003 occupational exposure decreased from 40.0 mSv to 1.6 mSv, in radiotherapy from the period 1960–1969 to 1991–2003 from 8.5 mSv to 1.6 mSv, and in nuclear medicine from the period 1970–1990 to 1991–2003 from 3.5 mSv to 1.7 mSv.

Cancer risk by cumulative dose

There were 1993 persons (258 men and 1735 women) who received a cumulative dose below 100 mSv and 257 persons (43 men and 214 women) received a cumulative dose of 100 and more mSv.

The risk of cancer in the group with a higher cumulative dose (≥100 mSv) was higher, though insignificantly, for both men (13 cases, SIR = 1.33, 95%CI = 0.71–2.27) and women (36 cases, SIR = 1.13, 95%CI = 0.79–1.56) (Table 9).

Table 9. Observed (Obs) and expected (Exp) numbers of cancer cases and standardized incidence ratios (SIRs) among medical radiation workers by cumulative dose during the follow-up period 1978–2004

Cumulative dose, mSv	Obs	Exp	SIR	95%CI*
Men				
<100	16	21.62	0.74	0.42–1.20
≥100	13	9.78	1.33	0.71–2.27
Total	29	31.40	0.92	0.62–1.33
Women				
<100	94	102.02	0.92	0.75–1.13
≥100	36	31.87	1.13	0.79–1.56
Total	130	133.89	0.97	0.81–1.15

* 95% confidence interval.

The risk of leukemia in the group with a higher cumulative dose (≥100 mSv) was insignificantly higher for men (2 cases, SIR = 6.90, 95%CI = 0.84–24.90). For women (4 cases, SIR = 3.81, 95%CI = 1.04–9.75), an increased risk of leukemia was significant (Table 10).

Table 10. Observed (Obs) and expected (Exp) numbers of leukemia and standardized incidence ratios (SIRs) among medical radiation workers by cumulative dose during the follow-up period 1978–2004

Cumulative dose, mSv	Obs	Exp	SIR	95%CI*
Men				
<100	1	0.62	1.61	0.04–8.99
≥100	2	0.29	6.90	0.84–24.90
Total	3	0.91	3.30	0.68–9.63
Women				
<100	6	2.70	2.22	0.82–4.84
≥100	4	1.05	3.81	1.04–9.75
Total	10	3.75	2.67	0.92–4.20

* 95% confidence interval.

DISCUSSION

The cohort of medical radiation workers did not reveal any work-related excess in cancer incidence from ionizing radiation. The SIRs of Lithuanian medical radiation workers were similar to the rates in the U.S. (Sigurdson et al. 2003) and Canada (Asmore 2000) cohorts (Yoshinaga et al. 2004). The risk of lung cancer among men (6 cases, SIR = 0.81, 95%CI = 0.30–1.77) and the risk of breast cancer among women (25 cases, SIR = 0.90, 95%CI = 0.58–1.33) were not increased. Only the risk of leukemia (excluding chronic lymphocytic leukemia, which has not been associated with radiation exposure) increased, but not significantly, among men (3 cases, SIR = 3.30, 95%CI = 0.68–9.63) and women (10 cases, SIR = 2.67, 95%CI = 0.92–4.20).

The differences among the occupational categories (diagnostic radiology, radiotherapy and nuclear medicine) were not significantly reflected in the exposure estimates.

No increased cancer risk was found among men (22 cases, SIR = 0.92, 95%CI = 0.62–1.33) and women (96 cases, SIR = 0.95, 95%CI = 0.77–1.16) who had been working in the environment of ionizing radiation for more than 10 years. The short-term workers men (2 cases, SIR = 1.77, 95%CI = 0.21–6.39) and women (8 cases, SIR = 1.21, 95%CI = 0.52–2.38) in our study had a higher incidence rate. Such patterns have been observed in other studies, and may be due to other lifestyle risk factors (for example, smoking). The risk of cancer in the group with a higher cumulative dose (≥100 mSv) was insignificantly higher both among men (13 cases, SIR = 1.33, 95%CI = 0.71–2.27) and women (36 cases, SIR = 1.13, 95%CI = 0.79–1.56). The increased risk of leukemia among men was insignificantly (SIR = 6.90,

95%CI = 0.84–24.90), among women – significantly higher (SIR = 3.81, 95%CI = 1.04–9.75). The positive associations between ionizing radiation exposure and risk in dose ranges were found primarily from high-dose studies of Hiroshima and Nagasaki bombing survivors in Japan and experimental studies on exposed animals. The level of a cumulative fractionate dose may be related to an increased risk of cancer, just like a high acute dose of ionizing radiation. Further investigations are needed to determine whether cumulative doses are as dangerous for human health as acute doses of the same level.

Firstly, the cohort of medical radiation workers was relatively small (N = 2250) and contributed 42479 person years. Secondly, the cohort of medical radiation workers in Lithuania was relatively young (the mean age at first exposure was 37, and at the end of the follow-up 56 years). These facts explain the small number of cancer cases. It was impossible to make conclusions for various sites of cancer because of the small numbers of cancer cases, especially for men (N = 301) where the analysis was limited. The majority (86%) of Lithuanian medical radiation workers in the study cohort were women. Half of all medical radiation worker cohorts worldwide were composed only of men, while other cohorts were mixed: in the USA 42%, in Canada 26%, in China 17% and in Denmark 45% women. Determination of individual doses was a problem in all cohorts of medical radiation workers. We have estimated the mean annual effective and cumulative doses on the individual level of exposure among medical radiation workers in Lithuania since 1950. The occupational exposure among Lithuanian medical radiation workers from 1950 to 2004 consistently decreased.

Although our study did not reveal any risk in site-specific cancer incidence, the problem of small numbers requires further investigations because the current study lacks statistically significant evidence of a dose-response relationship.

CONCLUSIONS

1. During the follow-up period (1978–2004) the risk of cancer among medical radiation workers (SIR = 0.92, 95%CI = 0.62–1.33 among men and SIR = 0.97, 95% CI = 0.81–1.15 among women) was the same as in the general Lithuanian population.

2. The differences among occupational categories (diagnostic radiology: in men SIR = 0.81, 95%CI = 0.51–1.23 and in women SIR = 1.04, 95%CI = 0.85–1.25; radiotherapy: in men SIR = 1.88, 95%CI = 0.69–4.09 and in women SIR = 0.79, 95%CI = 0.47–1.25; and nuclear medicine: in men SIR = 0.89, 95%CI = 0.02–4.93 and in women SIR = 0.25, 95%CI = 0.01–1.41) were not estimated.

3. The risk of leukemia was increased among women with the duration of employment 10 years and more (SIR = 2.79, 95%CI = 1.20–5.49). The risk of leukemia was increased among women with the cumulative dose 100 mSv and more (SIR = 3.81, 95%CI = 1.04–9.75).

4. The occupational exposure among Lithuanian medical radiation workers during 1950–2003 consistently decreased. Among medical workers engaged in diagnostic radiology, from the period 1950–1959 to 1991–2003 occupational exposure decreased from 40.0 mSv to 1.6 mSv, in radiotherapy from the period 1960–1969 to 1991–2003 from 8.5 mSv to 1.6 mSv, and in nuclear medicine from the period 1970–1990 to 1991–2003 from 3.5 mSv to 1.7 mSv.

SANTRAUKA

Šio darbo tikslas – įvertinti Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, riziką susirgti piktybiniais navikais 1978–2004 metų laikotarpiu.

Darbo uždaviniai:

1. Nustatyti Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, riziką susirgti piktybiniais navikais 1978–2004 metų laikotarpiu, palyginti su Lietuvos populiacijos rizika tuo pačiu laikotarpiu.

2. Nustatyti Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, riziką susirgti piktybiniais navikais pagal darbo pobūdį (diagnostinė radiologija, spindulinė terapija, branduolinė medicina).

3. Nustatyti Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, riziką susirgti piktybiniais navikais, atsižvelgiant į darbo jonizuojančiosios spinduliuotės aplinkoje trukmę ir kaupiamąją dozę.

4. Įvertinti Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, profesinę apšvitą įvairiais istoriniais dozimetrijos laikotarpiais.

Ginamieji teiginiai:

1. Medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, rizika susirgti kai kurių lokalizacijų piktybiniais navikais susijusi su profesinės jonizuojančiosios spinduliuotės poveikiu.

2. Skirtingų pagal darbo pobūdį – diagnostinės radiologijos, spindulinės terapijos ir branduolinės medicinos – darbuotojų rizika susirgti piktybiniais navikais nesiskyrė nuo Lietuvos populiacijos rizikos.

3. Medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, profesinė apšvita įvairiais istoriniais dozimetrijos laikotarpiais nuosekliai mažėjo.

Mokslinio darbo naujumas

Istoriniu (retrospektyviuoju) kohortiniu metodu įvertinta Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, rizika susirgti piktybiniais navikais. Nustatyta medicinos darbuotojų profesinė apšvita (vidutinės metinės efektinės dozės) nuo 1950 iki 2004 metų. Šio darbo rezultatai gali papildyti turimas žinias apie mažų jonizuojančiosios spinduliuotės dozių poveikį medicinos darbuotojų sveikatai.

Medžiaga ir metodai

Informacija apie medicinos darbuotojus, dirbusius jonizuojančiosios spinduliuotės aplinkoje, buvo surinkta iš 107 medicinos įstaigų, kurios gydymo praktikoje naudojo jonizuojančiosios spinduliuotės šaltinius. Buvo renkami tokie duomenys: pavardė, vardas, tėvo vardas, gimimo data, asmens kodas, adresas, darbovietė, padalinys (darbo pobūdis/ profesinė kategorija), pareigos, darbo jonizuojančiosios spinduliuotės aplinkoje pradžios ir pabaigos datos. Iš viso surinkti duomenys apie 2787 medicinos darbuotojus. 2250 (80,7%) medicinos darbuotojų atitiko įtraukimo į tyrimą kriterijus. Šių asmenų stebėjimo laikotarpis buvo nuo 1978-01-01 iki 2004-12-31.

Informacija apie gyvybinį statusą stebėjimo laikotarpio pabaigoje, emigracijos ar mirties datos buvo gautos iš Lietuvos migracijos departamento, Gyventojų registro

tarnybos prie Vidaus reikalų ministerijos ir Lietuvos archyvų departamento prie Lietuvos Respublikos Vyriausybės.

Duomenys apie piktybinių navikų atvejus gauti iš Vilniaus universiteto Onkologijos instituto Vėžio registro, o mirties aktų įrašai – iš Vilniaus universiteto Onkologijos instituto Vėžio registro ir Lietuvos metrikų archyvo.

Rizika susirgti piktybiniais navikais įvertinta retrospektyviuoju kohortiniu metodu, taikant netiesioginį standartizavimo būdą. Kaip palyginamoji grupė buvo naudota visos Lietuvos populiacija. Skaičiavome sustandartintus sergamumo santykius ir 95% pasikliautinuosius intervalus, pasirinkdami 5% reikšmingumo lygmenį ($p < 0,05$). Medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, rizika susirgti piktybiniais navikais taip pat buvo vertinta, atsižvelgiant į darbo pobūdį, darbo trukmę ir kaupiamosios dozės dydį.

Rezultatai

Stebėjimo laikotarpiu rizika susirgti visų lokalizacijų piktybiniais navikais nebuvo padidėjusi nei tarp Lietuvos medicinos darbuotojų vyrų (SSS = 0,92, 95%PI = 0,62–1,33), nei tarp moterų (SSS = 0,97, 95%PI = 0,81–1,15).

Tarp vyrų nustatyta statistiškai nereikšmingai padidėjusi rizika susirgti leukozėmis (SSS = 3,30, 95%PI = 0,68–9,63) ir priešinės liaukos piktybiniais navikais (SSS = 2,10, 95%PI = 0,85–4,33). Rizikos susirgti plaučių piktybiniais navikais padidėjimo tarp vyrų nenustatyta (SSS = 0,81, 95%PI = 0,30–1,77). Tarp moterų nustatyta nereikšmingai padidėjusi

rizika susirgti leukozėmis (SSS = 2,67, 95%PI = 0,92-4,20), skydliaukės (SSS = 1,63, 95%PI = 0,53–3,80), gimdos kūno (SSS = 1,23, 95%PI = 0,66–2,11), tiesiosios žarnos (SSS = 1,48, 95%PI = 0,64–2,91) piktybiniais navikais. Padidėjusi rizika susirgti krūties piktybiniais navikais nenustatyta (SSS = 0,90, 95%PI = 0,58–1,33).

Analizuojant rezultatus pagal darbo pobūdį, nustatyta, kad diagnostinės radiologijos darbuotojų rizika susirgti piktybiniais navikais nebuvo padidėjusi nei tarp vyrų (SSS = 0,81, 95%PI = 0,51–1,23), nei tarp moterų (SSS = 1,04, 95%PI = 0,85–1,25). Spindulinės terapijos, branduolinės medicinos skyriuose dirbusių medicinos darbuotojų sergamumo rodiklius sudėtinga interpretuoti dėl mažų stebėtų piktybinių navikų atvejų skaičių.

Analizuojant pagal darbo trukmę, padidėjusi rizika susirgti leukozėmis nustatyta tarp moterų, dirbusių jonizuojančiosios spinduliuotės aplinkoje 10 ir daugiau metų (SSS = 2,79, 95% PI = 1,20–5,49). Analizuojant duomenis pagal kaupiamosios dozės dydį, padidėjusi rizika susirgti leukozėmis nustatyta tarp moterų, gavusių kaupiamąją dozę, lygią 100 ir daugiau milizivertų (SSS = 3,81, 95% PI = 1,04–9,75).

Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, profesinė apšvita (vidutinės metinės efektinės dozės) nuosekliai mažėjo: diagnostinės radiologijos skyrių darbuotojų, lyginant 1950–1959 metų laikotarpį su 1991–2003 metų laikotarpiu, nuo 40 mSv iki 1,6 mSv; spindulinės terapijos skyrių darbuotojų, lyginant 1960–1969 metų laikotarpį su 1991–2003 metų laikotarpiu – nuo 8,5 mSv iki 1,6 mSv ir branduolinės medicinos darbuotojų, lyginant 1970–1990 metų laikotarpį su 1991–2003 metų laikotarpiu – nuo 3,5 mSv iki 1,7 mSv.

Išvados

1. 1978–2004 metų laikotarpiu medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, rizika susirgti piktybiniais navikais (SSS = 0,92, 95%PI = 0,62–1,33 tarp vyrų ir SSS = 0,97, 95%PI = 0,81–1,15 tarp moterų) nesiskyrė nuo Lietuvos gyventojų rizikos susirgti piktybiniais navikais.

2. Nenustatytas rizikos susirgti piktybiniais navikais skirtumas analizuojant pagal darbo pobūdį: tarp diagnostinės radiologijos (SSS = 0,81, 95%PI = 0,51–1,23; SSS = 1,04, 95%PI = 0,85–1,25), spindulinės terapijos (SSS = 1,88, 95%PI = 0,69–4,09; SSS = 0,79, 95%PI = 0,47–1,25) ir branduolinės medicinos darbuotojų (SSS = 0,89, 95%PI = 0,02–4,93; SSS = 0,25, 95%PI = 0,01–1,41 – atitinkamai tarp vyrų ir moterų).

3. Analizuojant pagal darbo trukmę, padidėjusi rizika susirgti leukozėmis nustatyta moterims, dirbusioms jonizuojančiosios spinduliuotės aplinkoje 10 ir daugiau metų (SSS = 2,79, 95%PI = 1,20–5,49). Pagal kaupiamosios dozės dydį – padidėjusi rizika susirgti leukozėmis nustatyta moterims, gavusioms 100 ir daugiau milizivertų kaupiamąją dozę (SSS = 3,81, 95%PI = 1,04–9,75).

4. Lietuvos medicinos darbuotojų, dirbusių jonizuojančiosios spinduliuotės aplinkoje, profesinė apšvita 1950–2003 metų laikotarpiu nuosekliai mažėjo:

- medicinos darbuotojų, dirbusių diagnostinėje radiologijoje 1950–1959 metų laikotarpiu, profesinė apšvita, palyginti su profesine apšvita dirbusiųjų 1991–2003 metų laikotarpiu, sumažėjo nuo 40,0 mSv iki 1,6 mSv,
- medicinos darbuotojų, dirbusių spindulinėje terapijoje 1960–1969 metų laikotarpiu, profesinė apšvita, palyginti su profesine apšvita dirbusiųjų 1991–2003 metų laikotarpiu, sumažėjo nuo 8,5 mSv iki 1,6 mSv,
- medicinos darbuotojų, dirbusių branduolinėje medicinoje 1970–1990 metų laikotarpiu, profesinė apšvita, palyginti su profesine apšvita dirbusiųjų 1991–2003 metų laikotarpiu, sumažėjo nuo 3,5 mSv iki 1,7 mSv.

LIST OF PUBLICATIONS

1. Slapšytė G, Mierauskienė J, Samerdokienė V. Cytogenetic monitoring of hospital workers occupationally exposed to low levels of ionizing radiation. In: Human Monitoring for Genetic Effects. Cebulska–Wasilewska A et al. (Eds.) Amsterdam: IOS Press, 2003. p. 119–22.

2. Slapšytė G, Gricienė B, Sipavičiūtė R, Samerdokienė V. Jonizuojančiosios spinduliuotės aplinkoje dirbančio personalo citogenetiniai tyrimai. Sveikatos mokslai 2004;14(2):55–7.

3. Samerdokienė V, Kurtinaitis J, Atkocius V, Valuckas KP. Prevalence of cancer risk factors among women radiologists and radiology assistants in Lithuania. Acta Medica Lithuanica 2005;12(2):51–6.

4. Valuckas KP, Atkocius V, Samerdokienė V. Occupational exposure of medical radiation workers in Lithuania, 1991–2003. Acta Medica Lithuanica 2007;14(3):152–6.

5. Samerdokienė V, Atkocius V, Kurtinaitis J, Valuckas KP. Occupational exposure of the Lithuanian medical radiation workers, 1950–2003. Radiation Protection Dosimetry 2008;130(2):239–243.

6. Samerdokienė V, Atkočius V, Valuckas KP. Pattern of cancer risk among Lithuanian medical radiation workers. Medicina, 2009; [in print].

BRIEF INFORMATION

Name	Vitalija Samerdokiene
Address of working place	Institute of Oncology, Vilnius University Laboratory of Molecular Oncology Street P. Baublio 3B LT-08406
Phone	+370 5 2190917, mob. +370 67386535
E-mail	Vitalija.Samerdokiene@gmail.com
Date of birth	05 January 1957

Qualification

Date on degree in Science:	Diploma in Natural Sciences, 1991 (Vilnius Pedagogical University)
Professional experience	1991–2005 assistant at Dept. of Cancer Epidemiology, 2005–2006 specialist at Dept. of Cancer Prevention, 2007 research assistant at Laboratory of Molecular Oncology

Experience Abroad (Postgraduate Training)

- Courses in Cancer Epidemiology, Norway/Lithuania. 1996.
- First Baltic Course on Quality Assurance and Risk Assessment of Occupational Health, NIVA, Finland/Lithuania, 1999.
- Cancer Prevention, Vilnius University, 2001.
- Assessment of Occupational Risk and Study of Causes of Occupational Diseases, Vilnius University, 2003.
- Basics on data analysis of the epidemiological studies, Vilnius University, 2004.
- The Third Baltic Congress of Oncology: 2–4 May, 2002, Vilnius.
- Radiation Protection 2003, Radiation Protection Centre, 2003.