

CANCER MORTALITY IN RUBBER TIRE WORKERS IN POLAND

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Abstract. The study aimed at assessing cancer risk in a cohort of workers employed in the rubber tire production. The cohort consisted of 17,747 workers (11,660 men and 6087 women) employed in a rubber tire plant for at least three months during the years 1950–1995. The cohort follow-up was completed on December 31, 1995. Deaths by causes were analyzed using standardized mortality ratio (SMR) calculated by the person-years method. The mortality pattern of the general population of Poland was used as the reference.

The study indicated significantly lower total mortality in the cohort (men: SMR = 72; women: SMR = 62) as compared to the general population, which is an example of a well known "healthy worker effect". The number of deaths from malignant neoplasms was also lower than expected (men: SMR = 67; women: SMR = 64). Only in a very small sub-cohort of men involved in dosing and mixing of raw material for the production of rubber, an excess of total mortality (SMR = 104) and from all cancers (SMR = 115) was found. Mortality from all neoplasms was enhanced (SMR = 108) in the sub-cohort of women employed in the technical service work area.

When analyzing individual cancer sites in men of the whole cohort or sub-cohorts, the observed number of deaths from cancers of the lip, tongue, pharynx, stomach, gallbladder, pancreas, peritoneum, articular cartilage, connective tissue, skin, testis, prostate, bladder, kidney, brain, as well as from Hodgkin's disease, multiple myeloma and leukemia was larger than the expected number. Among women the excess mortality was due to cancers of the large myeloma and leukemia. The SMR calculated for these sites were statistically insignificant.

The cohort under study was "young" and thus relatively small numbers of deaths were recorded. The excess mortality, based quite frequently on single cases of selected cancer sites, cannot be regarded as a basis for final conclusions. Nevertheless, the fact that these observations are in agreement with the findings of other authors who carried out studies in the rubber industry of other countries justifies the need to follow-up this cohort in the future.

Key words:

Cancer mortality, Rubber tire industry, Cohort study

INTRODUCTION

The technological process involved in the manufacture of rubber products is characterised by the occurrence of a broad variety of chemicals, including chemical compounds already recognised as agents carcinogenic to humans (β -naphthylamine, 4-aminodiphenol, benzidine, benzene, mineral oil, soot, vinyl chloride and asbestos), or probably carcinogenic to humans (styrene, acrylonitrile, N-phenol- β -naphthylamine, nitrosamines, formaldehyde, carbon tetra-

chloride) [1–5]. The health effects of the employment in the rubber industry have not as yet been unequivocally elucidated. However, already in 1934, an increase of 10% in total mortality among the rubber industry workers as compared to the general population was noted in the British Registrar General. This excess was mainly due to deaths from malignant neoplasms. Numerous studies carried out since the 1950s have indicated a higher risk of all cancers and a significant excess of cancers of different sites in the

The study was performed under Project 10.6 "Mortality with special reference to the risk of neoplastic diseases in the rubber industry workers employed in the tire production", sponsored by the Nofer Institute of Occupational Medicine, Łódź, Poland.

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workers exposed [6–20]. In 1987, the International Agency for Research on Cancer (IARC) recognized the rubber industry as responsible for a higher cancer risk. An excess of bladder cancer and leukemia has been observed and its relationship with the exposure occurring in the rubber industry has been evidenced. The incidence of bladder cancer is associated with the exposure to aromatic amines (β -naphthylamine) used in technological processes as antioxidants [7,8,10,13–18,21–31]. The increased risk of leukemia in the rubber industry is attributed to the exposure to benzene [13,15,16,22,26,28–30,32–35]. The enhanced incidence of the lung, stomach, prostate, large intestine, pancreas, oesophagus, gallbladder, rectum, larynx, thyroid gland, cervix uteri, ovary, kidney, liver and brain cancers reported in various studies encounters some difficulties in the cause-effect interpretation and requires further investigations [8,10,13–19,22,23, 26,30–32,36–49]. The epidemiological study of workers employed in the Polish rubber footwear industry, performed in the 1980s, revealed statistically significant excess mortality from all cancers, including those of the large intestine, gallbladder, larynx and lung. In addition, the observed number of the oesophagus, rectum, liver, pancreas and bladder cancers was larger than expected [50–52].

The purpose of this study was to assess the delayed health effects of the employment in the tire production where the range of harmful factors is wider and the level of exposure higher than in other branches of rubber production, e.g. rubber footwear. General mortality pattern was subject of an earlier paper [53]. It revealed an excess of deaths due to hypertensive disease in male cohort, especially in male maintenance workers. The objective of this analysis was to assess cancer risk by specific sites of neoplasm among workers employed in the rubber tire production.

The next paper will be devoted to the analysis of the relationship between cancer risk and the level of the workers' exposure to agents recognized as carcinogenic or probably carcinogenic to humans.

MATERIALS AND METHODS

The cohort covered by the study included employees of the rubber tire plant established in 1939, its rebuilding

took place in the aftermath of the war (1946). The plant regained its operation in 1950, since then it has produced various types of tires (for motor-cars, delivery trucks, lorries, trolleys, tractors, agriculture vehicles, motor-cycles, bicycles and motor-bicycles), as well as inner tubes and protectors. The measurements of chemical concentrations in the work environment covered 137 work area-job groups in 57 production divisions and sub-divisions of the plant. The results showed that in as many as 92 work areas concentrations exceeded maximum admissible levels by 50%. This also applied to carcinogenic agents such as aromatic amines, trichloroethylene, talc and soot.

The cohort consisted of workers employed in the rubber tire plant for at least three months during the years 1950–95. Each worker meeting these criteria had his or her file kept. The file included personal data and employment history. Based on the information and data obtained from the plant records and vital statistics departments, it was determined who was alive or deceased among those included in the cohort. The follow-up of the cohort members continued until the end of December 1995. The exact date and place of death, as well as the underlying cause of death were obtained for deceased cohort members.

Deaths by causes according to the ninth revision of the International Classification of Diseases (ICD-9) were analyzed using standardized mortality ratio (SMR) calculated by the person-years method. The general population of Poland was used as the reference. The person-years of workers included in the cohort were calculated for the period between starting the employment in the plant and "exit" from the cohort because of death or reaching the age of 80. For the workers remaining in the cohort, the person-years were calculated until the end of the study period. The SMR were standardized for calendar year and ten-year age categories. For causes with at least two observed deaths, 95% confidence intervals (95% CI) were calculated with an exact method based on a Poisson distribution. The data were analyzed by means of the PYRS program provided by IARC, separately for men and women, taking account of the employment duration and work area.

A worker performing several jobs was classified as that with the longest employment in one work area. The study included five sub-cohorts: 1) referred to as "preparation of materials" composed of workers involved in mixing and weighing of raw materials, milling, extruding and calendering; 2) workers engaged in the production of tires and inner tubes (component assembly, vulcanization, inspection and finishing); 3) maintenance workers (mechanics, maintenance technicians, electricians) and those responsible for the inner transport; 4) storage workers; and 5) others.

RESULTS

In all, 17,747 workers (11,660 men and 6087 women) employed in the plant for at least three months during the years 1950–1995 were included in the present study (Table 1). Vital status at the end of the follow-up was known for 94.0% of the cohort. Causes of death were determined for 94.2% of those deceased.

Table 2 shows the distribution of the cohort by the year of birth, year of entering the employment, duration of employment and work area.

Table 1. Vital status and follow-up of the cohort of tire plant workers

Subjects	Men	Women	Total
Included in the study	11660	6087	17747
- traced	10918 (93.6%)	5768 (94.8%)	16686 (94.0%)
- - alive	9721	5613	15334
- - deceased	1197	155	1352
- - - cause of death identified	1130 (94.4%)	144 (92.9%)*	1274 (94.2%)
- lost to follow-up	742 (6.4%)	319 (5.2%)	1061 (6.0%)
- - emigrated	75	44	119

Table 2. Distribution of the cohort of tire plant workers by the year of birth, year of entering the employment and work areas

Characteristics		Men		Women	
		number	%	number	%
Year of birth					
-1929		1093	10.0	279	4.8
1930–1939		1895	17.4	669	11.6
1940–1949		2266	20.7	1187	20.6
1950–		5664	51.9	3633	63.0
Year of entering the employment					
1950–1959		1713	15.7	424	7.4
1960–1969		2618	24.0	1225	21.2
1970–1979		3597	33.0	2803	48.6
1980–1992		2990	27.3	1316	22.8
Duration of employment					
below 5 yrs		5887	53.9	3840	66.6
5 yrs or more		5031	46.1	1928	33.4
Work area					
preparation of materials		2161	19.8	97	1.7
production of tires and inner tubes		4039	37.0	4781	82.9
maintenance		3938	36.1	414	7.2
storage		371	3.4	154	2.6
others		409	3.7	322	5.6
Cohort in total	persons	10918	100.0	5768	100.0
	persons-yr	239557		123801	

The majority of the cohort (51.9% of men and 63.0% of women) was born in 1950 or later. Over 60% of men and 70% of women had not started their work in the plant before 1970. The duration of employment for 53.9% of

men and 66.6% of women was no longer than five years. As to the work area, the largest group of workers (both men and women) was employed in the production of tires and inner tubes (37.0% and 82.9%, respectively).

Table 3. Mortality from malignant neoplasms (the number of observed deaths, SMR and 95% CI) in the cohort of male tire plant workers (n = 10918) by years of employment

Cause of death (code according to ICD-9)	Male cohort in total			Years of employment					
				less than 5 yrs			5 yrs or more		
	Obs.	SMR	95%CI	Obs.	SMR	95%CI	Obs.	SMR	95%CI
All causes (001-999)	1197	72	68–76	564	79	73–86	633	67	62–72
Malignant neoplasms (140-208)	236	67	59–76	88	63	51–78	148	70	59–82
- lip, oral cavity and pharynx (140-149)	7	59	24–122	2	41	5–148	5	71	23–166
- - lip (140)	2	174	21–29	1	234		1	138	
- - tongue (141)	1	43		-	0		1	74	
- - nasopharynx (147)	1	142		-	0		1	249	
- - hypopharynx (148)	1	45		-	0		1	75	
- digestive organs and peritoneum (150-159)	67	59	46–75	27	61	40–89	40	58	41–79
- - oesophagus (150)	2	22	3–79	1	28		1	18	
- - stomach (151)	43	90	65–121	20	109	67–168	23	78	49–117
- - colon (153)	2	21	3–76	1	26		1	17	
- - rectum and anus (154)	4	32	9–82	1	21		3	39	8–114
- - liver (155)	4	34	9–87	-	0		4	55	15–141
- - gallbladder (156)	1	36		-	0		1	58	
- - pancreas (157)	8	57	25–112	3	54	11–158	5	59	19–138
- - retroperitoneum and peritoneum (158)	1	107		-	0		1	188	
- respiratory and intrathoracic organs (160-165)	95	70	57–86	36	68	48–94	59	71	54–92
- - larynx (161)	11	80	40–143	3	54	11–158	8	96	41–189
- - lung (162)	82	69	55–86	32	70	48–99	50	69	51–91
- - pleura (163)	1	156		1	391		-	0	
- - mediastinum (164)	1	45		-	0		1	76	
- bone and articular cartilage (170)	1	27		1	60		-	0	
- connective tissue (171)	3	298	61–871	1	221		2	362	44–1308
- melanoma of skin (172)	2	63	8–228	1	71		1	56	
- skin, other (173)	2	140	17–506	-	0		2	225	27–813
- prostate (185)	8	87	38–181	3	97	20–283	5	82	27–191
- testis (186)	2	80	10–289	2	140	17–506	-	0	
- bladder (188)	6	61	22–133	2	56	7–202	4	64	17–164
- kidney (189)	10	107	51–197	1	27		9	160	73–304
- brain (191)	8	67	29–132	3	56	12–164	5	76	25–177
- lymphatic and haematopoietic tissue (200-208)	14	64	35–107	4	40	11–102	10	83	40–153
- - Hodgkin's disease (201)	3	66	14–193	2	89	11–231	1	43	
- - other of lymphoid and histiocytic tissue (202)	2	66	8–238	1	77		1	58	
- - multiple myeloma (203)	2	92	11–332	-	0		2	152	18–549
- - leukemias (204-208)	7	67	27–138	1	21		6	105	39–229
- - - lymphoid (204)	2	57	7–206	-	0		2	97	12–350
- - - myeloid (205)	2	36	4–130	-	0		2	70	8–253
- - - other specified (207)	1	178	5–991	-	0		1	346	

Mortality in the male cohort

In the cohort of men, 1197 deaths were noted, which results in $SMR = 72$ (95%CI: 68–76). This figure indicated a significantly lower mortality in the cohort than that in the general population. Mortality from all malignancies was also significantly lower than in the reference population (236 deaths, $SMR = 67$, 95% CI: 59–76). However, the analysis by cancer sites revealed certain insignificant excess mortality from cancers of the lip, nasopharynx, peritoneum, pleura, connective tissue and kidney (Table 3).

The analysis of mortality from neoplasms by the employment duration (less than 5 yrs and 5 yrs or more) showed the increased SMR values for the same sites as in the whole cohort. Generally speaking, the higher values were found in both employment duration groups, and their distribution did not suggest any upward trend in risk associated with longer employment. It should be noted, however, that in men employed for at least 5 years the excess mortality from cancer of kidney ($SMR = 160$) was observed, and of the 10 deaths from this cause, 9 were recorded in men with longer duration of employment.

Like in the whole male cohort, in all sub-cohorts, distinguished by the work area, general mortality and mortality from all cancers was lower than in the reference population (Table 4). Among workers employed in the department of material preparation, a higher risk of the lip, gallbladder, articular cartilage, testis, bladder and kidney cancers, as well as of Hodgkin's disease was found. When analyzing the risk, a still smaller sub-cohort of workers engaged in weighing and mixing of raw materials was discriminated (not showed in tables). This sub-cohort was composed of only 50 male workers; 12 of them died ($SMR = 104$, 95%CI: 54–182), including three deaths from malignant neoplasm ($SMR = 115$, 95%CI: 24–336): one from neoplasm of lip ($SMR = 10464$, $p < 0.05$) and one from neoplasm of stomach ($SMR = 250$, $p > 0.05$); the site in the third case was not defined in the death certificate.

In the sub-cohort of workers employed in the production of tires and inner tubes, the observed number of cancers of the tongue, hypopharynx, connective tissue, skin, prostate, testis, brain and multiple myeloma was larger than expected.

In the maintenance work area, the excess incidence of the following cancers was disclosed: nasopharynx, stomach, peritoneum, prostate, larynx, connective tissue, kidney and multiple myeloma.

The storage workers were characterized by a significantly increased risk of pleura cancer (1 death, $SMR = 4212$, $p < 0.05$), and enhanced, albeit insignificant risk of pancreas, prostate, bladder and brain tumors.

In the sub-cohort of "others" the increased SMR values were noted for cancers of the stomach, pancreas, mediastinum, prostate and lymphatic tissue.

Mortality in the female cohort

During the cohort follow-up, 155 deaths were recorded, which results in $SMR = 72$ (95% CI: 53–73). This figure indicates a significantly lower mortality in the cohort than that in the general population. Despite a significantly lower risk of all malignant neoplasms (49 cases, $SMR = 64$, 95% CI: 47–85), the observed mortality from cancers of the stomach, peritoneum, ovary and other genital organs, multiple myeloma and leukemia was higher than expected.

The analysis of mortality by the duration of employment did not reveal any significant excess incidence of neoplasms, but in the group of women employed for more than 5 years there was excess incidence of the large intestine (2 deaths, $SMR = 126$, 95% CI: 15–455) and lung cancers (5 deaths, $SMR = 138$, 95% CI: 43–322), the sites characterized in the total cohort by $SMR < 100$. This results from the fact that all observed cases of these neoplasms were found in the group of women with longer employment duration (Table 5).

All deaths were concentrated in four sub-cohorts distinguished by the work area: production of tires and inner tubes, maintenance, storage and "others". Because of a small number of women employed in the storage area and low mortality in this group (154 women; 3 deaths, including one from neoplasm), the mortality parameters were not calculated.

In all work areas, the general mortality was lower than in the reference population (Table 6). The standardized mortality ratio for all malignant neoplasms was significantly lower among women employed in the production of tires

Table 4. Mortality from malignant neoplasms (number of observed deaths, SMR and 95% CI) in the cohort of male tire plant workers (n = 10918) by work area

Cause of death (code according to ICD-9)	Work area														
	Preparation of materials			Production of tyres and inner tubes			Maintenance			Storage			Others		
	Obs.	SMR	95%CI	Obs.	SMR	95%CI	Obs.	SMR	95%CI	Obs.	SMR	95%CI	Obs.	SMR	95%CI
All causes (001-999)	279	78	65-83	433	68	62-75	402	74	62-8	49	77	57-102	35	57	40-79
Malignant neoplasms (140-208)	52	66	49-87	88	65	52-80	77	70	55-87	10	75	36-138	9	71	32-135
- lip, oral cavity and pharynx (140-149)	1	38		2	43	5-155	1	26		2	459	56-1658	-	0	
- - lip (140)	1	382		-	0		-	0		-	0		-	0	
- - tongue (141)	-	0		1	112		-	0		-	0		-	0	
- - nasopharynx (147)	-	0		-	0		1	437		-	0		-	0	
- - hypopharynx (148)	-	0		1	116		-	0		-	0		-	0	
- digestive organs and peritoneum (150-159)	12	47	24-82	23	53	34-80	27	76	50-111	2	45	5-163	3	73	15-213
- - oesophagus (150)	-	0		-	0		2	70	8-253	-	0		-	0	
- - stomach (151)	8	74	32-146	14	76	42-128	19	128	77-200	-	0		2	115	14-415
- - colon (153)	-	0		1	27		1	33		-	0		-	0	
- - rectum and anus (154)	-	0		3	63	12-184	1	26		-	0		-	0	
- - liver (155)	1	37		3	66	14-193	-	0		-	0		-	0	
- - gallbladder (156)	1	159		-	0		-	0		-	0		-	0	
- - pancreas (157)	2	63	8-228	-	0		2	45	5-163	1	188		1	194	
- - retroperitoneum and peritoneum (158)	-	0		-	0		1	328		-	0		-	0	
- respiratory and intrathoracic organs (160-165)	24	77	49-115	36	68	48-94	29	68	46-98	3	59	12-172	3	61	13-178
- - larynx (161)	1	32		4	75	20-192	6	137	50-298	-	0		-	0	
- - lung (162)	23	85	54-128	32	70	48-99	23	62	39-93	2	45	5-163	2	47	6-170
- - pleura (163)	-	0		-	0		-	0		1	4212		-	0	
- - mediastinum (164)	-	0		-	0		-	0		-	0		1	1243	
- bone and articular cartilage (170)	1	126		-	0		-	0		-	0		-	0	
- connective tissue (171)	-	0		1	259		2	601	73-2171	-	0		-	0	
- melanoma of skin (172)	-	0		1	82		1	94		-	0		-	0	
- skin, other (173)	-	0		2	363	44-1311	-	0		-	0		-	0	
- prostate (185)	1	47		4	113	31-289	1	36		1	250		1	296	
- testis (186)	1	207		1	107		-	0		-	0		-	0	
- bladder (188)	3	131	27-383	1	26		2	66	8-238	1	254		-	0	
- kidney (189)	3	143	29-418	3	83	17-243	4	135	37-346	-	0		-	0	
- brain (191)	1	39		5	109	35-254	1	25		1	236		-	0	
- lymphatic and haematopoietic tissue (200-208)9	2	42	5-152	6	71	26-155	5	69	22-161	-	0		1	124	
- - Hodgkin's disease (201)	1	107		1	57		1	64		-	0		-	0	
- - other of lymphoid and histiocytic tissue (202)	-	0		1	86		-	0		-	0		1	894	
- - multiple myeloma (203)	-	0		1	120		1	147		-	0		-	0	
- - leukemias (204-208)	1	45		3	75	15-219	3	87	18-254	-	0		-	0	
- - - lymphoid (204)	1	127		-	0		1	89	2-496	-	0		-	0	
- - - myeloid (205)	-	0		2	94	11-340	-	0		-	0		-	0	
- - - other specified (207)	-	0		1	462		-	0		-	0		-	0	

Table 5. Mortality from malignant neoplasms (the number of observed deaths, SMR and 95% CI) in the cohort of male tire plant workers (n = 10918) by years of employment

Cause of death (code according to ICD-9)	Female cohort in total			Years of employment					
	Obs.	SMR	95%CI	less than 5 yrs			5 yrs or more		
				Obs.	SMR	95%CI	Obs.	SMR	95%CI
All causes (001-999)	155	62	53-73	68	70	54-89	87	57	46-70
Malignant neoplasms (140-208)	49	64	47-85	18	64	38-101	31	65	44-92
- digestive organs and peritoneum (150-159)	15	69	39-114	4	52	14-133	11	79	39-141
- - stomach (151)	6	103	38-224	3	139	17-240	3	82	17-240
- - colon (153)	2	81	10-293	-	0		2	126	15-455
- - rectum and anus (154)	2	64	8-231	-	0		2	98	12-354
- - liver (155)	1	33		-	0		1	51	
- - gallbladder (156)	2	81	10-293	1	117		1	62	
- - pancreas (157)	1	39		-	0		1	60	
- - retroperitoneum and peritoneum (158)	1	296		-	0		1	472	
- respiratory and intrathoracic organs (160-165)	5	77	25-180	-	0		5	118	38-275
- - lung (162)	5	90	29-210	-	0		5	138	45-322
- breast (174)	6	47	17-102	2	44	5-159	4	49	13-125
- cervix uteri (180)	6	72	26-157	2	65	8-235	4	76	23-195
- ovary (183)	7	124	50-255	3	145	30-424	4	112	31-287
- other and unspecified genital organs (184)	2	164	20-592	2	441	53-1593	-	0	
- brain (191)	1	31		-	0		1	52	
- lymphatic and haematopoietic tissue (200-208)	4	73	20-187	3	132	27-386	1	32	
- - multiple myeloma (203)	1	186		1	548		-	0	
- - leukemias (204-208)	3	101	21-295	2	159	19-574	1	60	
- - - myeloid (205)	2	100	12-361	2	230	28-831	-	0	

and inner tubes. However, the observed mortality from the stomach, gallbladder, peritoneum and genital organs cancers and multiple myeloma was higher than expected.

In the maintenance work area, an insignificant excess of all malignant neoplasms was found, including deaths from cancers of the large intestine, liver, lung, cervix uteri and ovary. In other work areas, increased risks of leukemia and cancer of ovary, based on single cases of death, were observed. The overall cancer mortality was significantly lower than in the reference population.

DISCUSSION

The analysis of data collected during a 45-year period of retrospective observation of the cohort, including workers of the rubber tire plant showed significantly lower general mortality in the cohort than in the reference population.

This could be attributed to "healthy worker effect", a well known problem of numerous cohort studies. The observed number of deaths from all malignant neoplasms was also lower than expected. A similar situation has been observed in the cohort studies carried out in China and USA [36-37]. In the majority of sub-cohorts defined by specific work areas (male workers employed in the preparation of materials, production of tires and inner tubes, maintenance, inner transport and storage, and female workers employed in the production of tires and inner tubes) the total mortality risk and risk of all malignant neoplasms were similar to that found in the overall cohort. Only in a very small sub-cohort of male workers employed in weighing and mixing of raw materials for the rubber production, the excess total mortality and mortality from all cancers were observed, whereas the latter was found in the sub-cohort of female workers employed in the maintenance work area.



Table 6. Mortality from malignant neoplasms (number of observed deaths, SMR and 95% CI) in the cohort of female tire plant workers (n = 5768) by work area

Cause of death (code according to ICD-9)	Production of tires and inner tubes			Maintenance			Others		
	Obs.	SMR	95%CI	Obs.	SMR	95%CI	Obs.	SMR	95%CI
All causes (001-999)	123	64	53–76	19	64	39–100	10	74	35–136
Malignant neoplasms (140-208)	37	62	44–85	9	108	49–205	2	49	6–177
- digestive organs and peritoneum (150-159)	13	79	42–135	2	72	9–260	-	0	
- - stomach (151)	6	136	50–296	-	0		-	0	
- - colon (153)	1	53		1	333		-	0	
- - rectum and anus (154)	2	83	10–300	-	0		-	0	
- - liver (155)	-	0		1	243		-	0	
- - gallbladder (156)	2	108	13–390	-	0		-	0	
- - pancreas (157)	1	51		-	0		-	0	
- - retroperitoneum and peritoneum (158)	1	384		-	0		-	0	
- respiratory and intrathoracic organs (160-165)	3	59	12–172	2	274	33–990	-	0	
- - lung (162)	3	70	14–205	2	318	39–1149	-	0	
- breast (174)	5	49	16–114	1	78		-	0	
- cervix uteri (180)	3	45	9–132	3	382	79–1116	-	0	
- ovary (183)	4	90	25–230	1	180		1	334	
- other and unspecified genital organs (184)	2	212	26–766	-	0		-	0	
- brain (191)	1	39		-	0		-	0	
- lymphatic and haematopoietic tissue (200-208)	3	69	14–202	-	0		1	338	
- - multiple myeloma (203)	1	243		-	0		-	0	
- - leukemias (204-208)	2	84	10–303	-	0		1	625	
- - - myeloid (205)	2	124	15–448	-	0		-	0	

The analysis of individual cancer sites in the male overall cohort, or in the sub-cohorts defined by work areas, revealed that the observed number of deaths from cancers of the lip, tongue, pharynx, stomach, gallbladder, pancreas, peritoneum, pleura, bone and articular cartilage, connective tissue, skin, testis, prostate, bladder, kidney and brain, as well as from Hodgkin's diseases, multiple myeloma and leukemias was larger than the expected number. In the majority of the above-mentioned sites single cases of death were noted and the SMR values were statistically insignificant. There were only two exceptions, namely a markedly increased risk of the lip cancer among men employed in the mixing department (1 death, SMR = 10467, $p < 0.05$), and cancer of pleura (1 death, SMR = 4212, $p < 0.05$) in the storage workers.

In the total female cohort or in sub-cohorts employed in the production of tires and inner tubes or in the mainten-

ance work area, the observed number of cancers of the large intestine, stomach, liver, gallbladder, peritoneum, lung ovary and other genital organs, multiple myeloma and leukemias was larger than expected.

The division of the cohort by the duration of employment and the age at the start of the employment in the plant did not provide with grounds for a general statement that the cancer risk was related to these variables. Interestingly, liver and kidney cancers in men as well as intestinal and lung cancers in women were rather grouped in workers with longer duration of employment.

A considerable excess of cancer of the connective tissue in the total cohort, and neoplasm lip in the mixing area workers, not observed in other cohorts of workers employed in rubber tire plants, requires some comments. On the basis of the evidence provided by the epidemiologic studies, sarcomas of soft tissue are recognized as

neoplasms induced by exposure occurring in the production or application of chlorophenol herbicides [54]. However, chlorophenols have never been mentioned among a whole variety of chemicals found in the rubber industry. Therefore, the occupational exposure of fitters or mechanics to chlorophenol in a tire plant should be rather excluded.

It is also difficult to identify the causal factor of lip cancer observed in the employees of the mixing work area, as it is usually thought to be associated with the exposure to ultraviolet radiation [36].

In the cohort follow-up, 94.2% of workers have been traced. The majority of those lost to follow-up were subjects born before 1950 (68.1%) compared to 44.3% in the successfully traced group. As to the year of the start of employment, subjects lost to follow-up were older than those traced; 29.5% of those lost to follow-up started their work in the plant before 1960, and only 12.8% among those were traced. Therefore, the calculated mortality values are most likely underestimated. In spite of this, the study indicated an increased, albeit insignificant risk of numerous neoplasms, which is consistent with the results of other cohort studies of the rubber industry workers. The following cancer sites should be mentioned here: pharynx [19], stomach [15,17–19,26,30,36], pancreas [30,36,40,44], pleura [14,49], skin [14,30,44], prostate [19,24], bladder [14,17,26,30,44], kidney [14,26], brain [26,30,44], leukemia in men [15,26,30] and the large intestine in women [37]. The observed excess of deaths, frequently from single cases of cancers of individual sites, does not provide sufficient evidence to formulate final conclusions. In the light of the fact that the examined cohort was rather "young" (almost 56% of subjects were born in 1950 or later) and relatively small number of deaths was recorded, the obtained results justify a need to continue the follow-up of the cohort.

ACKNOWLEDGEMENTS

We wish to thank Ms Elżbieta Kurcz, Section of Work Safety and Hygiene of the plant covered by the project, for her kind co-operation, allowing the access to data charac-

terizing working conditions, assistance in assessing the exposure and comments on technological processes used in the past by the plant under study.

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Received for publication: February 20, 2001

Approved for publication: May 15, 2001

