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MORTALITY IN THE COTTON INDUSTRY WORKERS: RESULTS OF A COHORT STUDY

NEONILA SZESZENIA-DĄBROWSKA, URSZULA WILCZYŃSKA, ALICJA STRZELECKA and WOJCIECH SOBALA

Department of Occupational and Environmental Epidemiology
The Nofer Institute of Occupational Medicine
Łódź, Poland

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Abstract. The cohort consisted of persons found on the payroll of one of the Łódź cotton plants in 1964 – 1993 who were employed in the plant for at least 10 years. Death risk by causes was analysed using standardised mortality ratios (SMRs) calculated by the person-years method. The general population of Poland was used as the reference. In all, 7892 people were observed. As of December 31, 1995, the follow-up was completed for 7545 people (2852 men and 4693 women), i.e. the availability of the cohort was 95.6%. A total of 2069 deaths were recorded; the information on the cause of death was available for 97% of the subjects.

In the male cohort, the level of the general mortality was the same as in the general population (SMR = 99). However, there was a significant increase in the number of deaths from diseases of the digestive system (SMR = 142) and larynx cancer (SMR = 188). The analysis of the results by production departments revealed in the weaving department significantly higher mortality from atherosclerosis (SMR = 141), peritoneal carcinoma (SMR = 1057) and melanoma (SMR = 677); and in the spinning department the increased risk of the hypertensive disease (SMR = 239), atherosclerosis (SMR = 175), and Hodgkin's disease (SMR = 768).

Mortality in the female cohort was lower than that in the general population (SMR = 88). None of the disease groups or tumour sites caused statistically significant excess deaths either in the total cohort or in subcohorts selected according to departments.

Special attention was paid to the chemical processing departments where chemicals used could contribute to the increased risk of death from cancer. Our analysis did not reveal any significant increase either in the total cohort of the workers employed in those departments or in the cohorts analyzed by duration of employment.

Our results confirm the lower risk of lung cancer in the analysed group as compared with that in the general population. The numerous, but statistically insignificant increases in the incidence of malignant tumours at some specific sites detected in the subcohorts, distinguished according to the duration of employment or department, confirm the reported findings on the incidence of oral cavity, nose, throat, and larynx tumours among people exposed to harmful agents in the cotton industry.

Address reprint requests to Prof. N. Szeszenia-Dąbrowska, Department of Occupational and Environmental Epidemiology, The Nofer Institute of Occupational Medicine, P.O. Box 199, 90-950 Łódź, Poland.

INTRODUCTION

Textiles is a highly labour-intensive industry throughout the world. In Poland, in spite of a considerable reduction of employment in that sector by about two third compared with the late 1970s, over 160,000 people continued employment in the manufacture of fabrics in 1996.

The occupational exposure of the textile industry workers varies widely, depending on the type of material used to manufacture the products. Exposure to noise and dust constitute the most serious problem in the cotton industry, but there are also some minor hazards. These include, among others, exposure to bleaching, washing, mercerizing agents, textile dyes, various acids, fluorescent bleaching agents, organic solvents and dye setting media, agents applied to impart crease-, soil-resistant and rot-proof finish to the fabrics. Exposure to noise and cotton dust occurs practically in all departments, although its intensity varies considerably. Exposure to chemicals is mainly associated with the employment in the dyeing, printing, and finishing departments, but also in the warp sizing and in the bleaching, mercerizing and carbonizing rooms. Some of the exposures could result in an increased risk of cancer (26). In the literature on the occupational cancer, the cotton industry is classified among those with the increased cancer incidence, although the evidence of the increased cancer risk is not convincing (15).

The aim of the present work was, among other things, to assess mortality in the textile industry workers, including the risk of death due to malignant tumours.

MATERIALS AND METHODS

The cohort comprised employees, whose names were drawn from the payrolls of one of the Łódź cotton plants in 1964 – 1993, who worked for a minimum of 10 years, and lived in Łódź or its suburbs during the period of their employment. Personal data and the information on employment (departments, workplaces and respective periods of employment) were collected for each person meeting the criteria. Using the vital statistics department files, it was determined whether the members of the cohort were alive or deceased. December 31, 1995 was the closing day of the cohort observation. The exact date and place of death of each cohort member was recorded in order to obtain information on death cause from the files of the relevant institutions.

Death risk by causes was analyzed using standard mortality ratios (SMRs) calculated by the person-years method. The person-years of the cohort members were calculated for the period between their completing 10 years of employment and 'exit' from the cohort, because of death or reaching the age of 80. For the people remaining in the cohort, the person-years were calculated until the closing date. The Poisson distribution test was used to assess the statistical significance of the results. Confidence intervals for SMRs were calculated for categories in which at least two deaths were observed. The general population of Poland served as the reference to calculate SMR values. The data were analysed by means of the PYRS programme made available to the authors by the International Agency for Research on Cancer (IARC). The data were analysed separately for men and women, in the total cohort and in the subcohorts identified by individual departments and duration of employment. In determining the subcohorts, a worker employed in several departments was classified as the worker of the longest employment.

The plant characteristics

The cohort members were employed in a typical plant manufacturing cotton yarn and fabric, established in 1827, where the history of the development of cotton processing techniques is easily visible. The plant is equipped with conventional and modern cotton processing lines and include a number of departments: fine-, medium- and waste spinning, weaving, and finishing. The latter comprises bleaching, dyeing, printing, finishing, mechanical fabric processing and plaiting rooms. Cotton is used as the basic material but, in some periods of time coinciding partly with the period of the cohort employment, some other types of fibre were also processed: polyester (1973 – 1993), polyamide (1983 – 1990), rayon (1983 – 1993) and acrylics (1991 – 1993).

Since the early 1970s, the plant's laboratory has been monitoring the levels of dust and noise, as well as concentrations of some chemicals in the ambient air of the production rooms. The majority of the determinations are performed in the wet processing (bleaching dyeing, printing, finishing) departments and storage room. The most frequently determined chemicals are: hydrogen sulphide, acetic acid, sodium hydroxide, hydrogen chloride, chlorine, nitrogen oxides, kerosene, formaldehyde, ammonia, copper, formalin, and aniline. Some of the chemicals were monitored in some periods only (e.g. ammonia, copper, formaldehyde, aniline in the 1970s) because of changing processing techniques.

The comparison of the mean geometric concentrations of the aforesaid chemicals for individual years and workposts with MAC values showed that the hygiene standards were complied with. The workposts with the highest chemical exposure included: singeing machine operator, bleacher and bleaching-room mercerizer, dyer and dyeroom dryer, printer and printing-room dryer, printing roller engraver, finisher, store keeper and operator of printing-roller etching unit. The percentage of the subjects employed at those workposts was 13.3%. The engraver's workpost was the only exception where the annual maximum concentration of nitric oxide (8.7 mg/m^3) exceeded the MAC value (MAC = 5.0 mg/m^3).

Typically of the cotton industry, the majority of the cohort members were exposed to dust (67.3%) and noise (62.1%). Mean dust concentrations at the workposts ranged from 1.8 μg/m^3 (carding machine operator) to 11.7 μg/m^3 (cotton waste baling press operator). Weaving loom operators were also exposed to high dust concentrations – 11.4 μg/m^3 on average.

RESULTS

A total of 7892 workers (2949 men and 4943 women) met the cohort entry criteria. As of December 31, 1995, the follow-up was completed for 7545 people of the cohort (95.6%). Over 72.0% of the subjects were alive. The search for the information on the causes of death was successful in 97.0% of the recorded deaths. Table 1 gives the cohort follow-up results.

Table 2 describes the cohort by the year of and the age at entering the employment, duration of employment, and departments. The classification of the departments into four groups reflects the type of occupational exposure. The group of wet (chemical) processing departments (bleaching, dyeing, printing and finishing) was characterised by high exposure to chemicals.

Table 1. The cohort of the cotton plant workers. Status as of 31 December 1995

People	Men		Women	
	number	%	number	%
Included in the cohort	2949	100.0	4943	100.0
– traced	2852	96.7	4693	94.9
– alive	1618	54.9	3858	78.0
– deceased	1234	41.8	835	16.9
– cause of death determined	1197	**97.0 (100% = 1234)**	810	**97.0 (100% = 835)**
– lost to follow-up	97	3.3	250	5.1

Table 2. The cohort of the cotton plant workers by the year of and the age at entering the employment, duration of employment and department (%)

Specification	Men		Women	
	person	person-years	person	person-years
Year of entering the employment				
–1944	0.7	1.0	0.2	0.4
1945–1959	61.5	72.7	49.2	60.7
1960–1974	32.1	24.3	46.4	37.5
1975–	5.7	2.0	4.2	1.4
Age at entering the employment (yrs)				
–19	20.2	21.6	24.0	25.0
20–29	31.4	34.8	33.4	36.0
30–39	27.2	28.2	30.5	30.1
40–49	17.2	13.3	11.4	8.6
50–	4.0	2.1	0.7	0.3
Duration of employment (yrs)				
10–14	25.4	16.9	23.6	16.7
15–19	18.6	15.1	21.2	18.0
20–24	19.4	19.6	22.6	23.6
25–29	17.2	20.7	15.6	18.8
30–34	12.1	16.6	12.5	16.8
35–	7.3	11.1	4.5	6.1
Departments				
Chemical processing	15.7	15.7	4.1	3.6
Weaving	26.1	28.5	51.2	52.4
Spinning	19.0	19.2	32.9	33.3
Other	39.2	36.6	11.8	10.7
Cohort total	2852 = 100%	64597 = 100%	4693 = 100%	114717 = 100%

Work at the weaving and spinning departments was associated with the highest exposure to dust and noise. Employment in the departments classified as 'other' was characterized by least uniform exposures. The category of 'other' departments workers included mechanicians, electricians and storekeepers.

There were considerable differences in the structure of employment between the groups of men and women. As much as 16% of all men and only 4% of women were employed at the chemical processing. Women were in a majority (about 84%) among the workers of the weaving and spinning departments. A large proportion of men (about 39%) was employed in the 'other' departments.

The cohort of men

During the cohort observation period, 1234 men died, the standardised mortality ratio (SMR) being 99, which points to the same level of mortality as in the general population. Our analysis of deaths by death cause revealed a significant excess mortality in the diseases of the digestive system (74 deaths, SMR = 142) (Table 3). Every third death in that group was due to hepatic cirrhosis (25 deaths, SMR = 125). The mortality from the circulatory diseases was similar to that observed in the general population (562 deaths, SMR = 99), but there was the excess deaths from atherosclerosis (195 deaths, SMR = 145) and from the hypertensive disease (29 deaths, SMR = 135). In addition, the excessive number of deaths was due to mental disorders (9 deaths, SMR = 173), blood and blood-forming organs diseases (3 deaths, SMR = 155), diseases of the genitourinary system (22 deaths, SMR = 111), and ill-defined conditions (63 deaths, SMR = 110).

Table 3. Mortality in the cohort of the cotton plant workers

Cause of death (according to 9th Revision of ICD)	Men			Women		
	Deaths	SMR	95%CI[a)]	Deaths	SMR	95%CI[a)]
All causes (001–999)	1234	99	94–105	835	88	82– 94
Infectious and parasitic diseases (001–139)	9	23	11– 44	3	22	5– 64
Malignant neoplasms (140–208)	303	104	93–116	245	92	81–104
Endocrine, nutritional and metabolic diseases (240–279)	15	103	58–170	21	72	45–110
Diseases of blood and blood-forming organs (280–289)	3	155	32–453	2	75	9–271
Mental disorders (290–319)	9	173	79–328	3	83	17–243
Diseases of the nervous system and sense organs (320–389)	3	30	6– 88	3	27	6– 79
Diseases of the circulatory system (390–459)	562	99	91–108	378	84	76– 93
– hypertensive disease (401–405)	29	135	90–194	24	73	47–109
– ischaemic heart disease (410–414)	156	92	78–108	64	74	57– 94
– cerebrovascular disease (430–438)	58	81	62–105	55	67	50– 87
– atherosclerosis (440)	195	145	125–167	145	117	99–138
Diseases of the respiratory system (460–519)	62	77	59– 99	28	84	56–121
Diseases of the digestive system (520–579)	74	142	112–178	39	97	69–133
– chronic liver disease and cirrhosis (571)	25	125	81–185	13	106	56–181
Diseases of the genitourinary system (580–629)	22	111	70–168	17	93	54–149
– nephritis, nephrotic syndrome and nephrosis (580–589)	9	72	33–137	11	88	44–157
Diseases of the musculoskeletal system and connective tissue (710–739)	0	0		4	64	17–164
Symptoms, signs and ill-defined conditions (780–799)	63	110	85–141	4	64	17-164
Injury and poisoning (800–999)	72	79	62– 99	31	93	63–132

[a)] 95% CI denotes the confidence interval for the SMR values calculated at 0.95 confidence level.

Table 4. Mortality from malignant neoplasms in the cohort of the cotton plant workers

Cause of death (according to 9th Revision of ICD)	Men			Women		
	Deaths	SMR	95%CI[a]	Deaths	SMR	95%CI[a]
All causes (001–999)	1234	99	94– 105	835	88	82– 94
Malignant neoplasms (140–208)	303	104	93– 116	245	92	81– 104
– lip, oral cavity and pharynx (140–149)	7	89	36– 183	0	0	
– lip (140)	1	80		0	0	
– tongue (141)	2	160	19– 578	0	0	
– major salivary glands (142)	2	475	58–1716	0	0	
– gum (143)	1	681		0	0	
– other and ill-defined sites within the lip, oral cavity and pharynx (149)	1	144		0	0	
– digestive organs and peritoneum (150–159)	110	101	83– 122	88	91	73– 112
– oesophagus (150)	8	105	45– 207	1	51	
– stomach (151)	54	106	80– 138	22	86	54– 130
– small intestine (152)	2	213	26– 769	0	0	
– colon (153)	12	145	75– 253	10	94	45– 173
– rectum and anus (154)	9	81	37– 154	8	62	27– 122
– liver (155)	4	34	9– 87	13	89	47– 152
– gallbladder (156)	4	139	38– 356	19	156	94– 244
– pancreas (157)	15	134	75– 221	14	121	66– 203
– peritoneum (158)	2	304	37–1098	1	74	
– respiratory and intrathoracic organs (160–165)	104	96	78– 116	16	65	37– 106
– larynx (161)	18	188	111– 297	1	88	
– trachea, bronchus and lung (162)	85	89	71– 110	12	55	28– 96
– pleura (163)	0	0		2	428	52–1546
– thymus, heart and mediastinum (164)	1	60		1	131	
– connective tissue (171)	2	323	39–1167	1	155	
– melanoma of skin (172)	4	261	71– 668	1	44	
– skin, other (173)	3	204	42– 596	0	0	
– breast (174)	0	0		42	108	78– 146
– uterus, part unspecified (179)	0	0		6	143	52– 311
– cervix uteri (180)	0	0		18	83	49– 131
– body of uterus (182)	0	0		5	59	19– 138
– ovary (183)	0	0		24	142	91– 211
– other and unspecified female genital organs (184)	0	0		6	123	45– 268
– prostate (185)	13	102	54– 174	0	0	
– penis (187)	1	172		0	0	
– bladder (188)	9	85	39– 161	0	0	
– kidney (189)	9	137	63– 260	2	36	4– 130
– eye (190)	1	302		0	0	
– brain (191)	8	140	60– 276	1	15	
– thyroid gland (193)	1	164		4	224	61– 574
– other endocrine glands (194)	1	380		0	0	
– other and ill-defined sites (195)	2	197	24– 712	4	384	105– 983
– lymph nodes (196)	2	440	53–1589	0	0	
– without specification of site (199)	14	221	121– 371	15	208	116– 343
– lymphatic and haematopoietic tissue (200–208)	12	86	44– 150	12	87	45– 152
– Hodgkin's disease (201)	4	200	54– 512	0	0	
– other of lymphoid and histiocytic tissue (202)	1	58		1	62	
– multiple myeloma (203)	2	112	14– 405	2	83	10– 300
– lymphoid leukaemia (204)	1	32		4	175	48– 448
– myeloid leukaemia (205)	2	67	8– 242	4	100	27– 256
– leukaemia of unspecified cell type (208)	2	298	36–1076	1	151	

[a] 95% CI denotes the confidence interval for the SMR values calculated at 0.95 confidence level.

The mortality from cancer was slightly higher than that in the general population (303 deaths, SMR = 104). A significant increase in the incidence of larynx cancer became evident (18 deaths, SMR = 188). Other sites with increased risk of neoplasm development where the number of observed deaths was higher than 1 included: tongue (2 deaths, SMR = 160), salivary glands (2 deaths, SMR = 475), oesophagus (8 deaths, SMR = 105), stomach (54 deaths, SMR = 106), small intestine (2 deaths, SMR = 213), large intestine (12 deaths, SMR = 145), gallbladder (4 deaths, SMR = 139), pancreas (15 deaths, SMR = 134), peritoneum (2 deaths, SMR = 304), connective tissue (2 deaths, SMR = 323), melanoma and other skin cancers (4 deaths, SMR = 261 and 3 deaths, SMR = 204, respectively), prostate (13 deaths, SMR = 102), kidney (9 deaths, SMR = 137), brain (8 deaths, SMR = 140), Hodgkin's disease (4 deaths, SMR = 200), multiple myeloma (2 deaths, SMR = 112) (Table 4).

The analysis of the mortality by duration of employment does not point, with one exception, to an increased risk of death after many years of employment. A significantly increased mortality from atherosclerosis was observed both for the shorter and longer durations of employment, although in the latter instance the increase was greater (58 deaths, SMR = 132 and 137 deaths, SMR = 152, respectively). A significant excess mortality in the diseases of the gastrointestinal system, hepatic cirrhosis in particular, was recorded in the males with a 10–19 year duration of employment (15 deaths, SMR = 186). Larynx cancer is the only exception quoted above. The majority of cases were recorded in men with over 20 years of employment, and the risk was significantly higher in this group than in the general population (15 deaths, SMR = 254).

As a result of dividing the cohort into subcohorts by departments, a significant increase in deaths from atherosclerosis (56 deaths, SMR = 141), peritoneal carcinoma (2 deaths, SMR = 1,057) and melanoma (3 deaths, SMR = 667) was revealed in the weaving department workers. Increased risk of death from hypertensive disease (10 deaths, SMR = 239), atherosclerosis (47 deaths, SMR = 175) and Hodgkin's disease (3 deaths, SMR = 768) was detected in the workers of the spinning department. In the 'other' departments, the highest statistically significant increase was recorded with regard to mental disorders (6 deaths, SMR = 313), atherosclerosis (65 deaths, SMR = 141), diseases of the digestive system (28 deaths, SMR = 152), cancers of gallbladder (4 deaths, SMR = 400), pancreas (10 deaths, SMR = 256) and larynx (8 deaths, SMR = 238). It is worth stressing here that no significant excess was found in the wet (chemical) processing departments (Tables 5 and 6).

The cohort of women

The mortality in the cohort of women was significantly lower than that in the reference population (SMR = 88). Nevertheless, the number of deaths from atherosclerosis (145 deaths, SMR = 117), hepatic cirrhosis (13 deaths, SMR = 106), cancers of gallbladder (19 deaths, SMR = 56), pancreas (14 deaths, SMR = 121), pleura (2 deaths, SMR = 428), breast (42 deaths, SMR = 108), reproductive organs (59 deaths, SMR = 105), including uterine (6 deaths, SMR = 143) and ovary (24 deaths, SMR = 142), thyroid carcinoma (4 deaths, SMR = 224) and from lymphatic leukaemia (4 deaths, SMR = 175) was higher than expected, but the

Table 5. Mortality in the cohort of men employed in the cotton plant by departments

Cause of death (according to 9th Revision of ICD)	Chemical processing departments			Weaving department			Spinning department			'Other' departments		
	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI
All causes (001–999)	202	98	85–112	319	89	80–99	255	106	93–120	458	105	96–115
Infectious and parasitic diseases (001–139)	2	28	3–101	1	9		0	0		6	42	15–91
Malignant neoplasms (140–208)	50	104	77–137	84	99	79–123	60	105	80–135	109	106	87–128
Endocrine, nutritional and metabolic diseases (240–279)	3	127	26–371	4	94	26–3241	4	140	38–358	4	79	22–202
Diseases of blood and blood-forming organs (280–289)	2	619	75–2236	0	0		0	0		1	148	
Mental disorders (290–319)	1	122		2	137	17–495	0	0		6	313	115–681
Diseases of the nervous system and sense organs (320–389)	0	0		0	0		0	0		3	83	17–243
Diseases of the circulatory system (390–459)	90	96	77–118	142	86	72–101	127	115	96–137	203	102	88–117
– hypertensive disease (401–405)	1	28		8	129	55–252	10	239	115–440	10	132	63–243
– ischaemic heart disease (410–414)	31	113	77–160	40	82	59–112	25	76	49–112	60	101	77–130
– cerebrovascular disease (430–438)	6	51	19–111	14	68	37–114	15	107	60–176	23	92	58–138
– atherosclerosis (440)	27	124	82–180	56	141	107–183	47	175	129–233	65	141	109–180
Diseases of the respiratory system (460–519)	10	72	35–132	19	83	50–130	14	92	50–154	19	67	40–105
Diseases of the digestive system (520–579)	14	167	88–270	16	107	61–174	16	158	90–257	28	152	101–220
– chronic liver disease and cirrhosis (571)	4	122	33–312	8	139	60–274	2	51	6–184	11	155	77–277
Diseases of the genitourinary system (580–629)	3	90	19–263	5	87	28–203	2	52	6–188	12	172	89–300
– nephritis, nephrotic syndrome and nephrosis (580–589)	2	97	12–350	1	28		1	41		5	114	37–266
Symptoms, signs and ill-defined conditions (780–799)	4	40	11–102	21	131	81–200	9	85	39–161	29	139	93–200
Injury and poisoning (800–999)	16	113	65–184	12	46	24–80	17	96	56–154	27	80	53–116

Table 6. Mortality from malignant neoplasms in the cohort of men employed in the cotton plant by departments

Cause of death (according to 9th Revision of ICD)	Chemical processing departments			Weaving department			Spinning department			'Other' departments		
	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI
All causes (001–999)	202	98	85–112	319	89	80– 99	255	106	93– 120	458	105	96– 115
Malignant neoplasms (140–208)	50	104	77–137	84	99	79– 123	60	105	80– 135	109	106	87– 128
– lip, oral cavity and pharynx (140–149)	1	78		2	88	11– 318	0	0		4	143	39– 366
– digestive organs and peritoneum (150–159)	21	115	71–176	28	89	59– 129	18	85	50– 134	43	113	82– 152
– oesophagus (150)	2	157	19–567	2	92	11– 332	0	0		4	149	41– 381
– stomach (151)	11	126	63–225	14	96	52– 161	12	122	63– 213	17	95	55– 152
– colon (153)	4	297	81–760	4	166	45– 425	1	61		3	104	21– 304
– rectum and anus (154)	2	111	13–401	2	61	7– 220	2	91	11– 329	3	78	16– 228
– liver (155)	0	0		4	120	33– 307	0	0		0	0	
– gallbladder (156)	0	0		0	0		0	0		4	400	109–1024
– pancreas (157)	2	110	13–397	0	0		3	136	28– 397	10	256	123– 471
– peritoneum (158)	0	0		2	1057	128–3818	0	0		0	0	
– respiratory and intrathoracic organs (160–165)	17	96	56–154	24	76	49– 113	20	94	57– 145	43	113	82– 152
– larynx (161)	4	260	71–666	2	72	9– 260	4	214	58– 548	8	238	103– 469
– trachea, bronchus and lung (162)	13	83	44–142	22	79	50– 120	16	85	49– 138	34	102	71– 143
– melanoma (172)	0	0		3	677	140–1978	1	332		0	0	
– skin (173)	0	0		0	0		2	698	85–2521	1	195	
– prostate (185)	4	189	51–484	3	81	17– 237	3	120	25– 351	3	68	14– 199
– bladder (188)	0	0		6	195	72– 424	1	48		2	55	7– 199
– kidney (189)	2	189	23–683	2	104	13– 376	2	155	19– 560	3	130	27– 380
– brain (191)	0	0		4	243	66– 622	2	180	22– 650	2	98	12– 354
– lymphatic and haematopoietic tissue (200–208)	2	88	11–318	4	98	27– 251	5	181	59– 422	1	20	
– Hodgkin's disease (201)	0	0		1	173		3	768	158–2244	0	0	

Note: Tumours without specified site and those for which the number of deaths in none of the individual departments was not higher than 1 are not presented.

Table 7. Mortality in the cohort of women employed in the cotton plant by departments

Cause of death (according to 9th Revision of ICD)	Chemical processing departments			Weaving department			Spinning department			'Other' departments		
	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI
All causes (001–999)	0	99	71–135	387	84	76– 93	294	88	79– 99	114	96	79–115
Infectious and parasitic diseases (001–139)	1	187		1	15		1	21		0	0	
Malignant neoplasms (140–208)	15	140	78–231	114	86	71–103	82	89	71–110	34	111	77–155
Endocrine, nutritional and metabolic diseases (240–279)	1	82		13	92	49–157	6	58	21–126	1	28	
Diseases of blood and blood-forming organs (280–289)	0	0		1	76		1	107		0	0	
Mental disorders (290–319)	0	0		0	0		3	242	50–707	0	0	
Diseases of the nervous system and sense organs (320–389)	0	0		2	35	4–126	1	26		0	0	
Diseases of the circulatory system (390–459)	11	56	28–100	163	77	66– 90	144	90	76–106	60	102	78–131
– hypertensive disease (401–405)	1	70		12	75	39–131	8	70	30–138	3	72	15–210
– ischaemic heart disease (410–414)	2	55	7–199	24	57	37– 85	26	86	56–126	12	115	59–201
– cerebrovascular disease (430–438)	2	56	7–202	24	61	39– 91	19	65	39–102	10	95	46–175
– atherosclerosis (440)	3	53	11–155	60	109	83–140	59	129	98–166	23	132	84–198
Diseases of the respiratory system (460–519)	0	0		13	82	44–140	12	105	54–183	3	67	14–196
Diseases of the digestive system (520–579)	4	236	64–604	21	107	66–164	12	86	44–150	2	40	5–144
– chronic liver disease and cirrhosis (571)	1	197		4	66	18–169	8	190	82–374	0	0	
Diseases of the genitourinary system (580–629)	1	136		8	89	38–175	5	78	25–182	3	139	29–406
– nephritis, nephrotic syndrome and nephrosis (580–589)	1	198		4	65	18–166	3	69	14–202	3	204	42–596
Diseases of the musculoskeletal sytem and connective tissue (710–739)	1	383		2	64	8–231	0	0		1	131	
Symptoms, signs and ill-defined conditions (780–799)	1	64		16	101	58–164	8	70	30–138	6	126	46–274
Injury and poisoning (800–999)	5	343	111–800	17	90	52–144	10	78	37–143	3	69	14–202

Table 8. Mortality from malignant neoplasms in the cohort of women employed in the cotton plant by departments

Cause of death (according to 9th Revision of ICD)	Chemical processing departments			Weaving department			Spinning department			'Other' departments		
	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI	Deaths	SMR	95%CI
All causes (001–999)	40	99	71– 135	387	84	76– 93	294	88	78– 99	114	96	79–115
Malignant neoplasms (140–208)	15	140	78– 231	114	86	73– 103	82	89	71– 10	34	111	77–155
– digestive organs and peritoneum (150–159)	8	195	84– 384	40	85	61– 116	30	89	60– 27	10	83	40–153
– stomach (151)	3	271	56– 792	6	49	18– 107	9	102	47–194	4	120	33–307
– colon (153)	1	228		4	77	21– 197	4	107	29–274	1	79	
– rectum and anus (154)	1	190		4	63	17– 161	3	66	14–193	0	0	
– liver (155)	0	0		6	85	31– 185	5	99	32–231	2	107	13–387
– gallbladder (156)	1	197		10	167	80– 307	7	165	66–340	1	68	
– pancreas (157)	2	420	51–1517	9	158	72– 300	1	25		2	147	18–531
– respiratory and intrathoracic organs (160–165)	1	102		11	88	44– 157	2	23	3– 83	2	73	9–264
– trachea, bronchus and lung (162)	0	0		9	82	37– 156	1	13		2	84	10–303
– breast (174)	2	134	16– 484	22	110	69– 167	14	105	57–176	4	95	26–243
– uterus, part unspecified (179)	0	0		2	96	12– 347	3	205	42–599	1	203	
– cervix uteri (180)	1	122		4	36	10– 92	9	121	55–230	4	170	46–435
– body of uterus (182)	1	293		2	47	35–1058	0	0		2	200	24–722
– ovary (183)	1	155		11	126	63– 225	8	140	60–276	4	224	61–574
– other and unspecified female genital organs (184)	0	0		2	84	19– 303	4	235	64–602	0	0	
– thyroid gland (193)	0	0		3	340	70– 994	0	0		1	473	
– lymphatic and haematopoietic tissue (200–208)	0	0		5	73	24– 170	5	105	34–245	2	129	16–466
– lymphoid leukaemia (204)	0	0		12	181	22– 654	1	124		1	359	
– myeloid leukaemia (205)	0	0		2	99	12– 358	1	73		1	228	

Note: Tumours without specified site and those for which the number of deaths in none of the individual departments was not higher than 1 are not presented.

differences were not statistically significant. The threshold of the statistical significance were reached only by the standardised mortality ratios for malignant tumours of ill-defined or not specified sites classified as items 195 and 199 of the International Classification of Diseases (ICD, 9-th Revision), however, with total mortality from malignant tumours lower than in the general population. This observation suggests rather an imprecise description of the death causes in the source files and thus, cannot be used to conclude on the pattern of mortality in the cohort studied (Tables 3 and 4).

When analysing the mortality by duration of employment, in neither of the disease groups or tumour sites the relationship between increased female mortality and employment duration was found. Nor was significantly higher mortality due to any of the analysed causes found in the subcohorts by departments (Tables 7 and 8).

DISCUSSION

The observation of the cohort of workers employed for more than 10 years in conditions of exposure to harmful agents in a typical cotton-processing plant showed no difference in the total male mortality between the cohort and the general population (SMR = 99), however, in the female cohort the 'healthy worker effect' was apparent. Significant excess mortality from atherosclerosis was found in both the total male cohort and in spinning, weaving and 'other' departments subcohorts as well as in subcohorts with shorter and longer duration of employment (< 20 years and $\geqslant 20$ years). In the cohort of women, the number of deaths from atherosclerosis was higher than that in the general population, but the difference was not statistically significant. As the determination of the underlying cause of death for specific diseases of the circulatory system in Poland is thought not to be very reliable, the range of possible interpretations of the above results is very limited (17).

The results do not point to increased risk of cancer in total (SMR = 104 for the men and SMR = 92 for the women). Cancer of larynx (SMR = 188) was the only tumour of specified site showing a significantly increased mortality in the whole male cohort. The majority of deaths from that cancer was recorded in the men with employment duration longer than 20 years (SMR = 254).

A statistically significant increase in the number of deaths from tumours without specification of site was also recorded but, as statistically significant increase in total tumours was not recorded, it might result from not clearly stated diagnosis or careless filling of death certificates.

To compare the risk of death vs. duration of employment in workers exposed to harmful and noxious agents in the cotton industry, two subcohorts were distinguished (< 20 years and $\geqslant 20$ years). Our analysis shows that the duration of employment did not affect the total mortality, being at the level of the general mortality in both groups, with the 'healthy worker effect' slightly visible in the group of people with the shorter period of employment. At the same time, deaths from diseases of the digestive system were statistically significantly more frequent (by about 50%) than in the general population; this applies in particular to deaths from chronic disease of liver and cirrhosis (by about 90%). The mortality from malignant tumours was slightly (9%) higher in the group of people employed

for more than 20 years. A statistically significant (2.5-fold) excess mortality from larynx cancer was recorded for that group. Increased risk of death from total cancer and in any specified site was not detected among workers employed for the period below 20 years.

The classification of the industrial workers according to the departments in which they are employed is a useful tool in the indirect assessment of exposure. Four categories were defined: spinning department, weaving department, chemical processing department and the 'other' category of auxiliary (production-related) departments where the mechanical and production continuity services dominated. The general mortality in the subcohorts distinguished (according to the criterion of being employed in a specified department) was similar to that in the general population. The mortality from cardiovascular diseases showed a slight (about 15%) increase in the workers of the spinning department. The increase was due to the statistically significant (over 2-fold) increase in the risk of death from hypertensive disease and a 75% increase in the risk of death from atherosclerosis. Statistically significant increase in the risk of death from mental disorders (over 3-fold) and from diseases of the digestive system (about 50%) was found for the workers of the 'other' departments. Mortality from total malignant neoplasm, did not show increase among workers classified according to the four groups of departments in which they were employed. However, in the analysis by tumour site, statistically significant excess mortality from peritoneal carcinoma (over 10-fold) and from melanoma (over 6-fold) was detected in the weaving department. Over 7.5-fold increase in the mortality from Hodgkin's disease was noted in the spinning department. The analysis of deaths from malignant tumours among the workers of the 'other' departments showed statistically significant increase in the number of deaths from gallbladder cancer (about 4-fold) and from larynx cancer (about 2-fold).

Various operations involving the use of carcinogenic or probably carcinogenic dyes and chemicals are performed in the chemical processing departments. Therefore, the workers employed in those departments were the subject of special interest. As already mentioned, no excess mortality from any of the analysed (non-cancer or cancer) diseases were noted in that group. An increased risk of death was not recorded in any of the diseases analysed by duration of employment in those departments.

It could be difficult to relate the excess deaths from larynx cancer detected among the auxiliary department workers (and among the workers employed for more than 20 years) to the harmful agents typical of the modern cotton industry. It is generally recognised that tobacco smoking and abuse of strong alcohol drinks belong to the main causes of larynx cancer. Therefore, the detected increase may be attributable to the effects of the confounding factors combined with the effect of the environmental factors in those departments.

The increased risk of nasal, sinonasal, nasopharyngeal and oral cavity cancers reported by some authors has not been confirmed in our study (1,4,5,7,9,19–22,24,28). It should be stressed, however, that seven cases of very rare cancer of this group were recorded among the men. The risk of death from malignant neoplasms of gum, salivary glands and tongue was high but statistically insignificant because of small number of cases recorded.

Many authors report the increased mortality from bladder cancer among the textile industry workers (2,8,11,12,23,25). The risk of death from bladder cancer in our male cohort was lower than that in the general population (SMR = 85), while in the females no cases of bladder cancer were detected. The higher mortality from urinary bladder cancer was recorded for the weaving department workers (SMR = 195), while the corresponding level for the spinning department workers was low (1 case of death from bladder cancer, SMR = 48); the results are compatible with those of Gonzales (11,12).

As reported by Swedish and Chinese authors, mortality from gallbladder carcinoma was increased both in the men (SMR = 139) and in the women (SMR = 156) (6,21), but those values were not statistically significant.

The apparent, although, statistically insignificant, increase in the number of deaths from malignant tumours of the brain is in good agreement with the results of an Israeli research (16). It should be noted, however, that the increased risk of death from brain tumour was recorded among the males employed in the weaving and spinning departments. In the light of known relationship between chemical exposure and brain tumour the finding is difficult to interpret (3).

Our studies failed to confirm an exposure-response relationship between the level of exposure to cotton dust and the risk of cancer. Increased risk of malignant tumours among the workers exposed to harmful chemicals at the chemical processing department were not detected either. The numerous albeit statistically insignificant increases in the incidence of malignant tumours of some specific sites detected in the subcohorts defined according to the duration of employment or work place (department) are in line with the published evidence concerning the incidence of tumours (oral cavity, nose, throat, larynx) among people exposed to harmful agents in the cotton industry. Our results support the independent findings of a relatively low risk of lung cancer in the examined occupational population reported in the literature (9,13,14,18,27). This could be discussed in the light of hypothesis involving a anticarcinogenic activity of endotoxins that are present in the examined environment (10).

CONCLUSIONS

1. The results of a thirty-year follow-up study of the cotton industry workers indicated similar death risk in men and significantly lower in women as compared with the general population.

2. It was revealed that the technologies applied thus far in the cotton industry do not increase the cancer risk among workers. Nevertheless there is a constant need to monitor the concentration of chemicals and chemical preparations (particularly in the finishing processes) for their carcinogenic effect.

3. In the cohort of men statistically significant excess mortality from atherosclerosis, diseases of the digestive system and neoplasm of larynx was found.

4. In the cohort of women no statistically significant excess mortality from any cause analysed was indicated. Nor was its significance in the analysis of mortality by departments observed.

5. An interesting observation that deserves special mention is the increased death risk from mental disorders, diseases of the digestive system and cancers of pancreas, gallbladder and larynx in the cohort of men employed in 'other'

departments. These aforesaid causes of death show that mortality in this group of workers may be mainly attributed to life style-related factors.

6. The incidence of neoplasms of tongue, gum, salivary glands and nasopharynx, observed in the follow-up study showed considerable, albeit not statistically significant excess, also reported by many other authours. In order to elucidate this observation it is necessary to perform a meta-analysis or to carry out investigations on much larger cohorts.

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