Polish Journal of Occupational Medicine, Vol. 1, No. 3, 1988

MORTALITY AMONG FEMALE WORKERS IN AN ASBESTOS FACTORY IN POLAND

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Key words: Asbestos, Mortality, Malignant neoplasms, Follow-up, Cohort study, Cancer risk

Abstract. A cohort of 1190 females employed for at least 3 months between 1945 and 1973 at a plant producing different asbestos goods (yarn, cords, asbestos wool, gaskets, friction products) is described. Mortality analysis was performed twice, on 31 December, 1981 and on 31 December, 1985 in the subcohort of 444 female workers employed between 1945 and 1955. In the first analysis the subcohort was traced in 78.6% (in the second — 98.9%). The main parameter of the analysis was SMR calculated by the man-years method. The reference population was the general female population in Poland. The results of both analyses were compatible. In the second analysis the total SMR was 108.9. A statistically significant increase of mortality was found for malignant neoplasms in general (SMR = 169.5); for digestive system neoplasms (SMR = 254.1), and for liver and pancreas neoplasms (SMR = 407.6). In the female workers' cohort, one case of peritoneal mesothelioma was reported. The observation of the cohort is being continued in order to verify the hypotheses concerning the reasons for a remarkable excess mortality due to digestive organ neoplasms, especially those of the liver and pancreas.

METHOD AND THE OBSERVED COHORT

In the study carried out at chrysotile asbestos factory in Lodz, a cohort of 1190 female workers employed at the plant for at least 3 months between 1945 and 1973 was also observed. The vital status of this cohort was determined twice: on 31 December, 1981 and on 31 December, 1985 (Table 1). The main parameter of the analysis was SMR calculated using the man-years method (1, 2, 10). In the cohort of women, a subcohort of 444 female workers employed between 1945 and 1955 (Table 2) was isolated. As in the case of the analysis of the male cohort

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TABLE 1. Follow-up and Vital Status of the Cohort (1945—1973)

Subjects	I analysis Period of observation: from 1945 to 1981		II analysis Period of observation: from 1945 to 1985	
	Number	%	Number	%
Total in study	1190	100.0	1066	100.0
Traced	1066	89.6	1050	98.5
Alive	930	78.2	878	82.4
Dead	136	11.4	172	16.1
Lost to follow-up	124	10.4	16	1.5

TABLE 2. Follow-up and Vital Status of the Subcohort (1945—1955)

Subjects	I analysis Period of observation: from 1945 to 1981		II analysis Period of observation: from 1945 to 1985	
	Number	%	Number	%
Total in study	444	100.0	349	100.0
Traced	349	78.6	345	98.9
Alive	254	57.2	235	67.4
Dead	95	21.4	110	31.5
Lost to follow-up	95	21.4	4	1.1

(10), the isolation of this subcohort resulted from the long latency period required by lung cancer and the very high concentration of asbestos dust in the plant during these years.

RESULTS

The observation of the subcohort between 1945 and 1985 rendered it possible to determine the "vital status" of 345 women, i.e. 77.7% of the group satisfying the inclusion criteria to the subcohort. The subcohort was traced in 78.6% until 1981. This relatively small number of traced employees was the result of extensive migrations of population directly after the second world war and the changes of names of women after marriage. In recent years (1982—1985), the observation of the subcohort was more effective, only 4 women included in the first study were lost to follow-up (Table 4).

110 deaths in the subcohort were reported in the data of 31 December 1985. The group of causes most frequently responsible for death were circulatory system diseases (47 cases), among which atherosclerosis (18 cases) was dominant. Malignant neoplasms can be considered as the second most numerous group (32 deaths). Most often, they were located in the digestive organs and peritoneum (20 cases), and more precisely, in the

TABLE 3. Number of Deaths Observed and Expected by Cause in Subcohort (1945—1955)

Cause of death	I Analysis Period of observation: from 1945 to 1981			II Analysis Period of observation: from 1945 to 1985		
	9717.08 person-years			10526.92 person-years		
	Deaths obs.	Deaths exp.	SMR	Deaths obs.	Deaths exp.	SMR
All causes (001—999)	95	85.51	111.1	110	101.01	108.9
Malignant neoplasms (140—208)	32	16.35	195.7**	32	18.88	169.5**
Diseases of the circulatory system (390—459)	37	31.38	117.9	47	40.00	117.5
— ischaemic heart disease (410—414)	5	4.18	119.5	6	4.57	131.2
— cerebrovascular disease (430—438)	7	5.07	138.0	7	6.58	106.4
— atherosclerosis (440)	12	5.33	225.3*	18	8.90	202.3**
Diseases of the respiratory system (460—519)	6	4.26	140.7	6	4.76	126.1
Diseases of the digestive system (520—579)	4	3.52	113.7	4	4.00	99.9
— chronic liver disease and cirrhosis (571)	2	1.05	191.0	2	1.12	177.8
Injury and poisoning (800—999)	4	3.54	113.0	5	3.14	159.5

* $p < 0.05$
** $p < 0.01$
Figures in parentheses are ICD (9th Revision) code numbers

TABLE 4. Observed and Expected Deaths from Malignant Neoplasms by Site in Subcohort (1945—1955)

Cause of death	I Analysis Period of observation: from 1945 to 1981			II Analysis Period of observation: from 1945 to 1985		
	9717.08 person-years			10526.92 person-years		
	Deaths obs.	Deaths exp.	SMR	Deaths obs.	Deaths exp.	SMR
Malignant neoplasms (140—208)	32	15.53	206.1**	32	18.88	169.5**
— digestive organs and peritoneum (150—159)	20	6.43	311.0**	20	7.87	254.1**
— stomach (151)	3	2.38	126.1	3	2.82	106.6
— liver and pancreas (155—157)	12	2.22	541.5**	12	2.94	407.6**
— trachea, bronchus and lung (162)	1	0.80	125.0	1	1.05	95.6
— breast (174)	4	2.04	196.1	4	2.49	160.9
— uterus (179—182)	6	2.52	238.1	6	2.88	208.0

* $p < 0.05$
** $p < 0.01$
Figures in parentheses are ICD (9th Revision) code numbers

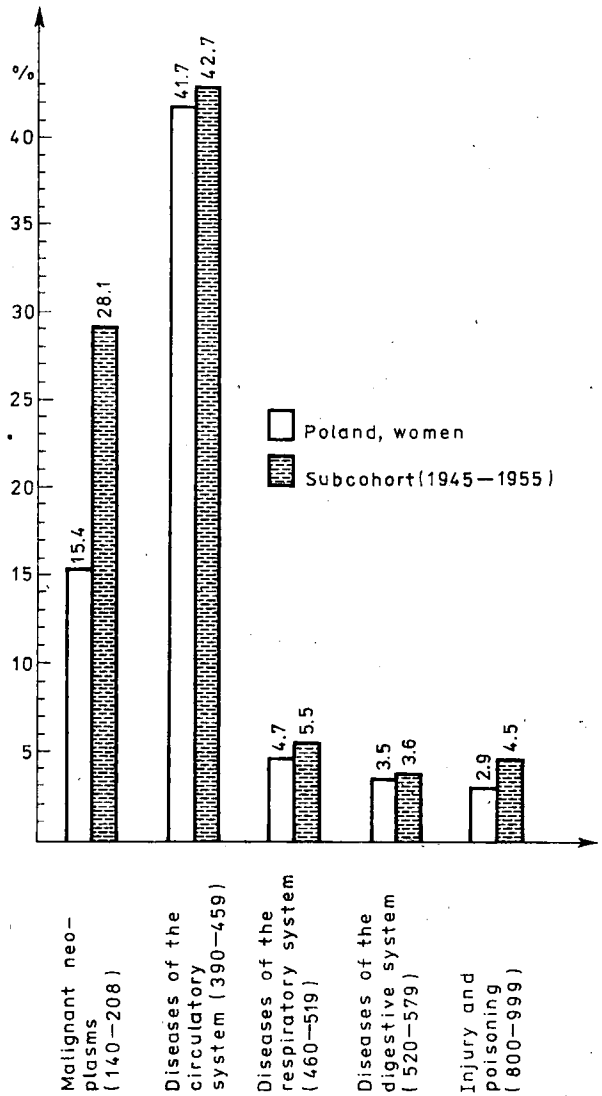

Fig. 1. Proportional mortality ratio from selected causes in Poland and in female cohort in period 1945—1985.

liver and pancreas (12 cases). Six deaths from uterine carcinoma and four from mammary cancer were noted. Except for one death from lung cancer, no neoplasms of the respiratory and introthoracic organs were reported. As far as the number of deaths is concerned, the following diseases should be mentioned: respiratory system diseases (6 deaths), traumas and intoxications (5 deaths) and digestive organ diseases (4 deaths). Proportional mortality ratios due to the above mentioned disease

groups exceed the analogous ratios for the reference population, which, in this study, was the female population aged 20 or more (Fig. 1). The greatest disproportion was to be noted for malignant neoplasms. Their proportion among the number of deaths in the cohort is twice that in the reference population (Fig. 2). This is shown most clearly in the group of malignant neoplasms of the liver and pancreas, the frequency of which is four times higher in the cohort mortality rate, which certainly affects the proportional mortality ratio from malignant neoplasms of the digestive organs and peritoneum. The ratio is 2.6 times higher than in the reference population. Next, malignant neoplasms of the uterus (their proportion is 2.6 times higher in the cohort deaths), and mammary cancer with PMR value twice that of the population in Poland, should be mentioned.

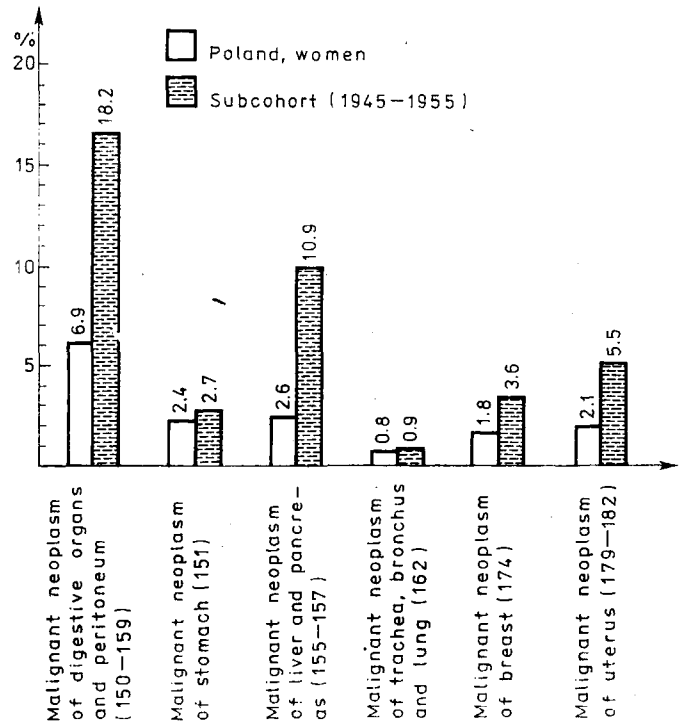

Fig. 2. Proportional mortality ratio from malignant neoplasms of selected sites in Poland and in female cohort in period 1945—1985.

The proportion of circulatory system diseases in the cohort is only slightly higher than in the reference population (42.7% and 41.7%, respectively), but more detailed examination of this group of causes reveals a significant disproportion of proportional mortality ratios due to

atherosclerosis: 11.0% in the reference population and 16.4% in the cohort.

The analysis of death-risk measured by SMR revealed an insignificant excess of the total mortality rate as compared to the expected rate (SMR = 108.9) (Table 3). The most frequent cause of death — circulatory system diseases — is characterized by an SMR = 117.5, which is not statistically significant, if we consider the 47 observed deaths. Excess mortality can be observed in every studied disease group, i.e. in ischaemic heart disease, cerebral vessels' disease and atherosclerosis, but only in the latter group is the excess statistically significant (SMR=202.3; $p < 0.01$).

The number of deaths was larger than expected from two groups of causes: injuries and poisonings, and respiratory system diseases (SMR = 126.1). Mortality from digestive system diseases was lower than in the general population (SMR = 99.9), but chronic liver disease and cirrhosis in this group represented SMR = 177.8. None of the SMR-s presented was statistically significant.

A remarkably higher mortality than expected could be observed in the group of malignant neoplasms (SMR = 169.5; $p < 0.01$), which resulted from the great number of deaths from digestive organs and peritoneum neoplasms (SMR = 254.1; $p < 0.01$), and — more precisely — from liver and pancreas cancers (SMR = 407.6; $p < 0.01$) (Table 4). A two-fold increase of death risk, as compared to the reference population, was observed in the group of malignant uterine carcinoma (SMR = 208.0). Also mammary cancer caused more deaths than expected (SMR = 160.9).

TABLE 5. Observed and Expected Deaths from Malignant Neoplasms by Age at First Exposure and Site in Subcohort (1945—1955)

Cause of death	— 39 years			40 and more years		
	7967.17 person-years			2559.75 person-years		
	Deaths		SMR	Deaths		SMR
	obs.	exp.		obs.	exp.	
Malignant neoplasms (140—208)	15	9.80	153.1	17	9.09	187.1*
— digestive organs and peritoneum (150—159)	7	3.50	200.2	13	4.38	297.0**
— stomach (151)	2	1.26	158.4	1	1.55	64.4
— liver and pancreas (155—157)	2	1.29	155.5	10	1.66	603.1**
— trachea, bronchus and lung (162)	1	0.52	192.3	—	0.53	—
— breast (174)	2	1.48	135.1	2	1.01	198.8
— uterus (179—182)	5	1.75	285.2	1	1.13	88.4

* $p < 0.05$

** $p < 0.01$

Figures in parentheses are ICD (9th Revision) code numbers

Because of the small absolute number of observed deaths, none of these ratios is statistically significant. Risk of death attributed to lung cancer is represented by SMR = 95.6 which was calculated on the basis of the one observed death from this type of cancer.

Division of the studied subcohort into two groups, according to age on beginning work involving exposure to asbestos dust, revealed mortality excess due to malignant diseases in both groups, but only in the group of women who started working in exposure after 40 years of age was the surplus statistically significant (SMR = 187.1; $p < 0.05$) (Table 5). A similar situation could be observed in the case of deaths from liver and pancreas cancers and from the larger group of causes: neoplasms of the digestive organs and peritoneum. Statistically remarkable SMR-s refer only to women exposed to asbestos dust for the first time at 40

TABLE 6. Observed and Expected Deaths from Malignant Neoplasms by Dose of Asbestos Dust and Site in Subcohort (1945—1955)

Cause of death	1—8 (mg/m³ × years)			9 and more (mg/m³ × years)		
	4042.33 person-years			6484.58 person-years		
	Deaths obs.	Deaths exp.	SMR	Deaths obs.	Deaths exp.	SMR
Malignant neoplasms (140—208)	8	6.95	115.1	24	11.94	201.1**
— digestive organs and peritoneum (150—159)	6	2.90	207.0	14	4.97	281.5**
— stomach (151)	1	1.04	96.5	2	1.78	112.5
— liver and pancreas (155—157)	5	1.08	462.1*	7	1.86	375.9**
— trachea, bronchus and lung (162)	1	0.38	261.1	—	0.66	—
— breast (174)	—	0.91	—	4	1.57	254.0
— uterus (179—182)	1	1.06	94.3	5	1.83	274.0

* $p < 0.05$
** $p < 0.01$
Figures in parentheses are ICD (9th Revision) code numbers

and over (SMR = 603.1; $p < 0.01$), and SMR = 297.0; $p < 0.01$, respectively). Deaths from other malignant neoplasms of lower observed numbers did not indicate any important surplus according to age at the first exposure. However, deaths from malignant neoplasms of the uterus, which in 5 cases out of 6 concerned women who started working in exposure to asbestos at a younger age (SMR = 285.2), are worth observing.

Exposure was determined using the cumulated dose of asbestos dust in two groups: small dose group, i.e. 1—8 mg/m³×years, and high dose group — more than 9 mg/m³. Only in the latter group was a statistically significant increase of deaths from malignant neoplasms in general (SMR = 201.1; $p < 0.01$) and malignant neoplasms of the digestive

organs and peritoneum (SMR = 281.5; $p < 0.01$) observed. Statistically significant excess mortality attributed to malignant neoplasms of the liver and pancreas, on the other hand, was found, irrespective of the dose (SMR = 462.1; $p < 0.05$) — in the small dose group and SMR = 375.9; $p < 0.01$ in the high dose group. It should be stressed that in the cohort all the reported deaths from mammary cancer and 5 out of 6 observed deaths from uterine carcinoma were observed in the group of women exposed to a high dose (SMR = 254.0 and SMR = 274.0) (Table 6).

DISCUSSION

Mortality among these women revealed a pattern different from that in the male cohort in the same plant (10). These results differ from the ones given by Newhouse et al (6) where the mortality patterns among females and males were similar and in both groups the statistical increase of lung cancer and pleural mesothelioma were alike. The duration of the observation period was similar in the cohort observed for about 30 years, the number of persons was smaller by half, 444 women were observed, and the cohort was traced in 77.7% of the total number of employees. Female workers observed until 31 December, 1985, employed between 1945 and 1955, were exposed to a very high concentration of asbestos dust. One case of lung cancer (1.05 case expected), and one case of peritoneal mesothelioma were reported.

The results of the repeated mortality analysis in the subcohort of women employed in exposure to asbestos dust in 1945—1955 confirm the results obtained from the 4-year shorter observation (9). From 31 December 1981 until 31 December 1985 15 "new" deaths were reported in the subcohort and most of them (10 cases) were attributed to circulatory system diseases. Malignant neoplasms were mentioned as the cause of death in death certificates of none of the women who died during this period. This situation seems to confirm the statement that the 30-year period of the observation of the cohort is long enough to evaluate the risk of death from cancer (3).

The values obtained of the standardized mortality ratio indicate a significant increase of risk of death from malignant neoplasms in the cohort, and especially, malignant neoplasms of the digestive organs and peritoneum, including cancers of the liver and pancreas. Analysis according to age at the time of beginning work in exposure showed a significant mortality excess attributed to the above mentioned causes only in the subcohort of female employees who started working in exposure to asbestos over 40 years of age. The fact that the remarkable increase of deaths from malignant neoplasms of the digestive organs and perit-

oneum refers to workers exposed to high doses of asbestos dusts, and that, for the majority of the causes of death considered, a higher SMR value is observed for a higher dust dose, proves that the study results obtained can be related to exposure to asbestos dust. What is interesting is the very significant mortality excess attributed to liver and pancreas cancer. The excess is irrespective of the extent of exposure. It is worth pointing out that analogous results of the study were noted in the whole female cohort employed in 1945—1973. The local female population (Lodz) is characterized by one of the highest SMR-s for liver and pancreas neoplasms (4,8). However, since access to the local data is very difficult, we were forced to exclude this group as the reference population. This fact does not explain the fivefold risk excess in the group of female workers employed in the asbestos industry. Taking into account the high ratios possibly resulting from other exogenous agents (water?, diet?) occurring locally, a hypothesis may be set forth that asbestos is a carcinogenic agent additionally affecting this population.

Neither is it possible to explain the wrong classification of neoplasms localized in the abdominal cavity (5,7). Postmortem examinations were performed only in few cases and perhaps some of these neoplasms were peritoneal mesotheliomae. In death certificates such diagnosis was encountered only once.

The results of our analyses indicate different mortality patterns for males and females connected with malignant neoplasms in cohorts exposed to asbestos dust.

Acknowledgement

This study was supported by the National Cancer Programme: Carcinogenesis of the Working Environment (CPBR 11.5.60.2).

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Received for publication: 22.04.1988.
Accepted for publication: 10.05.1988.

ANNOUNCEMENTS

SHORT COMMUNICATION NO 3

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MEDICHEM '89

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