

A MORTALITY STUDY OF WORKERS WITH REPORTED CHRONIC OCCUPATIONAL CARBON DISULFIDE POISONING

BEATA PEPLŃSKA, NEONILA SZESZENIA-DĄBROWSKA, WOJCIECH SOBALA
and URSZULA WILCZYŃSKA

Department of Epidemiology
The Nofer Institute of Occupational Medicine
Lodz, Poland

Key words: Mortality study, Carbon disulfide, Chronic poisoning

Abstract: A mortality cohort study was carried out on 2291 workers, including 169 women, with chronic occupational CS₂ poisoning diagnosed during the years 1970–90. Information on vital status was available for 98.2% as of December 31, 1992. Mortality assessment was based on the standardized mortality ratio using the person-years method. The general population of Poland was the reference population. The number of subjects who died during the period of observation accounted for 658 men and 21 women. The analysis of mortality in male subjects showed statistically significant excess of deaths from the circulatory system diseases (SMR = 139), in this from ischaemic heart disease (SMR = 137), cerebrovascular disease (SMR = 188) and colon cancer (SMR = 233). Over a two-fold increased risk of death from diseases of the nervous system and sense organs, although statistically insignificant, was also observed. Among women a statistically significant risk of death from atherosclerosis was noted (SMR = 286).

An elevated risk of death from the circulatory system diseases and from ischaemic heart disease (IHD) agrees with the results of some other cohort studies carried out in the viscose rayon workers. The increased mortality from malignant neoplasms is an unusual finding in cohorts of workers exposed to CS₂. Our own data reported here showed a significantly increased mortality from colon cancer (9 cases). All these cases were noted in workers of the two oldest rayon plants and they require a detailed analysis. Further survey is also needed to elucidate the excess of deaths from the nervous system and sense organs diseases.

INTRODUCTION

Carbon disulfide (CS₂) is a well known toxic substance used in industry with a long tradition of clinical, toxicological and epidemiological studies. Occupational CS₂ poisonings were noted as early as the mid 19th century. The clinical picture of CS₂ poisoning has been changing over the last decades which was associated with

Address reprint requests to Dr Beata Peplńska, Department of Epidemiology, The Nofer Institute of Occupational Medicine, P.O. Box 199, 90-950 Lodz, Poland.



the declining levels of exposure to CS₂. Concentrations, considered to be harmful to health, were recorded mostly in the viscose rayon industry.

Chronic CS₂ poisonings pose a serious problem both for Polish companies manufacturing viscose rayon and for the occupational health service. The data from the Register of Occupational Diseases at the Nofer Institute of Occupational Medicine indicate that carbon disulfide, along with lead and carbon monoxide, are the most prevalent causes of occupational poisonings. Over 2000 cases of chronic CS₂ poisonings were recorded between 1970 and 1990, and the number of new cases has remained high (7).

As results from epidemiological cohort studies carried out in the United Kingdom, USA, Finland, Holand and the Czech Republic, the circulatory system diseases are the main cause of mortality among the workers of viscose rayon plants (1,4,6,8,9). In the cross-sectional studies of the population occupationally exposed to CS₂ there was observed more frequent occurrence of such ischaemic heart disease risk factors as increased levels of cholesterol and its LDL fraction, declined levels of HDL fraction and high prevalence of arterial hypertension (2,3,11,12).

This study aimed at evaluating the mortality among the workers of viscose rayon plants in Poland. The criterion for inclusion in the study cohort was an ascertained chronic occupational carbon disulfide poisoning which helped identify those workers of viscose fibres plants who had been exposed to CS₂ at high concentrations as the certification of chronic occupational CS₂ poisoning has been based not only on the diagnosis of the nervous system pathology but also on the documented long period of work under conditions of significant exposure to CS₂.

MATERIALS AND METHODS

Total mortality and selected cause specific mortality risk were assessed in a historical cohort study. The cohort was assembled from the Register of Occupational Diseases at the Nofer Institute of Occupational Medicine in Lodz. The data retrieved from the Register allowed to identify 2291 subjects (in this 2122 men and 169 women) with chronic carbon disulfide poisoning diagnosed between 1970 and 1990. An essential element in the diagnosis of chronic CS₂ poisoning was the nervous system pathology in the form of organic changes or severe functional disorders. All persons enrolled in the cohort were employees of six viscose rayon plants in Poland. It is worth mentioning that 42% of the study population worked in the biggest viscose rayon plant which is still in operation, and that occupational disease (CS₂ poisoning) had been diagnosed in 43% of subjects before 1976. Most of the subjects started working in the viscose rayon plants in the 1950s and 1960s when the levels of exposure to CS₂ in the production departments was very high, reaching several hundred mg/m³ (5). High CS₂ concentrations exceeding the then MAC – 25 mg/m³, occurred at many work-posts in production departments of these plants already at the end of 1970s (3).

The study cohort consisted mainly of process workers performing the jobs involving the highest exposure to CS₂. The subjects included in the cohort were traced up until 1992. Causes of death were coded according to the International Classification of Diseases (ICD) 9th Revision. Information on the vital status was available for 2251 persons, i.e. 98,2% of those enrolled in the cohort. The remainder 40 persons were considered as lost to follow up. There were 679 deaths in the study



cohort. Causes of death were known for 643 deaths (94,7%). Only 671 deaths of persons (both men and women) aged under 79 years were considered. The general population of Poland was the reference population. The subjects who had died, but the cause of their death was unknown, were considered only in calculation of overall mortality and not taken into account in the detailed analysis of deaths by causes. The assessment of the risk of death was based on the standardized mortality ratio (SMR) calculated by the person-years method. Proportional mortality ratio (PMR) was also analysed. A computer program PYRS3 developed by the International Agency for Research on Cancer (IARC) was used for calculations. The statistical significance was determined by means of a two-tailed statistical test based on a Poisson distribution. Follow up and vital status of the cohort are given in Table 1.

Table 1. Follow-up and vital status of the cohort

Subjects	Men		Women	
	Number	%	Number	%
Total in the study	2122	100.0	169	100.0
Traced	2085	98.3	166	98.2
Alice	1427	68.4	145	87.3
Dead	658	31.6	21	12.7
Lost to follow-up	37	1.7	3	1.8

RESULTS

The number of diagnosed cases of chronic CS₂ poisoning differed significantly throughout a 20-year period of observation (Table 2). The greatest number of poisonings were recorded in 1975 and the lowest in 1985. A significant increase in the number of diagnosed CS₂ poisoning was recorded in the period of 1972–75. This phenomenon might result from manifestation or intensification of the CS₂ poisoning symptoms in persons who started working in viscose rayon plants in the 1940s and 1950s, i.e. when the levels of carbon disulfide in the working environment were very high (5). This could be also attributed to activities of one of the institutes of occupational medicine which at that period launched clinical examinations of viscose rayon workers on an unprecedented scale. The clinical examinations helped identify greater number of subjects with this pathology diagnosed as an occupational disease.

The analysis by age, at the moment of diagnosing the occupational disease, revealed that the greatest number of chronic occupational CS₂ poisonings were diagnosed in men and women aged 50–54 years. The mean age of men at the moment of diagnosis ranged, in particular viscose rayon plants, from 48.8 to 53.6 years. In women the difference in mean age was more pronounced reaching 11 years (Table 3).

Among subjects with chronic CS₂ poisoning employed in three viscose rayon plants which had been partially or totally closed down in the 1980s (plants 2,3 and 5) a higher proportion of those with occupational disease diagnosed under the age of 50 years were found. This proportion is different in the group of subjects working in the plants which are still operating (plants 1,4,6) where the highest number of cases of occupational disease were mostly diagnosed in persons over the age of 50.



Table 2. Numbers of workers with reported chronic carbon disulfide poisoning in 1970–90, included in the study cohort according to the factories

Year	Factories						Total
	1	2	3	4	5	6	
1970	41	24	21	13	14	12	125
1971	32	13	19	16	14	11	105
1972	70	14	8	12	2	32	138
1973	68	14	9	19	5	40	155
1974	92	7	5	11	6	31	152
1975	65	6	21	11	5	68	176
1976	52	18	6	8	2	33	119
1977	18	13	7	10	0	25	73
1978	45	15	10	16	1	21	108
1979	35	16	9	12	0	14	86
1980	45	13	7	15	4	22	106
1981	47	12	22	52	4	15	152
1982	60	27	9	18	1	20	135
1983	48	33	5	9	3	14	112
1984	28	17	14	4	0	13	76
1985	17	18	6	10	0	7	58
1986	20	21	5	9	0	15	70
1987	42	17	9	9	0	12	89
1988	39	27	3	5	0	13	87
1989	36	29	1	3	0	10	79
1990	45	21	3	12	0	9	90
Total	945	375	199	274	61	437	2291

Table 3. Age at diagnosis of chronic carbon disulfide poisoning according to factories and sex

		Age	Factories					
			1	2	3	4	5	6
Male	Structure %	–49	26.4	40.3	52.3	30.0	47.5	36.2
		50+	73.6	59.7	47.7	70.0	52.5	63.8
		$\bar{x}$	53.58	50.84	48.81	52.84	50.02	52.23
		SD	6.17	6.74	6.54	6.63	6.90	6.66
		Number	933	335	172	190	61	431
Female	Structure %	–49	25.0	65.0	74.1	50.0	–	16.7
		50+	75.0	35.0	25.9	50.0	–	83.3
		$\bar{x}$	54.51	47.20	43.44	49.19	–	54.45
		SD	6.30	6.03	7.42	5.64	–	8.14
		Number	12	40	27	84	0	6



MORTALITY ASSESSMENT

The analysis of mortality in men included in the cohort showed the excess of deaths from the circulatory system diseases — 55.3% of all cases of death. The most prevalent causes of death were ischaemic heart disease and atherosclerosis. Cardiac infarction and cerebrovascular diseases constited 16.3% and 9.6% of all causes of death in men, respectively. Malignat neoplasms were the next most prevalent causes of death in male subjects — 20.1% of all causes of death, in this lung cancer — 7%. The proportion of deaths by selected causes in male subjects included in the cohort to the general male population of Poland aged 40–79 years in the years 1970–92 is presented in Fig. 1.

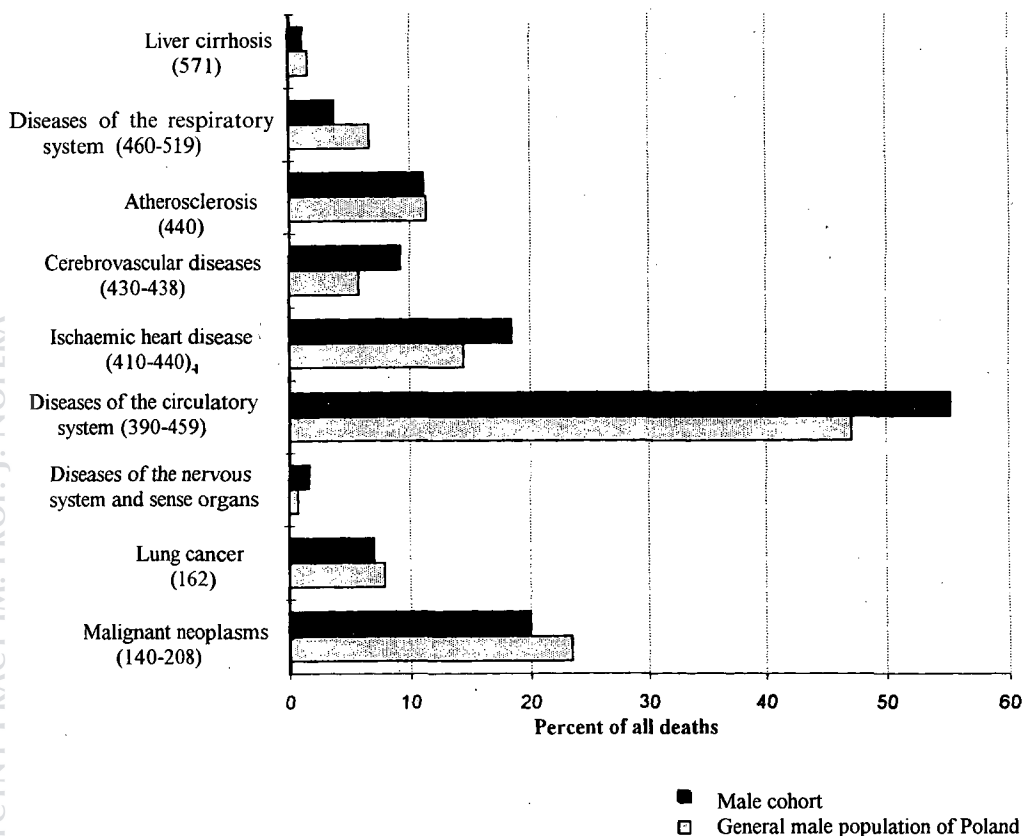


Fig. 1. Proportional mortality ratio in the general male population of Poland and in the study male cohort.

Based on the SMRs analysis in male subjects an excessive risk of death from all causes was found. The analysis of mortality by causes revealed a significant excess of deaths from the circulatory system diseases (SMR = 139), ischaemic heart disease (SMR = 137) and cerebrovascular disease (SMR = 188). Over a two-fold increase in mortality from diseases of the nervous system and sense organs was recorded, however, it was statistically insignificant. In this group the following causes of death

were identified: cerebral meningitis — 1 case, multiple sclerosis — 2 cases, Parkinson's disease — 2 cases, Jacob-Creutzfeld disease — 1 case, cerebral atrophy — 1 case, epilepsy — 1 case and one case classified as „other cerebral diseases”. In the total male population an insignificant 20% excess of deaths from atherosclerosis was noted. Almost a two-fold increase in mortality from this cause was found in male workers employed in the plant located in Central Poland. No excess of deaths from ischaemic heart disease was recorded there which seems to imply a difference in coding the causes of death.

An excessive risk of death from colon cancer (SMR = 233) was noted among male subjects. Observed and expected numbers of deaths by cause in the cohort of men are given in Table 4.

Table 4. Mortality from selected causes in the cohort of men with reported chronic carbon disulfide poisoning

Cause of death (according to 9th Revision of ICD)	Number of deaths		SMR	95% CI
	Observed	Expected		
All causes (001–999)	650	549.2	118	109–127
Malignant neoplasms (140–208)	132	145.3	91	76–108
– oesophagus (150)	6	3.7	61	59–350
– stomach (151)	13	20.2	64	34–109
– colon (153)	9	3.9	233	107–442
– rectum (154)	6	5.8	104	38–226
– liver (155)	4	5.4	74	20–189
– pancreas (157)	6	5.8	103	38–224
– larynx (161)	5	5.5	91	30–212
– trachea, bronchus and lung (162)	46	53.5	86	63–115
– prostate (185)	6	5.3	113	41–246
– kidney (189)	3	3.7	80	16–234
– brain (191)	2	3.23	62	8–224
– lymphatic and haematopoietic tissue (200–208)	5	6.6	76	25–177
Mental disorders (290–319)	0	2.3	0	–
Diseases of the nervous system and sense organs (320–389)	9	4.3	211	96–407
Diseases of the circulatory system (390–459)	359	257.4	139	125–154
– ischaemic heart disease (410–414)	122	89.0	137	114–164
– cerebrovascular disease (430–438)	60	31.9	188	143–242
– atherosclerosis (440)	73	60.6	120	94–151
Diseases of the respiratory system (460–519)	24	32.2	74	47–110
Diseases of the digestive system (520–579)	20	22.1	90	55–139
– chronic liver disease and cirrhosis (571)	8	9.5	84	36–166
Injury and poisoning (800–999)	27	35.7	76	50–111

Mortality analysis by age groups showed almost a three-fold increase in the risk of death from ischaemic heart disease in male subjects aged 40–49 years, whereas in the group aged 50–59 years the risk increased only by 54%. A gradual, related to age, increase in the risk of death from cerebrovascular diseases was found with a maximum almost a two-fold increased risk in the group aged 60–69 years (Table 5).



Table 5. Mortality from selected causes (SMR) according to age in the cohort of men with chronic carbon disulfide poisoning

Cause of death	Age groups				
	40–49	50–59	60–69	70–79	
All causes (001–999)	189* (37) ^a	121* (202)	117 (301)	105 (110)	118* (650)
Diseases of the circulatory system (390–459)	333* (22)	165* (113)	126* (154)	117 (70)	139* (359)
– ischaemic heart disease (410–414)	349* (12)	154* (49)	114 (48)	115 (13)	137* (122)
– cerebrovascular disease (430–438)	127 (1)	188* (16)	192* (32)	158 (11)	188* (60)

^a – number of observed deaths* – $p < 0.05$

Among woman only 21 deaths were observed. In the mortality pattern of women, the circulatory system diseases made up 76.2% of all causes of death, in this atherosclerosis (43.8%) and ischaemic heart disease leading to cardiac infarction (18.8%). A similar proportion was found for cerebrovascular diseases (18.8%). Two cases of malignant neoplasms were recorded. Mortality from all causes did not differ from that in the reference female population (Table 6.). There was noted over a two-fold statistically significant increase in the risk of death from atherosclerosis. The excessive risk was also noted for arterial hypertension, ischaemic heart disease and cerebrovascular diseases, however, because of too small number of cases it was insignificant.

Table 6. Mortality from selected causes in the cohort of women with reported chronic carbon disulfide poisoning

Cause of death (according to 9th Revision of ICD)	Number of deaths		SMR	95% CI
	Observed	Expected		
All causes (001–999)	21	21.1	100	62–153
Endocrine, nutritional and metabolic diseases and immunity disorders (240–279)	1	0.69	146	4–813
Diseases of the nervous system and sense organs (320–389)	0	0.26	–	–
Diseases of the circulatory system (390–459)	16	9.64	166	95–270
– hypertensive disease (401–405)	1	0.80	125	3–696
– ischaemic heart disease (410–414)	3	2.02	149	31–435
– cerebrovascular disease (430–438)	3	1.79	168	35–491
– atherosclerosis (440)	7	2.44	286	115–589
Malignant neoplasms (140–208)	2	6.40	31	4–112



DISCUSSION AND CONCLUSIONS

In the male subjects a 28% excess of deaths from all causes was recorded, in women the overall mortality level was similar to that observed in the reference population. This may be attributed to the criterion of inclusion in the study cohort i.e. the diagnosed chronic occupational disease (CS₂ poisoning). Therefore, the healthy worker effect – described in some other epidemiological studies – has no relevance to this cohort.

The number of women employed at workposts where CS₂ concentrations exceeded hygienic standards was limited, hence a small number of female subjects in our cohort (169 women, 21 deaths). The excess of deaths from the circulatory system diseases – found in this group – is statistically insignificant except for atherosclerosis with a 3-fold increased risk. Therefore, our attention was focused on the results of male cohort analysis.

The elevated by 37% risk of death from ischaemic heart disease (IHD) agrees with the results of some other cohort studies carried out in the viscose rayon workers in the USA, Finland, the Czech Republic, the Netherlands and Great Britain (1,4,6,8,9,10). However, this result seems to be surprisingly low in comparison with the Finnish data where a 5-fold increase in the number of deaths from ischaemic heart disease was recorded in workers of a certain viscose rayon plant at a certain time period before some steps to improve the situation had been taken. The British studies reported a 2-fold excess for IHD death in CS₂ exposed workers. The relevant data on the US rayon workers with a 15–24 year employment showed a 1.5-fold elevated risk for IHD death. Taking into account that the diagnosis of chronic occupational CS₂ poisoning was based not only on the symptoms of pathological changes in the central and peripheral nervous systems but also on the documented many-year industrial exposure to CS₂ at significant concentrations, we could expect much more pronounced excess of deaths from coronary heart disease in our cohort. The selection of subjects eligible for inclusion into our study cohort might be a factor which affected the reported mortality pattern. This facilitated inclusion into the study of the subjects with high and prolonged CS₂ exposure, selected from among all the workers of viscose rayon plants. On the other hand, it caused leaving out all those who had died before the diagnosis of occupational disease could be possible and those persons who, for various reasons, did not claim the right to such a diagnosis or had left their job in the viscose rayon plants because of health problems before the beginning of the study. It is worth mentioning that subjects aged under 50, at the moment of inclusion into the cohort made up 1/3 of the total study population only. Hence, we may speak about some deficit of young subjects in the cohort. We believe it would be feasible to assess the extent to which this selection has affected the mortality pattern after completing a mortality study in the cohort of all rayon workers.

Our data on the excess of deaths from cerebrovascular diseases differ from those of other studies mentioned earlier. It seems that the selection of subjects with diagnosed CS₂ poisoning could play a decisive role in this case. In the clinical picture of chronic CS₂ poisoning, neurological changes are associated directly with CS₂ toxic effect as well as with some vascular changes. Hence, a great number of haemorrhage and cerebral strokes recorded in our study.



The increased mortality from malignant neoplasms is an unusual finding in cohorts of workers exposed to CS₂. Our own data reported here shows a significantly increased mortality from colon cancer (9 cases). All these cases were noted in workers of the two oldest rayon plants and they require a detailed analysis. Further survey is also needed to elucidate the excess of deaths from the nervous system diseases (Jacob-Creutzfeld disease, brain atrophy, multiple sclerosis, Parkinson's disease).

ACKNOWLEDGEMENTS

The study was carried out under the Strategic Governmental Project: "Health protection and safety of man in the work environment", SPR II.4.5.

REFERENCES

1. Balcarowa O, Halik J. Ten-year epidemiological study of ischaemic heart disease (IHD) in workers exposed to CS₂. *Sci Total Environ* 101 (12): 97–99, 1991.
2. Egeland GM, Burkhart GA, Schnorr TM, Hornung RW, Fajen JM, Lee S. Effects of exposure to carbon disulfide on low density lipoprotein cholesterol concentration and diastolic blood pressure. *Br J Ind Med* 49: 287–293, 1992.
3. Epidemiological and clinical studies of workers exposed to carbon disulfide. *Studia Mat Monogr*, Lodz, 1982 (in Polish).
4. Hernberg S, Tolonen M, Nurminen M. Eight-year follow-up of viscose rayon workers exposed to carbon disulfide. *Scand J Work Environ Health* 2: 27–30, 1976.
5. Indulski J, Kowalski Z, Barański B, Jakubowski M, Głuszczyk M. The relationship between exposure monitoring and health status in the occupational setting. The information system on exposure levels and occupational diseases. *Pol J Occup Med* 3 (1): 1–14, 1990.
6. MacMahon B, Monson RR. Mortality in the US rayon industry. *J Occup Med* 30 (9): 698–705, 1988.
7. Occupational diseases in Poland in 1995. IMP Lodz, 1995 (in Polish).
8. Schilling RSF. Coronary heart disease in viscose rayon workers. *Am Heart J* 80, 1970.
9. Swaen GMH, Braun Chr, Slangen JJM. Mortality of Dutch workers exposed to carbon disulfide, (in press).
10. Sweetnam PM, Taylor SW, Elwood PC. Exposure to carbon disulfide and ischaemic heart disease in a viscose rayon industry. *Br J Ind Med* 44 (4): 220–227, 1987.
11. Wrońska-Nofer T, Laurman W, Rosłonek W. Selected risk factors of ischaemic heart disease in workers under conditions of chronic occupational exposure to CS₂. *Med Pr* XLI (5): 299–305, 1990 (in Polish).
12. Vanhoorne M, De Bacquer D, De Backer G. Epidemiological study of the cardiovascular effects of carbon disulfide. *Int J Epidemiol* 21 (4): 745–752, 1992.

Received for publication: August 22, 1996

Approved for publication: October 7, 1996

