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Primary liver cancer among women in laundry and dry-cleaning work in Denmark

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LYNGE E, THYGESEN L. Primary liver cancer among women in laundry and dry-cleaning work in Denmark. *Scand J Work Environ Health* 1990;16:108–12. Tetrachloroethylene has been the most commonly used solvent in dry cleaning in Denmark since the late 1950s. A cohort of laundry and dry-cleaning workers was identified from the Danish Occupational Cancer Register for the study of cancer incidence of persons exposed to tetrachloroethylene. The Register includes cancer incidence data for a 10-year period for 8567 women and 2033 men employed in laundry and dry-cleaning in 1970. A significant excess risk was found for primary liver cancer among the women, with 7 observed and 2.1 expected cases (standardized incidence ratio 3.4, 95 % confidence interval 1.4–7.0). No case of primary liver cancer was observed among the men, for whom the expected value was 1.1. The excess risk of primary liver cancer among the women is unlikely to be explained exclusively by excess alcohol consumption.

Key terms: cancer incidence, tetrachloroethylene.

An increased risk for primary liver cancer among women exposed to solvents was found in two case-referent studies in Finland (1, 2). No increase was found among exposed men. A review of the exposure pattern of the cases showed that nine of the 13 women had been exposed to chlorinated hydrocarbons, whereas painting was the most common solvent exposure for the men. With this information as background, data are reported in this study on the cancer incidence of persons working in Danish dry-cleaning shops, where tetrachloroethylene has been the most commonly used solvent and where the work force has included both men and women.

Subjects and methods

Cohort

A cohort of laundry and dry-cleaning workers was identified from the Danish Occupational Cancer Register for a 10-year follow-up study of cancer incidence in the 1970 census population (3). In the census the industry code 860 specified "laundries, cleaning and dyeing." A person with this work code could be either a self-employed person, a family worker (ie, a spouse), or an employee and then identified either by the occupation code 411 "laundry worker, ironer" or by the occupation code 380 "factory hand." The census codes do not allow a distinction to be made between laundries on the one hand and dry-cleaning shops on the

other. Table 1 shows the number of persons working in laundry and dry cleaning in Denmark in 1970.

Exposure

There were 2886 laundries and dry-cleaning shops in Denmark in 1970 (4). This number is close to the number of 2434 self-employed persons in the census. The workplaces were small with the average size of the work force being 3.7 (ie, 10 600/2886). Married couples were working together in about one-third of the shops (ie, 830/2434). Data were not available on the possible division of labor in these small workshops. Out of the 2886 shops, 695 (Danmarks Statistik, personal communication) were known to be dry-cleaning and dyeing shops, where dyeing was of quantitatively minor importance.

White spirit was the main solvent used in dry cleaning in Denmark after World War II. The consumption of white spirit, however, decreased when automatic cleaning machines were introduced in the late 1950s. Tetrachloroethylene then became the most commonly used solvent, supplemented by trichloroethylene for the cleaning of workclothes, and fluorocarbons 11 (trichlorofluoromethane) and 113 (1,1,2-trichloro-1,2,2-trifluoroethane) for the cleaning of fur coats, etc (5). The consumption of tetrachloroethylene in Denmark increased to a maximum of 3500 t in 1973 and decreased to about 1500 t around 1980. About 80–95 % of the tetrachloroethylene was used in dry cleaning, and the decrease in consumption was due to a decrease in the number of dry-cleaning shops and to the recycling of the cleaning fluid in the remaining shops (6). It was a common practice in the dry-cleaning shops to control for the quality of the drying process by smelling the clothes when they were taken from the machine. Measurements from 1979–1980 showed con-

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centrations of tetrachloroethylene of the order of 1000–7000 ppm in 11 samples of clothes upon their removal from the dry-cleaning machine and concentrations on the order of 0–100 ppm in 67 samples (7).

Cancer incidence

The cancer cases observed in the cohort were identified by linkage between the 1970 census data and the Danish Cancer Registry data through the use of the personal identification number. The numbers of cancer cases expected in the cohort were calculated by multiplying the person-years at risk during the 10-year follow-up period in each five-year age group with the site-specific incidence rates calculated in the same way for all persons economically active in 1970. The ratio between the total number of observed and the total number of expected cases is a standardized incidence ratio (SIR), and the 95 % two-tailed confidence interval (95 % CI) was calculated on the assumption that the total number of observed cases up to 30 followed a Poisson distribution (8), and for total numbers above 30 the distribution was normal (9).

Results

Table 2 shows the cancer incidence in 1970–1980 for persons aged 20–64 years and working in laundries and dry-cleaning shops in Denmark in 1970. A total of 378 cancer cases were observed among the women, for whom 397.3 were expected (SIR 1.0, 95 % CI 0.9–1.1), and 132 cancer cases were observed among the men, for whom 104.5 were expected (SIR 1.3, 95 % CI 1.1–1.5). The table includes all cancer sites for which there were at least five observed cancer cases for the men and women combined. A significant excess risk was found for primary liver cancer among the women with 7 observed and 2.1 expected cases (SIR

Table 1. Number of persons aged 20–64 years and engaged in laundry and dry-cleaning work in Denmark in 1970.

	Men	Women	Total
Self-employed	1456	978	2434
Family worker	15	815	830
Laundry worker, ironer	445	6392	6837
Factory hand	117	382	499
Total	2033	8567	10600

Table 2. Cancer incidence in 1970–1980 for persons aged 20–64 years and engaged in laundry and dry-cleaning work in Denmark in 1970.

Site ^a	Men		Women		Total	
	Observed	Expected	Observed	Expected	Observed	Expected
Stomach (151)	7	5.3	11	8.6	18	13.9
Colon (153)	10	6.9	25	27.0	35	33.9
Rectum (154)	9	6.5	11	15.5	20	22.1
Liver (155.0)	—	1.1	7	2.1 ^b	7	3.2
Gall bladder (155.1)	1	0.8	7	4.1	8	4.9
Liver, not primary (156)	—	0.3	—	0.8	—	1.1
Pancreas (157)	9	3.8	13	9.3	22	13.1 ^b
Lung (162.0, 1)	28	24.5	32	24.9	60	49.3
Prostate (177)	11	7.6	—	—	11	7.6
Breast (170)	·	0.2	94	110.7	94	110.9
Cervix (171)	·	·	34	40.3	34	40.3
Corpus (172)	·	·	24	28.4	24	28.4
Ovary (175)	·	·	38	29.0	38	29.0
Other and unspecified female genital organs (176)	·	·	5	3.6	5	3.6
Kidney (180)	6	4.0	5	8.6	11	12.5
Bladder (181)	6	9.7	8	9.1	14	18.9
Melanoma (190)	2	2.0	8	11.8	10	13.8
Other skin (191)	12	12.7	23	32.1	35	44.8
Brain (193)	5	3.3	12	11.8	17	15.1
Metastasis (198)	1	1.5	4	3.9	5	5.4
Non-Hodgkin's lymphoma (200, 202)	5	1.8	3	6.0	8	7.8
Multiple myeloma (203)	4	1.2	3	2.8	7	4.0
Leukemia (204)	2	2.8	5	6.7	7	9.5
All malignant neoplasms (140–205)	132	104.5 ^b	378	397.3	510	501.8

^a Code of the International Classification of Diseases and Causes of Deaths (seventh revision) in parentheses.

^b Lower limit of the 95 % confidence interval above 1.

3.4, 95 % CI 1.4—7.0). No case of primary liver cancer was observed among the men, for whom 1.1 cases were expected.

A significant excess risk of cancer of the pancreas was seen when the figures for the men and women were combined. Twenty-two cases were observed, and 13.1 were expected (SIR 1.7, 95 % CI 1.1—2.6). None of the other cancer sites showed incidence figures for workers in laundries and dry cleaning that differed significantly from the average level of all economically active persons.

Discussion

Tetrachloroethylene has been found to cause hepatocellular carcinomas in mice both after oral administration and after inhalation, and exposure of rats by inhalation produced an increased incidence of leukemia (10). The potential carcinogenic risk of dry cleaners has therefore been the focus of several epidemiologic studies.

Blair et al (11) studied the proportional mortality of 279 deceased members of two local unions of laundry, dry-cleaning, and dye-house workers. Katz & Jowett (12) conducted a proportional mortality study of 671 deceased female laundry and dry-cleaning workers. Duh & Asal (13) conducted a study of the deaths of 440 laundry and dry-cleaning workers identified from death certificates from Oklahoma in 1975—1981. Brown & Kaplan (14) formed a cohort of 1690 dry cleaners identified from records maintained by four local unions. Blair et al (15) studied the mortality of a cohort of 11 062 members of a dry-cleaning union. These studies are all from the United States (US), where tetrachloroethylene has been the predominant dry-cleaning fluid in use since the 1950s.

A statistically nonsignificant excess risk of liver cancer (4 observed versus 1.7 expected cases) was found in one of these studies (11). The observed to expected ratio in the other studies was 4:4.5 (12), 1:1.9 (13), 0:3.5 (14), and no data (15), respectively.

In the Swedish Cancer Environment Register for 1961—1973 (16) the incidence of cancer of the liver and gall bladder among laundry and dry-cleaning workers was close to the average for the Swedish population within the same regions. The observed to expected ratio was 17:14.8, and there was no difference between the men and the women.

Two proportional mortality studies have also been undertaken of workers exposed to tetrachloroethylene, among other solvents, in metal degreasing. Blair (17) conducted a proportional mortality study of 1292 deaths among white men identified from obituaries in a union journal for metal workers from 1951—1969. Dubrow & Gute (18) studied the proportional mortality of jewelry workers in Rhode Island in 1968—1978, where a total of 1372 men and 1111 women were included and degreasing was predominantly a male oc-

cupation. A statistically significant excess risk of primary liver cancer was found among the metal degreasers (5 observed versus 1.8 expected) and among the male jewelry workers (6 observed versus 2.0 expected) but not among the female jewelry workers (1 observed versus 2.3 expected).

Exposure to tetrachloroethylene has also been considered in several case-referent studies on primary liver cancer. Stemhagen et al (19) studied New Jersey residents diagnosed with primary liver cancer in 1975—1980, and employment in "laundering, cleaning and other garment service" showed a significantly elevated relative risk (RR) for men (RR 2.5), whereas employment as a "cleaning service worker" showed a significantly elevated risk for women (RR 4.3). Hardell et al (20) studied men diagnosed with liver cancer in 1974—1981 in northern Sweden and found a high level of exposure to organic solvents to be associated with a relative risk of 1.8. But only one case involved exposure to tetrachloroethylene. Austin et al (21) studied hepatocellular carcinomas in persons aged 18—84 years in five centers in the United States. In none of their cases was previous employment in the laundering and cleaning industry reported. Suarez et al (22) studied primary liver cancer deaths among Texas male residents aged 20 years and older in 1969—1980. Employment in "dry-cleaning service" showed an odds ratio close to unity.

Hernberg et al (1) studied primary liver cancer cases reported to the Finnish Cancer Registry in 1979—1980 and found exposure to solvents to be associated with an odds ratio of 2.3, with the excess of exposure among cases confined entirely to women. Hernberg et al (2) repeated the study, including primary liver cancer cases reported to the Finnish Cancer Registry in 1976—1978 and 1981. In this study exposure to solvents gave an odds ratio of 0.6 for the men and 3.4 for the women, for whom exposure to chlorinated hydrocarbons was reported for 9 out of 13 of the women.

Our study showed a significantly elevated risk for primary liver cancer among the women employed in laundry and dry cleaning in Denmark with 7 observed and 2.1 expected cases (SIR 3.4, 95 % CI 1.4—7.0). No case of primary liver cancer was observed among the men working in this industry. The male work force was, however, relatively small, and only 1.1 cases of primary liver cancer were expected.

The majority of primary liver cancer cases in Denmark is assumed to be associated with alcohol consumption (23). It is, however, not likely that the excess risk of primary liver cancer found among the women employed in laundry and dry-cleaning can be explained exclusively by an excess alcohol consumption. In the Danish Occupational Cancer Register no excess risk of primary liver cancer (3 observed versus 2.6 expected) was found among 13 000 women working in hotels and restaurants, and no case of primary liver cancer was observed among 2000 women working in breweries.

In order to pinpoint further the possible reasons for the excess risk of liver cancer among women in laundry and dry-cleaning work, it would be desirable to undertake a nested case-referent study with a thorough collection of exposure data. Current confidentiality rules do not, however, allow us to retrieve individual records from the linked registers.

The proportionate mortality and cohort studies of laundry and dry-cleaning workers from the United States have pointed to an excess risk of kidney cancer. The observed to expected ratios were 2:1.0 (11), 7:2.7 (12), 7:1.9 (13), and 4:2.0 (14), and no data (15), respectively. Our study did not point to an excess risk of kidney cancer among Danish laundry and dry-cleaning workers, as we found 11 observed and 12.5 expected cases.

The US studies have also found a consistent excess risk for cervical cancer among women working in laundry and dry-cleaning (11–14). Neither was this observation supported by our Danish data, in which there were 35 observed and 41.1 expected cases. The excess risk in the US studies has been suggested by the authors to be due to the low pay received for laundry and dry-cleaning work in the United States, and the women thus coming from lower socioeconomic groups (11, 14). The situation is different in Denmark with the many small workshops, and with 21 % of the women working in this industry being either self-employed or family workers.

Skin cancer was in excess in three of the US studies (11–13). Our Danish data did not support this observation either in that both the incidence for malignant melanoma (10 observed and 14.0 expected cases) and for nonmelanoma skin cancer (35 observed and 44.8 expected cases) were below the average for the Danish population.

An excess risk of bladder cancer has also been observed in three of the US studies (12, 14–15). Neither did this observation hold true in our Danish data, in which there were 14 observed and 18.9 expected cases.

The only cancer site, apart from primary liver cancer in women, for which we found a statistically significant excess risk in Denmark was pancreatic cancer (SIR 1.7, 95 % CI 1.1–2.6). This observation is only weakly supported by the results of the US studies, in which the observed to expected ratios for pancreatic cancer were 4:3.1 (11), 9:7.7 (12), 3:5.6 (13), 11:6.4 (14), and no data (15), respectively.

The existing studies of the cancer incidence and mortality among laundry and dry-cleaning workers thus do not allow firm conclusions to be drawn about the possible cancer risk in this occupational group. However, although the results from these and other studies on primary liver cancer in relation to tetrachloroethylene exposure are inconsistent, they are nevertheless intriguing. The positive results come from studies of metal degreasers with high and mixed exposure (17, 18), from relatively large case-referent studies (1, 2,

19), and from the present record-linkage study based on incidence data.

Retrieval of data on dry cleaners from other case-referent and record-linkage studies with incidence data, and an updating and collection of exposure data from the existing studies could shed further light on the possible risk of primary liver cancer following exposure to tetrachloroethylene.

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