ELSEVIER

Extended Mortality Follow-up of a Cohort of Dry Cleaners

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Purpose: The mortality follow-up of a cohort of dry cleaners was extended to further evaluate cancers risks associated with organic solvents.
Methods: The underlying and contributing causes of death among 5,369 members of a dry cleaning union in St. Louis were determined through December 31, 1993. The mortality experience of the cohort was compared to that of the US population adjusted for age at entry, year of death, race and gender.
Results: The total mortality was about as expected (SMR = 1.0, N = 2351, 95% CI = 1.0–1.1). Excesses were observed for emphysema (SMR = 1.7, N = 21, 95% CI = 1.0–2.5), Hodgkin's disease (SMR = 2.0, N = 5, 95% CI = 0.6–4.6) and cancers of the esophagus (SMR = 2.2, N = 26, 95% CI = 1.5–3.3), larynx (SMR = 1.7, N = 6, 95% CI = 0.6–3.7), lung (SMR = 1.4, N = 125), 95% CI = 1.1–1.6), and cervix (SMR = 1.6, N = 27, 95% CI = 1.0–2.3). These excesses occurred among men and women and blacks and whites. Bladder cancer was elevated among white men and women and kidney cancer among black men and women, but not significantly so. None of these causes of death showed strong relationships with duration or estimated level of exposure to dry cleaning solvents, although relative risks for cancers of the larynx, lung and kidney were larger among subjects estimated to have higher levels of exposure and risks from bladder cancer and chronic nephritis were greater among persons who entered the union after 1960.
Conclusion: The excesses observed are unlikely to be due to chance because most occurred in earlier as well as the recent follow-up. The specific factors contributing the excesses, however, are not clear. Socioeconomic, lifestyle, and occupational exposures are all possibilities. Lack of information on socioeconomic and lifestyle factors hampers evaluation.
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KEY WORDS: Dry Cleaners, Organic Solvents, Occupational Exposures, Cancer Risks, Mortality.

INTRODUCTION

Although a number of organic solvents have been used by the dry cleaning industry over the years, tetrachloroethylene (C_2Cl_4) became the solvent of choice in the 1960s and is the most important chemical used today (1). Approximately 50% of the tetrachloroethylene produced in the United States 1990 was used for dry cleaning. The National Institute for Occupational Safety and Health (NIOSH) estimated that about 500,000 dry cleaners may have been exposed to tetrachloroethylene in the early 1980s (2). Bioassays have noted significant excesses of liver tumors in mice, mononuclear cell leukemia in one strain of rats, and nonsignificant excesses of renal cell adenomas and adenocarcinomas in male rats. Epidemiologic studies among dry cleaners (1, 3) have reported inconsistent excesses for some cancers, including esophagus, lung, cervix, bladder and kidney. Because human findings have been inconsistent, there is a need for further epidemiologic evaluation. Consequently, we extended the mortality follow-up of a cohort of dry cleaners (4), established from members of a local union, to provide additional information on risks from cancer and other causes of death among workers occupationally exposed to dry cleaning solvents.

METHODS

The cohort was composed of members of Local No. 161 (St. Louis) of the Textile Processors Service Trades Healthcare Professional and Technical Employees admitted to the union before 1978 (4). Data available on cohort members included name, social security number, date of birth, year and age of entry into the union, number of dues paying months by calendar year, race, sex, job titles from around the time of entry (only one job was available for most subjects), and most recent firm where employed. Vital status during the initial

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Selected Abbreviations and Acronyms

NIOSH = National Institute for Occupational Safety and Health
SMRs = Standardized mortality ratios
TWA = time-weighted-average

follow-up period from date of entry into the union (January 1, 1948 was the earliest date of entry) through January 1, 1979 was determined using information from union records, Social Security Administration, motor vehicle departments, credit bureaus, state bureaus of social services, and telephone and street directories. The deaths during the extended follow-up from January 1, 1979 through December 31, 1993 were identified through the national death index. Deaths were coded according to the international classification of diseases rules in effect at the time of death and assigned rubrics according to the eighth revision.

Exposure assessment procedures were described in detail in the study on the earlier follow-up (4). Briefly, these procedures entailed developing an exposure score for the jobs held based on published monitoring studies of the dry cleaning industry. Monitoring data from these studies indicated that levels were highest for jobs performed at the washers and progressively decreased with distance from the washing machines. Cleaners were assigned an exposure score of 40 (high exposure) for an eight-hour time-weighted-average (TWA) and persons working as pressers, sewers, or at the counter were given a score of seven (medium exposure). Cohort members employed at pick-up stations where no dry cleaning occurred were assigned as unexposed (little or no exposure), even though they would have had a higher exposure than the general population due to off-gassing from the cleaned garments.

Standardized mortality ratios (SMRs) were calculated to evaluate cancer and other causes of death risks among dry cleaners. Expected numbers for the SMRs were developed from 5-year age and calendar-time mortality rates from the general United States population. Statistic significance of the SMRs was based on 95% confidence intervals according to Liddell (5). Person-year accumulation began on date of entry into the union, or January 1, 1948 (whichever came later) and ended on the closing date of the study (December 31, 1993) if alive, or date of death if deceased. The earliest date of entry into the cohort was January 1, 1948 because union records were incomplete prior to that date.

As in the previous study, this analysis included only individuals who were union members for one year or more with available information necessary for epidemiologic analyses. The entire cohort abstracted from union records consisted of 11,062 individuals, of which 5,369 were included in the analysis after excluding 5,272 individuals who worked less than one year and 421 who lacked the necessary demographic information for epidemiologic analysis (Table 1). There were four more individuals in this analysis than in the earlier study because critical demographic information, which was missing at the earlier analysis, was obtained during the extended follow-up. The analysis cohort was predominantly women (2,566 whites and 1,483 blacks), with smaller numbers of men (407 whites and 913 blacks).

RESULTS

Table 1 shows the number of deaths and averages for selected variables for subjects in the analyses. The average year of birth was slightly more recent for blacks than whites. Workers joined the union on average in the mid-1950s and years of union membership prior to 1978 was 6.6. Average year of entry into the cohort skewed toward early in the entry interval because the number of workers employed in the dry cleaning industry has diminished substan-

TABLE 1. Number of dry cleaners by race, sex, and study status

	Race/Gender					
Description	White men	Black men	White women	Black women	Unknown	Total
Number in Cohort						
Entire cohort	805	1,433	4,736	2,283	1,805	11,062
Worked 1 year or more	418	936	2,609	1,505	322	5,790
In analyses	407	913	2,566	1,483	0	5,369
Characteristics of Analytic Cohort (N = 5,369)						
Year of birth	1914	1919	1916	1924	NA	1919
Age at entry	38	33	40	31	NA	36
Year at entry	1953	1954	1957	1956	NA	1956
Years of membership	6.1	6.9	6.2	7.4	NA	6.6
Number of deaths	245	522	1125	459	NA	2351

NA = Not applicable

TABLE 2. Mortality among 5,369 dry cleaners for selected causes of death by follow-up period compared to the US population

	Follow-up to 1/1/1979		Follow-up from 1/1/79 to 12/31/93		Follow-up over entire period	
Cause of Death (ICDA 8th rev)	SMR*	(Obs.) 95% CI	SMR*	(Obs.) 95% CI	SMR*	(Obs.) 95% CI
All Causes	0.9	(1129) 0.9–1.0	1.1	(1126) 1.0–1.2	1.0	(2351) 1.0–1.1
Infective and parasitic diseases (000–009)	0.6	(15) 0.3–1.0	1.2	(19) 0.7–1.9	0.8	(34) 0.6–1.2
Tuberculosis (010–019)	0.4	(6) 0.2–0.9	1.2	(2) 0.2–4.8	0.5	(8) 0.2–1.0
All malignant neoplasms (140–209)	1.1	(294) 1.0–1.3	1.3	(296) 1.1–1.4	1.2	(590) 1.1–1.3
Buccal cavity and pharynx (140–149)	0.9	(5) 0.3–2.2	1.2	(5) 0.4–2.9	1.1	(10) 0.5–2.0
Esophagus (150)	2.1	(13) 1.1–3.6	2.4	(13) 1.3–4.1	2.2	(26) 1.5–3.3
Stomach (151)	0.8	(11) 0.4–1.4	1.1	(9) 0.5–2.1	0.9	(20) 0.6–1.4
Colon (153)	1.0	(25) 0.6–1.4	1.4	(35) 0.9–1.9	1.2	(60) 0.9–1.5
Rectum (154)	1.3	(10) 0.6–2.4	1.2	(5) 0.4–2.9	1.3	(15) 0.7–2.2
Liver (155)	0.7	(5) 0.2–1.6	1.0	(5) 0.3–2.4	0.8	(10) 0.4–1.5
Pancreas (157)	1.2	(15) 0.6–1.9	1.0	(13) 0.5–1.6	1.1	(28) 0.7–1.5
Larynx (161)	1.6	(3) 0.3–4.6	1.8	(3) 0.4–5.4	1.7	(6) 0.6–3.7
Lung (162,163)	1.2	(47) 0.9–1.6	1.4	(78) 1.2–1.8	1.4	(125) 1.1–1.6
Skin (172,173)	0.8	(2) 0.1–2.7	0.9	(2) 0.1–3.2	0.8	(4) 0.2–2.1
Breast (174)	1.0	(36) 0.7–1.3	1.1	(32) 0.8–1.6	1.0	(68) 0.8–1.3
Cervix uteri (180)	1.6	(21) 1.0–2.4	1.5	(6) 0.6–3.4	1.6	(27) 1.0–2.3
Corpus uteri (181)	0.9	(8) 0.4–1.9	1.3	(7) 0.5–2.6	1.1	(15) 0.6–1.8
Prostate (185)	0.7	(5) 0.2–1.6	1.2	(12) 0.6–2.1	1.0	(17) 0.6–1.6
Bladder (188)	1.6	(8) 0.7–3.2	1.0	(4) 0.3–2.5	1.3	(12) 0.7–2.4
Kidney (189)	0.5	(2) 0.1–1.8	1.5	(6) 0.6–3.3	1.0	(8) 0.4–2.0
Brain (191,192)	0.2	(1) 0.1–1.2	1.1	(4) 0.3–2.9	0.6	(5) 0.2–1.4
Lymphatic and hematopoietic (200–209)	1.2	(24) 0.7–1.7	0.7	(15) 0.4–1.2	1.0	(39) 0.7–1.3
Non-Hodgkin's lymphoma (200,202)	1.1	(7) 0.4–2.3	0.7	(5) 0.2–1.7	0.9	(12) 0.5–1.6
Hodgkin's disease (201)	2.0	(4) 0.5–5.1	1.9	(1) 0.1–10.4	2.0	(5) 0.6–4.6
Multiple myeloma (203)	1.0	(4) 0.3–2.6	0.6	(3) 0.1–1.7	0.8	(7) 0.3–1.6
Leukemia (204–207)	0.9	(7) 0.3–1.8	0.7	(5) 0.2–1.6	0.8	(12) 0.4–1.4
Diabetes mellitus (250)	1.1	(34) 0.7–1.5	1.0	(28) 0.7–1.4	1.0	(62) 0.8–1.3
Arteriosclerotic heart disease (410–414)	0.9	(314) 0.8–1.1	1.1	(336) 1.0–1.3	1.0	(650) 1.0–1.1
Emphysema (492)	2.0	(14) 1.1–3.3	1.3	(7) 0.5–2.6	1.7	(21) 1.0–2.5
Cirrhosis of liver (571)	1.0	(24) 0.6–1.4	1.3	(14) 0.7–2.1	1.1	(38) 0.7–1.4
Chronic nephritis (582)	0.5	(6) 0.2–1.2	6.9	(7) 2.8–14.2	1.1	(13) 0.6–1.8
Motor vehicle accidents (810–819)	0.7	(16) 0.4–1.1	1.3	(9) 0.6–2.5	0.8	(25) 0.5–1.2
Suicide (950–959)	1.0	(10) 0.5–1.8	0.6	(2) 0.1–2.0	0.9	(12) 0.4–1.5

*SMR adjusted for age at death, year of death, race, and gender.

tially over the past decades. During the extended follow-up period, the number of deaths in the cohort nearly doubled from 1,222 to 2,351.

Table 2 shows SMRs for selected causes of death using the US general population for comparison adjusted for age at death, year of death, race and gender. SMRs are provided for the total follow-up period, as well as for the early and more recent follow-up periods separately. The cohort provided 146,082 person-years of follow-up through December 31, 1993. During the entire follow-up period, the number of deaths was as expected (SMR = 1.0). Causes of death with significantly elevated SMRs include emphysema (SMR = 1.7), all malignant neoplasms combined (SMR = 1.2) and lung (SMR = 1.4), and of borderline significance for cancers of the esophagus (SMR = 2.2) and cervix (SMR = 1.6). Hodgkin's disease and cancer of the larynx were elevated, but SMRs were based on small numbers. There were no statistically significant deficits.

SMRs for cancers of the esophagus, larynx, lung, and cervix were elevated and similar in the two follow-up periods. A few causes of death showed differences between the first and second follow-up period. Total cancer increased from a SMR = 1.1 in the first to 1.3 in the second follow-up, colon cancer increased from 1.0 to 1.4, uterine cancer increased from 0.9 to 1.3, bladder cancer decreased (from a SMR = 1.6 in the first to 1.0 in the second period), and kidney increased (from a SMR = 0.5 in the first to 1.5 in the second period). SMRs for emphysema decreased from the first to second follow-up (2.0 and 1.3, respectively), mortality from chronic nephritis increased (from 0.5 to 6.9), and cirrhosis of the liver increased (from 1.0 to 1.3).

Race/gender-specific SMRs for selected causes of death over the entire follow-up period are shown in Table 3. Total cancer was slightly elevated in all four groups and statistically significant in all but white men. All groups, except black women (only two deaths), experienced excess mortal-

TABLE 3. SMRs for selected causes of death by race and gender for the entire follow-up period

	White men	Black men	White women	Black women
Cause of Death	SMR (Obs #) 95% CI	SMR (Obs #) 95% CI	SMR (Obs #) 95% CI	SMR (Obs #) 95% CI
Total Cancer	1.2 (55) 0.9–1.6	1.4 (139) 1.2–1.6	1.1 (264) 1.0–1.2	1.2 (132) 1.0–1.5
Esophagus	2.0 (2) 0.3−7.0	3.1 (18) 1.9–5.0	1.7 (4) 0.5–4.5	0.8 (2) 0.1–2.8
Colon	0.5 (2) 0.1–1.7	1.9 (13) 1.0–3.2	1.0 (32) 0.7–1.5	1.3 (13) 0.7–2.2
Pancreas	0.4 (1) 0.1–2.4	1.5 (8) 0.7–3.0	1.2 (15) 0.6–1.9	0.7 (4) 0.2–1.7
Larynx	1.7 (1) 0.1–9.3	1.7 (3) 0.3–5.0	(0)	3.9 (2) 0.4–14.2
Lung	1.3 (17) 0.8–2.1	1.3 (42) 0.9–1.8	1.3 (43) 1.0–1.8	1.7 (23) 1.0–2.5
Breast	(0)	(0)	0.9 (42) 0.6–1.2	1.4 (26) 0.9–2.0
Cervix uteri			1.8 (14) 1.0–2.9	1.4 (13) 0.8–2.4
Bladder	2.6 (4) 0.7–6.6	0.5 (1) 0.1–2.9	1.6 (6) 0.6–3.4	0.6 (1) 0.1–3.4
Kidney	(0)	1.9 (3) 0.4–5.5	0.5 (2) 0.1–1.8	2.4 (3) 0.5–6.9
Lymphatic/ hematopoietic	1.2 (5) 0.4–2.9	0.9 (6) 0.3–1.9	1.1 (24) 0.7–1.6	0.5 (4) 0.1–1.4
Emphysema	1.6 (5) 0.5–3.8	1.8 (5) 0.6–4.2	1.4 (8) 0.6–2.7	3.4 (3) 0.7–10.0

ity from esophageal cancer, although the excess was statistically significant only among black men. The SMR for lung cancer was elevated and similar in all groups and statistically significant among women. Cervical cancer was elevated among both black and white women. Laryngeal cancer was elevated in white men, black men and black women (no deaths occurred among white women), but these were all small numbers. Bladder cancer was elevated among whites, but not blacks, while kidney cancer was elevated among blacks, but not whites. Emphysema was excessive in all groups, although none of the SMRs was statistically significant. SMRs for selected causes of death by estimated level of exposure to dry cleaning solvents based on the job indicated in union records are presented in Table 4. Union records for most cohort members included only one job (usually that held when joining the union), thus it was not possible to calculate cumulative exposure. Numbers of deaths for some causes of death are quite small. For chronic nephritis, total cancer, and cancers of the larynx, lung, and kidney, SMRs in the higher exposure category were appreciably larger than those in the lower category. For the other causes of death, there was little difference between the SMRs in the two exposure categories.

TABLE 4. SMRs for selected causes of death by estimated level of exposure to dry cleaning solvents for the entire follow-up period

	Little or No Exposure (Index Score = 0)	Medium/High Exposure (Index Score of 7 or 40)
Cause of death	SMR:[a] (Obs. #), 95% CI	SMR: (Obs. #), 95%CI
Emphysema	1.9; (10), 0.9–3.5	1.6; (10), 0.7–2.8
Chronic nephritis	0.5; (2) < 0.1–3.8	1.4; (10), 0.7–2.5
Total cancer	1.0; (220), 0.9–1.2	1.3; (316), 1.1–1.4
Cancers		
Esophagus	2.1; (7), 0.9–4.4	2.2; (16), 1.2–3.5
Colon	1.1; (28), 0.8–1.6	1.2; (28), 0.4–1.5
Pancreas	1.2; (14), .7–2.0	0.8; (11), 0.4–1.5
Larynx	−; (0), 0.0–3.7	2.7; (6), 1.0–5.8
Lung	1.0; (34), 0.7–1.4	1.5; (78), 1.2–1.9
Breast	0.8; (30), 0.6–1.2	1.2; (29), 0.8–1.7
Cervix	1.5; (12), 0.8–2.7	1.4; (11), 0.7–1.7
Bladder	1.4; (5), 0.4–3.2	1.5; (7), 0.6–3.1
Kidney	0.3; (1), < 0.1–1.6	1.5; (7), 0.6–3.1
Lymphatic Hematopoietic	1.0; (18), 0.6–1.5	0.9; (17), 0.5–1.4

[a]SMR adjusted for age, gender and calendar time.

We also evaluated mortality risks by year of joining the union because the solvent of choice changed over the years and by years in the union (no table). Stoddard solvent dominated the industry until the 1930s, when carbon tetrachloride became more widely used. In the 1960s, perchloroethylene largely replaced both carbon tetrachloride and Stoddard solvent (6). SMRs for individuals joining the union before 1960 and after 1960 were similar for emphysema (1.7 and 1.6, respectively), total cancer (1.2 and 1.1), and cancers of the esophagus (2.2 and 2.3), larynx (1.7 and 1.8), lung (1.4 and 1.4), kidney (1.0 and 0.7), and cervix (1.6 and 1.4). For bladder cancer, the SMR for those entering the union prior to 1960 was 1.1 (N = 9 deaths), while it was 2.9 for those entering after 1960 (based on only 3 deaths) and for chronic nephritis was 1.0 (N = 11) prior to 1960 and 2.0 (N = 2) after 1960. For cancer of the lymphatic and hematopoietic system, the pre-1960 SMR was 1.1 and the post-1960 SMR was 0.3 (based on two deaths). SMRs by years in the union (using a cut point of 4.4 years, which was the median) showed no difference by duration for any cause of death of interest except bladder cancer where the SMR was 2.1 for less than the median and 0.9 for greater than the median. Mortality from cancer of the buccal cavity and pharynx was not elevated in the cohort, nor did it differ by year of entry into the union.

DISCUSSION

The results from this extended follow-up of a cohort dry cleaners are similar to the earlier report (4). During the ex-

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tended follow-up period, as with the earlier period, the all cause SMR was about as expected. There was a small, but significant, excess for total cancer (SMR = 1.3) in the extended follow-up period. Cancers of the esophagus (SMR = 2.4), larynx (SMR = 1.8), lung (SMR = 1.4), and cervix (SMR = 1.5) remained elevated. A few differences appeared between the earlier and more recent follow-up period. The SMRs decreased from the earlier follow-up for emphysema (2.0–1.3) and cancer of the bladder (1.6–1.0), while they increased for chronic nephritis (0.5–6.9) and cancer of the kidney (0.5–1.5).

What can we conclude about cancer risks among dry cleaners from the extended follow-up of this cohort? First, there was no excess of liver cancer, the cancer associated with perchloroethylene and other organic solvents in rodent bioassays (1). Excesses of liver cancer have been reported among women laundry and dry cleaners in Denmark (6), but not in the United States (7). Excesses of liver cancer have also been reported among persons in other solvent-exposed occupations (8–11). Thus, the epidemiologic literature on liver cancer among dry cleaners and other solvent-exposed workers in general is quite inconsistent. There may be several explanations for this. Liver cancer is a rare disease and the relatively small number of cases, or deaths, in any investigation would introduce inconsistencies between studies. Liver cancer is difficult to study using a retrospective mortality design because of inaccuracies that occur on death certificates. Only about 45% of the death certificates of decedents with liver cancer noted in hospital records had any mention of liver cancer on the death certificate (12). Conversely, only about 25% of the death certificates noting liver cancer can be confirmed by hospital records. Thus, the diagnostic error rate associated with death certificates is likely to be sizable, and nondifferential misclassification of outcome in cohort mortality studies would tend to bias estimates of relative risk toward the null (13). Even though our study showed no evidence of an elevated mortality rate from liver cancer, excesses in a few epidemiologic investigations (6, 8) and positive bioassays (1) indicate the issue regarding liver cancer among dry cleaners and others exposed to organic solvents is not closed.

The consistent excesses for cancers of the esophagus, larynx, lung and cervix in the two follow-up periods for our investigation indicate that these are unlikely to be chance findings. The most recent follow-up of the NIOSH dry cleaners cohort (7), subjects who were known to be exposed to perchloroethylene, also showed excess mortality from cancers of the esophagus, lung, and cervix. No information on laryngeal cancer was presented. The critical question is what are the factors that might be responsible for these excesses. The occurrence of several tobacco-related causes of death (i.e., emphysema and cancers of the esophagus, larynx, lung, and cervix) and the lack of information on tobacco use in this study raises the possibility of confounding. Dry cleaners and launderers may smoke slightly more than the general population. Using 1970 health interview survey data, Sterling and Weinkam (14) reported that 38% of white women employed in laundry and dry cleaning were current smokers. This compares to 31% of white women overall. Nelson (15), using health interview surveys from 1987 to 1990, found that 32% of workers in laundering and dry cleaning machine operations were smokers, compared with 27% for the overall US population. Although these data indicate that some confounding by smoking may occur, it is unlikely to be large. Axelson and Steenland (16) have shown that a difference in smoking rates between occupations of about 10% (as suggested by the two surveys (14, 15)) can only result in a confounded risk ratio for lung cancer of about 1.2. This is consistent with empirical reports that find crude and smoking adjusted relative risks of selected cancers associated with occupations are quite similar unless the smoking difference is large (17). Thus, if the magnitude of the difference in smoking for dry cleaners and the general population is in the range of 10% or less, confounding from smoking in this study is unlikely to result in a relative risk of greater than 1.2 for causes of death that are strongly linked to tobacco use, such as lung, larynx, and esophageal cancer and emphysema. It would be even lower for less strongly associated diseases. Confounding by smoking, therefore, is unlikely to fully explain the two-fold excess for esophageal cancer and cannot account for the 1.6 or 1.7-fold excesses for emphysema and cancers of the cervix and larynx. However, smoking might, explain most of the lung cancer excess.

The excess of esophageal cancer observed among black men in the earlier follow-up was also evident in the extended follow-up period and it now occurs among white men and white women. In our data, the risk did not increase with duration or estimated level of exposure. These findings differ from the positive exposure-response gradient by duration of exposure reported by Ruder et al. (7). The incidence of esophageal cancer was elevated in a study of trichloroethylene-exposed workers in Denmark (11) and solvent-exposed aircraft maintenance workers in the US (18). No information was provided about this tumor in a study of solvent-exposed workers in Finland (8). Although the esophageal excess among dry cleaners is not likely to be entirely explained by smoking differences, this cancer is affected strongly by socioeconomic status (19), and dry cleaning is a low-income industry (20). The average earnings of dry cleaners in 1980, 1990, and 1999 was about two-thirds that of average for private sector workers (20). Alcohol use and dietary practices may account for the socioeconomic association and these factors could be involved in the excesses observed in this investigation. Solvents have been associated with esophageal cancer in other epidemiologic studies (11, 18). Vaughan et al. (21) reported an excess of esophageal cancer among dry cleaners in a case-control

study where it was possible to adjust for socioeconomic status (based on only four cases). Although the excess of esophageal cancer has been observed in several studies of dry cleaners, inconsistencies make it difficult to conclude with any confidence what the causal factor(s) might be.

Excess cancers of the larynx and lung occurred in all race-sex groups (except laryngeal cancer among white women). Relative risks for both were greater among individuals estimated to have had greater exposures, although neither showed a relationship with duration of union membership. Vaughan et al. (21) reported a 2.7-fold excess of laryngeal cancer, based on five cases. The number of deaths from laryngeal cancer in the cohort (N = 6), however, are too small to perform subgroup analyses or to draw conclusions. The lung cancer excess is within the range that might be explained if dry cleaners smoked slightly more than the comparison population, although it is somewhat unusual to find this excess only in the high exposure category.

Elevated mortality from cervical cancer observed in this investigation was also noted in the NIOSH cohort (7). There was no clear association with duration or estimated level of exposure in either study. Human papillomavirus infection is the major cause of cervical cancer. This, and the strong inverse relationship between socioeconomic status and invasive cervical cancer, may account for the excesses observed among dry cleaners (22).

Other than the excess of Hodgkin's disease, there did not appear to be any association between work in the dry cleaning industry and lymphatic and hematopoietic cancer. These are the cancers most strongly linked to organic solvents in the occupational literature (23). Ruder et al. (7) also did not observe an excess for these tumors in their cohort.

The risk of death from chronic nephritis was elevated during the extended follow-up period (SMR = 6.9), compared with an SMR of 0.5 during the earlier follow-up. The expected number of deaths in the extended follow-up period, however, was very small. Although our data did not show a strong relationship between level of exposure, duration of employment as a dry cleaner, and mortality from chronic nephritis, there is some evidence that hydrocarbons may have a deleterious effect on the kidney. Nephropathies have been reported among dry cleaners (24), a meta-analysis noted an association between chronic renal failure and end stage renal disease (25) and kidney cancer was increased among individuals with the heaviest exposures.

This extended follow-up of a relatively large cohort of dry cleaners provides additional information on potential disease risks from exposure to perchloroethylene. It is unique among occupational cohorts in that the cohort has large numbers of women and nonwhites (26, 27). Limitations include lack of information on potential confounding factors, such as tobacco and alcohol use and lack of detailed job histories while employed in the dry cleaning industry. This information lack could lead to exposure misclassification. The reliance on death certificates presents difficulties for certain causes of death (12), such cancer of the liver, skin, and breast.

In summary, this extended follow-up of a cohort of dry cleaners increased the number of deaths available for analysis by 1,129. Excesses for cancers of the esophagus, larynx, lung and cervix seem unlikely to be due to chance, but it is unclear if they can be attributed to solvent exposures because it was not possible to clearly apportion the contribution from occupational and lifestyle factors.

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