Scand J Work Environ Health 1993;19(1):16-20
https://doi.org/10.5271/sjweh.1509
Issue date: 01 Feb 1993

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This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/8465167

Print ISSN: 0355-3140 Electronic ISSN: 1795-990X

Scand J Work Environ Health 1993;19:16—20

Lung cancer among textile workers in the Prato area of Italy

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ZAPPA M, PACI E, SENIORI COSTANTINI A, KRIEBEL D. Lung cancer among textile workers in the Prato area of Italy. *Scand J Work Environ Health* 1993;19:16—20. The association between lung cancer and occupational exposure in the textile industry was investigated in a population-based case-referent study conducted in the Prato area of the province of Florence (Italy) where there is a concentration of textile factories. A complete response to a postal questionnaire was obtained for 207 cases (85.1%) and 440 referents (76.1%). Those who had ever worked in the textile industry had an odds ratio (OR) of 1.45 [95% confidence interval (95% CI) 1.0—2.1]; when nine different textile job titles were considered, an increased OR was observed only for rag sorters (OR 2.2, 95% CI 1.3—3.8) and weavers (OR 1.7, 95% CI 1.1—2.7). Analysis by different "time windows" showed an OR of 3.0 (95% CI 1.6— 5.8) for rag sorters at work in the 1950s and an OR of 2.8 (95% CI 1.5—5.0) for weavers at work in the 1970s. This result supports the suggestion of two different carcinogenic exposures in the Prato textile industry (asbestos and mineral oils).

Key terms: asbestos, case-referent study, mineral oils, time windows.

The "Prato area" is an industrial zone in the province of Florence (Italy) where there is a high concentration of woolen textile industries. There are about 10 000 textile factories and 50 000 textile workers in this area. The particular feature of the local industrial process is in the reprocessing of the wool, which is derived from used clothes and rags ("ciclo del cardato") (1). The practice of recycling wool entails particular jobs, such as the sorting and treating of rags and the "oiling" of the fibers with mineral oils before the weaving. This latter operation is considered necessary in order to join together the regenerated fibers, which are shorter than those of virgin wool. (For a description of the Prato textile cycle see references 1 and 2.)

An increased risk of malignant mesotheliomas has been reported for textile workers, particularly for those engaged in "rag sorting" (3, 4). Subsequent industrial hygiene investigations led to the identification of the following three sources of asbestos exposure: (i) the use of jute and polypropylene bags which had once contained asbestos for wrapping rags, (ii) the release of asbestos fibers during the tearing phase of army uniforms and other war materials, (iii) the addition of chrysotile fibers to woolen yarns (1). Furthermore a case-referent study (hospital-based) on lung cancer, carried out in the major hospitals in the province of Florence (5), showed a moderately increased risk for textile workers compared with other "industrial workers" [odds ratio (OR) 1.5, 95% confidence interval (95% CI) 1.0—2.2]. Due to the type of study (hospital-based case-referent) and its size, we were not able to investigate the risk related to specific job titles of the Prato textile industrial process. Therefore, we carried out a population-based case-referent study giving particular attention to the gathering of information on work history in the textile industry so as to be able to analyze the pattern of risk in the different textile jobs over time.

Subjects and methods

Cases and referents

The cases were all male patients resident in one of the municipalities of the Prato area (Prato, Cantagallo, Carmignano, Montemurlo, Poggio a Caiano, Vaiano, and Vernio) with a diagnosis of primary lung cancer and reported as incident cases in the Tuscan Cancer Register in 1984—1986. We included only patients who had a histological confirmation of primary lung cancer and, for several reasons, those who had died before 31 December 1988. First 90% of the cases were already dead by that date, and we wished to maintain the comparability of the information by using only deceased cases and deceased referents. The second reason was logistical; we would have had to spend considerable time and effort to interview a small number of living (but critically ill) subjects.

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The referents were sampled from the Mortality Register of the Prato area. For each case up to three referents were selected matched by gender, age (±2 years), and year of death (±1 year). The selected causes of death were cancer (excluding cancer of the respiratory system, kidney, and bladder and ill-defined cancers), hypertension, ischemic heart disease, cerebrovascular diseases (congenital diseases being excluded), circulatory diseases (congenital and Burger's disease being excluded), and digestive system diseases (malabsorption and congenital diseases being excluded). We selected causes of death not known to be related, either positively or negatively, to work in the textile industry.

Altogether 288 incident cases of primary lung cancer, which had occurred in men resident in the Prato area, were collected for 1984—1986. Of these, 33 patients (11.4%) were still alive on 31 December 1988 and were therefore excluded. Three matched referents were not available for all of the cases so that only 611 referents were sampled for the analysis. For 12 cases (4.2%) and 33 referents (5.4%) it was not possible to trace a living next-of-kin, the total therefore being 243 cases and 578 referents eligible for the study. Complete responses to the questionnaire were obtained for 207 cases (85.1%) and 440 referents (76.1%).

Table 1 summarizes the relevant data on the cases and referents. The type of response (postal versus telephone), the reason for not responding, and the mean age did not differ between the two groups. Concerning the causes of death of the referents, the respondents had a cancer diagnosis about 10% more often than the nonrespondents.

The percentage of smokers was greater among the cases, as expected. When considering the never smokers as the reference category, we found an odds ratio of 6.4 for smokers (95% CI 3.4—12.3) and 3.6 (95% CI 1.7—7.4) for ex-smokers. A good correlation was found between the duration of smoking and the number of cigarettes smoked. People born in the southern part of Italy were slightly more likely to be referents, the adjusted odds ratio being 0.75 (95% CI 0.4—1.3). This result confirmed that of a previous report (10) in which birth in southern Italy demonstrated a protective effect for lung cancer.

Information on exposure

Information was obtained for the cases and referents through a semistructured questionnaire mailed to the nearest living relative. If an answer was not received within four weeks, a reminder was sent. When no reply was forthcoming, we attempted to interview the relative with the same questionnaire by telephone.

The questionnaire was designed to yield information about place of birth, smoking habits, and employment. The information concerning smoking habits included the year smoking started, the year smoking ended, and the daily number of cigarettes (classified as 1—15, 16—30, and >30 cigarettes daily). We considered as ex-smokers persons who had stopped smoking more than four years before death.

The information about occupational history included each job held for at least one year and start and end of employment. A standard occupational coding system was used to classify occupations into 21 major classes and 251 specific jobs [modified from the classification of the International Labour Organisation (6)]. If a subject had worked more than one year in the textile industry, the closest relative was also requested to specify the job title according to the following eight groups: (i) managers and clerical workers, (ii) chemical technicians, (iii) rag sorters, (iv) spinners, (v) weavers, (vi) dyers, (vii) finishing workers (other than dyers), and (viii) other textile workers (mechanics, etc).

Statistical methods

We obtained the present results with dissolved matching using unconditional methods. However, all of the essential results were also checked with preserved individual matching and conditional analysis, which gave similar estimates. To estimate the risk of lung cancer in different industrial sectors (and within textile groups) of different job titles, stratified analyses were carried out with the Mantel-Haenszel method; 95% confidence intervals were calculated with the test-based approach (7). Smoking habits (smokers, ex-smokers, nonsmokers) and place of birth (south/elsewhere) were used as confounders when the occupational risk was analyzed.

A new analysis was also carried out in which only those from the full data set who had ever worked in the textile sector in a blue-collar occupation were used as the cases and referents. Analysis by duration of work (two categories: <20 and ≥20 years) was also performed.

To analyze the effect of different calendar periods for the two textile jobs for which an elevated lung cancer risk was found, we considered three time windows, from 1950 to 1959, from 1960 to 1969, and from 1970 to 1979. We considered as exposed people who had worked as either rag sorters or as weavers (in two separate analyses) for more than four years

Table 1. Characteristics of cases and referents.

Characteristic	Cases		Referents	
Eligible	243		578	
Respondents[a]	207	(85.1%)	440	(76.1%)
Postal response	145		321	
Telephone response	62		119	
Nonrespondents	36	(14.9%)	138	(23.9%)
Refused	4		11	
Not found	32		127	

[a] Mean age = 65.4 (SD 9.6) years for the cases and 65.8 (SD 9.5) years for the referents.

in one of the three periods, and we created a separate variable coding for exposure in each of the three periods. Because case ascertainment occurred in 1984—1986; all of the workers identified as exposed in the coding scheme had at least 10 years of latency.

An unconditional logistic regression was carried out with the program of Campos-Filho & Franco (8). The odds ratio for an exposure effect was calculated as the antilog of the beta estimate, and the 95% confidence intervals were calculated using the standard error. Simultaneous adjustment was performed for smoking habits, place of birth, and age (as a continuous variable). Another analysis was carried out by adjusting also for the different time windows (9). For example, the risk among rag sorters at work in the 1950s was estimated from the following model: logit $P = b_0 + b_1$ (Smoke) + b_2 (Ex Smoke) + ... + b_7 (Exp_{70-79}), where P was the risk of lung cancer, the variate Smoke was coded 1 if the subject was a smoker and was 0 if he was an ex-smoker or nonsmoker, the variate Ex Smoke was coded 1 for exsmokers or 0 for smokers or nonsmokers, Age was age in years, the variate Birth was coded 1 if the subject was born in the southern part of Italy and 0 if born elsewhere, and the exposure variables (Exp) were coded 1 or 0 if the subject worked or not, respectively, for more than four years as a rag sorter in the three time windows.

Table 2. Adjusted Mantel-Haenszel odds ratios and 95% confidence intervals for lung cancer by industrial group. (OR = odds ratio, 95% CI = 95% confidence interval)

Industrial group	Cases (N)	Referents (N)	OR[a]	95% CI
Textile	129	227	1.45	1.0—2.1
Agriculture	48	136	0.77	0.5—1.1
Construction	27	74	0.71	0.4—1.2
Trade	33	60	1.22	0.8—2.0
Transport	16	38	0.83	0.4—2.4
Public administration	9	26	0.70	0.3—1.5
Mechanics	10	23	0.95	0.4—2.1
Food and beverages	4	18	0.49	0.2—1.4
Policemen, firefighters and soldiers	7	15	1.0	0.4—2.4
Wood	6	14	1.03	0.4—2.1
Quarry and mining	9	12	1.48	0.6—3.6
Electricity and water supplies	5	11	0.88	0.3—2.7

[a] Adjusted Mantel-Haenszel OR for age, smoking habits, and place of birth.

Results

Table 2 shows adjusted odds ratios for broad industrial groups. Every job held for more than one year

Table 3. Adjusted Mantel-Haenszel odds ratios and 95% confidence intervals for lung cancer by job title in the textile industry. (OR = odds ratio, 95% CI = 95% confidence interval)

Job title	Cases (N)	Referents (N)	OR[a]	95% CI
Managers and clerical workers	9	22	0.88	0.5—1.4
Technicians	—	3	—	.
Rag sorters	32	31	2.22	1.3—3.8
Spinners	30	71	0.84	0.5—1.4
Weavers	41	50	1.73	1.1—2.7
Dyers	9	31	0.64	0.3—1.4
Finnish workers	16	35	0.86	0.5—1.6
Others	20	28	1.53	0.8—2.8

[a] Adjusted Mantel-Haenszel OR for age, smoking habits, and place of birth.

Table 4. Adjusted odds ratios and 95% confidence intervals from the logistic regression model examining lung cancer risk for the rag sorters by period of exposure. (OR = odds ratio, 95% CI = 95% confidence interval)

Calendar periods	Cases (N)	Referents (N)	Adjusted OR[a]	95% CI for adjusted OR[a]	Adjusted OR[b]	95% CI for adjusted OR[b]
1950—1959	23	17	3.03	1.6—5.8	4.12	1.0—17.2
1960—1969	21	19	2.42	1.3—4.7	1.55	0.7—3.5
1970—1979	11	14	1.55	0.2—5.5	0.47	0.1—1.6

[a] Adjusted for smoking habits, age, and place of birth.
[b] Adjusted for smoking habits, age, place of birth, and the other time windows.

Table 5. Adjusted odds ratios and 95% confidence intervals from the logistic regression model examining lung cancer risk for the weavers by period of exposure. (OR = odds ratio, 95% CI = 95% confidence interval)

Calendar periods	Cases (N)	Referents (N)	Adjusted OR[a]	95% CI for adjusted OR[a]	Adjusted OR[b]	95% CI for adjusted OR[b]
1950—1959	22	29	1.63	0.9—2.9	1.20	0.5—2.9
1960—1969	20	19	1.71	0.9—3.0	0.52	0.2—1.6
1970—1979	27	22	2.78	1.5—5.0	4.29	1.6—11.8

[a] Adjusted for smoking habits, age, and place of birth.
[b] Adjusted for smoking habits, age, place of birth, and the other time windows.

was considered, and therefore each person could be counted for more than one occupation. (The table reports only occupations with more than 10 referents.) The only industrial group that showed a borderline, significantly increased risk was the textile group (OR 1.45, 95% CI 1.0—2.1).

The adjusted odds ratios for specific job titles in the textile industry are presented in table 3. Only the rag sorters and the weavers showed significantly increased risks. We carried out a new analysis selecting only cases (N = 129) and referents (N = 227) who had ever worked in the textile sector as blue-collar workers. The odds ratios for having worked as rag sorters or as weavers, compared with having worked in the other textile manual job titles, were similar to the results obtained using the complete pool of cases and referents (OR 2.58 versus 2.22 for rag sorters and 1.67 versus 1.73 for weavers).

The analysis by duration of employment gave an odds ratio of 1.66 for rag sorters having worked less than 20 years and an odds ratio of 2.99 for those having worked more than 20 years. For weavers the odds ratios were 1.79 and 1.81, respectively.

The results by time windows are presented in tables 4 and 5. Adjusted (for smoking habits, age, and place of birth) odds ratios are shown for those who worked as either rag sorters or weavers in the three calendar periods. The patterns of risk over time were different for the two job titles. The analysis by different time windows showed the highest risk for rag sorters at work in the 1950s (OR 3.0, 95% CI 1.6—5.8) and for weavers at work in the 1970s (OR 2.8, 95% CI 1.5— 5.0). When we adjusted also for having worked in the other time windows, the estimates increased for the two periods at the highest risk (4.1 versus 3.0 for rag sorters in the 1950s and 4.3 versus 2.8 for weavers in the 1970s).

Discussion

We carried out a population-based case-referent study with the aim of investigating the risk of lung cancer related to different job titles of the textile cycle in Prato. Analysis for the different industrial groups showed an excess of risk only among workers who had been employed in the textile industry. It is noteworthy that the estimate of the risk was the same as that observed in the previous hospital-based case-referent study (5).

When the different textile job titles were examined separately, we found that the textile industry risk was based on a higher frequency of cases reporting work as a weaver or rag sorter. The two job titles are independent in that only six subjects (two cases and four referents) had been employed in both occupations. The estimates of the risk did not differ when only the cases and referents who had worked in the textile sector as blue-collar workers were considered. The confirmation of the results in a homogeneous socioeconomic group makes us more confident of the validity of the study in relation to a hypothetical bias introduced by using referents selected by cause of death. It seems unlikely that the selected causes of death might be linked to specific job titles within the occupations of blue-collar textile workers. An analysis of different time windows provided the best possibility of studying the pattern of risk over time. This analysis showed a different temporal pattern of risk for the rag sorters and weavers, a finding suggesting the possibility of two different types or patterns of carcinogenic exposures.

The lung cancer risk was highest for rag sorters at work in the first time window (1950—1959). This lung cancer risk for rag sorters was probably related to asbestos exposure deriving from the reprocessing of asbestos cloth or other material which had been polluted by this substance (1). Moreover the epidemic of malignant mesotheliomas among people who had worked as rag sorters continues (4, 11). The temporal pattern of risk is in good agreement with our previous knowledge that the most intense exposure occurred after the Second World War and thereafter exposure decreased.

The adjustment for the other windows limited the risk for rag sorters to the first period. Statistical problems due to the multicollinearity of the time variables have been stressed (9, 12), and the results have to be looked at with caution. It is noteworthy that the boundaries of the 95% confidence intervals became very large. Nevertheless, in the case of our study, the adjusted results support our prior etiologic hypothesis.

It is more difficult to understand the excess risk for weavers. This risk was highest for people at work as weavers in the 1970s. After adjustment for other time periods, the weavers exposed in this time window remained the only ones at risk.

At least two hypotheses are possible for the weavers' excess risk. The first one is related to asbestos exposure. At the end of the 1960s chrysotile was directly woven into blends with wool and other fibers in some Prato factories. The stated reason for this practice was to reduce the tariff for cloth exported to the United States (1). There were no import duties on this kind of fiber. This practice went on for only a few years and ended in the early 1970s. The hazard of blending asbestos into wool does not seem to be sufficient to explain fully the observed risk, however, because of its short duration and the fact that it was not a very widespread practice. (As far as we are able to discern, it seems that only a small percentage of companies blended asbestos.)

Another possible causal agent is mineral oil exposure, although for this possibility we have only indirect suggestions. Mineral oils were commonly used to lubricate textile looms. A survey on the use of mineral oils carried out by the Italian National Health Institute (Istituto Superiore di Sanità) (13) found that weavers were exposed to mineral oils containing polycyclic aromatic hydrocarbons (PAH), which are potentially carcinogenic for the lung. This exposure was particularly high with the first type of "high speed" looms. The concentration of aerosol near weaving machines in a large woollen textile factory in the district of Vicenza (north Italy) averaged levels two to three times greater than the occupational exposure limit (5 mg · m^{-3}) at the beginning of the 1970s (14). This type of loom was introduced in the Prato area in the middle of the 1960s. Moreover, in the Prato textile cycle, there is exposure to aerosol derived from the oil used during the weaving of oiled yarns. The practice of oiling fibers was common in Prato because of the poorer quality of the reprocessed wool, which was the principal raw material of the industry. Unfortunately no studies exist on either the chemicals in the mineral oils used in Prato or on the air concentrations of these oils. Furthermore, in some factories, workers could have been exposed simultaneously to asbestos and PAH, with a possible synergistic effect (15).

In summary this study confirmed the risk for lung cancer among textile workers in the Prato area. This risk concerned only two job titles, rag sorting and weaving. For rag sorting the cause of the elevated risk was probably asbestos exposure, which was particularly high after the Second War World and then gradually decreased. Concerning the risk for weavers, we can only put forward some hypotheses. For this reason it will be necessary to carry out further epidemiologic studies and investigate the hygienic aspects of this phase of the textile cycle.

Acknowledgments

Part of the results of this study was presented at the Eighth International Symposium on Epidemiology in Occupational Health in Paris (France) in September 1991.

The authors wish to thank Dr E Buiatti and Dr G Vannucchi for their critical suggestions and nurses Ms V Cacciarini and Ms G Barni for their careful work.

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Received for publication: 3 March 1992