Malignant Mesotheliomas in Textile Rag Sorters

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ABSTRACT

Objectives: To analyse the asbestos exposure characteristics and mesothelioma trend in textile workers operating in the larger Tuscan textile industrial province of Prato between 1988 and 2012. Methods: All cases of textile workers recorded by the Tuscan mesothelioma register are considered. The demographic and clinical characteristics and asbestos exposure of cases working in the province of Prato are examined. Crude incidence rates between 1988 and 2012 and their 95% confidence intervals (CI) are calculated in rag sorters and other textile workers. The trends of standardized rates are also evaluated, as well as the sources of occupational asbestos exposure from occupational histories of cases affected by other asbestos-related diseases in rag sorters. Results: One hundred and seventy-two malignant mesotheliomas (MMs) have been diagnosed in textile workers in Tuscany. Among these, 46.5% were residents in the province of Prato at the time of diagnosis, half of whom working as rag sorters. All rag sorters with MM are classified as occupationally asbestos exposed, while 71.7% are other textile workers exposed to asbestos. The estimated crude incidence rate in rag sorters in Prato ranges from 74.1 × 100 000 (95% CI: 52.5–101.8) to 166.8 × 100 000 (95% CI: 118.1–229.0). The standardized rates in Prato rag sorters appeared higher throughout the 1990s while in other Prato textile workers the rates increased later on, at the very end of the 1990s. Another 40 cases of asbestos-related diseases in rag sorters were also collected. Conclusions: A very high incidence of MMs was observed in textile workers in Prato, especially among rag sorters. This result, together with the high number of other asbestos-related diseases in rag sorters, strongly supports the hypothesis of diffuse asbestos exposure in rag sorting, in the absence of any other relevant aetiological factor for malignant mesothelioma.

KEYWORDS: asbestos; asbestos occupational exposure; malignant mesothelioma; textile rag sorters; textile workers

INTRODUCTION

Malignant mesothelioma (MM) is a rare cancer, the pathogenesis of which is closely related to exposure to asbestos (IARC, 2012), detectable in around 70–90% of male cases and less frequently in female cases. Other natural mineral fibres, such as erionite (Baris and Grandjean, 2006), vermiculite (Whitehouse et al., 2008), and fluoro-edenite (Bruno et al., 2006), as well as artificial fibres (IARC, 2002) and high aspect ratio nanomaterials (Donaldson et al., 2011; Fubini et al.,...
have been suggested to play an aetiopathological role on MM occurrence. In Italy, the geographical and temporal differences in disease incidence are basically due to past occupational and environmental asbestos uses and exposure (Facchini et al., 1986; Mastrantonio et al., 2002; Marinaccio et al., 2005; Marinaccio et al., 2008).

During the 1980s, a survey of MM conducted in Tuscany showed for the first time a large amount of pleural MM s in textile industry workers in the province of Prato (22 cases out of 61 registered MM s), 16 cases of which were diagnosed in rag sorters (Paci et al., 1987, 1991). Following, the Tuscan mesothelioma register was created (Buiatti and Chellini, 1989; Chellini et al., 1992), even before enforcement of the national laws on preventive asbestos intervention (Legislative Decree no. 277/1991 and Decree of the President of the Council of Ministers no. 308/2002) that provided for the establishment of a national mesothelioma register called RENAM. At that time, the Tuscan register was also incorporated, as an Operating Regional Centre (COR), into the national epidemiological surveillance system RENAM (Nesti et al., 2001, 2004).

In the mid 1980s, following the unexpected detection of MM s among workers in Prato, the Occupational Health Service (OHS) of the Local Health Authority of Prato performed an industrial hygiene survey to evaluate the presence of asbestos in rag sorting workplaces. A long and widespread practice of recycling sacks made of jute and polypropylene coming from Italian asbestos cement factories, was registered (Monechi et al., 1987; Quinn et al., 1987). Other sources of asbestos exposure for rag sorters were also suggested during the tearing up of military uniforms containing asbestos in the years immediately after the second world war, and for other textile workers during the 1960s, when 8% of asbestos was added to wool fabrics intended for the US market in order to avoid the high import taxes for pure wool in force in that country (Quinn et al., 1987).

From that time on, many other cases were recorded in textile rag sorters in Prato by the Tuscan mesothelioma COR, a separate registry from the population cancer registry, which uses standardized procedures to ascertain Tuscan mesothelioma cases and their occupational and non-occupational asbestos exposure (Chellini et al., 2013).

The objective of this study was to examine the characteristics and trends of MM s, diagnosed in the 1988–2012 period, in Tuscan textile workers, especially those operating in the industrial province of Prato, and to further evaluate their possible past asbestos exposure.

The textile industry in Prato, mainly involved in the production of reprocessed wool, was very prosperous up to the last two decades when the national economic crisis also affected the textile sector, changing the local industrial scenario, despite the counter effect due to the increasing number of migrants from China working in this industrial sector, although mainly engaged in clothing activities (Berti et al., 2013). In the past rags arrived in Prato from national and international rag markets for being recycled. These included clippings from package industries, waste materials from textile industries, and second-hand clothes and fabrics. The reprocessed wool was produced by breaking down used wool garments and re-forming the wool to make yarn for re-weaving. The first step in reprocessed wool making is called rag sorting, characterized by two different phases: an initial sorting phase which includes hand tearing out of linings, fur coat collars, and other unusable accessories, and a second one in which materials are classified by type of fabric, conservation level, and colour. The dispersion of inhalable fibres, including asbestos, when present, would have been possible, especially during the first sorting phase.

METHODS

All MM cases diagnosed between 1988 and 2012 in textile workers, recorded by the Tuscan mesothelioma COR, are considered. For each case working in the Prato textile industries, their demographic information (gender, age at diagnosis and residence), clinical information (diagnostic procedure, cancer topography, histotype, and survival), employment history (job, company location, and work period) and asbestos exposure grading were extracted from the COR database. All data are collected and registered by the Tuscan mesothelioma COR using standardized national procedures (Nesti et al., 2003): personal occupational and lifestyle histories are detected by means of a specific national questionnaire by trained interviewers; if the case is deceased or not able to carry out an interview, a next-of-kin or a workmate is interviewed; asbestos exposure is evaluated and
classified by industrial hygienists and occupational health physicians.

For each case, a latency period was calculated as the difference between the beginning of supposed exposure (first year of job activity) and year of MM diagnosis.

The distribution of demographic and clinical characteristics and asbestos exposure in rag sorters and other textile workers was examined and compared using the Chi-Square ($\chi^2$) statistical significance test (<0.05 for statistically significant differences) or Fisher’s exact test.

Crude incidence rates from 1988 to 2012 and their 95% confidence intervals (CI) were calculated for rag sorters and other textile workers.

The number of textile workers in the province of Prato, both rag sorters and other textile workers, at risk of having an MM diagnosis in the 1988–2012 period was assumed as stable throughout the whole period, considering that those at risk of MM had worked from the 1950s to the 1980s (with mesothelioma latency lasting about 30–40 years), a prosperous economic period for textile industry in Prato, and experienced the same mortality pattern as the Prato population in the following years.

In the absence of any official data, the number of rag sorters in Prato at risk of MM in the observation period was estimated on the assumption that there was a stable yearly amount of processed rags (those imported in 1985 equal to 94 292 tons), and a stable daily work time necessary to pick out an amount of rags ranging between 200 and 450 kg per day per person, as reported in a previous survey (Monechi et al., 1987), but arbitrarily halved considering that a rag sorter’s working day was also devoted to other activities, such as rag receiving and packaging.

The number of other textile workers at risk of MM was calculated as the difference between the number of workers in the Prato textile industrial sector, as recorded by national statistics in 1981 (ISTAT, 1982), and the estimated number of rag sorters.

Although the total number of rag sorters by year and age class is unknown, a time trend of the mesothelioma rates for these workers was evaluated using the age class distribution of the general population of the province of Prato and the Tuscany region as denominators for calculating the age specific incidence rates of Prato and Tuscan textile workers, respectively.

Five-year standardized incidence rates were calculated using the European population as a reference.

Possible past asbestos exposure in the Prato textile sector was further evaluated through an examination of working histories collected for other asbestos-related diseases in textile workers registered by the OHS of the Local Health Authority of the province of Prato.

RESULT

One hundred and seventy-two MMs were diagnosed in the 1988–2012 period in textile workers residing in Tuscany, 52 (30.2%) of whom were rag sorters (44 males and 8 females). Table 1 shows the characteristics of this case series by job.

The average age at diagnosis was 69 years both in rag sorters and other textile workers. The median survival from diagnosis was 9 months (range: 0.2–51.5 months) in rag sorters, excluding one case discovered at post-mortem examination. In the other group, the median survival was 8 months (range: 0.1–75.4 months).

The vast majority of cases had a histological diagnosis (85.5%): the most common histotype was epithelial mesothelioma (81 cases, 55.1%), followed by biphasic (29 cases, 19.7%) and fibrous (4 cases, 2.7%); there were 33 cases (22.4%) of not otherwise specified mesotheliomas. No difference was observed in histotype distribution between rag sorters and other textile industry workers ($P = 0.4375$ in Fisher’s exact test).

A higher frequency of male cases was observed in rag sorters compared to other textile workers ($\chi^2 = 16.84$ and $P < 0.001$). The vast majority of cases in rag sorters at the time of diagnosis lived in the province of Prato (rag sorters: 39 in Prato versus 13 in other provinces; other textile workers: 41 in Prato versus 79 in other provinces; $\chi^2 = 24.31$ and $P < 0.001$), and worked in Prato (rag sorters: 46 in Prato versus 6 in other provinces; other textile workers: 48 in Prato versus 72 in other provinces; $\chi^2 = 34.38$ and $P < 0.001$).

Most textile workers were classified as occupationally exposed to asbestos (138 cases, 80.2%) and this was the case for all rag sorters. Job duration was on average 15.6 years in rag sorters, and 21.3 in other textile workers; 19 cases (36.5%) were ‘always’ engaged as rag sorters, while 33 rag sorters had other jobs in textile industries or less frequently in other industrial sectors.
The number of rag sorters with <5 years’ occupation was high compared to other textile workers (26.9% versus 16.8%, respectively).

In rag sorters, the average latency period between the beginning of occupation and mesothelioma diagnosis was 51.4 years (range: 20–76), whereas...
for the other textile workers it was 41.7 years (range: 8–75).

The asbestos exposure grading of 47 cases in rag sorters was ‘possibly professional’, almost double that observed for cases in other textile workers (90.4% versus 45.8%, $\chi^2 = 29.21$ and $P < 0.001$). Only five rag sorters (9.6%) were classified as cases with ‘certain’ occupational asbestos exposure because a large amount of crocidolite was detected in their lung tissue (3 cases), pleural plaques were observed during post-mortem examination (1 case), or they declared when interviewed that rags were stored in sacks previously containing asbestos (1 case).

The crude incidence rates of MMMs in the 1988–2012 period in rag sorters (both genders) working in the province of Prato was equal to 74.1 per 100 000 (95% CI: 52.5–101.8) assuming that each worker was able to pick out half of 200 kg of rags daily, or 166.8 per 100 000 (95% CI: 118.1–229.0) assuming that each worker was able to pick out half of 450 kg of rags daily with an estimated total of 2050 or 911 yearly-working rag sorters, respectively. In other textile workers in Prato the crude incidence rate (both genders) was equal to 3.5 per 100 000 (95% CI: 2.5–4.7). During the 25 years of observation, the 5-year standardized incidence rates in Prato rag sorters appeared to double throughout the 1990s while for the other Prato textile workers the incidence rate increased later on, at the very end of the 1990s, and then decreased immediately afterwards. At the beginning and at the end of the observation period, the 5-year standardized incidence rates in Prato rag sorters and other textile workers were similar and were five times higher than those calculated for the textile workers in Tuscany as a whole.

Twenty eight cases of other diseases associated with asbestos exposure (10 diffuse pleural thickening, 9 asbestosis, and 9 pleural plaques), as well as another 12 MMMs diagnosed before 1988, were registered by the OHS of the public Local Health Authority of Prato, in rag sorters operating in Prato. From interviews with these cases, the past use was also recorded of compressed air systems to clean textile machinery and workplaces that could have caused extensive indoor dispersion of asbestos fibres.

**DISCUSSION**

The process to select and separate wool fabrics (the rag sorting process) has been relevant in Prato in the past decades, contributing to the great development of the reprocessed wool industry in that area after the second world war.

The large number of mesotheliomas in rag sorters suggests important past asbestos exposure of these workers, difficult to investigate and retrieve from the exposure histories or the companies’ documentation. A significant number of sacks made of jute or polypropylene previously containing asbestos, which were labelled with the country of origin, the manufacturer, the word ‘Asbestos’ and the warnings about the danger of their content in English, was discovered in two rag sorting workplaces during the investigation conducted in the 1980s (Monechi et al., 1987). Before being used in rag packaging, these sacks, which came from Italian asbestos-cement factories, were opened with electric cutters, causing dispersion of asbestos fibres in the environment. Furthermore, the presence of asbestos fibres was observed in breathing zone samples, collected during the above-mentioned survey from workers assigned to cut sacks and press and package sorted rags (Quinn et al., 1987). Similar sacks were also recycled for other uses during the same period in Italy, such as genuine raw materials in the textile industry, product padding for couches, mattresses, jackets, and coats (Quinn et al., 1987), and in agriculture for harvesting and trading agricultural products such as cereals, olives, and hazelnuts (Barbieri et al., 2008). Other asbestos uses and exposure have been suggested in the textile industry: asbestos was used for its antifriction properties in brakes and clutches of mechanical textile looms, and in building structures for its heat-resistant properties (Chiappino et al., 2003). Exposure to asbestos, when present, was also possible due to past use of compressed air systems to clean textile machinery and workplaces.

The crude incidence rate of MMMs in rag sorters in Prato appears incredibly high, 41–92 times higher than that calculated for the general resident population in the province of Prato (1.8 per 100 000; 95% CI: 1.5–2.2), while the crude incidence rate of mesothelioma in other textile workers is double. Considering the poor prognosis of mesothelioma with almost equal incidence and mortality rates, the observed crude rate in rag sorters appears consistent with the pleural mesothelioma crude rate that can be calculated using the number of deaths for pleural and peritoneal cancer and the person-years at risk reported for the
The cohort of the Italian asbestos cement workers of the Eternit plant of Casale Monferrato from 1965 to 2003 (Magnani et al., 2008). This is between three to seven times higher than that of the Breda cohort of railway rolling-stock workers in Tuscany from 1960 to 2004 (Gasparotti et al., 2008), and the cohort of chrysotile asbestos miners in North Italy from 1946 to 2003 (Pira et al., 2009).

Unfortunately, data on past age and sex distribution of textile workers in Prato by job, including rag sorters, are not available: this is a heavy setback for estimating a standardized incidence rate of MM in this working population. Only an estimation of the total number of rag sorters at risk of MM from 1988 to 2012 was possible. Nevertheless, standardized incidence rates have been calculated using the age-class distribution of the general population of the province of Prato for the resident cases in this province, and the general population for all Tuscan cases in textile workers. Despite definitely being underestimated, these rates gave information about the time trend of MM in workers. Standardized incidence rates (standard population: Italy 2001) are available for pleural MM in the general Italian and Tuscan population in the 1993–2004 period: equal to 3.49 per 100,000 in Italian men and 1.25 per 100,000 in Italian women, while in Tuscany they were 2.63 per 100,000 and 0.75 per 100,000 by gender, respectively (Marinaccio et al., 2012).

Other drawbacks related to asbestos exposure identification include the difficulty in gathering accurate information from cases on past occupational asbestos exposure at the time of diagnosis so many years after possible exposure, and, in the same cases, the difficulty in collecting information directly from subjects (only 45.8% of the interviews were conducted directly with the cases and 54.2% with proxies). There were direct interviews with all 5 cases of rag sorters and 16 out of the 19 cases (84.2%) of other textile workers, characterized by ‘certain’ occupational asbestos exposure.

According to the RENAM classification of asbestos exposure, a case known to have worked in an economic sector in which the presence of use of asbestos had been revealed, without any other relevant individual occupational exposure to asbestos, is classified as ‘possibly’ occupationally exposed (Nesti et al., 2003). This is the case for the vast majority of rag sorters affected by MM, as a consequence of the information gathered during the aforementioned survey conducted at the end of the 1980s in two rag sorting sites (Monechi et al., 1987; Quinn et al., 1987). Only 5 cases were classified as ‘certain’ occupationally asbestos-exposed because they had a diagnosis of pleural plaques, asbestos fibres were detected in lung tissue, or asbestos exposure at work was reported. However, the high number of MMs, and the observation of another 40 asbestos-related diseases in rag sorters strongly support the hypothesis of widespread asbestos exposure in the rag sorting process, in the absence of any other relevant aetiological factors for MM. Moreover, a case-control study conducted in the early 1990s on the aetiology of lung cancer in textile workers in Prato showed a higher risk, adjusted for smoking, place of birth, and age, in rag sorters compared to other textile workers (Zappa et al., 1993).

**CONCLUSIONS**

This study confirms the high incidence of MM in rag sorters, highlighting the asbestos exposure in these workers and in the entire textile sector in Prato. It also suggests the opportunity of adding epidemiological criteria to those used for asbestos-exposure classification of cases recorded by the regional and national mesothelioma registries: nowadays only an evident personal history of occupational asbestos exposure and well-known exposure data in specific industrial workplaces results in a high-level asbestos-exposure grading. A similar high-level grading of professional asbestos exposure should be attributed to occupations with documented high-incidence rates of MM, such as rag sorting, despite the limitations, and uncertainties of available individual exposure data.

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The authors declare that they have no conflict of interest.

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