Lung Cancer Risk in the Electroplating Industry in Lombardy, Italy, Using the Italian Occupational Cancer Monitoring (OCCAM) Information System

Celestino Panizza, MD,[1] Edoardo Bai, MD,[2] Enrico Oddone, MD,[3] Alessandra Scaburri, PhD,[2] Stefania Massari, PhD,[4] Carlo Modonesi, PhD,[2] Paolo Contiero, PhD,[2] Alessandro Marinaccio, PhD,[4] and Paolo Crosignani, MD[2]*

Background *Occupational Cancer Monitoring (OCCAM) is an Italian organization that monitors occupational cancers, by area and industrial sector, by retrieving cases and employment history from official databases. OCCAM previously estimated a relative risk (RR) of lung cancer of about 1.32 among "metal treatment" workers in Lombardy, northern Italy, potentially exposed to chrome and nickel. In the present study, lung cancer risk was estimated among electroplating workers only.*

Methods *Lombardy electroplating companies were identified from descriptions in Social Security files. Lung cancer risk was evaluated from 2001 to 2008 incident cases identified from hospital discharge records.*

Results *The RR for lung cancer among electroplating workers was 2.03 (90% CI 1.33–3.10, 18 cases) for men; 3.00 (90% CI 1.38–9.03, 4 cases) for women.*

Conclusions *Electroplaters had higher risks than "metal treatment" workers. Although the risks were due to past exposure, case histories and recent acute effects indicate a present carcinogenic hazard in some Lombardy electroplating factories.*

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KEY WORDS: metal plating, chrome, nickel, lung cancer, Occupational Cancer Monitoring

INTRODUCTION

Chromium compounds in which chromium is in the VI oxidation state are classified as carcinogenic to humans by the International Agency for Research on Cancer [IARC, 1980, 1990] based on the findings of numerous epidemiologic studies and other data, including documentation of damage caused by chromium VI at the molecular level. The IARC Special Report published in Lancet Oncology in 2009 [IARC, 2009] found there was ''sufficient evidence in humans'' that chromium VI compounds cause cancer in lung; and that there was ''limited'' evidence that chromium VI also causes cancer in the nasal cavity and paranasal sinuses.

Chromium VI compounds are used in several industries, but particularly the electroplating industry. Workers in electroplating are also exposed to nickel, which is also

[1]Service for Occupational Safety and Prevention, Local Health Unit (ASL), Brescia, Italy
[2]Environmental Epidemiology and Cancer Registry Unit, Fondazione IRCCS Istituto dei Tumori, Milan, Italy
[3]Occupational Medicine Unit, University of Pavia and Fondazione Salvatore Maugeri, Pavia, Italy
[4]Occupational Medicine Department, National Institute for Occupational Health, Rome, Italy

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*Correspondence to: Paolo Crosignani, MD, Head, Environmental Epidemiology and Cancer Registry Unit, Fondazione IRCCS Istituto dei Tumori, Via Venezian 1, I-20133 Milano, Italy. E-mail: occam@istitutotumori.mi.it

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carcinogenic to humans [IARC, 2009]. There is evidence that electroplating industry workers have increased risks of developing cancers at other sites in addition to lung, including the nasal cavity, paranasal sinuses, and larynx, because of exposure to acid fumes [Steenland, 1997], and hematological cancers in relation to exposure to organic solvents [Seniori Costantini et al., 2001].

The Italian Occupational Cancer Monitoring organization (OCCAM) uses a case–control methodology to estimate the risk of specific occupational cancers, by geographic area and industrial sector, using available archives [Crosignani et al., 2006].

In a specific OCCAM study, lung cancer cases incident in the Region of Lombardy in 2001–2008 were identified from hospital discharge files. Hospital discharge records contain patient identification code and six discharge diagnostic codes. Incident cases were identified as subjects with a lung cancer discharge code in 2001–2008 without previous discharge for the same neoplasm and without any previous discharge for other malignant neoplasms (excluding skin carcinoma). Controls were selected at random from National Health Service population files used to provide health care; these files include almost all residents of Lombardy region. The ''exposed'' industrial sector considered was the ''metal treatment'' sector. The ''unexposed'' or reference sector was the services sector (banks, hotels, restaurants, insurance, education, and social services). Using the case–control methodology, OCCAM found a relative risk (RR) for lung cancer of 1.32 (90% confidence interval (CI) 1.06–1.64, 67 cases) among men and 1.33 (90% CI 0.51–3.59, 10 cases) among women who had worked in the ''metal treatment'' industry compared to the services sector. The study also found that for men working in the same industrial sector, RRs for laryngeal cancer were 1.68 (90% CI 1.12–2.53, 18 cases), for cancer of the pleura 1.35 (90% CI 0.51–3.59, 3 cases), for non-Hodgkin lymphoma 0.94 (90% CI 0.62–1.42, 17 cases), and for leukemia 1.30 (90% CI 0.80–2.13, 12 cases).

''Metal treatment'' is a category assigned to companies by INPS for purely statistical purposes; actual activities are never verified. It is likely, therefore, that the category does not include all electroplating companies (companies whose workers are most likely to exposed to chromium VI and nickel), and also includes non-electroplating companies with minimal or no exposure to carcinogenic metals. Therefore, the risks of cancers among electroplating workers are likely to be underestimated using ''metal treatment'' as the exposed category.

The aim of the present study was to estimate the lung cancer risk among personnel working in the electroplating industry in the Region of Lombardy, northern Italy, rather than among those working in ''metal treatment.''

MATERIALS AND METHODS

We found that INPS categorized 2,377 companies operating in the Region of Lombardy over the period 2001–2008 as ''metal treatment'' companies. By checking for the words ''electroplating,'' ''chrome plating,'' and ''nickel plating'' in company names and also in the activities listed in the INPS files, companies considered to be doing electroplating were identified. As in the previous studies [Crosignani et al., 2006] controls were selected at random from population files; the unexposed reference category was services sector workers; and incident lung cancer cases in 2001–2008 in the exposed and unexposed populations were determined from hospital discharge records. Unconditional logistic regression modeling was then used to estimate the RR of lung cancer (with 90% CI) among exposed employees compared to unexposed employees, controlling for age and province of domicile. As the control sampling was concurrent with case ascertainment, the odds ratio estimated by logistic regression corresponds to the rate ratio, that is, to the relative risk.

As this study did not involve any contact with subjects and the use of personal information is explicitly authorised by the Italian law on occupational safety (d.lgs. 81/2008), approval from the Institutional Ethics Committee was not requested.

RESULTS

Although INPS considered that 2,377 companies were ''metal treatment'' companies, only 417 (17%) of these were identified by us as electroplating companies. However an additional 56 companies were identified as electroplating even though not classified as ''metal treatment''. Twenty-six of these were classified as ''metal-working''; the others belonged to various other categories. Thus the INPS ''metal treatment'' category had high (88%) sensitivity, but poor (17%) specificity for electroplating. Eighteen cases of lung cancer in men and four cases in women were identified among those who had worked in one or more of the 473 electroplating companies.

The RR of lung cancer among electroplating employees was 2.03 (90% CI 1.33–3.10) for men and 3.00 (90% CI 1.38–9.03) for women (Table I). The RR of cancer at other sites was also evaluated. A non-significantly increased RR (1.67, 90% CI 0.63–4.37, 3 cases) of laryngeal cancer was also found among men. Five of the 18 male electroplating industry employees diagnosed with lung cancer were still working when diagnosed, and all these workers started in 1989 or later (Table II).

TABLE I. Relative Risk (RR) of a Lung Cancer Diagnosis Among Employees in the "Metal Treatment" and Electroplating Industries in the Region of Lombardy, Northern Italy, Compared to Service Sector Workers

	No of companies	No. of cases (men)	RR (90% CI)	No. of cases (women)	RR (90% CI)
"Metal treatment" industry	2,377	67	1.32 (1.06–1.64)	10	1.33 (0.51–3.59)
Electroplating industry	473[a]	18	2.03 (1.33–3.10)	4	3.00 (1.38–9.03)

Cases were incident in 2001–2008 and obtained from hospital discharge records.
[a]Four hundred seventeen of which were classified as "metal treatment" companies in the Italian Social Security database.

DISCUSSION

The industrial activity categories assigned by INPS to companies are nominal and do not accurately characterize the activities carried out: they can only be an approximate indicator of employee exposure to carcinogens. We therefore sought to obtain a more precise estimate of the lung cancer risk among companies specifically involved in electroplating. To do this we used the simple method of equating electroplating activity with the presence of electroplating terms in company names and INPS descriptions. Using this method we were able to identify a group of companies whose employees had an RR of being diagnosed with lung cancer that was higher than that of the ''metal treatment'' category, attributable to an increase in both the sensitivity and specificity of the classification. There was a corresponding decrease in the number of lung cancer cases between the two categories: from 67 in men and 10 in women to 18 in men and 4 in women. The cases were notified to the health authorities as suspected occupational cancers.

It is important to consider that electroplating workers are also frequently exposed to nickel compounds, which are known carcinogens to humans (group 1 agents IARC) with lungs as target organ [IARC, 2009]. Although nickel salts are often considered less important than chromium

TABLE II. Characteristics of the 22 Lung Cancer Cases Identified in the Exposed Population

Case no.	Sex	Year of starting work in electroplating[a]	Year of stopping work in electroplating	Years of employment in electroplating	Year of diagnosis	Age at diagnosis (years)
1	F	1974	2003	>29	2003	52
2	F	1974	1990	>16	2006	49
3	F	1974	1989	>15	2007	54
4	F	1976	1993	17	2002	49
5	M	1974	1977	>3	2001	67
6	M	1974	1976	>2	2002	70
7	M	1974	1977	>3	2003	52
8	M	1974	1984	>10	2003	68
9	M	1974	1982	>8	2003	64
10	M	1974	1987	>13	2006	66
11	M	1974	1996	>22	2006	66
12	M	1974	1976	>2	2007	70
13	M	1976	1993	17	2001	65
14	M	1978	1996	18	2004	63
15	M	1986	1996	10	2001	65
16	M	1987	1993	6	2007	60
17	M	1987	1988	1	2008	68
18	M	1989	2001	12	2001	55
19	M	1989	2005	16	2005	44
20	M	1989	2005	16	2005	51
21	M	1990	2003	13	2003	63
22	M	1994	2005	11	2005	57

[a]Italian Social Security work history records start from 1974.

(VI), nickel plating vats generally work at temperatures of around 60°C, air jets for mixing are inside the vats (which are often open to the air or hoods are ineffective) and air extraction systems are rare or insufficient.

Metal objects are often subjected to both nickel and chrome plating in a single process on a single industrial site. However it would impossible, from the information available in INPS files, to identify a subset of metal plating companies that do nickel plating only. Doing this would require specifically contacting each of 473 factories identified using the OCCAM database. Analyses by year of hire and duration of service are also precluded since working histories of persons in electronic form are only available from 1974 (which is why so many of the cancer cases in Table II started working in electroplating in that year). Smoking and other potential confounders are similarly unavailable to OCCAM from pre-existing archives; however, a twofold increased risk for lung cancer is unlikely to explained as due to confounding by smoking or other factors [Blair et al., 2007].

Although our findings provide clear evidence that the lung cancer risk is increased among people working in the electroplating industry, it is possible that these risks apply to past rather than present working exposure in this industry, particularly since there is usually considered to be a long latency between exposure and diagnosis for carcinogenic exposures. Note, however, that 6 of the 18 men diagnosed with lung cancer between 2001 and 2006, had started work in the industry relatively recently (one in 1986 and the other five in 1989 or later).

We aware of only one study that has analyzed the time relation between exposure to chromium VI and lung cancer diagnosis [De Marco and Bernardinelli, 1990]. The study suggests that chromium VI acts in the later stages of the cell transformation process. It is possible therefore that some of the risk of lung cancer is due to exposure in the recent past, particularly for the five cases still working in the industry when they were diagnosed. High risk of lung cancer has been reported for electroplating industry workers, with latencies of less than 10 years [Franchini et al., 1983], between 10 and 19 years but also for brief exposures [Sorahn et al., 1998] and less than 15 years [Roberti et al., 2006]. It is noteworthy that the Lombardy Registry of Occupational Illnesses [Magna B, personal communication] lists three cases of perforated nasal septum among personnel exposed to electroplating, all diagnosed in 2008. The trade union organization INCA (Istituto Nazionale Confederale di Assistenza, i.e., Trade Unions National Patronage) has records of two additional cases, one diagnosed in 2005 and the other in 2008 [Della Torre L, personal communication]. These cases are attributable to recent chromium exposure since nasal septum perforation typically develops shortly after the initiation of exposure [Lindberg and Hedenstierna, 1983]. All these considerations lead to the conclusion that metal plating is a continuing source of excess lung cancer risk in the Region of Lombardy, northern Italy.

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