Estimates of work-related cancers in workers exposed to carcinogens

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Aim
To evaluate the proportion of work-related cancers.

Methods
A descriptive study of incident cases of cancer during 3 years in a French county. All people with cancer having a current or past working history were included in the studied population which was recruited from local hospitals. A working history was obtained from each subject by interview. The different organ cancers were linked using well-defined criteria, to specific occupational carcinogenic exposures. The results obtained were compared to international data on work-related cancer incidences.

Results
A total of 2009 cases were included and 3.18% (64) met the criteria for work-related cancer as defined. Asbestos and polycyclic hydrocarbons were the main occupational carcinogens identified. Construction and fabricated metal products sectors were linked to almost two-thirds of work-related cancers. The percentage of the studied population with attributable risk for occupational cancer was relatively close to international data (mean 4%) and organ cancer distribution percentages did not vary significantly from international published validated data.

Conclusion
Work-related cancers tend to be concentrated in relatively small groups of people among whom the risk of developing the disease may be quite large. The detection of occupational hazards should therefore have a higher priority in any programme of cancer prevention. Well-defined criteria to identify specifically cancers with an occupational origin should be specified by the scientific international community.

Key words
Assessment; work-related cancer.

Introduction
Cancer is a major cause of morbidity and mortality worldwide. Occupational carcinogens were among the first human carcinogens to be identified. The causal relationship between occupational exposure and some human cancers has been established [1]. Doll and Peto [2] indicated that the true proportion of cancer due to occupation may vary between 1.5 and 10%, but is unlikely to be outside this range. The number of well-established occupational carcinogens and associated cancers is relatively small. For example, in Germany four exposures are responsible for >90% of attributed cases [3]. Overall, the predominant cause is asbestos and in the chemical industry aromatic amines, polycyclic hydrocarbons (PAHs) and benzene.

No national cancer registry is available in France and the usual approach has been to consider each type of cancer separately and attribute a proportion to occupation on the basis of a few geographically restricted case–control studies or in the absence of such data estimates have been made on the basis of clinical impression.

Descriptive cancer epidemiology is of great importance in occupational health. It would be impossible to set up effective cancer control programmes for working populations in the absence of such data [4].

The aim of the study was to assess estimates of work-related cancer in a working population of a French county.

Methods
In this study, an attempt was made to calculate the proportion of work-related cancers using quantitative...
estimates of the effects of 13 known occupational carcinogens or groups of carcinogens (Table 1). These carcinogenic agents are encountered predominantly in occupational settings, have been the subject of International Agency for Research on Cancer (IARC) Monographs (volumes 1–58) [5] and are identified by the French legislation concerning occupational cancer. All cancers at these sites were considered regardless of pathology.

Data for people >16 years old (minimum work age) and without upper age limit, with newly diagnosed first cancers for the period of 15 September 1995 to 15 September 1998, were provided by the Regional Comprehensive Cancer Centre (RCCC) and the University Hospital of the county of Champagne-Ardenne, where the patients were admitted. Cancer sites were coded according to the International Classification of Disease ninth revision. All those included gave their written informed consent as approved by the French ethical commission (Commission Nationale Informatique et Liberté). Housewives and persons permanently unemployed were excluded.

An occupational history was obtained from each subject by interview conducted in the hospital and the RCCC. Each case gave a summary of their lifetime work history and the industries in which they had been or were employed. The data obtained indicated a high degree of concordance between responses of cases and their pension plan record [6–8] or job exposure matrices [9]. For occupational exposure assessment, to reduce criterion and interpretation variance, we used a structured procedure in which each reported job was evaluated with regards to the following factors: the quality of information available on each job, the familiarity of a local experienced industrial hygienist with the reported job/industry, the probability that exposure occurred in the job/industry, and if exposure was possible (referring to exposure environment [10]. The intensity of exposure would be in most cases impossible to be provided, consequently these data were excluded.

The diagnosis of work-cancer was based on a systematic approach in which specified sites were confirmed and there was potential exposure to carcinogens based on meeting two criteria. Firstly, the carcinogen agent had to be found close enough to an employee that one or more physical phases of that agent or product were likely to enter or contact the body of the employee. Secondly, the duration of the potential exposure had to meet the minimum duration guideline, at least 5 weeks a year during not less than 3 years, in succession or not, because an exposure to most carcinogens during 5 weeks (some-time less) has potential mutagenic effects. If the previous criteria were validated, the patient with cancer was included in the group of the malignant tumour linked to an occupational origin. These criteria imply that work-related cancers appointed should be considered ‘more likely than not’ or ‘rather than certainty’ as occupational origin. This means that we accepted all cases that were compatible with occupational causation.

Secondly, we determined the numbers (highest and lowest) of specific site cancers attributable to occupational carcinogen exposures, using the international highest and lowest published percentages (lung [11–12], pleura [13], ethmoid and nasal cavity [2], urinary bladder [14–15], leukaemia [2], all cancer sites [2]).

These percentages were applied to each total number of organ cancers obtained in the study and expressed as a proportion of cases to give a second comparative estimate.

Results

A total of 2009 patients (1092 males and 917 females) were included during the studied period. Ninety-three individuals refused to participate in the study, interviews were impossible for 18 patients and 90 housewives or permanent unemployed were excluded.

The average age of the studied cancer population was 63.8 years (range 22–102) for males and 61.9 years (range 22–96) for females.

The distribution of occupations in the cancer patients group and the general population of the Champagne county (estimated from the 1996 adjusted census data) was approximately the same. The recruitment of patients of the RCCC and the University Hospital was appreciably representative for the county. Sixty-four cases of cancer were attributed to occupational exposure to 68 carcinogens (exposure to asbestos and PAHs in four cases).

The percentage of total attributed work-related cancer was 3.18% (5.67% in men and 0.22% in women). The average age of the work-related cancer population was
60 years old (range 38–82) for males and 39 years old for the two females (range 37–41).

Table 2 summarizes the percentage of work-related cancers according to organ site or systems. Three quarters of mesothelioma were attributed to a work-related exposure. Over 16% of lung cancer was attributed to occupational exposure. Ethmoid and nasal cavity cancers, urinary bladder cancers and leukaemia represented between one and three work-related cancers.

Table 3 describes the exposure patterns of the work-related cancer population. Asbestos was by far the most common exposure and accounted for the two females cases. Twenty-five per cent of cases were considered to have had exposure to PAHs. Only one person had been exposed to benzene. The duration of exposure was between 21 and 32 years.

Lung cancers and mesothelioma with a work-related origin represent almost 90% of the cases in relationship with asbestos and PAH exposures.

The association of carcinogens with industrial groups is shown in Table 4. The three main industrial sectors concerned by work-related cancers were construction, fabricated metal products and manufacturing machinery which accounted for 67% of cases. The two female cases worked in chemicals and allied products and food and tobacco manufacturing sectors.

Table 5 gives number of work-related cancers using the highest and the lowest organ work-related cancer percentages published. Studies using job-exposure matrices approaches gave attributable risks for occupational lung cancer ranging from 1 to 53% and for ethmoid and nasal cavity cancers ranging from 5 to 25%. These highest percentages applied to the numbers of organ cancers obtained in our study gave, respectively, for the two previous cancer sites named, the absolute numbers of 160 and 70.

Discussion

Our study estimates that ~3% of all cancers are more likely than not or rather than certainty occupational in origin and our estimates were close to the results of international research concerning this topic.

In the European Union, at least 22 million workers were exposed to IARC Group 1 carcinogens with a mean of 1.3 exposures for each exposed worker (42 million exposures in total). The most common exposures were solar radiation (9.1 million workers exposed at least 75% of work time), environmental tobacco smokers (7.5 million workers exposed at least 75% of working time), crystalline silica (3.2 million exposed), radon (2.7 million),
These last compounds were the two single carcino-
genic exposures included in our data. Consequently, in our study, the exclusion of the four first current occupational carcinogen exposures could minimize the proportion of work-related cancers.

An important factor in human studies is the duration of exposure. In our study, duration had to meet minimum guidelines comparable to other studies with, for example, at least 30 min a week averaged over the year, or at least once a week for 90% of the working year [16]. The French legal criteria: ‘usually exposed’ was felt to be too imprecise. While the criteria used in our study can be debated, the typical duration of carcinogenic exposures was almost always 10 years and often 20 years.

Table 4. Association of carcinogenic agents with specific industrial groups (cancer cases and percentages)

<table>
<thead>
<tr>
<th>Industrial groups</th>
<th>Carcinogen agents (cancer cases and percentages)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Asbestos</td>
</tr>
<tr>
<td></td>
<td>$n = 43%$</td>
</tr>
<tr>
<td>Construction</td>
<td>17 (25)</td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>7 (10.2)</td>
</tr>
<tr>
<td>Manufacturing machinery</td>
<td>3 (4.4)</td>
</tr>
<tr>
<td>Manufacturing transport equipment</td>
<td>3 (4.4)</td>
</tr>
<tr>
<td>Chemicals and allied products</td>
<td>3 (4.4)</td>
</tr>
<tr>
<td>Food and tobacco manufacturing</td>
<td>3 (4.4)</td>
</tr>
<tr>
<td>Lumber and wood products</td>
<td>3 (4.4)</td>
</tr>
<tr>
<td>Car-repair services</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Gas–water–electricity production</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>and transportation</td>
<td></td>
</tr>
<tr>
<td>Whole sale and retail trade</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>Other transportation</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>Public administration</td>
<td>1 (1.5)</td>
</tr>
<tr>
<td>Fabricated mineral products</td>
<td>1 (1.5)</td>
</tr>
</tbody>
</table>

Table 5. Highest and lowest percentages of work-related cancers obtained from published international data, applied to the studied population data

<table>
<thead>
<tr>
<th>Sites of cancer (number of cases in the study)</th>
<th>Highest published percentage (estimated work-related cancer numbers)</th>
<th>Lowest published percentages (estimated work-related cancer numbers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung (303)</td>
<td>53% (160.6)</td>
<td>1% (3.03)</td>
</tr>
<tr>
<td>Mesothelioma (12)</td>
<td>95% (11.4)</td>
<td>60% (7.2)</td>
</tr>
<tr>
<td>Ethmoid and nasal cavity (283)</td>
<td>25% (70.75)</td>
<td>5% (14.15)</td>
</tr>
<tr>
<td>Urinary bladder (95)</td>
<td>25% (23.75)</td>
<td>1% (0.95)</td>
</tr>
<tr>
<td>Leukaemia (82)</td>
<td>10% (8.2)</td>
<td>1% (0.82)</td>
</tr>
<tr>
<td>Other cancer sites (1234)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total (2009)</td>
<td>10.65% (213.95)</td>
<td>1.5% (30.13)</td>
</tr>
</tbody>
</table>

Since Doll and Peto estimated that 4% of total cancer mortality was work caused in 1981 [2], other workers have estimated 6–10% in the United States [17], 6% in the United Kingdom [18], 4% in Spain [19] and 1.5% in Australia [20]. Our estimates are around 3% (64 cases) with a range from 1.5% (30 cases) to 10% (213 cases). The working population of Champagne county is representative of the French working population as a whole and therefore extrapolating these data suggests that the number of work-related cancer cases deserving compensation could be ~8400 (3% of 280 000 new cases of cancer) each year in France instead of around 500 cases currently compensated.

diesel exhaust (3.0 million) and wood dust (2.6 million) [16]. These last compounds were the two single carcinogenic exposures included in our data. Consequently, in our study, the exclusion of the four first current occupational carcinogen exposures could minimize the proportion of work-related cancers.

An important factor in human studies is the duration of exposure. In our study, duration had to meet minimum guidelines comparable to other studies with, for example, at least 30 min a week averaged over the year, or at least once a week for 90% of the working year [16]. The French legal criteria: ‘usually exposed’ was felt to be too imprecise. While the criteria used in our study can be debated, the typical duration of carcinogenic exposures was almost always >10 years and often >20 years.

According to a review by Vinais and Simonato [21], which includes only studies in which smoking was controlled, the estimates range for occupational origin for lung cancer was 0–40%. Morabia et al. [22] have put the attributable risk of lung cancer at 9.2% for men employed in occupations characterized by carcinogenic exposures. Kjuus et al. [23] estimated the aetiological fractions for lung cancer in Telemark at 1% for asbestos alone, 22% for smoking and asbestos and 61% for smoking alone. In our study, the most important agents were
asbestos and combustion products of fossil fuel which are believed to cause 16% of lung cancers which represent 75% of the total number of work-related cancer in this study. But any adjustment has been made concerning tobacco use, diet and other environmental poisonous factors. Consequently, in our study, we cannot assume that, for example, lung cancers are not partly due to smoking. Obviously, not everyone exposed to asbestos (for example) gets lung cancer from asbestos. But exposure duration is respected (methodological criteria), lung cancer should be considered to have an occupational origin and should be included in the work-related cancer group. A fraction of the lung cancer cases exposed, for example, to asbestos with insufficient exposure length were excluded from the work-related cancer group. Consequently, this methodology should minimize under or over estimation of (for example) asbestos work-related cancer numbers.

In Europe, it is estimated that occupational exposures might be responsible for 1–10% of urinary bladder cancers [24] and it is estimated that 1% of leukaemia could be avoided in Nordic countries, if industrial carcinogens were eliminated [25]. These data are similar to the results obtained in our study, with, respectively, 2.1% for bladder cancer and 1.2% for leukaemia.

In contrast, the percentage of work-related ethmoid and nasal cavity cancers in our study (1.06%) differs from those of international data (range 5–25%) [25] but this could be explained by an under-representation in our study of ethmoid cancers.

We have compared our findings with data from published relative risk estimates (Table 5). These studies are mainly from North America and Western Europe in the last 30 years but show that our findings regarding almost all the cancer sites studied, and the total estimated number of work-related cancers are similar to international published data. This suggests that our criteria for designating occupational cancer and our findings are appropriate to the population studied.

Acknowledgements

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Conflicts of interest

None declared.

References