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OCCUPATION AND BLADDER CANCER IN MALES: A CASE-CONTROL STUDY

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A case-control study of 512 male cases of bladder cancer and 596 male hospital controls (all living in the province of Turin, Northern Italy, an *area* with a high proportion of *car* workers) has been analyzed for occupations. Relative risks were 1.8 (95% c.l. 0.9-3.6) for the textile industry, 3.8 (1.3-11.5) for the leather industry, 1.8 (0.8-4.0) for printing, 8.8 (2.7-28.6) for dyestuff production, 1.2 (0.6-2.4) for tire production and 2.5 (1.0-6.0) for other rubber goods, 2.0 (0.9-4.5) for brickyards and related activities. A relative risk of 3.1 (0.9-10.5) was found for turners having started work before 1940 and with at least 10 years of activity. For truck drivers the relative risk was 1.2 (0.6-2.5). A job-exposure matrix was developed for the development of new hypotheses; an association with bladder cancer was found for aromatic amines only. The attributable risk percent in the population was estimated as 10%, when only those occupations consistently associated with bladder cancer were considered.

In a few industrialized areas of the Western World it has been estimated that between 8-10% (Howe *et al.*, 1980) and 20% (Anthony and Thomas, 1970; Cole *et al.*, 1972; Schoenberg *et al.*, 1984) of bladder cancer cases occurring in the general male population can be attributed to occupational exposure.

The present paper describes a hospital-based case-control study conducted in the province of Torino (Northern Italy), an area with a high prevalence of workers in the car and rubber industries. Results concerning smoking, published in a previous paper (Vineis *et al.*, 1984), suggested a multiplication of relative risks between smoking and high-risk occupation (dyestuff and rubber industries).

MATERIAL AND METHODS

Cases and controls

A case-control study was conducted in the Main Hospital of the city of Torino between 1978 and 1983 (Department of Urology and Institute of Urology of the University). In a first phase, 225 male cases, aged less than 70, were matched by age (± 4) with an equal number of controls having benign urological conditions. In the first phase, recruitment of cases was random and 70 eligible subjects could not be interviewed. The second phase started in 1981, when an effort was made to collect all male cases under age 75 in the same departments; 287 were interviewed and 29 were lost (a mailed questionnaire was sent to the latter and 20 replied). In the second phase, controls were a random sample of 371 male patients under 75, treated for a wide range of mostly benign conditions in 9 surgical departments (for a list of control diagnoses see Vineis *et al.*, 1984). All cases and controls lived in the province of Torino. Refusals were 11 cases, 8 urological controls, and 4 surgical controls. Out of 512 cases, 210 (40%) were first diagnosed 6 months or more before the interview; for 79% cases a histologic diagnosis was traced, whereas for the others, diagnosis was cystoscopic.

Case-control comparability and internal comparisons

Comparisons of socioeconomic level and years in school have been previously reported (Vineis *et al.*, 1984). Table I gives the distribution of the 5 groups of controls in general categories of working activity (in this and the following Tables, when not otherwise specified, we refer to having "ever" worked in each activity for at least 6 months).

Interviews and coding

Interviews were conducted in the hospital using a questionnaire concerning life-long smoking habits, the whole occupational history and other information. For each job lasting at least 6 months the job title. activity of the plant and type of production were collected. The principal investigator examined all questionnaires for completeness and coherence immediately after the interview, and discussed dubious information with the interviewers.

Blind coding of occupational histories was performed by the principal investigator. Job titles were coded according to the ILO classification (ILO, 1968), which describes 1,506 job titles in detail and with high specificity. Activities of the plants were coded according to 160 categories (branches) (United Nations, 1975). For the purpose of the present study, some of these categories lack specificity (*e.g.*, dyestuff work is included in the general category of the chemical industry; we have classified it together with paint production: this was the main deviation from the given classification). Because of insufficient information, coding was impossible for at least one job title in the case of 12 patients and 20 controls; and for at least one plant activity in the case of 15 patients and 22 controls.

Quality checks

Ten per cent of the questionnaires were double-checked for accuracy of coding; 16 coding errors out of approximately 480 working activities were found. In addition, all questionnaires including job titles or activities of the plants associated with RRs significantly higher or lower than 1.0 were checked for accuracy of coding *a posteriori* and no errors were found.

Analyses

Analyses were performed using *ad hoc* programs for an HP-67 calculator (Rothman and Boice, 1979). Age-adjusted and smoking-adjusted relative risks (odds ratios) were computed with Mantel-Haenszel's estimator (Mantel and Haenszel, 1959). Age at diagnosis for

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cases and at interview for controls was used for adjustments in 4 age groups; 95% confidence limits and attributable risk percent in the population were computed according to Miettinen (1976).

All industrial activity branches and job titles have been screened; the reported results and discussion relate to (1) statistically significant associations (including new hypotheses) and (2) categories which are of interest due to previous findings in the literature (*e.g.*, truck drivers) or suspected exposure to bladder carcinogens (*e.g.*, painters).

Job-exposure matrix

Seventy-four chemicals with sufficient evidence of carcinogenicity to humans and/or experimental animals, evaluated in IARC Monographs 1-20 (IARC 1972–1979; IARC, 1979) were included in a job-exposure matrix with the purpose of generating new hypotheses on chemical bladder carcinogenesis. Asbestos, polycyclic aromatic hydrocarbons and heavy metals were excluded; auramine and magenta (for which only manufacture has been shown to be carcinogenic to man) and 1-naphthylamine (because of impurities of 2-naphthylamine) were included. Information on the uses of these chemicals was retrieved from published sources (IARC, 1972–1979; Kirk-Othmer, 1963; Van Alphen, 1973; Candura, 1974) and coded according to the ILO and United Nations classifications used in the case-control study. In this way job titles and activities of the plants, in which cases and controls were involved, could be linked with potential exposure to chemical carcinogens. A preliminary exercise with the jobexposure matrix has been reported (Macaluso *et al.*, 1983). In order to increase its sensitivity (Acheson, 1981), this analysis was limited to age under 60.

RESULTS

A separate analysis of the first 225 pairs included in the study has been published (Vineis *et al.*, 1981).

Table II gives absolute numbers of cases and controls and age-adjusted RRs in activity branches including more than 10 individuals. The lower 95% confidence limit exceeds 1.0 for leather industry, dyestuff production, and rubber goods (other than tire) production; high but not statistically significant relative risks are observed for textile industry, printing, brick-yards and related industries, radio and TV production, retail sale of machines, and, limited to age 60+, car repair. When incident cases only were considered, RRs (95% c.l.) were 2.1 (0.6-7.9) for the leather industry; 5.1 (1.2-21.1) for dyestuff production; 2.1 (0.8-5.6) for rubber goods (other than tire) production; 1.9 (0.9-4.2) for the textile industry; 1.2 (0.5-3.3) for printing; 2.0 (0.8-5.0) for brick-yards and related industries; 2.1 (0.3-13.8) for radio-TV production; and 1.8 (0.8-3.8) for car repair.

The most frequently represented job titles in the branches reported above were carder (4 cases and 0 controls) and warehouse-keeper (3/1) in the textile industry; shoemaker (2/1) in the leather industry; printer (unspecified) (2/1) in the printing industry; sheet metal worker (6/0) and car painter (2/1) in car and motorcycle repair.

Table III gives in detail periods of activity and job titles for rubber workers; Table IV shows the distribution of cases and controls according to age and period of starting work in the rubber industry.

Table V shows distribution by age, period of start and duration of job for turners; this was the most frequently represented category of machine-tool opeators or engineers in the study. The risk seems to be

TABLE I – COMPARISON AMONG 5 GROUPS OF CONTROLS FOR TYPE OF WORKING ACTIVITY (GENERAL CATEGORIES). PROPORTIONS IN BRACKETS[1]

Working activities (general categories of United Nations classification)	Urological controls (n = 225)	Vascular pathologies (n = 77)	Hernias, gall-bladder stones, appendicitis, hemorrhoids (n = 136)	Malignant tumors (n = 28)	Other surgical conditions (n = 130)
1. Agriculture, fishing and related act.	72 (0.3)	22 (0.3)	31 (0.23)	10 (0.3)	25 (0.2)
2. Mines	4 (0.02)	4 (0.05)	1 (0.01)	1 (0.03)	4 (0.03)
31. Food industries	27 (0.12)	5 (0.06)	12 (0.09)	1 (0.03)	7 (0.05)
32. Textile leather and clothing industries	18 (0.08)	3 (0.04)	3 (0.02)	1 (0.03)	10 (0.07)
33. Wood industries	12 (0.05)	6 (0.08)	7 (0.05)	2 (0.07)	10 (0.08)
34. Paper industries and printing	5 (0.02)	3 (0.04)	5 (0.04)	0	5 (0.04)
35. Chemical industries	25 (0.1)	3 (0.04)	16 (0.1)	1 (0.03)	11 (0.08)
36. Glass and related industries	6 (0.03)	4 (0.05)	6 (0.04)	1 (0.03)	0
37. Foundries	11 (0.05)	3 (0.04)	8 (0.06)	4 (0.14)	3 (0.02)
381. Metal works	33 (0.14)	13 (0.17)	17 (0.13)	7 (0.2)	11 (0.08)
382. Machinery construction	33 (0.14)	14 (0.18)	13 (0.1)	3 (0.1)	24 (0.18)
383. Electric machinery	8 (0.03)	7 (0.09)	9 (0.06)	1 (0.03)	10 (0.08)
384. Vehicles	88 (0.4)	23 (0.3)	52 (0.4)	8 (0.3)	44 (0.32)
385. Precision instruments	3 (0.01)	0	1 (0.01)	1 (0.03)	5 (0.04)
39. Other manufactures	2 (0.01)	1 (0.01)	5 (0.04)	1 (0.03)	5 (0.04)
4. Gas and electricity	5 (0.02)	2 (0.02)	1 (0.01)	2 (0.07)	5 (0.04)
5. Building industries	51 (0.23)	24 (0.3)	38 (0.3)	7 (0.25)	23 (0.2)
61. Wholesale	14 (0.06)	6 (0.08)	8 (0.06)	2 (0.07)	8 (0.06)
62. Retail sale	20 (0.08)	7 (0.09)	19 (0.14)	9 (0.3)	10 (0.08)
63. Bars, hotels	10 (0.04)	4 (0.05)	5 (0.04)	0	9 (0.07)
7. Transports and communications	38 (0.17)	10 (0.13)	14 (0.10)	9 (0.3)	13 (0.10)
8. Banks and other services	22 (0.1)	6 (0.08)	13 (0.10)	0	14 (0.1)
9. Public administration and miscellaneous	68 (0.3)	18 (0.23)	49 (0.36)	4 (0.14)	31 (0.24)
Unclassifiable	21 (0.09)	0	0	0	1 (0.01)

[1]Individuals may have worked in more than one category, so that the sums do not correspond to the number of controls for each group. Proportions were computed using the number of subjects as a denominator.

TABLE II - CASES/CONTROLS AND AGE-ADJUSTED RRs (MANTEL-HAENSZEL) FOR WORKING ACTIVITY (BRANCHES EXHIBITING MORE THAN 10 CASES + CONTROLS; DURATION OF WORK 6 + MONTHS,[1]

Working activities (United Nations code)	Cases/ controls	$RR_{(MH)}$	95% c.l.
Agriculture (1110–30)	110/146	0.75	(0.6–1.0)
Bakeries (3117)	16/26	0.7	(0.4–1.4)
Textile industries (3211)	21/13	1.8	(0.9–3.6)[3]
Clothing industries (3220)	12/11	1.2	(0.5–2.7)
Leather industries			
Tanneries (3231)	5/2		
Shoe production (3240)	3/1	3.8	(1.3–11.5)[3]
Other leather goods (3233)	3/0		
sawmills (3311)	4/11	0.4	(0.1–1.2)
Wood furniture industry (3320)	16/23	0.8	(0.4–1.5)
Printing and publishing (3420)	17/12	1.8	(0.8–4.0)[3]
Man-made fibers, synthetic resins (3513)	9/7	1.4	(0.5–3.5)
Dyestuff and paints (3521)	14/2	8.8	(2.7–28.6)[3]
Rubber tire industries (3551)	14/14	1.2	(0.6–2.4)
Other rubber goods (3559)	15/7[2]	2.5	(1.0–6.0)[3]
Plastics transformation (3560)	8/8	1.4	(0.5–4.0)
Brick-yards and related industries (3691, 3692, 3699	16/9	2.0	(0.9–4.5)[3]
Foundries (3710)	15/24	0.7	(0.4–1.3)
M ni di (d) (3800)	22/16	1.5	(0.8–2.9)
Tc and la good production	5/10	0.6	(0.2–1.7)
Structural steel work (3813)	12/13	1.1	(0.5–2.4)
Met w not cl f elsewhere (3819)	40/40	1.3	(0.8–2.0)
Engines and turbines (3821)	14/12	1.3	(0.6–2.7)
Macti l (3823)	16/13	1.5	(0.7–3.3)
Special machines for i di (3824)	10/19	0.7	(0.3–1.6)
i (3825)	4/7	0.8	(0.3–2.6)
and material not f elsewhere	37/30	1.5	(0.9–2.5)
ctric ac ine a ateri l (3831)	8/14	0.8	(0.3–2.0)
TV set du (3832)	8/3	3.8.	(0.9–15.7)[4]
Other electric equipment (3839)	9/11	1.0	(0.4–2.5)
Shipbuilding (3841)	4/7	0.6	(0.2–2.2)
Railway equipment production (3842)	11/13	0.9	(0.4–2.1)
Car production (3843)	12/91/176	0.8	(0.6–1.1)
Aircraft industries (3845)	14/14	1.2	(0.6–2.7)
Mechanic industries, not classifiable (3899)	6/9	0.9	(0.3–2.5)
Electricity production (4101)	5/10	0.6	(0.2–1.8)
Building industries (5000)	126/143	1.0	(0.8–1.3)
Wholesale (different goods) (6100)	8/6	1.6	(0.5–4.6)
Wholesale: foodstuff (6131)	5/10	0.6	(0.2–1.7)
Wholesale: machines (6138)	5/8	0.8	(0.2–2.7)
Retail sale: different goods (6200)	9/7	1.6	(0.6–4.5)
Retail sale: foodstuff (6231)	28/20	1.6	(0.9–2.9)
Retail sale: textiles (6232)	8/11	0.8	(0.3–2.2)
Retail sale: chemicals (6235)	9/7	1.5	(0.6–4.0)
Retail sale: machines (6238)	11/17	2.3	(0.9–5.9)[4]
Restaurants, bars, hotels (6300)	21/28	0.9	(0.5–1.5)
Railways (7090)[5]	7/13	0.5	(0.2–1.4)
Road haulage industries (goods transport.) (7170)[5]	14/12	1.4	(0.6–3.2)
Road haulage (passengers) (7180)	10/14	0.9	(0.4–2.1)
Telephone and telegraph (7200)	13/12	1.2	(0.5–2.5)
Banks (8100)	11/18	0.7	(0.3–1.7)
Insurance comp. (8200)	8/7	1.2	(0.4–3.3)
Engineers, architects (8324)	5/8	0.5	(0.2–1.4)
Services (not elsewhere classified) (8329)	5/9	0.7	(0.2–2.4)
Public Administration and Defense (9100)	35/61	0.6	(0.4–1.0)
Schools (9310)	9/8	1.4	(0.5–3.6)
Health services (9331)	6/13	0.5	(0.2–1.4)
Recreation services (9490)	7/5	1.5	(0.54.7)
Shoe repair (9511)	7/7	1.2	(0.4–3.4)
Car and motorcycle repair (9513)	23/19	1.6	(0.8–3.0)[6]
Other repair services (9519)	8/9	1.0	(0.4–2.5)
Beauty centers, barbers, hair-dressers (9591)	9/11	0.9	(0.4–2.3)
Unclassifiable activities	15/22	0.7	(0.4–1.5)
Total cases/controls	512/596		

[1] Individuals may have worked in more than *one* category; consequently the sum does not correspond to the total number of cases and controls.–[2] Control in tire production and 1 case in dyestuff production also.–[3] One-sided lower 95% confidence limits: textile 1.05; leather 1.5; printing 0.9; dyestuff 3.3; rubber (other than tires) 1.2; brick-yards 1.0.–[4] One-sided lower 95% confidence limits: radio-TV 1.2; retail sale (machines) 1.07.–[5] These codes do not correspond to the UN classification.–[6] Age 60 + 13 cases/3 *controls*.

concentrated in people having started work before 1940 and with a duration longer than 10 years.

A new supposition, resulting from the analysis of job titles and concerning butchers, is reported in Table VI, together with relative risks for truck drivers and painters. Table VII reports, for activities or job titles associated with increased RRs, smoking-adjusted estimates, through 3 categories of cigarette daily consumption (0, 1-14, 15 +).

When only working activities lasting at least 5 years and starting at least 10 years before the diagnosis or interview were considered, RRs were those reported in Table VIII.

For the analysis with jobexposure matrix a first screening was done through activities of the plants (branches) using RR > 1.5 as a threshold. This analysis produced, among 74 chemicals which were considered, 15 RRs greater than 1.5 under age 60 (260 cases and 369 controls); among these, for only 6 chemicals did RRs exceed 1.5 when job titles were considered. Such chemicals were thiourea, 3,3'-dimethoxybenzidine, I-naphthylamine, benzyl violet 4B, magenta and 4-aminobiphenyl, *i.e.*, with the sole exception of thiourea, all were aromatic amines (Table IX). The relative risk for thiourea, adjusted for exposure to aromatic amines, was 1.2 (0.4-3.3)(branches).

TABLE III - CASES AND CONTROLS WORKING IN THE RUBBER INDUSTRY[1]

Age	Time period	Jobs
Cases		
A. Tire production		
64	1921-69	Engineering fitter in a tire plant
58	1951-58	Tire assembler in a tire plant
51	1959-60	Several jobs in a tire plant
45	1968-79	Tire repair and final inspection in a tire plant
53	1953-55	Covering with rubber of old tires (molding)
40	1964-78	Tire assembling and final inspection in a tire plant
66	1945-70	Mixing of rubber in a tire plant
55	1960-80	Watchman in a tire plant
63	1936-38	Tire assembler in a tire plant
46	1954-80	Final inspection and repair of tires
63	1951-78	Assembling and molding in a tire plant
61	1946-76	Several jobs (molding, calendering, laboratory work) in a tire plant
47	1948-68	Messenger and gauge-operator in a tire plant
59	1970-82	Messenger in a tire plant
B. Other than tire production		
64	1925-29	Worker in a rubber tube plant
43	1950-51	Mixing in a rubber plant (+ dyestuff prod.)[1]
45	1950-57	Technical designer in a rubber plant
55	1946-65	Engineering fitting and laboratory work in a rubber cable plant
46	1968-69	Assembler in a rubber tube plant'
54	1960-79	Wire twisting in a rubber cable plant
53	1952-60	Engineering fitter in a rubber plant
67	1964-70	Assembler in a rubber tube plant
68	1937-40 + 1950-71	Wire twisting, tarring and assembling of cables, truck-loader and cook in a rubber cable plant
56	1971-74	Final inspection in a rubber plant
58	1945-50	Foreman in a rubber shoe plant (milling)
54	1956-80	Mixing and extruding in a rubber cable plant
60	1942-44	Foreman in a rubber plant
42	1960-70	Engineering fitter and designer in a rubber plant
64	1952-76	Plumber and foreman in a rubber plant
Controls		
A. Tire production		
68	1949-71	Worker at tire finishing
63	1946-52	Tire and other rubber goods production (calendering)
70	1926-28	Foreman in a tire plant
	1934-50	Calenderer in a rubber shoe plant'
	1951-70	Warehouse-keeper in a tire plant
68	1947-49	Rubber heating in a bicycle tire plant
47	1962-80	Tire assembler
56	1955-81	Extruding worker (tread) + foreman in a tire plant
72	1938-47	Curing of rubber in a tire plant
51	1958-60	Spray-painter in a tire plant
44	1961-82	Final inspection in a tire plant
62	1962-78	Material tester in a tire plant
60	1958-73	Watchman in a tire plant
49	1966-82	Tire assembler
50	1969-83	Plumber and engineering fitter in a tire plant
59	1953-83	Clerk in a tire plant
B. Other than tire production		
69	1950-72	Worker in a rubber tube plant
68	1965-69	Mixing in a rubber tube plant
59	1963-65	Molding of rubber goods
56	1946-78	Assembling, wire twisting and watchman in a rubber cable plant
63	1964-77	Worker in a rubber stamp plant
25	1971-73 + 1977-81	Re-molding + milling in a rubber tube plant

[1] In a previous report (Vineis *et al.*, 1984) total workers in the rubber industry were 28 cases and 20 controls: 1 case working in dyestuff production also was not *considered*; and 1 control working both in tire and ocher rubber goods production was considered once.

TABLE IV - CASES AND CONTROLS WORKING IN THE RUBBER INDUSTRY: DISTRIBUTION BY AGE (AT DIAGNOSIS/INTERVIEW) AND YEAR OF BEGINNING WORK IN THE RUBBER INDUSTRY

Age	Year of start			Total	Age-specific RRs
	< 1950	1950-59	1960 +		
Tire production					
< 50	1/0	1/0	2/3	413	2.5
50-59	010	3/3	211	514	1.5
60+	415	1/1	0/1	517	0.6
Other rubber goods					
< 50	010	21d	211	411	7.5
50-59	211	210	2/1	612	3.7
60+	311'	1/1	1/2	514	1.1

[1] 1 control in tire production also. -[2] 1 case in dyestuff production also

DISCUSSION

Dyestuff workers

The analysis of industrial activities in which cases and controls were engaged suggests that a very high risk of bladder cancer is present in the province of Torino for dyestuff workers; this confirms previous indications of Trade Unions and of a follow-up study (Rubino *et al.*, 1982). Ten cases and no controls had worked in a plant manufacturing benzidine and beta-naphthylamine.

Rubber industry

According to recent studies in England (Baxter and Werner, 1980) and the USA (Monson and Fine, 1978; Checkoway et *al.*, 1981) high risks have persisted even recently in the rubber industry, particularly in the jobs of warehouse-shipping, milling, calendering and tire assembling (see also IARC, 1982). In our study, the risk is concentrated in production of rubber goods other than tires, among workers starting their job in 1950 or later, and in the age group 40-59; job titles more frequently reported by cases included "engineering fitter" (3 cases/0 controls) and "assembler" (7 cases/3 controls, including tire production also).

Textile industry

The textile industry has been suggested by Anthony and Thomas (1970) to entail a high risk of bladder cancer (RR = 6.5 for weavers and 12.2 for tailors). Cartwright (1982) has found more recently, in the same geographic area, a relative risk of 1.3 (95% c.l. 0.8-2.4) for dye users in the wool industry. For tailors, Howe *et* al. (1980) have reported relative risks of 1.5 (95% c.l. 0.2-18.0) in males and of 2.0 (0.3-22.1) in females. Silverman *et al.* (1983) have found, for the same category, a RR of 1.2 (0.3-4.6). In our study the estimate is 1.8 (0.9-3.6), but 0.9 when only cases and controls living in the city of Turin are considered

TABLE V - TURNERS (CASES/CONTROLS AND RELATIVE RISKS)

Duration of job	Age			
	<40	40-49	50-59	60+
Non-exposed	14/72	74/91	154/191	243/214
<5 yrs	0/2	4/1	3/2	1/5
5-9 yrs	0/0	0/3	5/3	0/3
10+ yrs	2/2	1/0	3/2	8/5
RR (10+ yrs)	2.7		1.9	1.4

Age	Duration	Date of start	
		<1940[1]	≤1945
<50	<10	0/1	0/1
	10+	2/0	2/0
50-59	<10	4/1	6/4
	10+	1/1	2/2
60+	<10	0/5	0/5
	10+	6/2	7/4

[1] RR_{MH} (<1940, duration 10+) = 3.1 (0.9-10.5).

(indicating a possible selection bias). Among textile workers, the only job titles showing some excess of cases are carder and warehouse-keeper; however the former association is based on 4 patients, all of whom were heavy smokers (Table VII).

Leather industry

The leather industry has been suggested by Cole *et al.* (1972) to be a high-risk activity (RR = 2.0; 95% c.l. 1.37-2.9), particularly in finishing processes (RR = 2.65; 1.6-4.5), and by Decouflé (1979) (RR = 6.3 for males and 4.4 for females; when only males having worked at least 5 years in leather industry were considered, the estimate was 11.25). Howe *et* al. (1980) reported an RR of 1.2 (0.3-6.3) in Canada, and Cartwright (1982) an RR of 1.2 (0.5-3.1) in England. In the present study the RR was 3.8 (1.3-11.5).

Printers

Among printers, Cartwright (1982) has reported a relative risk of 3.1 (95% c.l. 1.3-6.8); a small study in the USA (Najem *et al.*, 1982) found an RR of 2.7 (0.8-9.6), whereas in Detroit, Silverman *et* al. (1983) reported an estimate of 3.0 (0.6-14.8). There is no evidence, however, that printers in different parts of the world share similar exposures. In addition, no evidence of risk is present in our study when incident cases only are considered.

Machinists

The job title of turner and, more generally, the category of machinist, has been already associated with bladder cancer. Relative risks were 4.0 (4 cases *vs.* 1 expected) in the USA (Dunham et *al.*, 1968); 4.8 (13 cases exposed for 20 or more years *vs.* 4 surgical controls) in England (Anthony and Thomas, 1970); 2.7 (95% c.l. 1.1-7.6) in Canada (Howe *et* al., 1980); 5.0 (5 cases and 1 referent) in Finland (Tola *et* al., 1980); 1.5 (95% c.l. 1.2-1.8) in a more recent study in the U.K. (Cartwright, 1982). In addition, Silverman *et* al. (1983) found an increased risk both for machinists in the car industry (RR = 2.6; 0.5-13.6) and for a related category, tool and dye makers (RR = 2.0 for those having worked 30+ years). Such activities are known to entail heavy exposure to cutting oils, which sometimes contain aromatic amines as antioxidants (Kirk-Othmer, 1981). Cohort studies on workers exposed to mineral oils are only partially informative, due to small numbers (IARC Monographs, 1984).

TABLE VI - ABSOLUTE NUMBERS (CASES/CONTROLS) AND RELATIVE RISKS FOR BUTCHERS, TRUCK DRIVERS, AND PAINTERS

Butchers	Age			Total
	<50	50-59	60+	
ca/co	3/0	2/3	5/1	10/4
$RR_{(MH)}$	2.2		4.6	2.9
95% c.l.				(1.0-8.6)

Truck drivers	Age				Total
	<40	40-49	50-59	60+	
ca/co	1/2	2/3	6/7	7/4	16/16
RR	2.4	0.8	1.0	1.6	RR_{MH} = 1.2
95% c.l.					(0.6-2.5)

Painters	Age				RR_{MH}	95% c.l.
	<40	40-49	50-59	60+		
Painter in building industry	0/1	3/6	6/3	3/4	1.0	(0.4-2.2)
Painter in carpentry	0/0	0/1	0/1	1/0	0.6	(0.04-8.4)
Car painter	1/1	0/0	2/2	4/1	2.0	(0.6-7.0)
Spray-painter in different industries	1/1	1/0	0/2	0/0	1.2	(0.2-5.8)

TABLE VII - RELATIVE RISKS FOR BLADDER CANCER GREATER THAN 1.0 IN RECENT INVESTIGATIONS: COMPARISON WITH PREVIOUS FINDINGS: ADJUSTMENT FOR CIGARETTE CONSUMPTION[1]

		RR Age-adjusted		RR Cig-adjusted
Textile industries		1.8		1.9
Leather industries		3.8		4.1
Printing industries		1.8		1.7
Rubber industries (other than tires)		2.5		2.8
Brick-works and related industries		2.0		2.3
Radio, TV industries		3.8		3.3
Carders in textile industries	4 cases 0 controls		NS 1-14 cig/day	0/0
			15+ cig/day	3/0
Sheet metal workers	6 cases 0 controls		NS	0/0
			1-14 cig/day	1/0
			15+ cig/day	5/0
Turners (<1940, duration 10+)		3.1		3.0
Butchers		2.9		3.6

[1] Categories: non-smoker (NS), 1-14 cig/day, 15+ cig/day

Butchers

Butchers have not previously been reported to be a category at high risk of bladder cancer; the association suggested in our study cannot be explained by smoking (Table VII) or by geographic selection bias (the RR for butchers living in Turin was 6.2). A high risk of lung cancer has been suggested for butchers in the U.K. and the Scandinavian countries (Fox *et* al., 1982; Doerken and Rehpenning, 1982; Lynge *et al.*, 1983). It is difficult to formulate hypotheses on exposures which could be carcinogenic both to the bladder and the lung. Butchers included in the study started work more frequently in the 20's (6 cases and 1 control). For both turners and butchers, RRs for incident cases alone did not differ from those including also prevalent cases.

TABLE VIII - RELATIVE RISKS SIGNIFICANTLY GREATER THAN 1.0 AND/OR CONSISTENT WITH PREVIOUS FINDINGS: WORKING ACTIVITIES OR JOB TITLES LASTING AT LEAST 5 YEARS AND STARTED AT LEAST 10 YEARS BEFORE DIAGNOSIS OR INTERVIEW

	Age				RR (95% c.l.)
	<40	40-49	50-59	60+	
Textile	1/0	3/0	1/3	5/2	2.3 (0.9-6.2)
Leather	0/0	2/0	1/0	3/3	2.0 (0.6-7.3)
Printing	0/0	0/0	1/1	3/2	—
Rubber (other than tires)	0/0	2/0	4/1	3/1	5.0 (1.3-19.1)
Brick-yards and related industries	0/0	1/0	4/0	3/1	8.1 (1.6-42.1)
Radio-TV industries	0/0	0/0	0/0	1/0	—
Retail sale of machines	0/1	1/1	0/0	2/0	—
Butchers	0/0	3/0	0/3	5/1	2.3 (0.7-7.2)
Truckdrivers	1/2	2/3	6/7	7/4	1.2 (0.6-2.5)
Car painters	1/1	0/0	2/2	4/1	2.0 (0.6-7.1)

Truck drivers

Silverman *et* al. (1983) and, before them, Decouflé *et al.* (1977) and Milham (1983) found increased relative risks for truck drivers; in addition, truck drivers exposed to diesel exhaust fumes had a very high RR (11.9; 95% c.l. 2.3-61.1) in the study in Detroit, and subjects exposed to such fumes had an RR of 2.8 (0.8-11.8) in the Canadian study reported by Howe *et* al. (1980). Our study does not confirm, however, such suggestions concerning truck drivers (Table VI).

Painters

For painters the evidence in the literature points basically to a lack of association; Cole *et al.* (1972) have reported an RR of 1.4; Anthony and Thomas (1970) an RR lower than 1.0; Howe *et al.* (1980) an estimate of 1.0 (95% c.l. 0.6-2.3) for "commercial painting" and 1.8 (0.7-4.6) for "spray painting"; and Silverman *et al.* (1983) an estimate of 1.0 (0.5-2.2) for painters in general and of 0.5 (0.1-2.1) for painters in the car industry. In a cohort study by Englund (1980), no excess of bladder cancer in painters was reported. It should be stressed, however, that a category such as "painters" is very heterogeneous and dilution of risks could occur. Our study suggests an increased risk for car painters, which, however, is not statistically significant.

Furnacemen

Our study suggests an association between bladder cancer and brick production and other activities related to the transformation of non-metallic minerals. This is consonant with findings in the Roswell Park Memorial Institute study (Decouflé, *et al*, 1977) for furnacemen, founders and pourers (RR = 2.4, based on 7 cases). Both this category and truck drivers are heavily exposed to polycyclic aromatic hydrocarbons; it has been suggested that such exposure could be shared also with other occupations showing increased risks of bladder cancer: gas workers (Doll *et* al., 1972), roofers (Hammond *et* al., 1976), and aluminium workers (Thériault *et al.*, 1984).

Other occupations suggested by our study as being at high risk are sheet metal workers (who, however, include a high proportion of heavily smoking cases); and radio-TV workers. In the latter category, cases included 1 turner, 1 spray-painter, 2 electricians and 2 electronic technicians (none among controls). Anthony and Thomas (1970) have reported an RR of 6.1 for individuals having worked as electricians for 20 or more years; however, the RR for the same category was 0.8 in the more recent study by Silverman *et* al. (1983).

The most frequently represented category of workers in our study was that employed in the car industry. Previous studies on bladder cancer and employment in this industry do not suggest increased risks; Baxter *et* al. (1977) found 2 cases *vs.* 2.6 expected in a car-assembly plant; Silverman et *al.* (1983) did not report high risks for car workers other than tool and die makers and machinists. Also in our study, with the exception of turners and, possibly, of car painters and sheet metal workers in car repair, there is no increase in risks for this category.

TABLE IX - CASES AND CONTROLS AND AGE-ADJUSTED RRs FOR INDUSTRIAL ACTIVITIES (BRANCHES) (A) AND JOB TITLES (B) ASSOCIATED WITH CHEMICALS IN THE JOB-EXPOSURE MATRIX (INFORMATION ON EXPOSURE BASED ON BIBLIOGRAPHIC SOURCES); CHEMICALS ASSOCIATED WITH RRs > 1.5 ONLY. FOR BOTH BRANCHES AND JOB TITLES

		Age			RR_{MH}	95% c.l.
		<40	40-49	50-59		
Thiourea	(A)	3/5	13/7	17/16	1.8	(1.0-2.9)*
	(B)	0/1	2/1	2/0	3.5	(0.6-18.5)
3,3'-dimethoxy-benzidine	(A)	3/2	12/5	7/10	1.9	(1.0-3.9)
	(B)	0/0	1/0	0/0	—	—
1-naphthylamine	(A)	1/1	1/1	5/3	2.1	(0.7-6.5)
	(B)	0/1	1/0	1/1	1.7	(0.2-15.8)
Benzyl violet 4B	(A)	3/5	17/10	16/16	1.7	(1.0-2.9)
	(B)	1/0	0/0	0/0	—	—
Magenta	(A)	4/8	17/9	20/19	1.8	(1.1-2.9)
	(B)	1/0	1/1	0/0	3.0	(0.4-20.0)
4-amino-diphenyl	(A)	1/1	1/1	4/3	1.8	(0.6-5.8)
	(B)	0/1	1/0	1/1	1.7	(0.2-15.8)

*RR = 1.2 (0.4-3.3) when adjusting for exposure to aromatic amines.

Job-exposure matrix

Other researchers have developed job-exposure matrices for the analysis of case-control studies focused on occupation (Hoar *et* al., 1980; Medical Research Council, 1983; Coggon *et al.*, 1984). *A priori* matrices (*i.e.*, based on bibliographic information on uses of chemicals) like ours are not place- and time-specific. Information included was derived from international sources and was not necessarily relevant to the area where the study was conducted. With these limitations, it is surprising that all chemicals suspected of being associated with bladder cancer are aromatic amines. Due to overlapping of uses of different aromatic amines, it is not possible to disentangle the role played by each of them. Considering all the aromatic amines included in the matrix as a group, the age-adjusted RR (under age 60) for this category of chemicals was 1.6 (1.0-2.4) when based on industrial activity codes (branches); and 2.3 (1.1-4.7) when based on job title codes. The first criterion of classification included production of chemicals, rubber tires, other rubber goods, dyestuffs, drugs, man-made fibers, printing, textiles, electro-mechanic, leather, paper, health services; the second criterion of classification was more specific and included printers, leather dyers, fabric and yarn dyers, rubber workers (mixing), wood preservation workers, paper workers (mixing), biologists and other biological technicians, and dye producers.

Attributable risks

The attributable risk percent in the population for exposure to aromatic amines was 7% according to the first criterion of classification (28% under age 40; 15% in the age-group 40-49; 2% in the age-group 50-59; all smoking-adjusted); according to the second criterion it was 4% (15% under age 40; 8% in the age-group 40-49; 0% in the age group 50-59; all smoking-adjusted). It should be stressed that a more accurate estimation is achieved with a high sensitivity in assessing exposures (Berrino, 1982; Walter, 1983), as when using industrial activity codes. However, since attributable risks have been computed from a hospital-based study, they are not necessarily accurate; in fact, cases and controls which have been recruited are not necessarily representative respectively of all cases and of the general population for the distribution of occupations.

When only occupations consistently suggested in the literature to entail an increased risk of bladder cancer were considered (textile, leather, printing, dyestuff, rubber) the attributable risk percent in the male population was. in our study, 10%(all ages).

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