Occupation and Cancer of the Lower Urinary Tract in Detroit[1,2]

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ABSTRACT—The relationship between occupation and cancer of the lower urinary tract in Detroit was examined by means of a population-based case–control study conducted as part of the National Bladder Cancer Study. Three hundred three white male patients with transitional or squamous cell carcinoma of the lower urinary tract and 296 white male controls selected from the general population of the study area were interviewed to obtain lifetime occupational histories. Our findings suggested that truck drivers have a significant increased risk of lower urinary tract cancer [relative risk=2.1; 95% confidence interval (CI)=1.4–4.4]. A significant trend in risk was apparent with increasing duration of employment as a truck driver (P=0.004); the relative risk estimated for truck drivers employed at least 10 years was 5.5 (CI=1.8–17.3). Truck drivers with a history of operating vehicles with diesel engines experienced a significant elevated risk compared to non-truck drivers (relative risk=11.9; CI=2.3–61.1), but whether the increased risk observed among truck drivers was attributable to diesel exposure could not be evaluated. Nonsignificant excess risks were also seen for tool and die makers as well as for workers in several other industries and occupations. Employment in the motor vehicle manufacturing industry was associated with no significant excess risk of lower urinary tract cancer (relative risk=1.1; CI=0.8–1.5).—JNCI 1983; 70:237–245.

For at least 25 years, the bladder cancer mortality rate for white males in Detroit has been among the highest in the United States.[9] Mapping of U.S. mortality from bladder cancer by county from 1950 to 1969 (*1*) revealed that the age-adjusted mortality rate for bladder cancer in the tri-county metropolitan Detroit area was in the highest decile of white male rates for all U.S. counties. Incidence data from the Third National Cancer Survey (*2*) conducted in 1969–71 and from the Surveillance, Epidemiology, and End Results Program (*3*) for 1973–77 indicated that white males in metropolitan Detroit also experienced high bladder cancer incidence rates compared to residents of other participating areas.

In 1975, a descriptive study (*4*) suggested that the high bladder cancer mortality among males in Detroit and some other areas may be related to occupational exposures within the motor vehicle or machinery manufacturing industry. This study noted that 1.9% of all employed males in the United States worked in the motor vehicle manufacturing industry. In contrast, in counties where both the bladder cancer mortality rates among males and male-to-female rate ratios were elevated compared to the national averages, 4.8% of male employees worked in the motor vehicle industry.

The purpose of the present study was to identify industries and occupations in Detroit in which workers might have an increased risk of developing bladder cancer. Since motor vehicle manufacturing is a major industry in Detroit, this study provided the opportunity for us to determine directly if high bladder cancer risk is associated with employment in the motor vehicle industry (subsequently referred to as the "auto industry").

METHODS

Subjects.—Our population-based case–control study was conducted as part of the National Bladder Cancer Study (*5*). The case series consisted of all histologically confirmed cases of newly diagnosed carcinoma (or papilloma not specified as benign) of the lower urinary tract (bladder, renal pelvis, ureter, and urethra). Since 95% of the case series had urinary bladder specified as the primary site, we refer to lower urinary tract cancer as "bladder cancer." To be eligible for study, a case had to occur in a resident of the tricounty metropolitan Detroit area (Macomb, Oakland, and Wayne Counties) between the ages of 21 and 84 years and be diagnosed from December 1, 1977, through November 30, 1978. Of the 61 hospitals that serve cancer patients in Detroit, 60 participated in the study and contributed 97% of the total number of cases diagnosed in the area.

For the purpose of occupational analysis, the study group was limited to males. Of the 420 identified male cases, interviews were obtained for a total of 339 subjects (81%).

ABBREVIATIONS USED: CI=confidence interval(s); NEC=not elsewhere classified; NS=not specified; PAH=polycyclic aromatic hydrocarbon(s).

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[9] Unpublished mortality rates for the tricounty metropolitan Detroit area tabulated from data provided by the National Center for Health Statistics, Health Services and Mental Health Administration, Public Health Service, U.S. Department of Health, Education, and Welfare.

Of these interviews, 31 were conducted with proxy respondents because the patient was either too ill to be interviewed or had died. Seventeen patients had physicians who refused permission for interview, 11 patients could not be located, 29 refused to cooperate, and proxy respondents were not available for 11 who were too ill and 13 who had died.

The control series was selected from the general population of the study area in such a way that the case and control series had similar age distributions. Approximately as many controls as cases were selected. The procedure followed for control selection depended on age. Controls aged 21–64 years were selected by random digit dialing (*6*). First, 2,368 households were selected at random from all Detroit residences with telephones to obtain the age and sex of every household member between the ages of 21 and 64. Of these households, 2,110 (89%) provided a household census. Second, a stratified random sample of 164 male controls aged 21–64 years was chosen from the household censuses. Of the 164 controls selected, 138 (84%) were interviewed. Six controls could not be located and 20 refused to cooperate. Controls aged 65–84 years were selected by random sampling from the Health Care Financing Administration's lists of Detroit residents 65 years or older. Of the 255 older controls selected, interviews were obtained for a total of 228 (89%). Eight of these interviews were conducted with proxy respondents. Five older controls could not be located, 18 refused to cooperate, and proxy respondents were not available for 3 controls who were too ill and 1 control who had died.

The analysis was further restricted to white males because there were too few nonwhite males (31 cases and 66 controls) for satisfactory analysis. In addition, 5 cases and 4 controls were excluded for several reasons: The subject never held a job for at least 6 months, the interview was considered to be unreliable, the potential control had bladder cancer before the study period, or the case had a tumor with the histologic type not specified as transitional or squamous cell carcinoma. In total, there were 303 white male cases and 296 white male controls included in the present analysis.

Data collection.—Interviews were usually conducted in the subjects' homes by a trained interviewer. The questionnaire was designed to obtain detailed information on every job a subject had held for at least 6 months since the age of 12 years. Each subject was asked to account for all time periods during his working life. For each job, the subject was queried about the job title, industry, year employment started and ended, employment as either full- or part-time, a description of duties, materials exposed to, and frequency of exposure. After the lifetime occupational history was completed, the interviewer showed the subject check lists of known and suspected high-risk industries, occupations, and materials to elicit information the subject may not have recalled initially. The questionnaire also included items on smoking history, coffee consumption, artificial sweetener use, residential history, source of water, fluid intake, hair dye use, and medical history.

Industry and job title were coded according to the U.S. Bureau of the Census' alphabetical index of industries and occupations (*7*). Since the Census occupation code was designed to reflect professional status rather than exposure, the code was rearranged to group occupations with similar exposures. For example, foremen (census code: 441) and laborers (census code: 780, 785) in the auto industry were grouped as auto workers, NEC. Jobs assigned identical occupation codes were combined into one "occupation." For each occupation, we computed duration of employment (total number of years). Exposures occurring after the starting date of the study were excluded.

Follow-up interview of truck drivers.—Because analysis of the data showed an excess bladder cancer risk for truck drivers, we recontacted respondents who indicated during the initial interview that they had been truck drivers for at least 6 months. Of the 42 cases and 18 controls who were truck drivers, additional interviews were obtained for 36 cases and 16 controls. Permission to be recontacted was refused by 4 cases and 1 control, and 2 cases and 1 control were unavailable. The follow-up questionnaire was administered on the telephone by a trained interviewer. The interview contained questions pertaining to potential exposure to diesel exhausts, types of freight transported, work-related illnesses, and use of medications to stay awake.

Analytic methods.—The association between occupation and the incidence rate of bladder cancer was quantified by the "relative risk" as estimated by the odds ratio. The effect of potential confounding by age, smoking, or employment in other high-risk industries or occupations was controlled by stratification in the analysis. Summary relative risks were computed by the method of maximum likelihood (*8*). Relative risk estimates were unaffected by adjustment for age, smoking, or employment in other high-risk industries or occupations, unless otherwise specified. Two-sided 95% CI for the crude relative risk estimates were computed by Woolf's method (*9*); CI for the summary relative risk estimates were computed by use of a test-based interval estimation procedure (*10*). Two-tailed significance tests for trend were computed by the Mantel extension of the Mantel-Haenszel procedure (*11*).

Both industry-based and occupation-based analyses were conducted. We used two overall measures of employment experience: 1) Whether an individual was "ever employed" in each occupation or industry; 2) an individual's "usual employment." "Usual occupation" and "usual industry" were defined as that occupation and that industry in which the subject was employed for the longest time period. In the analysis of usual employment, we excluded 5 individuals whose occupational histories were inadequate to determine usual employment.

The definition of the unexposed group varied depending on the type of analysis. The risk associated with each industry or occupation was estimated relative to the risk for subjects "never employed" in that industry or occupation, unless otherwise specified. When the risks associated with various occupations within the auto industry were considered, the unexposed group included only subjects who "never worked in the auto industry."

Results are presented for industries and occupations in which 15 subjects or more had worked unless the industry or occupation was one in which we had a special interest because of previous reports. For simplicity, relative risks were referred to as "elevated" if they were greater than or

equal to 1.9, regardless of whether they were statistically significant.

RESULTS

We compared cases and controls with respect to a number of descriptive variables pertaining to occupational history. Controls were similar to cases when we considered the following: age at starting work, number of years employed, number of industries and occupations ever employed in, and number of jobs held. Cases and controls were also comparable with respect to the number of years of education.

Industry

Table 1 presents the relative risks estimated for those subjects ever employed in specified industries. Trucking service was the only industry in which the relative risk differed significantly from 1. This finding should be interpreted with caution inasmuch as the excess bladder cancer risk observed for trucking service was the only significant elevation among the 32 comparisons made in table 1 and may have been due to chance. Relative risks were elevated, but not significantly higher than 1, for the following industries: petroleum extracting and refining, glass manufacturing, railroad and railway express service, and dry cleaning and laundry service. After adjustment for smoking, the relative risk for dry cleaning service decreased to 2.0. Overall, little or no excess risk was seen for the auto manufacturing industry. We observed relative risks that were considerably less than 1 for paint manufacturing and the chemical industry. However, the relative risks estimated for these industries were based on few observations and tended to be unstable.

The statistically significant increase in risk observed for trucking service was mainly attributable to an excess risk among truck drivers (*see below*). The nonsignificant increased risk seen for railroad and railway express service was due to risks associated with two occupations: gandy dancer and laborer (relative risk=3.7; 11 cases and 3 controls) and freight and baggage handler (relative risk=5.0; 5 cases and 1 control). The nonsignificant elevated risk seen for dry cleaning service could not be attributed to specific occupations within the industry. There were too few males employed in petroleum extracting and refining and glass manufacturing to identify high-risk occupations within these industries.

Although most results were similar regardless of whether usual industry or ever employed in each industry was considered, some differences were observed. Subjects ever employed in auto manufacturing had little or no increased risk, whereas subjects whose usual industry was auto manufacturing had an age- and smoking-adjusted relative risk of 1.4 (CI=0.9–2.0). The relative risk for subjects employed in trucking service increased from 2.1 for those ever employed to 4.3 (10 cases and 2 controls) for those "usually employed." Although little or no excess risk was observed for males ever employed in engineering, the retail trade industry, and the auto repair and auto services industry (table 1), relative risks increased when engineering (2.5; 5 cases and 2 controls), retail trade (2.1; 32 cases and 16 controls), and auto repair (2.0; 4 cases and 2 controls) were indicated as the usual industry.

TABLE 1.—*Numbers of cases and controls ever employed in each industry category and relative risks*

Industry	Cases	Controls	Relative risk[a]	95% CI[b]
Motor vehicle manufacturing	183	175	1.1	0.8–1.5
Rubber	5	8	0.6	0.2–1.9
Leather & leather products: manufacturing & repair	4	8	0.5	0.1–1.6
Printing	50	45	1.1	0.7–1.7
Paint manufacturing	1	4	0.2	0.0–2.2
Chemical	5	13	0.4	0.1–1.0
Petroleum extracting & refining	6	1	6.0	0.7–49.8
Coal mining	16	13	1.2	0.6–2.6
Metal	59	60	1.0	0.6–1.4
Machinery, except electrical	74	62	1.2	0.8–1.8
Metalworking machinery	39	25	1.6 (1.4)	0.9–2.7
Engineering & architectural service	8	5	1.6	0.5–4.9
Textiles	7	10	0.7	0.3–1.8
Construction	62	53	1.2	0.8–1.8
Beauty & barber shops	3	2	1.5	0.2–8.9
Glass & glass products manufacturing	6	1	5.9	0.7–49.8
Trucking service	28	13	2.2	1.1–4.4
Railroad & railway express service	22	12	1.9	0.9–3.8
Dry cleaning & laundry service	12	5	2.4	0.8–6.9
Gasoline service	18	11	1.6 (1.3)	0.8–3.5
Wholesale trade, NEC	44	32	1.4	0.9–2.3
Retail trade, NEC	119	104	1.2	0.9–1.7
Automotive repair & automotive services	14	12	1.1	0.5–2.5
Ordnance manufacturing	16	14	1.1	0.5–2.3
Agriculture	72	82	0.8	0.6–1.2
Aircraft manufacturing	25	34	0.7	0.4–1.2
Bakery products manufacturing	7	11	0.6	0.2–1.6
Hotels & motels	6	11	0.5	0.2–1.4
Entertainment & recreation services	10	13	0.7	0.3–1.7
Education: primary & secondary	11	14	0.8	0.3–1.7
Public administration, federal	124	116	1.1	0.8–1.5
Real estate	10	13	0.7	0.3–1.7

[a] For each industry, relative to a risk of 1.0 for males never employed in that industry. Crude relative risks are given in every instance. Relative risks adjusted for age and smoking are presented *in parentheses* if: 1) the adjusted relative risk differed from the crude relative risk, 2) there were sufficient numbers of subjects to permit such adjustment, and 3) the crude relative risk exceeded 1.1.

[b] For the crude relative risk.

Occupation

Relative risks by occupation are presented in table 2. Of the specified occupations, truck driver was the only occupation in which workers experienced a statistically significant increased risk. Nonsignificant elevations in risk were seen for workers in the following occupations: printer, machine tradesman, metal heater, cook and food counter worker, and cab driver. However, the relative risks estimated for machine tradesman and metal heater decreased to 1.6 and 1.8, respectively, after adjustment for other high-risk occupations and smoking. Bladder cancer risk was signif-

TABLE 2.—*Numbers of cases and controls ever employed in each occupation category and relative risks*

Occupation title	Cases[a]	Controls[a]	Relative risk[b]	95% CI[c]
Dyer	0	1	—	—
Rubber worker	2	0	—	—
Printer	6	2	3.0	0.6–14.8
Painter	15	14	1.0	0.5–2.2
Chemical worker	1	8	0.1	0.0–1.0
Shoe repairman & bootblack	3	4	0.7	0.2–3.3
Auto worker, NEC	82	79	1.0	0.7–1.5
Mechanic & repairman	61	62	1.0	0.6–1.4
Metal machinist	137	130	1.1	0.8–1.5
Machinist, NS	13	10	1.3	0.6–3.0
Drill press operative	16	14	1.1	0.5–2.3
Machine operative, miscellaneous & NS	46	34	1.4	0.9–2.2
Job & die setter, metal	11	9	1.2	0.5–2.9
Tool & die maker	32	21	1.5	0.9–2.7
Machine trades occupation, NEC	11	7	1.6 (2.1)	0.6–4.1
Occupation in metalworking & fabricating metal products	80	59	1.4	1.0–2.1
Tinsmith, coppersmith, sheetmetal worker	9	5	1.8	0.6–5.4
Filer, polisher, sander, buffer, grinding machine operative	46	33	1.4	0.9–2.3
Heater, metal	3	1	3.0	0.3–28.5
Punch & stamping press operative	22	19	1.1	0.6–2.2
Welder, flame cutter, solderer	18	30	0.6	0.3–1.0
Engineer	13	15	0.8	0.4–1.8
Electrician	17	20	0.8	0.4–1.6
Textile worker	2	4	0.5	0.1–2.7
Barber & hairdresser	3	2	1.5	0.2–8.9
Medical worker	3	9	0.3	0.1–1.2
Tailor, sewer, stitcher	5	4	1.2	0.3–4.6
Carpenter & cabinetmaker	18	12	1.5	0.7–3.2
Cook & food counter worker	15	8	1.9 (2.5)	0.8–4.5
Construction worker	49	40	1.2	0.8–1.9
Sailor, deckhand, fisherman	6	16	0.4	0.1–0.9
Clerical worker	52	49	1.0	0.7–1.6
Shipping, receiving & stock clerk	27	39	0.6	0.4–1.1
Packaging & materials handling occupation	93	74	1.3	0.9–1.9
Factory worker, NEC	91	70	1.4	1.0–2.0
Truck driver	42	18	2.5 (2.1)	1.4–4.4
Deliveryman	41	27	1.6 (1.8)	0.9–2.6
Bus driver	6	4	1.5	0.4–5.3
Taxicab driver & chauffeur	12	6	2.0	0.7–5.4
Garage worker & gas station attendant	18	15	1.2	0.6–2.4
Janitor	22	18	1.2	0.6–2.3
Stationary fireman	11	6	1.8	0.7–5.0
Recreation worker	10	7	1.4	0.5–3.8
Farmer	71	82	0.8	0.6–1.2
Newsboy	40	37	1.1	0.7–1.7
Mine operative & laborer	15	15	1.0	0.5–2.0
Ore refining & foundry occupation	5	10	0.5	0.2–1.4
Guard & watchman	15	16	0.9	0.4–1.9
Artillery gunner	10	16	0.6	0.3–1.3
Member of armed forces	29	32	0.9	0.5–1.5
Telephone, telegraph, radio operator	8	8	1.0	0.4–2.6
Salesman & sales clerk	42	32	1.3	0.8–2.2
Manager & administrator	84	73	1.1	0.8–1.7
Bank teller & cashier	9	12	0.7	0.3–1.7
Architect, draftsman, designer	8	11	0.7	0.3–1.8
Housekeeper	4	12	0.3	0.1–1.0

[a] Ever employed in each occupation, regardless of industry.

[b] For each occupation, relative to a risk of 1.0 for males never employed in that occupation. Crude relative risks are given in every instance. Relative risks adjusted for age and smoking are presented *in parentheses* if: 1) the adjusted relative risk differed from the crude relative risk, 2) there were sufficient numbers of subjects to permit such adjustment, and 3) the crude relative risk exceeded 1.1.

[c] For the crude relative risk.

icantly decreased for workers employed as sailors, deckhands, and fishermen. We also observed nonsignificant decreases in risk for workers in the following occupations: chemical worker, medical worker, and housekeeper.

Although patterns in risk were generally similar when either usual occupation or ever employed in each occupation was considered, the following differences were apparent. Compared to the results of the ever employed analysis, smoking-adjusted relative risks increased when the usual occupation was auto worker, NEC (1.6; 20 cases and 14 controls), metal machinist (1.7; 36 cases and 23 controls), packager and materials handler (1.9; 12 cases and 7 controls), and truck driver (5.4; 11 cases and 2 controls). In contrast, a substantial decrease in relative risk was observed for subjects usually employed as clerical workers (0.4; 5 cases and 12 controls).

Occupations in the Auto Industry

Table 3 shows the relative risks estimated for the specified occupations within auto manufacturing. The referent group consisted of subjects never employed in the auto industry. Observations for the auto industry that appear in table 3 are also included in table 2.

None of the estimated relative risks was significantly different from 1. Although nonsignificant, elevations in risk were observed for machinist, NS and machine operative. Relative risks were also slightly increased for drill press operative; operative, miscellaneous; tool and die maker; engineer; some subcategories of metalworker; shipping clerk; packager and materials handler; and manager and administrator. Little or no excess bladder cancer risk was observed among other occupations within the auto industry.

Duration of Employment

We examined the relationship between risk of disease and duration of employment for each occupation in which 15 subjects or more had ever or usually been employed and the relative risk was at least 1.4. Of the occupations examined, relative risk in the longest duration category exceeded the total relative risk in the entire group for only the following four occupations: truck driver, tool and die maker, cook and food counter worker, and packager and materials handler. There were too few cooks for us to investigate this occupation in greater detail. For packagers and materials handlers, the relationship of bladder cancer risk to duration was inconsistent and was not pursued further.

Tool and Die Maker

Table 4 shows relative risks by duration of employment as a tool and die maker. Tool and die makers who worked 30 years or more had a relative risk of 2.0; the relative risk for those who worked less than 30 years was 1.3. The relationship between risk and year of starting employment as a tool and die maker is also presented in table 4. Tool and die makers who started employment before 1940 experienced no excess risk, whereas the relative risk estimated for those who started after 1940 was 2.0. However, this trend was not statistically significant.

TABLE 3.—*Numbers of cases and controls ever employed in each occupation category within the motor vehicle manufacturing industry and relative risks*

Occupation title[a]	Cases	Controls	Relative risk[b]	95% CI[c]
Never motor vehicle manufacturing	111	114	1.0	
Ever motor vehicle manufacturing				
Printer	0	4	—	—
Painter	3	6	0.5	0.1–2.1
Chemical worker	0	1	—	—
Inspector, checker, foreman, laborer, assembler	80	73	1.1	0.8–1.7
Metal machinist	73	63	1.2	0.8–1.8
Machinist, NS	5	2	2.6	0.5–13.6
Drill press operative	9	7	1.3	0.5–3.7
Machine operative, misc. & NS	20	12	1.7 (2.1)	0.8–3.7
Operative, misc. & NS	12	8	1.6	0.6–3.9
Tool & die maker	18	14	1.3	0.6–2.8
Mechanic & repairman: machinery & heavy equipment	6	11	0.6	0.2–1.6
Mechanic & repairman, auto	19	19	1.0	0.5–2.1
Engineer	6	5	1.2	0.4–4.2
Electrician	2	2	1.0	0.1–7.5
Occupation in metal processing, metalworking, fabricating metal products	48	40	1.2	0.8–2.0
Punch & stamping press operative	16	13	1.3	0.6–2.8
Filer, polisher, sander, buffer, grinding machine operative	26	23	1.2	0.6–2.2
Welder, flame cutter, solderer	12	22	0.6	0.3–1.2
Shipping, receiving & stock clerk	14	12	1.2	0.5–2.7
Clerical worker	27	25	1.1	0.6–2.0
Packaging & materials handling occupation	29	20	1.5	0.8–2.8
Manager & administrator	15	13	1.2	0.5–2.6

[a] Miscellaneous, misc.

[b] Relative to a risk of 1.0 for all respondents who never worked in the motor vehicle manufacturing industry. Crude relative risks are given in every instance. Relative risks adjusted for age and smoking are presented *in parentheses* if: 1) the adjusted relative risk differed from the crude relative risk, 2) there were sufficient numbers of subjects to permit such adjustment, and 3) the crude relative risk exceeded 1.1.

[c] For the crude relative risk.

TABLE 4.—*Numbers of cases and controls and relative risk according to duration and year of starting employment as a tool and die maker*[a]

History of employment as a tool and die maker	Cases	Controls	Relative risk[b]
Never tool and die maker	254	267	1.0
Ever tool and die maker			
Duration of employment, yr			
<5	9	8	1.3
5–29	12	9	1.3
30+	8	4	2.0
		(χ=1.29; P=0.196)	
Year of starting employment			
1910–39	11	12	1.0
1940–77	18	9	2.0
		(χ=1.51; P=0.132)	

[a] Males with unknown smoking history, duration, and/or year of starting employment were excluded.
[b] Relative to a risk of 1.0 for males never employed as a tool and die maker; adjusted for age and smoking.

Truck Driver

A statistically significant trend in risk with increasing duration of employment as a truck driver is seen in table 5. A relative risk of 5.5 (CI=1.8–17.3) was estimated for truck drivers employed for at least 10 years. The risk associated with year of starting employment as a truck driver is also shown in table 5. We observed a relative risk of 6.5 in truck drivers who started employment since 1950, but this estimate was based on few subjects. Risks for earlier time periods were elevated to a lesser degree. Although the overall trend was statistically significant, a consistent trend prior to 1950 was not apparent.

In view of the findings regarding year of starting employment, we examined the association between bladder cancer risk and duration of employment as a truck driver during the time period from 1950 to 1978, controlling for duration of such work before 1950. Risk was estimated relative to the risk for truck drivers who never worked as truck drivers during 1950–78. A consistent gradient of risk with increasing duration was apparent. Among truck drivers, relative risks for successive duration categories were: never employed as a truck driver from 1950 to 1978, 1.0 (21 cases and 13 controls); less than 5 years' duration from 1950 to 1978, 1.4 (5 cases and 2 controls); and 5 years' or more duration from 1950 to 1978, 2.6 (14 cases and 3 controls). We also estimated the risk associated with duration of employment as a truck driver during the time period prior to 1950, adjusting for duration from 1950 to 1978. Risk was estimated relative to the risk for truck drivers who never worked as truck drivers during the time period before 1950. No association between bladder cancer risk and duration of employment as a truck driver prior to 1950 was observed.

Table 6 shows the independent effects of smoking and employment as a truck driver, as well as the effect of these factors acting jointly. The increase in risk with smoking level was apparent for both truck drivers and non-truck drivers. We also observed a significant interaction between employment as a truck driver and smoking (χ^2_2=6.6; P=0.04). The relative risk for truck drivers who were nonsmokers or smoked one pack per day or less was 1.3. The relative risk for truck drivers who smoked more than one and less than or equal to two packs per day was 6.8, clearly exceeding the risk expected if each of these factors was acting independently. In addition, there were 8 cases and no controls who were truck drivers and smoked more than two packs per day.

Table 7 presents the results of the follow-up interviews of truck drivers. When only respondents of the follow-up interview were considered, the overall relative risk estimate for truck drivers (2.1; 36 cases and 16 controls) was identical to the relative risk estimated from the original data (2.1; 42 cases and 18 controls). Truck drivers with a history of operating vehicles with diesel engines (subsequently referred to as diesel-exposed truck drivers) experienced the highest risk observed in this study. The relative risk for diesel-exposed truck drivers was 11.9 (CI=2.3–61.1) when the unexposed group included only males never employed as truck drivers and 7.2 (CI=0.9–56.2) when the unexposed group included only truck drivers who had never operated

TABLE 5.—*Numbers of cases and controls and relative risk according to duration and year of starting employment as a truck driver*[a]

History of employment as a truck driver	Cases	Controls	Relative risk[b]
Never truck driver	244	270	1.0
Ever truck driver			
Duration of employment, yr			
<10	23	15	1.4
10+	16	3	5.5
		(χ=2.88; P=0.004)	
Year of starting employment			
1910–29	8	6	1.6
1930–39	12	5	2.0
1940–49	10	6	1.5
1950–69	7	1	6.5
		(χ=2.23; P=0.03)	

[a] Males with unknown smoking history, duration, and/or year of starting employment were excluded.
[b] Relative to a risk of 1.0 for males never employed as a truck driver; adjusted for age and smoking.

TABLE 6.—*Numbers of cases and controls and relative risk according to cigarette smoking and employment as a truck driver*[a]

Usual amount smoked	Employment as a truck driver	Cases	Controls	Relative risk[b]
Nonsmoker or ≤1 pack/day	Never	153	200	1.0
	Ever	15	15	1.3
>1–≤2 packs/day	Never	75	61	1.6
	Ever	17	3	6.8
2+ packs/day[c]	Never	16	9	2.1
	Ever	8	0	—

[a] Males with unknown smoking history were excluded.
[b] Relative to a risk of 1.0 for males who were never employed as a truck driver and never smoked or smoked one pack/day or less; adjusted for age.
[c] All subjects included in this category smoked more than two and less than or equal to three packs/day except for 1 patient and 1 control who were never employed as truck drivers.

TABLE 7.—*Numbers of cases and controls and relative risk according to factors related to truck driving*[a]

Exposure	Cases	Controls	Relative risk[b]	95% CI[c]
Never truck driver	261	278	1.0	
Ever truck driver				
Ever operated vehicle with diesel engine				
No	21	15	1.4	0.7–2.9
Yes	13	1	11.9	2.3–61.1
Ever transported chemicals				
No	21	14	1.5	0.7–3.1
Yes	12	2	5.5	1.4–21.8
Ever transported petroleum products				
No	27	14	1.8	0.9–3.6
Yes	7	2	3.6	0.8–16.4
Ever transported coal				
No	32	12	2.6	1.3–5.1
Yes	2	4	0.5	0.1–3.0
Type of truck heater				
No heater	7	5	1.6	0.5–5.1
Manifold heater	5	2	2.2	0.4–11.4
Hot water heater	15	7	2.0	0.8–5.0
Truck usually fueled by				
Others	17	10	1.7	0.8–3.9
Self	15	6	2.3	0.9–6.1

[a] Males with unknown smoking history were excluded.
[b] Relative to a risk of 1.0 for males never employed as a truck driver; adjusted for age and smoking.
[c] For the summary relative risk.

vehicles with diesel engines. However, only 5 cases and no controls had ever driven a diesel truck while employed as a truck driver. Rather, most diesel exposure occurred when truck drivers were employed in non-trucking occupations (i.e., mechanic, engineer, deliveryman, bus driver, and end loader).

Truck drivers with a history of transporting chemicals also experienced an increased risk (relative risk=5.5; CI=1.4–21.8). Although no particular high risk chemical was identified, most of the chemicals specified during the interview were organic. The relative risk estimated for truck drivers who transported petroleum products was also elevated (relative risk=3.6), but this elevation was not statistically significant. There were no major differences in risk among truck drivers according to type of truck heater used or whether they or others fueled their trucks. In addition, the follow-up interview included questions pertaining to history of work-related illnesses and/or conditions and use of medications to stay awake. Nine cases and 3 controls reported a history of work-related illnesses and conditions, but most conditions were injuries. Of the cases, 1 reported having had carbon monoxide poisoning and another reported having had emphysema. Only 3 cases and 1 control admitted having used medications to stay awake.

Smoking

In addition to occupation, the only other known risk factor for bladder cancer is smoking. In our study, smoking was clearly associated with risk of developing bladder cancer. The relative risk estimated for smokers was 2.4 (CI=1.6–3.6). We also observed a consistent gradient of risk with increasing quantity smoked. The following risks were estimated for smokers relative to the risk for nonsmokers: less than or equal to half a pack per day, 1.4 (CI=0.8–2.5); more than half and less than or equal to one pack per day, 2.2 (CI=1.4–3.6); more than one and less than or equal to two packs per day, 2.9 (CI=1.8–4.7); more than two packs per day, 5.3 (CI=2.3–12.5).

DISCUSSION

The results of this study indicate that, overall, employment in the auto industry is associated with little or no excess risk of bladder cancer. The relative risk estimated for those subjects ever employed in the auto industry was 1.1. When we considered subjects usually employed in the auto industry, the relative risk increased to 1.4, but this estimate was not significantly different from 1. No consistent gradient of risk with duration of employment was observed in either instance. The elevations in risk seen for several subcategories of metal machinist accounted for most of the small excess of risk observed within the industry.

Our findings are in agreement with those of three previous studies of bladder cancer and employment in the auto industry. Baxter et al. (*12*) observed only two bladder cancer deaths compared to 2.6 expected among males employed at a British Leyland car-assembly plant from 1966 to 1972. In a death certificate study of occupation and bladder cancer in Wisconsin, Cooper and Moss (*13*) estimated a relative risk of 1.0 for males usually employed in the auto industry. The results of the Third National Cancer Survey Interview Study (*14*) indicated a nonsignificant increased bladder cancer risk among males usually in transportation equipment manufacturing (relative risk=1.6).

In our study, the strongest evidence of increased bladder cancer risk was seen for truck drivers. The relative risk for this group was estimated to be 2.1. Among truck drivers employed since 1950, there was a trend in risk with increasing duration of employment. Since diesel trucks became more prevalent after 1950,[10] this finding suggested a relation of bladder cancer risk to diesel exposure. Results of the follow-up interviews of truck drivers indicated that diesel-exposed truck drivers experienced a significant elevated risk compared to non-truck drivers (relative risk=11.9, CI=2.3–61.1). However, determination was not possible of whether the elevated bladder cancer risk observed among truck drivers was attributable to diesel exposure. First, we could not evaluate the association between risk and duration of diesel exposure because only 1 control had ever been exposed to diesels. Second, most diesel exposure reported by truck drivers occurred during employment in non-trucking occupations. Third, the high risk observed among diesel-exposed truck drivers may have been partly due to recall bias. Since the data on diesel eposure were obtained during the follow-up interviews, truck drivers who were cases may have been more likely to claim some lifetime diesel exposure than truck driver controls.

[10] Data on U.S. factory sales of trucks with diesel engines provided by the Motor Vehicle Manufacturers Association of the United States, Inc.

There have been only two previous reports of an increased risk of bladder cancer among truck drivers. Decoufle et al. (*15*) estimated the relative risk for truck drivers as 1.7, based on the lifetime occupational histories of patients admitted to Roswell Park Memorial Institute. Milham (*16*) observed 42 bladder cancer deaths among truck drivers compared to 30 expected in a death certificate study of occupation in Washington State. In addition, data from two case–control studies have suggested that exposure to motor exhausts may be associated with excess risk. In a New York study, Wynder et al. (*17*) found that 33 cases and 24 controls had been exposed to motor exhausts. A more recent study conducted in Canada by Howe et al. (*18*) indicated that the relative risk for subjects exposed to diesel and traffic fumes was 2.8. Exhausts from both gasoline and diesel engines contain PAH. Observations of increased bladder cancer risk among gas workers (*19*) and roofers (*20*) exposed to PAH suggest that PAH exposure may be related to bladder cancer risk.

Our study also suggests a slight elevation in risk among tool and die makers. The overall relative risk for this group was 1.5. We observed an increased risk associated with long-duration employment as a tool and die maker. We also noted an increase in risk among tool and die makers who started employment after 1940. This observation is consistent with either the introduction of a hazardous exposure in tool and die making after 1940 or a peak latent period of less than 40 years.

Increased bladder cancer risk among tool and die makers has been observed in three earlier studies. Cooper and Moss (*13*) estimated a relative risk of 2.3 for tool and die makers in Wisconsin. In a death certificate study of occupation in the state of California, Petersen and Milham (*21*) found 10 bladder cancer deaths among tool and die makers compared to four expected. Williams et al. (*14*) estimated a relative risk of 2.0 for tool and die makers, using data from the Third National Cancer Survey.

Tool and die makers are exposed to mists from cutting and lubricating oils used as coolants and lubricants in metal machining processes. In a death certificate study of occupation and bladder cancer in England and Wales, Henry et al. (*22*) observed that cotton spinners and piecers who sustained substantial exposure to mineral oils experienced almost twice the expected bladder cancer mortality. In contrast, Decoufle (*23*) observed only six bladder cancer deaths compared to five expected in a cohort study of workers exposed to cutting oil mists. The recent introduction of synthetic cutting fluids (*23*) is consistent with the increased risk we observed among workers first employed after 1940. The extent to which tool and die makers in our study were exposed to synthetic cutting fluids is unknown. Therefore, we were not able to determine whether the increased risk seen for tool and die makers who started employment after 1940 was, in fact, related to synthetic cutting fluid exposure.

We conclude that occupational exposures in the auto industry do not explain the high bladder cancer risk observed among white males in Detroit. However, the increased risks seen for truck drivers, tool and die makers, and smokers may account for at least part of this excess risk. We also examined other potential risk factors for bladder cancer, such as the use of artificial sweeteners, coffee drinking, and alcohol consumption; none of these factors was associated with increased risk of bladder cancer in Detroit males.

We observed substantial elevations in risk among workers in a number of industries and occupations that were suggested to have elevated risks in previous studies: petroleum extracting and refining (*17*), engineering (*24, 25*), glass manufacturing (*18*), printer (*14, 26–28*), and cook (*16, 29*). Increased risks were not observed for several other previously suspected industries, such as dyestuffs (*25, 27, 29, 30*), rubber (*18, 27, 29, 31–33*), and leather (*17, 29, 32, 34, 35*). However, this does not necessarily conflict with the results of prior positive studies since employment in these industries is not prevalent in the Detroit area. In addition, our study suggested previously unsuspected risks in the following industries and occupations: trucking service, railroad and railway express service, dry cleaning and laundry service, retail trade, auto repair and auto services, packager and materials handler, and cab driver. However, these results should be interpreted with caution for two reasons: 1) Of the larger number of comparisons made in this study, some of the observed elevations in bladder cancer risk may have been chance occurrences. 2) Since relative risk estimates were often based on small numbers of exposed subjects, true elevations in risk might not have appeared as "statistically significant."

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