Truck Driving and Bladder Cancer Mortality in Rural New England [1]

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ABSTRACT—The relationship between truck driving and bladder cancer mortality was investigated in a case-control study in New Hampshire and Vermont. In-person interviews were conducted with the next-of-kin of 325 bladder cancer cases and 673 controls who died during 1975–79. There were 35 cases and 53 controls who had ever been employed as truck drivers [odds ratio (OR)=1.5, 95% confidence interval (CI)=0.9,2.6]. There was a statistically significant, but inconsistent, positive association between number of years of truck driving and the OR's, rising to 2.3 (1.2,4.1) for 5 years or more of truck driving. Risk was greatest in men who began driving in the 1930's and 1940's (OR=2.6, 95% CI=1.3,5.1) and among residents of two of the most urbanized counties (OR=3.0, 95% CI=1.2,7.4). The association of bladder cancer with truck driving was unaffected by control for possible confounding factors, such as cigarette smoking and coffee drinking. It was not possible to determine whether the risks associated with truck driving were specifically due to diesel fumes. Truck drivers reporting diesel exposures had an OR=1.8 (95% CI=0.5,7.0), but those without diesel exposure still had an OR=1.5 (95% CI=0.8,2.7). Twenty-six cases and 39 controls reported exposure to diesel emissions in any occupation (OR=1.5, 95% CI=0.8,2.8), and a significant duration-response relationship was seen, rising to threefold for those employed in such jobs for 30–39 years.—JNCI 1985; 74:771–774.

A recent study of cancer of the lower urinary tract in Detroit by Silverman et al. revealed a significantly increased risk among truck drivers (*1*). The risk rose with increasing duration of employment as a truck driver and was elevated for drivers of vehicles with diesel engines. A preliminary report on data from all 10 areas of the National Bladder Cancer Study indicated that the increased risk was present primarily in the Northeast and Midwest areas of the United States (*2*). In a case-control study aimed at elucidating reasons for high rates of bladder cancer in both sexes in a relatively rural area, New Hampshire and Vermont, we had the opportunity to determine if an association with truck driving was apparent.

METHODS

Cases consisted of all white residents of New Hampshire and Vermont who died from bladder cancer (International Classification of Disease Code: Eighth Revision-188, Ninth Revision-188.0–188.9) in 1975–79. One control per case was randomly selected from all other deaths among residents, excluding suicides, matching on state, sex, race, age (±2 yr), and year of death. A second control per case was selected with the additional matching criterion of county of residence. A mortality-based study design was chosen because of the lack of an existing cancer registry, the lack of a rapid reporting mechanism for future incident cancer cases, and the number of years required to accrue sufficient cases for a study among the sparse population of the two-state area.

Subject selection procedures differed slightly in the two states. The Vital Records and Health Statistics Office of New Hampshire provided copies of the death certificates for all eligible study subjects. The next-of-kin were traced, their cooperation was solicited, and they were interviewed by us. In Vermont, the Public Health Statistics Office identified the eligible study subjects, traced the next-of-kin, and solicited their cooperation. Vermont's contact letters contained cards to be returned to the state if the next-of-kin did not want to participate in the study. Only those who did not initially refuse were referred to us for interview.

There were 230 and 210 residents of New Hampshire and Vermont, respectively, who died from bladder cancer during 1975–79 (table 1). No attempts were made to confirm the diagnosis of bladder cancer as reported on the death certificate. Controls were selected (923). The number of controls totals to more than 2 controls per case due to exclusions of ineligible cases after controls were already interviewed and due to double reporting of cases by both states. Next-of-kin for 76 (17%) cases and 165 (18%) controls either refused to allow contact or could not be located by Vermont officials. Twenty-six more Vermont residents and 98 New Hampshire residents declined to be interviewed when we contacted them. Including the Vermont study subjects who were not referred to us, the response rate was 87% for New Hampshire residents and 58% for Vermont. The nonrespondents were similar to the respondents with respect to case-control status, sex, age, and county of residence.

In-person interviews with next-of-kin covered the subjects' demographic characteristics, lifetime occupational and residential histories, tobacco exposure, diet, and medical history. The average length of time for the interview was 62.0 minutes for cases and 60.4 minutes for controls. Interviews were provided by spouses (cases: 32%; controls: 32%), daughters (cases: 23%; controls: 23%), sons

ABBREVIATIONS USED: CI=confidence interval(s); OR=odds ratio(s).

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TABLE 1.—*Number of bladder cancer cases and controls by sex, state of residence, and interview status*

Specification	Identified by state officials	VT: Not allowed to contact	Allowed to contact	Completed interviews
Cases	440	76	364	325
Men	307	61	246	224
NH	154	0	154	135
VT	153	61	92	89
Women	133	15	118	101
NH	76	0	76	64
VT	57	15	42	37
Controls	923	165	758	673
Men	640	120	520	459
NH	335	0	335	287
VT	305	120	185	172
Women	283	45	238	214
NH	165	0	165	146
VT	118	45	73	68
Total	1,363	241	1,122	998

(cases: 18%; controls: 19%), and other relatives or friends (cases: 28%; controls: 26%). Completed interviews were obtained from 325 cases and 673 controls, 89% each of the subjects given to us for study. There were no female truck drivers, so the analysis was restricted to men.

The measure of association between truck driving and risk of bladder cancer was the OR. Separate analyses of the two control series, which differed by matching of county of residence, yielded similar results, so the two control series were combined. When necessary, the effects of county of residence and other confounding variables, such as cigarette smoking, were taken into account by stratification. Maximum likelihood estimates of the overall risk and 95% CI were computed by Gart's method (*3*). Matched analyses yielded results similar to those provided by the unmatched approach. However, the unmatched approach allowed control of additional factors that were not matching factors, such as coffee drinking and smoking. Therefore, the unmatched analyses are presented. For duration-response relationships, significance was assessed by means of Mantel's one-tailed linear trend test (*4*). Logistic regression was also performed (*5*) to control simultaneously for several potential confounding factors. These results are presented when they differ from the stratified analyses.

RESULTS

There were 35 (16%) cases and 53 (12%) controls who had ever been employed as a truck driver, yielding an OR of 1.5 (95% CI=0.9,2.6), after adjustment for county of residence (24 counties) and age at death (<66, 66-80, >81). The OR were 1.3 (95% CI=0.7,2.3) for New Hampshire residents and 1.7 (95% CI=0.8,3.4) for Vermont residents. We examined the risk of bladder cancer according to characteristics of employment as a truck driver (table 2). There was a statistically significant, but inconsistent, positive association between the number of years of truck driving and risk. However, for a large number of subjects duration of truck driving was unknown by the next-of-kin. Risk was greater in men who began truck driving in the 1930's and 1940's. Addition of control for age, county, coffee drinking (4 categories), and cigarette smoking (6 categories) did not alter the crude OR in table 2. No relationship with age started employment as a truck driver was seen. Control for education, a surrogate measure for social class, did not affect the risk estimates.

TABLE 2.—*Number of cases and controls and OR for bladder cancer according to characteristics of employment as a truck driver*

Duration	Cases	Controls	OR (95% CI)
Never	188	406	1.0
1-4 yr	9	14	1.4 (0.6,3.3)
5-9 yr	12	9	2.9 (1.2,6.7)
>10 yr	11	13	1.8 (0.8,4.1)
Unknown	3	17	—
Chi for trend = 2.53, P=.006 (one-tailed)			
Calendar year first employed	**Cases**	**Controls**	**OR (95% CI)**
<1929	10	18	1.2 (0.5,2.6)
1930-49	18	15	2.6 (1.3,5.1)
>1950	6	9	1.4 (0.5,4.1)
Unknown	1	11	—

There was little variation in risk according to the industry in which the men had driven trucks (table 3). The truckers in the lumber, logging, and paper industry had slightly higher risks than men in other industries, but the difference was not statistically significant. Also, the risk among truck drivers was not explained by nontrucking employment in industries generally associated with bladder cancer, such as the leather and textile industries. The OR for truck driving among persons who never worked in the leather or textile industry was 1.5 (95% CI=0.9,2.5).

The risk associated with truck driving appeared to be highest in two counties, Hillsborough and Rutland, which are among the most urbanized counties in New Hampshire and Vermont, respectively (OR=3.0, 95% CI=1.2,7.4). The risk varied by calendar time. Men from Hillsborough and Rutland who began truck driving before 1950 had an OR of 3.9 (95% CI=1.4,10.6), whereas men who began driving after 1950 had an OR of 1.3 (95% CI=0.2,8.1). The reason for the elevated risk in these two counties is unclear. The distribution of industries in which the men were employed as truck drivers differed only slightly in Hillsborough and Rutland from the rest

TABLE 3.—*Number of cases and controls and OR for bladder cancer according to major industry of truck driving*

Ever employed	Cases	Controls	OR (95% CI)
Never truck driver	188	406	1.0
Construction	6	9	1.4 (0.5,4.1)
Agriculture and food delivery	7	11	1.4 (0.5,3.6)
Lumber, logging, and paper	6	6	2.2 (0.7,6.6)
Petroleum products delivery	5	7	1.5 (0.5,4.9)
Truck driving, unspecified	7	10	1.5 (0.6,4.0)
Other	10	21	1.0 (0.5,2.2)

TABLE 4.—*Number of cases and controls and OR for bladder cancer according to duration of jobs with self-reported exposure to diesel fuel or engines*

Duration[a]	Cases	Controls	OR (95% CI)
Never held job with diesel exposure	197	421	1.0
1-19 yr	5	12	0.9 (0.3,2.8)
20-29 yr	5	5	2.1 (0.5,8.6)
30-39 yr	6	4	3.2 (0.8,13.7)
>40 yr	7	9	1.7 (0.5,5.0)
Chi for trend = 1.98, P=.024 (one-tailed)			

[a] Excludes 3 cases and 9 controls with unknown duration.

of the two-state area. Truck drivers in these two counties were twice as likely to be employed as local and long-distance truckers, not otherwise specified, whereas the drivers in the non-high-risk counties were twice as likely to be employed in agriculture and food-products delivery. However, the high bladder cancer rates in Hillsborough and Rutland were not explained by confounding by industry or duration of employment as a truck driver.

The next-of-kin reported that 14 men had exposure to diesel fuel or engines during their truck-driving jobs, yielding an OR for bladder cancer of 1.8 (95% CI=0.5,7.0) compared to an OR of 1.5 (95% CI=0.8,2.7) for those not reporting diesel exposure, adjusted for age and county.

We also examined the effects of reported diesel exposure in any occupation. Besides truck driving, these occupations included aircraft, auto and heavy equipment mechanics, service station attendants, railroad workers, construction workers, lumberjacks, farmers, amusement park ride operators, and miners. Twenty-six cases and 39 controls reported exposure to diesels, yielding an OR of 1.5 (95% CI=0.8,2.8), adjusted for county of residence and age at death. A significant duration response was seen rising to a threefold excess risk for persons in such jobs for 30-39 years with a decrease in risk seen among men employed for 40 years or more (table 4).

DISCUSSION

In 1977, the Environmental Protection Agency found that soot emitted by diesel engines produced mutations in the Ames *Salmonella* bioassay (*6*). These direct-acting mutagens have been identified as nitroaromatic compounds, in particular, dinitropyrenes (*7*). Although much attention has been given to possible carcinogenic effects of diesel fumes on the human lung, there has been relatively little concern for the effects on other organs. Recently, however, there has been growing concern about reports of increased risk of bladder cancer among truck drivers (*1-2, 8-10*).

The present study of bladder cancer mortality in New Hampshire and Vermont found an OR of 1.5 for men ever employed as truck drivers, with a two- to threefold excess seen in men driving more than 5 years. These findings are similar to those found in all 10 areas of the National Bladder Cancer Study (OR=1.6 for truck drivers employed at least 10 yr) (*2*). Three other bladder cancer studies also report relative risks in the 1.4-2.0 range for truck driving (*8-10*). Data from one area of the National Bladder Cancer Study, Detroit, showed a five-fold increase in bladder cancer among men who drove trucks for 10 years or more (*1*). An association with mortality does not necessarily infer an association with incidence. However, the National Bladder Cancer Study and most of the other studies reporting an association between bladder cancer and truck driving were incidence-based studies.

This study relied on next-of-kin who may provide less complete occupational histories than living cases and controls. The next-of-kin reported an average of 5.1 jobs per study subject, whereas the living subjects in the National Bladder Cancer Study reported an average of 6.6 jobs in their lifetimes. The effects, if any, of this underreporting by the next-of-kin would probably be to underestimate an association rather than cause a spurious association.

It is not clear whether the excess bladder cancer risk is due to exposure to diesel emissions or some other factor associated with truck driving. The risks for truck drivers reporting exposure to diesel were higher than truck drivers who did not specify diesel exposure in the current study and the Detroit bladder cancer study. However, nondiesel truck drivers were also at increased risk in these studies. Diesels gained widespread use in the 1950's, yet the highest risks in New Hampshire and Vermont were seen among men who began driving before 1950. This finding is in contrast with the high risk among Detroit men who began truck driving after 1950.

Self-reported exposure to diesels in any occupation has been associated with excess bladder cancer risk in several studies. In New England, a duration-related excess was seen with an OR of 3.2 for men with 30-39 years of exposure to diesels. A Canadian case-control study observed an OR of 2.8 (95% CI=0.8,11.8) for men reporting exposure to diesel and traffic fumes (*11*). A Danish study reported an OR of 2.7 (95% CI=1.2,6.1) for men who worked with oil or gasoline (*12*). Finally, a British death certificate-based bladder cancer study found a relative risk of 1.7 (95% CI=0.9,3.3) for men exposed to diesel fumes, as determined by a job-exposure matrix (*13*). Meanwhile, a cohort study of retired railway workers did not find any excess of bladder cancer in men employed in occupations with heavy exposure to diesel fumes (*14*).

If truck driving were causally related to bladder cancer, it would explain 5% of the mortality in the current study, according to Cole and MacMahon's (*15*) method of calculating the population-attributable risk percent. In Hillsborough and Rutland, 17% of the bladder cancer mortality among men would be estimated to be attributable to truck driving. The reasons for the increase in the relative risk for truck driving in these two counties are unknown. Multiple comparisons were made; New Hampshire and Vermont have 24 counties. It is possible that chance alone is responsible for the higher OR seen in Hillsborough and Rutland.

Finally, truck driving does not explain the high

bladder cancer mortality in New Hampshire and Vermont relative to the rest of the United States. Approximately 12% of the men had ever been employed as truck drivers, as opposed to 20%, as estimated from the National Bladder Cancer Study (*2*).

In conclusion, this study confirms several others that have found an association between bladder cancer and truck driving. The association appears to be common to other motor exhaust-related occupations, such as bus drivers and taxi cab drivers (*1, 2, 8, 11*). Most of the studies report elevated risks of approximately the same magnitude, in the 1.4-2.8 range. Diesel exposure is unlikely to be the sole explanation, since the risks also occurred among non-diesel-exposed drivers. In the National Bladder Cancer Study and in the current study, increased relative risks for truck drivers were seen in more urbanized areas. This may be related to the inhalation of exhaust from nearby vehicles as drivers sit in congested traffic. The "traffic" theory may explain the risks seen in Detroit (*1*) and, at first glance, may seem to explain the elevated risk seen in Hillsborough and Rutland. However, although more congested than most of New Hampshire and Vermont, Hillsborough and Rutland are much less congested than cities like Detroit. The risks do not appear to be related to exposures from the trucks' cargo, since there was no association with the industry of truck driving. Also, the observed risks have not been due to confounding by known risk factors, such as cigarette smoking, coffee drinking, or employment in the leather and textile industry. The possible roles of other aspects of the urban road environment, truck driving life-style, such as urinary retention and concentrated cigarette smoke within the confined space of a truck cab, or medical conditions, such as benign prostatic hypertrophy, could not be evaluated in this study.

Future case-control studies of bladder cancer should continue to quantify the magnitude of the risk and its temporal and geographic variation. We are pursuing this finding by attempting to conduct industrial hygiene monitoring of truck drivers' exposures to urine mutagens and other biochemical and environmental factors.

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