Published in final edited form as:

Occup Environ Med. 2011 April ; 68(4): 239–249. doi:10.1136/oem.2009.052571.

Occupation and Bladder Cancer in a Population-Based Case-control Study in Northern New England

Joanne S. Colt¹, Margaret R. Karagas², Molly Schwenn³, Dalsu Baris¹, Alison Johnson⁴, Patricia Stewart⁵, Castine Verrill³, Lee E. Moore¹, Jay Lubin¹, Mary H. Ward¹, Claudine Samanic¹, Nathaniel Rothman¹, Kenneth P. Cantor⁶, Laura E. Beane Freeman¹, Alan Schned², Sai Cherala⁷, and Debra T. Silverman¹

¹ Division of Cancer Epidemiology and Genetics, National Cancer Institute, National Institutes of Health, Department of Health and Human Services, Bethesda, MD, USA

² Dartmouth Medical School, Hanover, NH

³ Maine Cancer Registry, Augusta, ME, USA

⁴ Vermont Cancer Registry, Burlington, VT, USA

⁵ Formerly of the National Cancer Institute, currently Stewart Exposure Assessments, LLC, USA

⁶ KP Cantor Environmental, LLC, Silver Spring, MD, USA

⁷ New Hampshire Department of Health and Human Services, Concord, NH, USA

Abstract

Objectives—We used data from a large, population-based case-control study in New England to examine relationships between occupation, industry, and bladder cancer risk.

Methods—Lifetime occupational histories were obtained by personal interview from 1,158 patients newly diagnosed with urothelial carcinoma of the bladder between 2001 and 2004 among residents of Maine, New Hampshire, and Vermont, and from 1,402 population controls selected from Department of Motor Vehicle records (ages 30 to 64 years) or Medicare beneficiary records (65 to 79 years). Unconditional logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs), adjusted for demographic factors, smoking, and employment in high-risk occupations other than the one being analyzed.

Results—Male precision metalworkers and metalworking/plasticworking machine operators had significantly elevated risks and significant trends in risk with duration of employment (precision metalworkers: OR=2.2; CI: 1.4, 3.4, $P_{\text{trend}}=0.0065$; metalworking/plasticworking machine operators: OR=1.6; CI: 1.01, 2.6, $P_{\text{trend}}=0.047$). Other occupations/industries for which risk increased significantly with duration of employment included: for men, textile machine operators, mechanics/repairers, automobile mechanics, plumbers, computer systems analysts, information clerks, and landscape and horticultural services industry workers; and for women, service occupations, health services, cleaning and building services, management-related occupations, electronic components and accessories manufacturing, and transportation equipment manufacturing. Men reporting use of metalworking fluids (MWF) had a significantly elevated bladder cancer risk (OR=1.7; 95% CI: 1.1, 2.5),

Address correspondence to: Joanne S. Colt, National Cancer Institute, Occupational and Environmental Epidemiology Branch, 6120 Executive Boulevard, Room 8002, Bethesda, MD 20892-7240; Phone number: (301) 435-4704; FAX number (301) 402-1819; coltj@mail.nih.gov.

Competing Interest: None declared.

Conclusions—Our findings for metalworkers and for MWF exposure support the hypothesis that some component(s) of MWF may be carcinogenic to the bladder in humans. Our results also corroborate many other previously-reported associations between bladder cancer risk and various occupations. More detailed analyses using information collected in job-specific questionnaires administered in this study may help to identify components of MWF that may be carcinogenic, and other bladder carcinogens to which people are exposed in a variety of occupations.

Keywords

bladder cancer; occupation; case-control study; epidemiology

INTRODUCTION

Occupational risk factors for bladder cancer have been examined in many studies. Although over 40 occupations have been associated with an elevated risk, the evidence is compelling for only a small number of occupations: dyestuffs workers and dye users, aromatic amine manufacturing workers, rubber workers, leather workers, painters, truck drivers, and aluminum workers. There is strong evidence of human bladder carcinogenicity for certain aromatic amines. Associations have been observed for several other occupational exposures, including polycyclic aromatic hydrocarbons (PAHs), diesel engine exhaust, leather dust, mineral oils, combustion and pyrolysis products, chlorinated solvents, creosote, herbicides/pesticides, and asbestos [1]. We used interview data from a large, population-based case-control study in New England, where bladder cancer mortality rates have been elevated for decades[2], to examine the relationships between occupation, industry, and bladder cancer risk. This study builds upon earlier studies of bladder cancer and occupation in this region[3–5] by studying disease incidence rather than mortality and by using detailed exposure assessment techniques. The extent to which occupational exposures might explain the New England bladder cancer excess will be examined as part of a broader effort integrating findings from this analysis with those for several other risk factors.

METHODS

Study population

The study was conducted in Maine, Vermont, and New Hampshire. All residents newly diagnosed with a histologically-confirmed carcinoma of the urinary bladder (including carcinoma *in situ*) at ages 30 to 79 years between September 1, 2001 and October 31, 2004 (Maine and Vermont) or between January 1, 2002 and July 31, 2004 (New Hampshire) were eligible for study. Rapid patient ascertainment in each state was conducted through hospital pathology departments, hospital cancer registries, and the state cancer registries. We interviewed 1,213 cases (65% of 1,878 eligible cases). Of non-participating cases, 50% refused, 22% were deceased, 12% were too ill, 5% did not speak English, 5% had a physician refusal, and 5% were not locatable. Based on a diagnostic slide review by the study's expert pathologist (AS), we excluded 20 patients determined not to have bladder cancer and 23 patients with non-urothelial carcinoma, leaving 1,170 cases.

Controls aged 30 to 64 years were selected randomly from Department of Motor Vehicle (DMV) records in each state, and controls aged 65 to 79 years were selected from beneficiary records of the Centers for Medicare and Medicaid Services (CMS). Controls were frequency matched to cases by state, gender, and age at diagnosis or control selection (within 5 years). We interviewed 1,418 (594 DMV and 824 CMS) controls (65% of eligible DMV and 65% of eligible CMS controls). Of non-participating controls, 70% and 65% of DMV and CMS controls, respectively, refused; 24% of DMV and 11% of CMS controls were not locatable; 3% of DMV and 10% of CMS controls did not speak English; 1% of

DMV and 7% of CMS controls were too ill; and 1% of DMV and 7% of CMS controls were deceased.

All respondents gave written informed consent to participate in this study. The study protocol was approved by the National Cancer Institute Special Studies Institutional Review Board, as well as the human subjects review boards of each participating institution.

Questionnaire data

Individuals who agreed to participate were asked to complete a mailed residence and work history calendar before the home visit. During the home visit, a trained interviewer reviewed the calendar and administered a computer-assisted personal interview (CAPI). The interviewer recorded all jobs held for at least 6 months since age 16, excluding unpaid jobs and absentee business ownership. For each job, participants were queried about the employer name and location, years started and ended, type of business, products made or services provided, and the participant's main duties, tools used, and chemicals handled. For certain occupations, job-specific questionnaires were administered to solicit detailed information about exposures of interest[6] (Appendix A). The CAPI also covered demographics, tobacco use, and other exposures.

A total of 1,158 of 1,170 cases (99%) and 1,402 of 1,418 controls (99%) were included in the analysis; the remainder had no qualifying jobs or were missing information on potential confounders.

Occupational coding and statistical analysis

We coded each job using the 1980 Standard Occupational Classification (SOC)[7] and the 1987 Standard Industrial Classification (SIC) [8] schemes. Using unconditional logistic regression models, we computed sex-specific odds ratios (ORs) and 95% confidence intervals (CIs) for bladder cancer for each two-, three-, and four-digit SOC and SIC code using SAS statistical software, version 9.1 (Cary, NC). For each OR, the reference group comprised those never employed in the occupation or industry. ORs were adjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic ethnicity (yes/no), state, smoking status (never, occasional [<100 cigarettes over the lifetime], former, current), and employment in a high-risk occupation other than the one being analyzed (ever/never). Occupations were identified as “high-risk” (see Appendix B) for men and women separately if ORs in this study were 1.5 or higher prior to the high-risk occupation adjustment and 10 or more individuals were employed; however, if a three-digit occupational code met these criteria but had substantial variation in risk among the four-digit codes it comprised, we selected only those four-digit codes with elevated risk, regardless of the number of people employed. We further evaluated smoking effects by replacing smoking status with smoking duration (never smoked, smoked occasionally, smoked for <10 years, 10–19 years, 20–29 years, 30–39 years, 40–49 years, 50+ years) and found minimal changes in the ORs; therefore, the final models were adjusted for smoking status only. ORs and 95% confidence intervals for ever/never employment in each SOC and SIC code are presented in the tables if the occupation or industry was held by at least 15 men or 15 women in our study and (1) had an OR that was either statistically significant or ≥ 2.0 or ≤ 0.5 in our study, or (2) is considered to be an *a priori* high-risk occupation (i.e., an occupation with multiple reports of elevated risk in the literature and/or listed in Schottenfeld and Fraumeni's textbook)[1] or Appendices B and C provide complete results for ever/never employment in all occupations and industries held by our study participants.

We assessed risk by duration of employment for occupations and industries with a significant association for ever/never employed. In addition to the reference category (never

held the job), two duration categories (with 5 or 10 years of employment as cutpoints) were used if fewer than 50 people held the job, and three (with 5 and either 10 or 15 years of employment as cutpoints) were used if there were 50+ people. Selection of cutpoints was job-specific, based on the distribution of years of employment. Tests of linear trend were performed by treating the median duration of employment among controls for each duration category as a continuous variable; participants who never held the job of interest were assigned a duration of zero.

For occupations with a significant positive trend in risk with increasing duration of employment, we examined the relationship between initial year of employment and bladder cancer risk if numbers permitted. We also tested for interactions between smoking and occupation by adding a cross-product term to the logistic model. Finally, because controls under age 65 were limited to those with driver's licenses, we also restricted the cases under age 65 to those with a valid driver's license at the time of diagnosis; the changes in the risk estimates were minimal and the results are not presented.

RESULTS

We focus mainly on occupations and industries with significant trends in risk with duration of employment. All statistically significant associations, both positive and negative, are shown in bold typeface in Tables 1 and 2.

Risk by SOC code

Among men, bladder cancer risk was significantly elevated (Table 1) and increased significantly with duration of employment (Table 3) in several *a priori* high-risk occupations: information clerks (SOC 464, OR=2.6, CI: 1.1, 6.5, $P_{\text{trend}}=0.011$), mechanics and repairers (SOC 61, OR=1.3, CI: 1.04, 1.6, $P_{\text{trend}}=0.0030$), vehicle and mobile equipment mechanics (SOC 611, OR=1.5, CI: 1.1, 2.0, $P_{\text{trend}}=0.0023$), automobile mechanics (SOC 6111, OR=1.6, CI: 1.05, 2.4, $P_{\text{trend}}=0.030$), precision metalworkers (SOC 681–682, OR=2.2, CI: 1.4, 3.4, $P_{\text{trend}}=0.0065$), machine operators and tenders (metal and plastic) (SOC 75, OR=1.6, CI: 1.05, 2.4, $P_{\text{trend}}=0.023$), metalworking/plasticworking machine operators (SOC 751–752, OR=1.6, CI: 1.01, 2.6, $P_{\text{trend}}=0.047$), and textile/apparel/furnishings machine operators (SOC 765, OR=2.0, CI: 1.2, 3.3, $P_{\text{trend}}=0.0013$). Plumbers/pipefitters/steamfitters (SOC 645), another *a priori* high-risk occupation, had a significant positive trend in risk ($P_{\text{trend}}=0.032$) and a nonsignificantly increased risk for ever/never employed (OR=1.5, CI: 0.8, 2.5). The only *a posteriori* high-risk occupation with a significant duration trend was computer systems analysts (SOC 1712, OR=4.4, CI: 1.3, 14, $P_{\text{trend}}=0.021$). Bladder cancer risk was significantly reduced among male accountants/auditors/financial specialists (SOC 141, OR=0.5, CI: 0.3, 0.9), with a significant negative trend with duration of employment ($P_{\text{trend}}=0.045$).

Among women, bladder cancer risk was significantly elevated (Table 1) and increased significantly with duration of employment (Table 3) in management-related occupations (SOC 14, OR=2.7, CI: 1.3, 5.5, $P_{\text{trend}}=0.0018$) and service occupations, except private household and protective (SOC 52, OR=1.6, CI: 1.1, 2.3, $P_{\text{trend}}=0.031$). Among the service occupations, risks were elevated in health services (SOC 523, OR=2.5, CI: 1.4, 4.4, $P_{\text{trend}}=0.0013$) and in cleaning and building service occupations (SOC 524, OR=3.7, CI: 1.8, 7.3, $P_{\text{trend}}=0.0010$) (both *a priori* high-risk occupations). Women in miscellaneous administrative support occupations (SOC 479) had a significantly reduced risk (OR=0.4, CI: 0.2, 0.8) with a significant duration effect ($P_{\text{trend}}=0.043$).

Risk by SIC code

Men in the landscape and horticultural services industry (SIC 078) had a significantly elevated risk of bladder cancer (OR=2.4, CI=1.2, 4.8) (Table 2) and a significant positive trend in risk with duration of employment ($P_{\text{trend}} = 0.023$) (Table 3), as did women in the electronic components and accessories industry (SIC 367, OR=2.2, CI: 1.1; 4.7, $P_{\text{trend}}=0.028$) and the transportation equipment industry (SIC 37, OR=8.7, CI: 2.0, 37, $P_{\text{trend}}=0.023$). Significant reductions in risk with significant duration effects were observed for men working as real estate agents/managers (SIC 6531, OR=0.5, CI: 0.3, 0.9, $P_{\text{trend}}=0.011$) and in nursing and personal care facilities (SIC 805, OR=0.3, CI: 0.1, 0.97, $P_{\text{trend}}=0.037$), and for women working in colleges and universities (SIC 8221, OR=0.05, CI: 0.2, 0.9, $P_{\text{trend}}=0.012$).

Risk by Decade First Employed

The overall increased risk among vehicle and mobile equipment mechanics, particularly automobile mechanics, was limited to men who began working before 1970 and was highest for those first employed before 1950 (Table 4). Only those plumbers/pipefitters/steamfitters first employed before 1960 were at elevated risk. The elevated risk for metalworking/plasticworking machine operators was evident only among men who first held this job before 1970. Men who first operated textile/apparel/furnishing machines in the 1950s had an eight-fold risk of bladder cancer that was statistically significant, but there was no discernable pattern in risk by year of first employment.

Interactions with Cigarette Smoking

The only occupation with a statistically significant smoking interaction was precision metalworking (Table 5). Although the interaction was not significant for metalworking/plastic working machine operators, the joint effect was stronger than an additive model would yield, with a six-fold risk among smokers compared to nonsmoking men never employed in that occupation. The elevated risk observed among male precision metalworkers and metalworking/plasticworking machine operators was evident only among smokers.

Exposure to Metalworking Fluids

The excess risk of bladder cancer among male precision metalworkers and metalworking/plasticworking machine operators prompted us to explore the association between metalworking fluids (MWF) and bladder cancer risk. These complex chemical mixtures are used as coolants and lubricants in the machining process and are characterized as: straight oils (typically mineral oil), soluble oils, semi-synthetic fluids (mineral oil emulsified in water), and synthetic fluids (water with organics and additives; no oil content). Using information from the occupational histories and job-specific questionnaires, we grouped study participants into four mutually exclusive categories: (1) people reporting use of MWF in a job-specific questionnaire; (2) people assessed as having possible exposure to MWF by the study's industrial hygienist (PS); (3) people assessed as having no exposure to MWF, but possible exposure to mineral oil; and (4) people assessed as having no exposure to either MWF or mineral oil (referent group). We observed statistically significant elevations in risk among men exposed to MWF (OR= 1.7, CI: 1.1, 2.5) and those with possible exposure to mineral oil (OR=1.3, CI: 1.1, 1.7) (Table 6).

DISCUSSION

Several occupations and industries were associated with a significantly elevated risk of bladder cancer in this study. Of particular note are the findings for precision metalworkers

and metalworking/plasticworking machine operators (most of whom worked with metals). There is strong *a priori* evidence of an excess bladder cancer risk among metalworkers[4,9–27], and this has been widely hypothesized to be attributable to MWF exposure. In our study, reported use of MWF carried a 70% excess risk of bladder cancer that was statistically significant, adding to the evidence that some of these fluids contain bladder carcinogens. However, changes over time in the composition and prevalence of use of the different MWF make it difficult to identify the components potentially associated with bladder cancer.

The early, “straight” MWF were typically mineral oils that contained PAHs, one class of possible bladder carcinogens[17,28,29]. PAH removal began in the 1950s[30] and levels were drastically lower by the mid-1980s[31]; however, small amounts may be created during machining [32]. Synthetic MWF, first marketed in the 1950s[31], contained nitrites and amine additives for corrosion inhibition, often leading to the formation of N-nitrosamines[32,33], which are bladder carcinogens in animal models[34]. Although nitrite was eliminated as an additive in the 1980s[31], nitrosamines are still found at low levels[35]. Synthetic MWF may also contain N-phenyl-2-naphthylamine[32] and other additives and contaminants. In our study, only those metalworking/plasticworking machine operators first employed before 1970 had an elevated risk, but it is not possible to distinguish between secular changes in exposure and latency effects in this study. A recent cohort study of automotive workers in Michigan found that exposure to straight MWF increased bladder cancer risk but was unable to determine whether this was attributable to PAH exposure; synthetic MWF were not associated with an elevated risk of bladder cancer in that study [36]. Also noteworthy in our study were the significant interaction between smoking and precision metalworking, and the observation that the increased bladder cancer risk was observed largely among smokers.

The trend in risk with duration of employment among male operators of textile/apparel/furnishing machines was highly statistically significant ($P_{\text{trend}}=0.0013$), with a ten-fold risk for long-term employment. Most of these jobs were in the textile industry or the leather industry, with higher risk in the latter (OR=3.3, 95% CI=1.4–8.0) than the former (OR=1.6, 95% CI=0.8–3.3) (not shown). Most of the textile machine operators in the leather industry worked in shoe manufacturing. There are many potential exposures in shoe manufacturing; leather dust and solvents are the most common. Many investigators have reported elevated bladder cancer risk among shoemakers/repairers[12,13,29,37–39], but it is unclear whether these studies included shoe manufacturers. Machine operators in the textile industry worked mostly in wool or cotton mills operating winding/twisting machines or knitting/weaving machines. The excess risk observed among operators of these types of machines is consistent with several previous studies[17,40–42]. Chemicals used in spinning and weaving areas have included mineral oils, polymers, and sizing agents[42,43].

The bladder cancer excess risk observed among male mechanics and repairers, particularly automobile mechanics, has been reported previously[9,12,17,23,27,29,44]. In our study, only those who started this work before 1970 had elevated risk. This could indicate that exposure to a carcinogen has diminished over time, or it could be a latency effect. The work environment of mechanics may involve exposure to many substances, including asbestos, oils and greases, metal dust, welding and soldering fumes, solvents, machining fluids, and paints[10,12,27,44–46].

Men working as plumbers for 15 years or more had a significantly elevated risk of bladder cancer in our study. Previous studies of plumbers have been inconsistent, with some reporting significant bladder cancer excesses[18,27] and others reporting nonsignificant excesses[4,10,37,47] or null findings[12,17,41,44,46]. Plumbers have been reported to be

exposed to many hazardous materials (e.g., lead and other welding fumes, various solvents, tar, greases, and asbestos), making it difficult to identify putative agents. Only those men who worked as plumbers before 1960 had an excess bladder cancer risk.

Risk was significantly elevated among men in the landscape and horticultural services industry, consistent with previous reports of excess bladder cancer risk among nursery workers, gardeners, and lawn care service employees[9,12,14,17,25,48,49]. Although it has been postulated that exposure to pesticides and/or fertilizers might be responsible, the evidence is conflicting; some studies of pesticides and fertilizers reported an elevated risk[14,17,50–54], while others did not[11,12,55,56].

We observed a significant, two-fold risk of bladder cancer among women in the electronic components and accessories industry that was attributable mainly to the manufacture of semiconductors and related devices. Employment in computer manufacturing, a related industry, was identified as a high-risk industry in Detroit women [57], but a study of cancer incidence among male and female workers in a semiconductor manufacturing plant and a plant manufacturing computer hard drives and other electronic storage devices did not observe a bladder cancer excess [58]. Workers in the semiconductor and computer manufacturing industries may have been exposed to a variety of known or suspected carcinogens, including metals (arsenic, nickel, chromium), electromagnetic fields, asbestos, acids, and various solvents [58,59].

Risk was not significantly elevated among male construction/maintenance painters in our study, contrary to several previous studies[23,27,60,61]. However, when we identified men who had worked as painters (construction and maintenance painters; coating/painting/spraying machine operators; painting supervisors; or hand painting, coating and decorating occupations) and whose job titles or reported duties, tools, or exposures indicated that they had performed spray painting, there were many more cases (n=14) than controls (n=5). Several other investigators have reported elevated risks for spray painters [11,12,14,52], who have been reported to be exposed to many known or suspected carcinogens, including solvents and metals.

The strengths of our study include the population-based design and ascertainment of complete occupational histories from direct interviews with study participants, and the ability to adjust for smoking, employment in high-risk occupations, and other risk factors. Limitations include the small number of people in many occupations and industries, and the large number of comparisons performed, allowing for chance associations. We reduced the number of comparisons and therefore the likelihood of chance findings to some extent by restricting the analysis to occupations held by at least 15 participants of a single gender, but it is likely that some of the significant associations reported here arose by chance. The 65% participation rate for cases and controls can be viewed as a limitation; however, because study participation is unlikely to have differed between cases and controls in an exposure-dependent manner, we do not believe that this led to bias in the risk estimates. Assigning SOC and SIC codes was challenging for some jobs because of limitations in the information available from the interview; coders were blinded to case-control status and any misclassification was likely to be nondifferential.

Finally, occupation and industry titles are only a crude surrogate for exposures. An individual job or industry title may be associated with a wide range of exposures, and grouping people with a given job title who may be highly exposed with those potentially unexposed attenuates the strength of an association.

In conclusion, our results lend support to the hypothesis that some as yet unidentified components of MWF are carcinogenic to the bladder in humans and corroborate many other

previously-reported associations between bladder cancer risk and various occupations. More detailed analyses using information collected in job-specific questionnaires administered in this study may help to identify components of MWF that may be carcinogenic, and other bladder carcinogens to which people are exposed in a variety of occupations.

What this paper adds

- Over 40 occupations have been associated with an elevated risk of bladder cancer in epidemiologic studies, but the evidence is compelling for only a few.
- A large, population-based case-control study with lifetime occupational histories and detailed exposure assessment techniques provided the opportunity to further examine occupational risk factors for bladder cancer.
- Men reporting use of metalworking fluids (MWF) had a significantly elevated bladder cancer risk, supporting the hypothesis that these fluids contain bladder carcinogens and contribute to the often observed association between bladder cancer and metalworking.
- Significant findings were observed for many other occupations/industries, including: for men, textile machine operators, automobile mechanics, plumbers, and landscape workers; and for women, health services, cleaning and building services, electronic components manufacturing, and transportation equipment manufacturing.

More detailed analyses using information collected in job-specific questionnaires administered in this study may help to identify components of MWF that may be carcinogenic, and other bladder carcinogens to which people are exposed in a variety of occupations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Silverman, DT.; Devesa, SS.; Moore, LE., et al. Bladder cancer. In: Schottenfeld, D.; Fraumeni, JF., editors. *Cancer Epidemiology and Prevention*. New York, Oxford: Oxford University Press; 2006. p. 1101-27.
2. Devesa, SS.; Grauman, DG.; Blot, WJ., et al. *Atlas of Cancer Mortality in the United States, 1950–1994*. Washington, D.C: U.S. Government Printing Office, NIH Publication No. 199–4564; 1999.
3. Brown LM, Zahm SH, Hoover RN, et al. High bladder cancer mortality in rural New England (United States): an etiologic study. *Cancer Cause Control* 1995;6:361–8.
4. Colt JS, Baris D, Stewart P, et al. Occupation and bladder cancer risk in a population-based case-control study in New Hampshire. *Cancer Cause Control* 2004;15:759–69.
5. Hoar SK, Hoover RN. Truck driving and bladder cancer mortality in rural New England. *JNCI* 1985;74:771–4. [PubMed: 3857373]
6. Stewart PA, Stewart WF, Heineman EF, et al. A novel approach to data collection in a case-control study of cancer and occupational exposures. *Int J Epidemiol* 1996;25 (4):744–52. [PubMed: 8921451]
7. U.S. Department of Commerce. *Standard Occupational Classification Manual*. Washington, D.C: Office of Federal Statistical Policy and Standards; 1980.
8. Office of Management and Budget. *Standard Industrial Classification Manual*. Washington, D.C: Executive Office of the President; 1987.

9. Band PR, le ND, MacArthur AC, et al. Identification of occupational cancer risks in British Columbia: a population-based case-control study of 1129 cases of bladder cancer. *J Occup Environ Med* 2005;47:854–8. [PubMed: 16093936]
10. Brownson RC, Chang JC, Davis JR. Occupation, smoking, and alcohol in the epidemiology of bladder cancer. *Am J Pub Health* 1987;77:1298–300. [PubMed: 3631363]
11. Claude JC, Frentzel-Beyme RR, Kunze E. Occupation and risk of cancer of the lower urinary tract among men. A case-control study. *Int J Cancer* 1988;41:371–9. [PubMed: 3346100]
12. Cordier S, Clavel J, Limasset JC, et al. Occupational risks of bladder cancer in France: A multicentre case-control study. *Int J Epidemiol* 1993;22:402–11.
13. Dolin PJ, Cook-Mozaffari P. Occupation and bladder cancer: a death-certificate study. *Br J Cancer* 1992;66:568–78. [PubMed: 1520596]
14. Howe GR, Burch JD, Miller AB, et al. Tobacco use, occupation, coffee, various nutrients, and bladder cancer. *JNCI* 1980;64:701–13. [PubMed: 6928984]
15. Iscovich J, Castelletto R, Esteve J, et al. Tobacco smoking, occupational exposure and bladder cancer in Argentina. *Int J Cancer* 1987;40:734–40. [PubMed: 3692621]
16. Kabat GC, Dieck GS, Wynder EL. Bladder cancer in nonsmokers. *Cancer* 1986;57 (3):362–7. [PubMed: 3942969]
17. Kogevinas M, 't Mannetje A, Cordier S, et al. Occupation and bladder cancer among men in Western Europe. *Cancer Cause Control* 2003;14:907–14.
18. Malker HS, McLaughlin JK, Silverman DT, et al. Occupational risks for bladder cancer among men in Sweden. *Cancer Res* 1987;47:6763–6. [PubMed: 3677105]
19. Porru S, Aulenti V, Donato F, et al. Bladder cancer and occupation: a case-control study in northern Italy. *Occup Environ Med* 1996;53:6–10. [PubMed: 8563860]
20. Schifflers E, Jamart J, Renard V. Tobacco and occupation as risk factors in bladder cancer: a case-control study in southern Belgium. *Int J Cancer* 1987;39:287–92. [PubMed: 3818120]
21. Schulz MR, Loomis D. Occupational bladder cancer mortality among racial and ethnic minorities in 21 states. *Am J Ind Med* 2000;38:90–8. [PubMed: 10861770]
22. Silverman DT, Hoover RN, Albert S, et al. Occupation and cancer of the lower urinary tract in Detroit. *JNCI* 1983;70:237–45. [PubMed: 6571931]
23. Silverman DT, Levin LI, Hoover RN, et al. Occupational risks of bladder cancer in the United States: I. White men *JNCI* 1989;81:1472–80.
24. Steenland K, Burnett C, Osorio AM. A case-control study of bladder cancer using city directories as a source of occupational data. *Am J Epidemiol* 1987;126:247–57. [PubMed: 3605053]
25. Teschke K, Morgan MS, Checkoway H, et al. Surveillance of nasal and bladder cancer to locate sources of exposure to occupational carcinogens. *Occup Environ Med* 1997;54:443–51. [PubMed: 9245952]
26. Vineis P, Di PS. Cutting oils and bladder cancer. *Scand J Work Environ Health* 1983;9 (5):449–50. [PubMed: 6673102]
27. Zheng T, Cantor KP, Zhang Y, et al. Occupation and bladder cancer: a population-based, case-control study in Iowa. *J Occup Environ Med* 2002;44:685–91. [PubMed: 12134533]
28. Boffetta P, Jourenkova N, Gustavsson P. Cancer risk from occupational exposure to polycyclic aromatic hydrocarbons. *Cancer Cause Control* 1997;8:444–72.
29. Bonassi S, Merlo F, Pearce N, et al. Bladder cancer and occupational exposure to polycyclic aromatic hydrocarbons. *Int J Cancer* 1989;44:648–51. [PubMed: 2793238]
30. Calvert GM, Ward E, Schnorr TM, et al. Cancer risks among workers exposed to metalworking fluids: A systematic review. *Am J Ind Med* 1998;33:282–92. [PubMed: 9481427]
31. Childers, JC. The Chemistry of Metalworking Fluids. In: Ed Byers, JP., editor. *Metalworking Fluids*. 2. Vol. Chapter 6. New York: CRC Taylor and Francis; 2006.
32. Tolbert PE. Oils and cancer. *Cancer Cause Control* 1997;8 (3):386–405.
33. Fan TY, Morrison J, Rounbehler DP, et al. N-Nitrodiethanolamine in synthetic cutting fluids: a part-per-hundred impurity. *Science* 1977;196:71–2. [PubMed: 841342]
34. Bryan GT. The pathogenesis of experimental bladder cancer. *Cancer Res* 1977;37:2813–6. [PubMed: 326392]

35. Woskie SR, Virji MA, Hallock M, et al. Summary of the findings from the exposure assessments for metalworking fluid mortality and morbidity studies. *Appl Occup Environ Hyg* 2003;18:855–64. [PubMed: 14555438]
36. Friesen MC, Costello S, Eisen EA. Quantitative exposure to metalworking fluids and bladder cancer incidence in a cohort of autoworkers. *Am J Epidemiol* 2009;169 (12):1471–8. [PubMed: 19414495]
37. Baxter PJ, McDowall ME. Occupation and cancer in London: an investigation into nasal and bladder cancer using the Cancer Atlas. *Br J Ind Med* 1986;43:44–9. [PubMed: 3947560]
38. Lohi J, Kyyronen P, Kauppinen T, et al. Occupational exposure to solvents and gasoline and risk of cancers in the urinary tract among Finnish workers. *Am J Ind Med* 2008;51:668–72. [PubMed: 18561141]
39. Vineis P, Magnani C. Occupation and bladder cancer in males: a case-control study. *Int J Cancer* 1985;35:599–606. [PubMed: 3997281]
40. Carpenter L, Roman E. Cancer and occupation in women: Identifying associations using routinely collected data. *Environ Health Perspec* 1999;107:299–303.
41. González CA, López-Abente G, Errezola M, et al. Occupation and bladder cancer in Spain: a multi-centre case-control study. *Int J Epidemiol* 1989;18:569–77. [PubMed: 2681016]
42. Serra C, Kogevinas M, Silverman DT, et al. Work in the textile industry in Spain and bladder cancer. *Occup Environ Med* 2008;65 (5):552–9. [PubMed: 18045847]
43. Maffi L, Vineis P. Occupation and bladder cancer in females. *Med Lav* 1986;77:511–4. [PubMed: 3796432]
44. Gaertner RR, Trpeski L, Johnson KC, et al. A case-control study of occupational risk factors for bladder cancer in Canada. *Cancer Cause Control* 2004;15:1007–19.
45. Hansen ES. Mortality of auto mechanics. *Scand J Work Environ Health* 1989;15:43–6. [PubMed: 2922588]
46. Samanic CM, Kogevinas M, Silverman DT, et al. Occupation and bladder cancer in a hospital-based case-control study in Spain. *Occup Environ Med* 2008;65:347–53. [PubMed: 17951336]
47. Burns PB, Swanson GM. Risk of urinary bladder cancer among blacks and whites: the role of cigarette use and occupation. *Cancer Cause Control* 1991;2:371–9.
48. Silverman DT, McLaughlin JK, Malker HS, et al. Bladder cancer and occupation among Swedish women. *Am J Ind Med* 1989;16:239–40. [PubMed: 2773951]
49. Zahm SH. Mortality study of pesticide applicators and other employees of a lawn care service company. *J Occup Environ Med* 1997;39:1055–67. [PubMed: 9383716]
50. Akdas A, Kirkali Z, Bilir N. Epidemiological case-control study on the etiology of bladder cancer in Turkey. *Eur Urol* 1990;17:23–6. [PubMed: 2318234]
51. Fincham SM, Hanson J, Berkel J. Patterns and risks of cancer in farmers in Alberta. *Cancer* 1992;69:1276–85. [PubMed: 1739927]
52. La Vecchia C, Negri E, D'Avanzo B, et al. Occupation and the risk of bladder cancer. *Int J Epidemiol* 1990;19:264–8. [PubMed: 2376434]
53. Ugnat A-M, Luo W, Semenciw R, et al. Occupational exposure to chemical and petrochemical industries and bladder cancer risk in four western Canadian provinces. *Chronic Diseases in Canada* 2004;25:7–15. [PubMed: 15554606]
54. Viel F-F, Challier B. Bladder cancer among French farmers: does exposure to pesticides in vineyards play a part? *Occup Environ Med* 1995;52:587–92. [PubMed: 7550798]
55. Barbone F, Franceschi S, Talamini R, et al. Occupation and bladder cancer in Pordenone (north-east Italy): a case-control study. *Int J Epidemiol* 1994;23:58–65. [PubMed: 8194925]
56. Schoenberg JB, Stemhagen A, Mogielnicki AP, et al. Case-control study of bladder cancer in New Jersey. I. Occupational exposures in white males. *JNCI* 1984;72:973–81. [PubMed: 6585596]
57. Swanson GM, Burns PB. Cancer incidence among women in the workplace: a study of the association between occupation and industry and 11 cancer sites. *J Occup Environ Med* 1995;37:282–7. [PubMed: 7796194]
58. Bender TJ, Beall C, Cheng H, et al. Cancer incidence among semiconductor and electronic storage device workers. *Occup Environ Med* 2007;64 (1):30–6. [PubMed: 16847035]

59. Clapp RW. Mortality among US employees of a large computer manufacturing company: 1969–2001. *Environ Health* 2006;5:30. [PubMed: 17052328]
60. Jensen OM, Wahrendorf J, Knudsen JB, et al. The Copenhagen case-referent study on bladder cancer. *Scand J Work Environ Health* 1987;13:129–34. [PubMed: 3602967]
61. Steenland K, Palu S. Cohort mortality study of 57,000 painters and other union members: a 15-year update. *Occup Environ Med* 1999;56:315–21. [PubMed: 10472305]

Table 1

Risk of Bladder Cancer by Occupation (SOC), by Sex, New England, 2001–2004^a

		Men (n=895 Cases, 1,031 Controls)				Women (n=263 Cases, 371 Controls)			
SOC	Occupation	Cases	Cont	OR	95% CI	Cases	Cont	OR	95% CI
A Priori High-Risk Occupations									
141	Accountants, auditors, and other financial specialists	22	51	0.5	0.3-0.9	8	8	2.2	0.8-6.6
162-3	Engineers	55	85	0.7	0.5-1.1	1	0	--	--
	1634 Industrial engineers	12	7	2.2	0.8-5.8	0	0	--	--
29	Registered nurses	2	3	--	--	13	25	0.9	0.4-2.0
42	Sales occupations, commodities except retail	48	66	0.9	0.6-1.3	3	3	--	--
43	Sales occupations, retail	114	125	1.1	0.8-1.5	74	115	1.0	0.7-1.5
	4359 Salespersons, NEC	7	15	0.5	0.2-1.3	5	13	0.7	0.2-2.0
46-47	Administrative support occupations, including clerical	209	264	0.9	0.8-1.2	124	191	0.7	0.5-0.99
	462 Secretaries, stenographers and typists	4	12	0.3	0.1-1.1	58	66	1.3	0.8-2.0
	464 Information clerks	13	9	2.6	1.1-6.5	13	30	0.7	0.3-1.4
	471 Financial record processing occupations	18	35	0.6	0.3-1.2	42	47	2.4	1.4-4.0
	4713 Payroll and timekeeping clerks	4	12	0.4	0.1-1.3	2	6	0.3	0.1-1.5
	479 Misc. administrative support occupations, including clerical	11	14	1.0	0.4-2.3	17	46	0.4	0.2-0.8
51	Protective service occupations	71	83	0.9	0.7-1.3	4	5	--	--
	5123 Firefighting occupations	13	21	0.7	0.3-1.5	0	0	--	--
	514 Guards	34	32	1.1	0.6-1.8	3	3	--	--
5214	Cooks, except short order	31	36	0.9	0.5-1.5	13	18	0.8	0.4-1.9
5215	Short-order cooks	15	10	1.6	0.7-3.7	3	6	--	--
5216	Food counter, fountain, and related occupations	11	7	2.6	1.0-7.2	12	18	0.9	0.4-2.1
523	Health service occupations	29	29	1.3	0.7-2.3	38	36	2.5	1.4-4.4
524	Cleaning and building service occupations, except private household	82	65	1.8	1.3-2.6	28	19	3.7	1.8-7.3
	5242 Maids and housemen	2	1	--	--	17	10	2.5	1.02-6.1
	5244 Janitors and cleaners	70	52	1.4	1.0-2.1	11	7	2.7	0.9-8.0
5253	Hairdressers and cosmetologists	1	1	--	--	7	10	1.7	0.6-5.3
5622	Groundskeepers and gardeners, except farm	31	45	0.8	0.5-1.4	2	1	--	--

SOC	Occupation	Men (n=895 Cases, 1,031 Controls)				Women (n=263 Cases, 371 Controls)			
		Cases	Cont	OR	95% CI	Cases	Cont	OR	95% CI
61	Mechanics and repairers	217	212	1.3	1.04–1.6	2	4	–	–
	611 Vehicle and mobile equipment mechanics and repairers	119	110	1.5	1.1–2.0	1	1	–	–
	6111 Automobile mechanics	59	46	1.6	1.05–2.4	0	0	–	–
	615 Electrical and electronic machinery repairers	58	49	1.5	1.02–2.3	0	1	–	–
64	Construction trades	186	204	1.1	0.8–1.3	5	1	–	–
	641 Brickmasons, stonemasons, and hard tile setters	13	8	2.2	0.9–5.6	0	0	–	–
	6422 Carpenters	67	88	0.8	0.5–1.1	2	0	–	–
	6432 Electricians	19	20	1.1	0.6–2.1	0	0	–	–
	6442 Painters (construction and maintenance)	19	21	1.0	0.5–2.1	1	0	–	–
	645 Plumbers, pipefitters, and steamfitters	33	25	1.5	0.8–2.5	0	0	–	–
681-2	Precision metalworkers	53	37	2.2	1.4–3.4	0	2	–	–
	6813 Machinists	23	17	1.6	0.8–3.1	0	1	–	–
683	Precision woodworkers	7	12	0.7	0.2–1.7	0	1	–	–
763	Woodworking machine operators and tenders	15	18	0.8	0.4–1.7	3	4	–	–
687	Precision food production occupations	15	24	0.7	0.3–1.4	2	0	–	–
	6871 Butchers and meat cutters	11	14	0.9	0.4–2.0	0	0	–	–
6931	Stationary engineers	11	8	1.5	0.6–3.9	0	0	–	–
73	Machine setup operators (metals and plastics)	14	7	2.3	0.9–5.9	2	0	–	–
75	Machine operators and tenders (metals and plastics)	58	50	1.6	1.05–2.4	7	6	–	–
	751-2 Metalworking and plasticworking machine operators & tenders	47	35	1.6	1.01–2.6	5	3	–	–
	7529 Miscellaneous metalworking/plasticworking machine operators	14	6	2.8	1.002–7.6	0	1	–	–
764	Printing machine operators and tenders	9	17	0.5	0.2–1.2	2	4	–	–
765	Textile, apparel and furnishings machine operators & tenders	46	29	2.0	1.2–3.3	27	32	1.0	0.6–1.9
77	Fabricators, assemblers, and hand working occupations	109	104	1.1	0.8–1.5	36	40	1.4	0.8–2.3
	7714 Welders and cutters	21	20	1.0	0.5–2.0	1	1	–	–
821	Motor vehicle operators	202	208	1.0	0.8–1.3	8	9	1.0	0.3–2.8
	8212 Truck drivers, tractor-trailer	54	69	0.9	0.6–1.3	1	0	–	–
	8213 Truck drivers, heavy	57	47	1.3	0.9–2.0	1	0	–	–

SOC	Occupation	Men (n=895 Cases, 1,031 Controls)				Women (n=263 Cases, 371 Controls)			
		Cases	Cont	OR	95% CI	Cases	Cont	OR	95% CI
	8214 Truck drivers, light	43	56	0.8	0.5–1.2	2	2	--	--
	8216 Taxicab drivers and chauffeurs	23	21	1.1	0.6–2.0	1	1	--	--
8243	Sailors and deckhands	19	13	1.7	0.8–3.6	0	0	--	--
873	Garage and service station related occupations	42	44	1.0	0.7–1.6	0	2	--	--
91	Military occupations	180	170	1.3	1.02–1.7	2	0	--	--
A Posteriori High- and Low-Risk Occupations									
1352	Managers, entertainment and recreation facilities	4	13	0.3	0.1–0.97	0	4	--	--
14	Management-related occupations	54	95	0.7	0.5–0.9	20	20	2.7	1.3–5.5
	144 Purchasing agents and buyers	7	15	0.5	0.2–1.2	2	3	--	--
1712	Computer systems analysts	13	4	4.4	1.3–14	0	2	--	--
20	Social, recreation and religious workers	18	28	0.8	0.4–1.6	13	8	2.4	0.9–6.5
	203 Social and recreation workers	10	15	0.7	0.3–1.8	12	7	2.6	0.9–7.7
	2032 Social workers	8	8	1.0	0.4–3.0	10	6	2.6	0.8–8.3
22	Teachers, college, university and other postsecondary institution	25	35	1.3	0.8–2.3	6	23	0.5	0.2–1.3
	223 Teachers, health specialties/business/agriculture/art/music/English	11	6	3.9	1.4–11	3	13	0.6	0.1–2.1
232	Elementary school teachers	3	12	0.4	0.1–1.4	7	15	0.7	0.3–2.0
32	Writers, artists, performers and related workers	24	33	1.2	0.7–2.0	12	8	3.7	1.4–10
	322 Designers	5	16	0.4	0.2–1.3	7	5	--	--
372	Drafting occupations	28	18	2.0	1.05–3.7	0	2	--	--
473	Communications equipment operators	9	3	--	--	10	24	0.5	0.2–1.0
	4732 Telephone operators	6	1	--	--	9	22	0.4	0.2–1.1
474	Mail and message distribution occupations	44	43	1.2	0.8–2.0	8	7	2.4	0.8–7.4
478	Adjusters, investigators, and collectors	13	16	1.5	0.7–3.2	9	6	2.4	0.8–7.3
50	Private household occupations	1	4	--	--	15	16	2.7	1.2–6.1
52	Service occupations, except private household and protective	216	204	1.5	1.2–1.9	125	152	1.6	1.1–2.3
58	Fishers, hunters, and trappers	17	11	2.1	0.9–4.7	0	1	--	--
6157	Telephone line installers and repairers	14	8	2.2	0.8–5.5	0	0	--	--
6313	Supervisors, carpenters and related workers	5	14	0.4	0.1–1.1	0	0	--	--

SOC	Occupation	Men (n=895 Cases, 1,031 Controls)			Women (n=263 Cases, 371 Controls)		
		Cases	Cont	OR	95% CI	OR	95% CI
78	Production inspectors, testers, samplers, and weighers	29	41	0.8	0.5–1.3	14	3.6
	782 Production inspectors, checkers, and examiners	16	25	0.6	0.3–1.3	12	2.2
81	Supervisors, transportation and material moving occupations	9	7	2.1	0.8–5.9	0	--

CI = Confidence interval; OR = Odds ratio; SOC = Standard Occupational Classification

Bold = statistically significant association

^a Adjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic ethnicity (yes/no), state (Maine, New Hampshire, Vermont), smoking status (never, occasional [<100 cigarettes over lifetime], former, current), and employment in high-risk occupations other than the one being analyzed (ever/never).

Table 2

Risk of Bladder Cancer by Industry (SIC), by Sex, New England, 2001–2004^a

SIC	Industry	Men (n=895 Cases, 1,031 Controls)				Women (n=263 Cases, 371 Controls)			
		Cases	Cont	OR	95% CI	Cases	Cont	OR	95% CI
078	Landscape and horticultural services	25	14	2.4	1.2–4.8	1	3	--	--
1629	Heavy construction, NEC	13	9	2.0	0.8–5.1	0	0	--	--
201	Meat products	11	4	2.8	0.8–9.4	1	2	--	--
202	Dairy products	8	16	0.4	0.2–1.0	2	0	--	--
205	Bakery products	6	12	0.4	0.2–1.3	0	1	--	--
361	Electric transmission and distribution equipment	4	12	0.3	0.1–1.1	3	0	--	--
367	Electronic components and accessories	38	31	1.4	0.8–2.3	25	15	2.2	1.1–4.7
	3674 Semiconductors and related devices	9	11	1.1	0.4–2.8	10	5	2.5	0.7–8.5
37	Transportation equipment	106	123	0.8	0.6–1.1	12	3	8.7	2.0–37
38	Instruments and related products	38	55	0.8	0.5–1.3	4	11	0.4	0.1–1.4
	382 Laboratory apparatus and analytical, optical, measuring, and controlling instruments	7	17	0.4	0.1–0.97	1	3	--	--
39	Miscellaneous manufacturing industries	24	17	1.7	0.9–3.3	5	13	0.3	0.1–0.98
4215	Courier services, except by air	6	9	0.5	0.2–1.4	1	0	--	--
451	Air transportation, scheduled, and air courier services	10	7	2.4	0.8–6.7	2	3	--	--
4813	Telephone communications, except radiotelephone	19	20	0.9	0.5–1.8	9	19	0.5	0.2–1.2
506	Electrical goods	6	13	0.4	0.2–1.2	1	1	--	--
5143	Dairy products, except dried or canned	14	5	3.3	1.1–9.4	0	0	--	--
5149	Groceries and related products, NEC	9	20	0.4	0.2–0.9	3	0	--	--
5211	Lumber and other building materials	8	15	0.5	0.2–1.2	1	2	--	--
5531	Auto and home supply stores	11	23	0.4	0.2–0.8	1	2	--	--
571	Home furniture and furnishing stores	8	16	0.5	0.2–1.2	9	4	--	--
	5712 Furniture stores	3	13	0.3	0.1–0.97	3	3	--	--
5813	Drinking places	4	12	0.3	0.1–0.9	1	2	--	--
596	Nonstore retailers	7	15	0.5	0.2–1.3	5	12	0.6	0.2–1.8
599	Retail stores, NEC	6	14	0.4	0.1–1.0	5	4	--	--

		Men (n=895 Cases, 1,031 Controls)				Women (n=263 Cases, 371 Controls)			
SIC	Industry	Cases	Cont	OR	95% CI	Cases	Cont	OR	95% CI
62	Security, commodity brokers, and service	3	13	0.3	0.1–1.0	3	1	--	--
6311	Life insurance	11	6	2.6	0.9–7.3	7	3	--	--
6531	Real estate agents and managers	16	34	0.5	0.3–0.9	7	9	1.1	0.3–3.5
70	Hotels, rooming houses, camps, and other lodging	33	57	0.6	0.4–0.9	23	17	1.7	0.8–3.6
	7011 Hotels and motels	23	46	0.5	0.3–0.9	19	13	1.6	0.7–3.8
7629	Electrical and electronic repair shops, NEC	12	4	3.3	1.01–11	0	2	--	--
7699	Repair shops and related services, NEC	16	9	2.0	0.8–4.7	0	2	--	--
80	Health services	59	73	1.0	0.7–1.5	77	119	0.7	0.5–0.99
	805 Nursing and personal care facilities	4	15	0.3	0.1–0.97	32	32	1.0	0.6–1.8
81	Legal services	9	10	1.7	0.6–4.5	11	7	2.4	0.8–6.9
822	Colleges, universities, professional schools, junior colleges	54	64	1.2	0.8–1.8	16	46	0.4	0.2–0.8
	8221 Colleges and universities	52	61	1.2	0.8–1.9	16	43	0.5	0.2–0.9
	8231 Libraries	1	2	--	--	3	13	0.4	0.1–1.4
8361	Residential care	5	9	--	--	11	4	3.5	1.0–13
91	Executive, legislative and general government	11	16	1.0	0.4–2.2	13	11	2.0	0.8–4.9

CI = Confidence interval; OR = Odds ratio; SOC = Standard Occupational Classification

Bold = statistically significant association

^a Adjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic ethnicity (yes/no), state (Maine, New Hampshire, Vermont), smoking status (never, occasional [<100 cigarettes over lifetime], former, current), and employment in high-risk occupations other than the one being analyzed (ever/never).

Table 3

Risk of Bladder Cancer by Duration of Employment for Occupations and Industries with Significant Duration Trends, New England, 2001–2004^{a,b}

		Duration (yr)	Case ^c	Conf ^c	OR	95% CI	Trend test (P)
OCCUPATION, MEN							
<i>A Priori High-risk Occupations</i>							
SOC 141	Accountants, auditors, and other financial specialists	<5	7	13	0.6	0.2–1.5	
		5–<15	6	17	0.5	0.2–1.4	
		15+	9	21	0.5	0.2–1.1	0.045
SOC 464	Information clerks	<5	8	8	1.5	0.5–4.2	
		5–	5	1	14.5	1.6–129	0.011
SOC 61	Mechanics and repairers	<5	60	65	1.1	0.8–1.6	
		5–<15	65	71	1.1	0.8–1.6	
		15+	92	76	1.7	1.2–2.4	0.0030
SOC 611	Vehicle and mobile equipment mechanics and repairers	<5	41	41	1.4	0.9–2.2	
		5–<15	38	37	1.2	0.7–2.0	
		5–	40	32	2.1	1.3–3.5	0.0023
SOC 6111	Automobile mechanics	<5	25	22	1.4	0.7–2.5	
		5–<15	17	12	1.6	0.7–3.4	
		5–	17	12	2.1	0.98–4.6	0.030
SOC 645	Plumbers, pipefitters, and steamfitters	<5	11	10	1.0	0.4–2.5	
		5–<15	8	10	1.2	0.4–2.7	
		15+	14	5	3.3	1.1–9.6	0.032
SOC 681-2	Precision metalworkers	<5	14	11	1.9	0.8–4.3	
		5–<10	19	12	2.4	1.1–5.1	
		10+	20	14	2.2	0.98–4.6	0.0065
SOC 75	Machine operators and tenders (metal and plastic)	<5	33	29	1.6	0.95–2.8	
		5–<10	10	12	0.8	0.3–2.0	
		10+	15	9	2.8	1.2–6.6	0.023
SOC 751-2	Metalworking/plasticworking machine operators/tenders	<5	26	22	1.5	0.8–2.7	
		5–<10	8	6	1.4	0.4–4.1	
		10+	13	7	2.4	0.9–6.3	0.047

		Duration (yr)	Case ^c	Cont ^c	OR	95% CI	Trend test (P)
SOC 765	Textile/apparel/furnishing machine operators/tenders	<5	24	18	1.6	0.8–3.1	
		5–<10	9	9	1.2	0.4–3.1	
		10+	13	2	10.3	2.2–48	0.0013
<u>A Posteriori High- and Low-risk Occupations</u>							
SOC 1712	Computer systems analysts	<10	5	2	2.7	0.5–15	
		10+	8	2	6.3	1.2–33	0.021
<u>OCCUPATION, WOMEN</u>							
<u>A Priori High-risk Occupations</u>							
SOC 523	Health service occupations	<5	14	19	1.6	0.7–3.5	
		5–<10	14	10	3.0	1.2–7.3	
		10+	10	7	4.4	1.5–12	0.0013
SOC 524	Cleaning and building service occup., exc. private household	<5	12	9	3.0	1.2–7.9	
		5+	16	10	4.4	1.7–11	0.0010
<u>A Posteriori High- and Low-risk Occupations</u>							
SOC 14	Management-related occupations	<10	10	16	1.6	0.7–3.9	
		10+	10	4	7.1	2.0–25	0.0018
SOC 479	Misc. administrative support occupations, inc. clerical	<5	11	27	0.5	0.2–1.2	
		5–<15	5	11	0.4	0.1–1.4	
		15+	1	8	0.2	0.02–1.6	0.043
SOC 52	Service occup., exc. private household and protective	<5	55	74	1.4	0.9–2.3	
		5–<15	40	42	1.7	1.01–2.9	
		15+	30	36	1.9	1.06–3.5	0.031
<u>INDUSTRY, MEN</u>							
SIC 078	Landscape and horticultural services	<5	9	9	1.8	0.7–4.7	
		5+	16	5	3.3	1.1–9.6	0.023
SIC 6531	Real estate agents and managers	<5	6	13	0.5	0.2–1.4	
		5–<10	6	5	1.4	0.4–4.9	
		10+	4	16	0.2	0.1–0.7	0.011
SIC 805	Nursing and personal care facilities	<5	4	4	1.4	0.3–6.0	
		5+	0	11	--	--	0.037
<u>INDUSTRY, WOMEN</u>							

		Duration (yr)	Case ^c	Conf ^c	OR	95% CI	Trend test (P)
SIC 367	Electronic components and accessories industry	<5	11	9	1.6	0.6–4.3	
		5+	14	6	3.3	1.1–9.9	0.028
SIC 37	Transportation equipment industry	<5	7	0	--	--	--
		5+	5	3	5.2	0.98–28	0.023
SIC 822	Colleges, universities, professional school, junior college	5	11	20	0.8	0.3–1.8	
		5–<15	5	7	0.7	0.2–2.5	
		15+	0	19	--	--	0.0079
SIC 8221	Colleges and universities	5	11	18	0.9	0.4–2.2	
		5–<15	5	9	0.5	0.1–1.7	
		15+	0	16	--	--	0.012

^aTable includes only SOC and SIC codes with a significant association in Table 1 or Table 2 and a significant trend in risk with duration of employment. Plumbers (SOC 645) are included despite the lack of statistical significance in Table 1 because this is an *a priori* high-risk occupation with a significant trend in risk with duration of employment.

^bAdjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic ethnicity (yes/no), state (Maine, New Hampshire, Vermont), smoking status (never, occasional [<100 cigarettes over lifetime], former, current), and employment in high-risk occupations other than the one being analyzed (ever/never).

^cNumber of men or women employed in each occupation or industry for the specified duration.

Table 4

Risk of Bladder Cancer by Year of First Employment Among Men, Selected Occupations, New England, 2001–2004^a

	Year Started Employment	Cases	Controls	OR (95% CI)
MEN				
Vehicle and Mobile Equipment Mechanics (SOC 611)	<1950	22	15	2.3 (1.1–4.6)
	1950–59	37	33	1.8 (1.1–3.0)
	1960–69	32	27	1.5 (0.9–2.6)
	1970–79	18	20	1.2 (0.6–2.4)
	1980+	10	15	0.7 (0.3–1.8)
Automobile Mechanics (SOC 6111)	<1950	12	4	4.4 (1.3–14)
	1950–59	14	12	1.6 (0.7–3.7)
	1960–69	17	11	1.8 (0.8–4.1)
	1970–79	10	11	0.9 (0.4–2.3)
	1980+	6	8	0.9 (0.3–2.9)
Plumbers, Pipefitters, and Steam Fitters (SOC 645)	<1950	7	2	3.1 (0.6–16)
	1950–59	11	5	3.4 (1.1–10)
	1960–69	7	6	1.3 (0.4–4.1)
	1970–79	3	6	0.6 (0.1–2.6)
	1980+	5	6	0.6 (0.2–2.1)
Precision Metalworkers (SOC 681-2)	<1950	9	8	1.6 (0.6–4.5)
	1950–59	22	13	3.0 (1.4–6.2)
	1960–69	12	7	2.2 (0.8–6.0)
	1970–79	5	6	1.1 (0.3–3.8)
	1980+	5	3	2.6 (0.6–12)
Metalworking and Plasticworking Machine Operators and Tenders (SOC 751-2)	<1950	5	4	1.9 (0.5–7.4)
	1950–59	19	13	1.9 (0.9–4.1)
	1960–69	12	6	2.8 (0.98–7.8)
	1970–79	8	8	0.7 (0.3–2.1)
	1980+	3	4	0.9 (0.2–4.7)
Textile, Apparel, and Furnishing Machine Operators and Tenders (SOC 765)	<1950	13	9	2.0 (0.8–4.8)
	1950–59	18	4	8.5 (2.7–27)
	1960–69	8	11	0.6 (0.2–1.5)
	1970+	7	5	1.6 (0.5–5.2)
WOMEN				
Health Service Occupations (SOC 523)	<1960	6	7	2.2 (0.7–7.1)
	1960–69	7	10	1.9 (0.6–5.4)
	1970–79	11	6	4.7 (1.6–14)

	Year Started Employment	Cases	Controls	OR (95% CI)
	1980+	14	13	2.2 (0.9–5.2)
Cleaning and Building Service Occupations, Except Private Household (SOC 524)	<1970	10	4	5.5 (1.6–19)
	1970–79	5	7	2.4 (0.7–8.5)
	1980+	13	8	3.6 (1.3–9.9)

CI = Confidence interval; OR = Odds ratio; SOC = Standard Occupational Classification

^a Table shows three- and four-digit occupational codes with significant positive trends in risk with duration of employment. Computer system analysts and information clerks are excluded because of small numbers. Adjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic ethnicity (yes/no), state (Maine, New Hampshire, Vermont), smoking status (never, occasional [<100 cigarettes over lifetime], former, current), and employment in high-risk occupations other than the one being analyzed (ever/never).

Table 5

Risk of Bladder Cancer by Cigarette Smoking and Employment in Selected Occupations, New England, 2001–2004^a

	Smoking Status		P for interaction
Occupation	Never Smoked	Smoked	
<u>Men</u>			
Vehicle and Mobile Equipment Mechanics (SOC 611)			
No	1.0 (ref.)	3.0 (2.3–3.9)	0.83
	102/277 ^b	674/644	
Yes	1.5 (0.7–3.0)	4.7 (3.2–7.0)	
	12/28	107/82	
Automobile Mechanics (SOC 6111)			
No	1.0 (ref.)	3.1 (2.4–3.9)	0.78
	107/293	729/692	
Yes	1.8 (0.7–4.9)	4.8 (2.9–8.0)	
	7/12	52/34	
Precision Metalworker (SOC 681–682)			
No	1.0 (ref.)	2.9 (2.2–3.7)	0.021
	109/287 ^b	733/707	
Yes	0.7 (0.3–2.1)	8.6 (4.8–15)	
	5/18	48/19	
Metalworking/plasticworking Machine Operator (SOC 751–752)			
No	1.0 (ref.)	2.9 (2.3–3.8)	0.13
	108/289	740/707	
Yes	0.9 (0.3–2.4)	6.3 (3.5–12)	
	6/16	41/19	
Textile, Apparel, and Furnishing Machine Operators (SOC 765)			
No	1.0 (ref.)	3.1 (2.4–3.9)	0.48
	109/299	740/703	
Yes	3.0 (0.9–10)	5.6 (3.2–10)	
	5/6	41/23	
<u>Women</u>			
Health service occupations (SOC 523)			
No	1.0 (ref.)	3.3 (2.2–4.9)	0.17
	47/152	178/183	
Yes	4.4 (1.7–12)	6.7 (3.4–13)	
	9/11	29/25	
Cleaning and Building Service Occupations, Except Private Household (SOC 524)			
No	1.0 (ref.)	3.0 (2.0–4.4)	0.84
	51/156	184/196	
Yes	3.5 (1.03–12)	9.0 (4.0–20)	
	5/7	23/12	

SOC = Standard Occupational Classification

^aTable shows three- and four-digit occupational codes with significant positive trends with duration of employment. Computer system analysts, information clerks, and plumbers are excluded because of small numbers. Adjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic ethnicity (yes/no), state (Maine, New Hampshire, Vermont), and employment in high-risk occupations other than the one being analyzed (ever/never).

^bCases/controls

Table 6Risk of Bladder Cancer by Exposure to Metalworking Fluids (MWF) Among Men, New England, 2001–2004^a

	Cases ^b	Controls ^b	OR (95% CI)
Unexposed to MWF and mineral oil	264	365	1.0 (ref)
Exposed to MWF	68	53	1.7 (1.1–2.5)
Possibly exposed to MWF	186	219	1.1 (0.9–1.5)
Unexposed to MWF, possibly exposed to mineral oil	376	392	1.3 (1.1–1.7)

CI = Confidence interval; OR = Odds ratio; MWF = Metalworking fluids

^a Adjusted for age (<55, 55–64, 65–74, 75+ years), race (white only, Native American/white, other races), Hispanic status (yes/no), state (Maine, New Hampshire, Vermont), smoking status (never, occasional [<100 cigarettes over lifetime], former, current), and employment in high-risk occupations other than those involving MWF or mineral oil exposure (ever/never).

^b Table excludes 1 case and 2 controls whose exposure status could not be determined.