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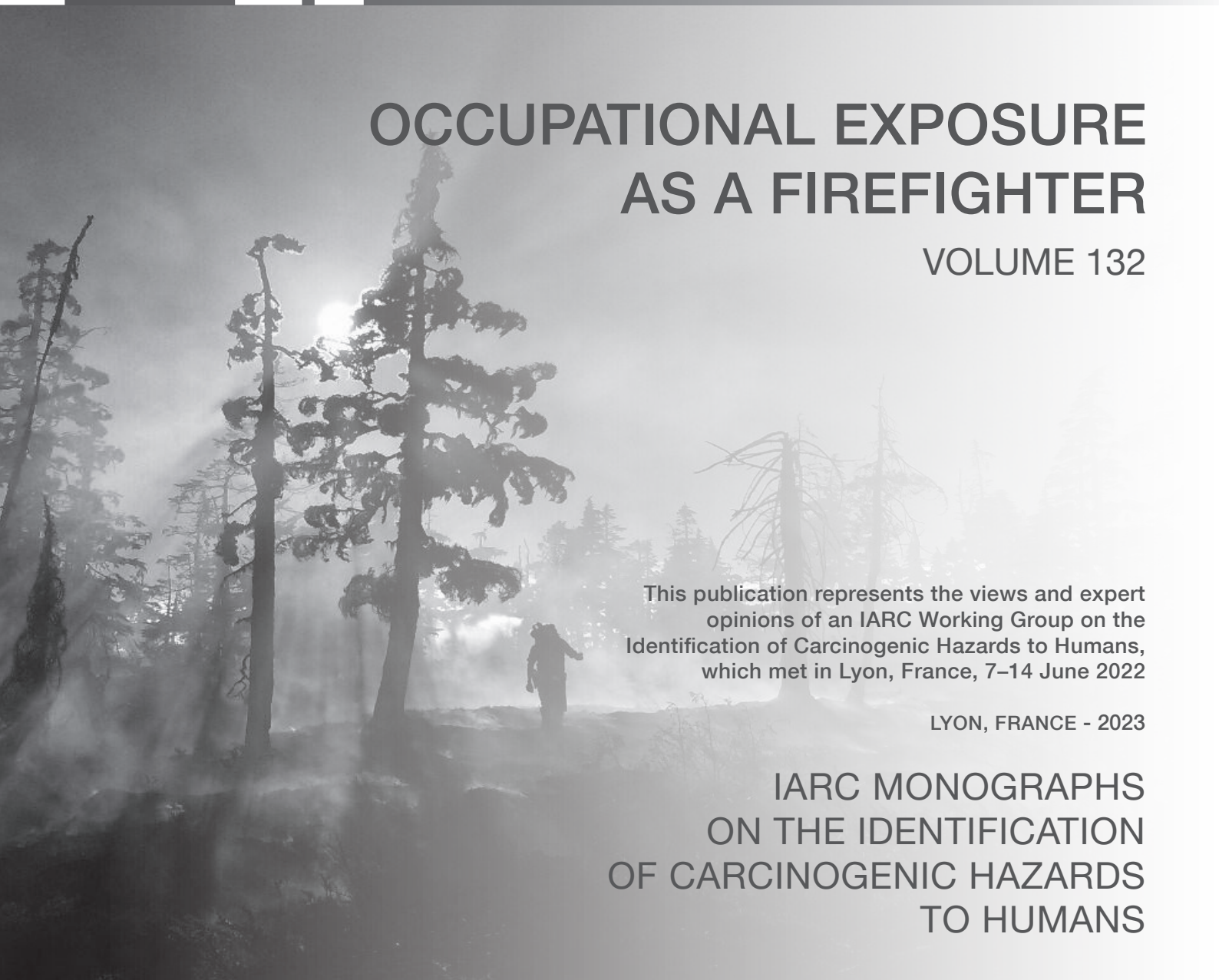

# OCCUPATIONAL EXPOSURE AS A FIREFIGHTER

VOLUME 132

This publication represents the views and expert opinions of an IARC Working Group on the Identification of Carcinogenic Hazards to Humans, which met in Lyon, France, 7–14 June 2022

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IARC MONOGRAPHS ON THE IDENTIFICATION OF CARCINOGENIC HAZARDS TO HUMANS

International Agency for Research on Cancer

World Health Organization

## Table S2.4 Cohort and case–control studies only reporting having ever worked as a firefighter and cancers of the urogenital system

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Amadeo et al. (2015)<br>France<br>Enrolment, 1 January 1979; follow-up, 1979–2008<br>Cohort | 10 829 male professional [career] firefighters employed in France on 1 January 1979, identified from 89 French administrative departments (93% of population)<br>Exposure assessment method: ever employed as firefighter from employment records | Prostate, mortality<br>Kidney, mortality<br>Urinary bladder, mortality | SMR (French population referent):<br>Firefighters<br>SMR (French population referent):<br>Firefighters<br>SMR (French population referent):<br>Firefighters | 17<br><br>10<br><br>15 | 0.54 (0.31–0.86)<br><br>0.63 (0.30–1.16)<br><br>0.73 (0.41–1.21) | Age, calendar year | *Exposure assessment critique*: Minimal quality. Exposure assessment only one point in time. Employed as any type of paid [career] firefighter. May include municipal and rural firefighters.<br>*Strengths*: cohort coverage at the national level; relatively large cohort with long follow-up; robust linkages.<br>*Limitations*: probable healthy-worker selection bias; includes only the 16% who were career civilian firefighters (79% were volunteers and 5% were military); lack of information on exposure and potential confounders. |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Deschamps et al. (1995)<br>Paris, France<br>Enrolment, 1 January 1977; follow-up, 1977 to 1 January 1991<br>Cohort | 830 professional [career] male firefighters with ≥ 5 yr of service in the Paris Fire Brigade before 1977<br>Exposure assessment method: employed as firefighter with ≥ 5 yr of active fire combat duty from employment records | Genitourinary cancers (ICD-9, 180–189), mortality | SMR (French population referent):<br>Firefighters | 2 | 3.29 (0.40–11.88) | Age, calendar year | *Exposure assessment critique*: Satisfactory quality. Duration of active fire combat assessed only for deaths, not used in analyses. Municipal firefighters.<br>*Strengths*: complete cohort enumeration.<br>*Limitations*: small study size; probable healthy-worker selection bias; lack of information on exposure and potential confounders; probabilistic linkage of outcome data. |
| Ma et al. (2006)<br>Florida, USA<br>Enrolment, 1972–1999, follow-up, 1981–1999<br>Cohort | 36 813; all male (34 796) and female (2017) professional [career] firefighters certified in Florida from 1972 to 1999; the certification date was considered to be the date of first exposure<br>Exposure assessment method: ever career firefighter from professional certification records | Cervix/uterine cervix, incidence<br><br>Prostate, incidence<br><br>Testis, incidence | SIR (Florida population referent):<br>Female firefighters<br>SIR (Florida population referent):<br>Male firefighters<br>SIR (Florida population referent):<br>Male firefighters | 15<br><br>209<br><br>54 | 5.24 (2.93–8.65)<br><br>1.10 (0.95–1.42)<br><br>1.60 (1.20–2.09) | Age, calendar year | *Exposure assessment critique*: Minimal quality. Only one point in time measure of exposure, no indication when exposure stopped. May include municipal and rural firefighters. |

## Table S2.4 (continued)

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Ma et al. (2006) (cont.) | | Kidney, incidence | SIR (Florida population referent): | | | Age, calendar year | *Strengths*: assesses cancer incidence; includes female firefighters; large male cohort. *Limitations*: probable healthy-worker selection bias; small female cohort; young age at end of follow-up; lacks information on exposure and potential confounders. |
| | | | Male firefighters | 27 | 0.78 (0.52–1.14) | | |
| | | | Female firefighters | 1 | 4.17 (0.05–23.18) | | |
| | | Urinary bladder, incidence | SIR (Florida population referent): | | | | |
| | | | Male firefighters | 73 | 1.29 (1.01–1.62) | | |
| | | | Female firefighters | 1 | 10.00 (0.13–55.60) | | |
| Ma et al. (2005) Florida, USA Enrolment, 1972–1999; follow-up, 1972–1999 Cohort | 36 813, all male (34 796) and female (2017) professional [career] firefighters certified in Florida from 1972 to 1999 Exposure assessment method: ever career firefighter from professional certification records | Prostate, mortality | SMR (Florida population referent): | | | Age, calendar period | *Exposure assessment critique*: Minimal quality. Only one point in time measure of exposure, no indication when exposure stopped. May include municipal and rural firefighters. *Strengths*: includes female firefighters; large male cohort; multiple linkages to assess vital status; conducted a sensitivity analysis among firefighters with longest tenure (certified 1972–1976). *Limitations*: probable healthy-worker selection bias; small female cohort; young age at end of follow-up; lacks information on exposure and potential confounders. |
| | | | Male firefighters | 21 | 1.08 (0.67–1.65) | | |
| | | | Male firefighters certified 1972–1976 | 19 | 1.07 (0.3–1.45) | | |
| | | Urinary bladder, mortality | SMR (Florida population referent): | | | | |
| | | | Male firefighters | 14 | 1.79 (0.98–3.00) | | |
| | | | Male firefighters certified 1972–1976 | 13 | 1.95 (1.04–3.33) | | |
| | | | Female firefighters | 0 | 0 (NR) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Grimes et al. (1991)<br>Honolulu, Hawaii, USA<br>1969–1988<br>Cohort | 205 deaths; all male firefighters with ≥ 1 yr of service in the City of Honolulu Fire Department<br>Exposure assessment method: death certificate coding of usual occupation | Genitourinary cancers (ICD-9, 179–189), mortality | PMR (state population referent): | | | NR | *Exposure assessment critique*: Minimal quality. Crude, relying on knowledge of usual occupation by death certifier. Possible differential misclassification from missing occupation on death certificates. May include municipal and rural firefighters. *Strengths*: long follow-up; examined risk by ethnic group (White/Hawaiian). *Limitations*: probable healthy-worker selection bias; unclear if underlying assumption that PMR will estimate an SMR is valid in this cohort; PMRs were not standardized by age or calendar period; no information on exposure and potential confounders. *Other comments*: number of deaths calculated by the Working Group. |
| | | | All firefighters | [11] | 2.28 (1.28–4.06) | | |
| | | | Caucasian [White] firefighters | [7] | 3.02 (1.49–6.15) | | |
| | | | Hawaiian firefighters | [4] | 3.52 (1.32–9.36) | | |
| | | Prostate, mortality | PMR (state population referent): | | | NR | |
| | | | All firefighters | [9] | 2.61 (1.38–4.97) | | |
| | | | Caucasian [White] firefighters | [6] | 3.7 (1.71–8.02) | | |
| | | | Hawaiian firefighters | [3] | 3.35 (1.07–10.45) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Musk et al. (1978)<br>Boston, Massachusetts, USA<br>1915–1975<br>Cohort | 5655 male professional [career] firefighters employed by the Boston Fire Department for ≥ 3 yr since 1915<br>Exposure assessment method: employed as municipal firefighter ≥ 3 yr from employment records | Genitourinary cancers (ICD-7, 177–181), mortality | SMR (Massachusetts population referent):<br>Firefighters | 64 | [0.92 (0.71–1.17)] | Age, calendar period | *Exposure assessment critique*: Satisfactory quality. Ever employed as municipal firefighter.<br>*Strengths*: long follow-up.<br>*Limitations*: probable healthy-worker selection bias; lack of information on cause for a proportion of deaths; lack of information on exposure and potential confounders; results tabulated only for all urogenital cancers combined. |
| Giles et al. (1993)<br>Melbourne, Australia<br>Enrolment, 1917–1989; follow-up, 1980–1989<br>Cohort | 2865 operational active male firefighters employed between 1917 and 1989 by the Metropolitan Fire Brigade in Melbourne, Australia<br>Exposure assessment method: ever employed from employment records | Prostate, incidence<br>Testis, incidence<br>Urinary tract, incidence | SIR (Victoria population referent):<br>Firefighters<br>SIR (Victoria population referent):<br>Firefighters<br>SIR (Victoria population referent):<br>Firefighters | 5<br><br>2<br><br>4 | 2.09 (0.67–4.88)<br><br>1.15 (0.13–4.17)<br><br>1.02 (0.28–2.62) | Age, calendar period | *Exposure assessment critique*: Minimal quality. Only ever municipal firefighter exposure.<br>*Strengths*: assesses cancer incidence.<br>*Limitations*: probable healthy-worker selection bias; small cohort size; no description of registry linkage methods; lack of information on exposure and potential confounders. |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Eliopulos et al. (1984)<br>Western Australia<br>Follow-up, 1939–1978<br>Cohort | 990, all men employed as permanent full-time firefighters by the Western Australian Fire Brigade between October 1939 and December 1978<br>Exposure assessment method: ever employed as a permanent full-time firefighter, and categorical employment duration (years) as firefighters from employment records | Genitourinary cancers, mortality | PMR (Western Australia referent):<br>Employment as firefighter | 4 | 1.08 (0.29–2.76) | Age, calendar period | *Exposure assessment critique*: Satisfactory quality. Unsure if permanent full-time status was maintained throughout study period. Municipal firefighters.<br>*Strengths*: long follow-up time; low loss to follow-up.<br>*Limitations*: probable healthy-worker selection bias; small study size; no personal information on exposure or potential confounders. |
| Zhao et al. (2020)<br>Spain<br>Enrolment, 2001/follow-up, 2001–2011<br>Cohort | 9 579 759 (27 365 firefighters); men identified as residing in Spain on 1 November 2001, employed on the census date, and aged 20–64 yr; followed for mortality using a national death registry<br>Exposure assessment method: questionnaire; employed as firefighter in week before census | Prostate, mortality | Occupation (MRR):<br>All other occupations<br>Firefighters | 3408<br>10 | 1<br>1.26 (0.67–2.36) | Age | *Exposure assessment critique*: Minimal quality. Firefighting self-reported at one point in time. Years of firefighting, may include municipal and rural firefighters.<br>*Strengths*: large study size; low loss to follow-up; cohort coverage at the national level.<br>*Limitations*: occupation determined by self-report at baseline; short follow-up and young cohort age; lack of information on exposure and potential confounders. |
| | | Kidney, mortality | Occupation (MRR):<br>All other occupations<br>Firefighters | 2710<br>8 | 1<br>1.18 (0.57–2.44) | | |
| | | Kidney (urinary pelvis/UUT), mortality | Occupation (MRR):<br>All other occupations<br>Firefighters | 51<br>1 | 1<br>7.42 (1.02–53.82) | | |
| | | Urinary bladder, mortality | Occupation (MRR):<br>All other occupations<br>Firefighters | 4800<br>10 | 1<br>0.62 (0.32–1.17) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Stang et al. (2003)<br>Bremen, Essen, Hamburg, Sarbrücken, Saarland, Germany<br>1995–1997<br>Case–control | Cases: 269 (4 firefighters); diagnosis of testicular cancer or extragonadal germ cell tumour reported by clinical and pathological departments in the study regions, age 15–69 yr at the time of diagnosis, and sufficient command of the German language<br>Controls: 797 (3 firefighters); 2 (for cases aged 15–34 yr) or 4 (for cases aged 35–69 yr) randomly selected for each case from mandatory registries of residence, matched on age and region of residence<br>Exposure assessment method: questionnaire; self-reported work as firefighter | Testis, incidence | Worked as a firefighter (OR):<br>Ever<br>≥ 10 yr duration<br>≥ 5 yr before diagnosis | <br>4<br>2<br>3 | <br>4.5 (0.7–31.9)<br>3.2 (0.2–48.4)<br>3.2 (0.4–25.6) | Age at diagnosis, place of residence, history of cryptorchidism | *Exposure assessment critique*: Minimal quality. Ever firefighter exposure only. Possible recall bias. May include municipal and rural firefighters.<br>*Limitations*: small study; potential selection bias; minimal exposure information. |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Pukkala et al. (2014)<br>Denmark, Finland, Iceland, Norway, Sweden<br>1961–2005<br>Cohort | 16 422 male professional [career] firefighters in the NOCCA cohort (a registry-based cohort study of Nordic country residents who participated in any computerized population census (1960, 1970, 1980/81, or 1990) and were followed up through linkage to national cancer registries), aged 30–64 yr, alive, and in the country in the year following census participation<br>Exposure assessment method: records; employed as firefighter at time of census | Penis, incidence | SIR (national referent): | | | Country, age, calendar period | *Exposure assessment critique*: Satisfactory quality. Self-reported firefighter as current job. Includes municipal and rural firefighters.<br>*Strengths*: large study size; long follow-up time; assesses cancer incidence using high-quality outcome data; contrasts by country, observation period, and age; multiple sensitivity analyses.<br>*Limitations*: probable healthy-worker selection bias; lack of information on exposure and potential confounders. |
| | | | Firefighters | 12 | 1.53 (0.79–2.67) | | |
| | | Prostate, incidence | SIR (national referent): | | | | |
| | | | Firefighters | 660 | 1.13 (1.05–1.22) | | |
| | | Prostate, incidence | Country (SIR): | | | Age, calendar period | |
| | | | Denmark | 27 | 1.03 (0.68–1.50) | | |
| | | | Finland | 143 | 1.21 (1.02–1.43) | | |
| | | | Iceland | 6 | 0.90 (0.33–1.95) | | |
| | | | Norway | 137 | 1.16 (0.97–1.37) | | |
| | | | Sweden | 347 | 1.11 (1.00–1.24) | | |
| | | Prostate, incidence | Age at follow-up (SIR): | | | Country, age, calendar period | |
| | | | 30–49 yr | 12 | 2.59 (1.34–4.52) | | |
| | | | 50–69 yr | 309 | 1.16 (1.04–1.30) | | |
| | | | ≥ 70 yr | 339 | 1.09 (0.98–1.21) | | |
| | | Prostate, incidence | Follow-up period (SIR): | | | | |
| | | | 1961–1975 | 20 | 0.97 (0.59–1.49) | | |
| | | | 1976–1990 | 145 | 1.10 (0.93–1.29) | | |
| | | | 1991–2005 | 495 | 1.15 (1.05–1.26) | | |
| | | Testis, incidence | SIR (national referent): | | | | |
| | | | Firefighters | 9 | 0.51 (0.23–0.98) | | |
| | | Kidney, incidence | SIR (national referent): | | | | |
| | | | Firefighters | 84 | 0.94 (0.75–1.17) | | |
| | | Urinary bladder, incidence | SIR (national referent): | | | | |
| | | | Firefighters | 194 | 1.11 (0.96–1.28) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Sritharan et al. (2022)<br>Ontario, Canada<br>Enrolment, 1983–2019; follow-up, 1983–2020<br>Cohort | 2 368 226 (firefighters, 13 642; police, 22 595); workers aged ≥ 15 yr who submitted lost-time workers' compensation injury and disease claims to the Workplace Safety and Insurance Board with known sex, birthdate, claim date, and occupation and industry information; incident cases identified using the Ontario Cancer registry<br>Exposure assessment method: employed as firefighter at time of workers' compensation claim | Prostate, incidence | Referent (HR): | | | Age at start of follow-up, birth year, sex | *Exposure assessment critique*: Minimal quality. Duration of firefighter work unclear. May include full-time, part-time, municipal and rural firefighters.<br>*Strengths*: large study size; long follow-up time; includes female firefighters; working population used as referent; assesses cancer incidence.<br>*Limitations*: potential selection bias into claims database, as compensation claims used to identify the cohort may differ by occupation; lack of information on exposure and potential confounders. |
| | | | Firefighters vs all other workers | 492 | 1.43 (1.31–1.57) | | |
| | | | Firefighters vs police | 492 | 0.99 (0.88–1.12) | | |
| | | Testis, incidence | Referent (HR) | | | | |
| | | | Firefighters vs all other workers | 30 | 2.56 (1.78–3.68) | | |
| | | | Firefighters vs police | 30 | 1.96 (1.19–3.23) | | |
| | | Kidney, incidence | Referent (HR): | | | | |
| | | | Firefighters vs all other workers | 94 | 1.52 (1.24–1.87) | | |
| | | | Firefighters vs police | 94 | 1.31 (0.98–1.75) | | |
| | | Urinary bladder, incidence | Referent (HR): | | | | |
| | | | Firefighters vs all other workers | 120 | 1.15 (0.96–1.37) | | |
| | | | Firefighters vs police | 120 | 0.94 (0.74–1.19) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Harris et al. (2018) Canada Enrolment, 1991; follow-up, 1992–2010 Cohort | CanCHEC: 1 108 410 (4535 firefighters); men participating in the long form Canadian census in 1991, employed with a valid occupation and aged 25–74 yr at cohort entry; incident cancers identified using a national cancer registry Exposure assessment method: questionnaire; ever employed as firefighter data from census | Prostate, incidence | Occupation (HR): | | | Age, region | *Exposure assessment critique:* Minimal quality. Self-reported firefighter as current or longest job. Includes municipal and rural firefighters. *Strengths*: study size; long follow-up time; national coverage of working population; assesses cancer incidence. *Limitations*: occupation determined at 1991 census based on self-report. Lack of information on exposure and potential confounders. |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 170 | 1.15 (0.99–1.34) | | |
| | | Prostate, incidence | Occupation (HR): | | | Age, region, education | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 170 | 1.18 (1.01–1.37) | | |
| | | Prostate, incidence | Occupation, age < 50 yr (HR): | | | Age, region | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 10 | 1.17 (0.38–3.64) | | |
| | | Prostate, incidence | Occupation, age < 50 yr (HR): | | | Age, region, education | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 10 | 1.18 (0.38–3.67) | | |
| | | Testis, incidence | Occupation (HR): | | | Age, region | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 10 | 1.80 (0.85–3.78) | | |
| | | Testis, incidence | Occupation (HR): | | | Age, region, education | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 10 | 1.80 (0.85–3.78) | | |
| | | Kidney, incidence | Occupation (HR): | | | Age, region | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 25 | 1.18 (0.77–1.82) | | |
| | | Kidney, incidence | Occupation (HR): | | | Age, region, education | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 25 | 1.14 (0.74–1.74) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Harris et al. (2018) (cont.) | | Urinary bladder, incidence | Occupation (HR): | | | Age, region | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 25 | 0.92 (0.62–1.36) | | |
| | | Urinary bladder, incidence | Occupation (HR): | | | Age, region, education | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters | 25 | 0.89 (0.60–1.33) | | |
| Lee et al. (2020) Florida, USA 1981–2014 Case–control | Cases: 3760 male firefighters, 168 female firefighters, non-firefighters, NR; cancer patients identified via linkage of FCDS and FMO records on firefighter certification and employment<br>Controls: varies by cancer site; control patients are all other cancer types except the cancer of interest<br>Exposure assessment method: employment as firefighter, from employment and professional certification records | Cervix/uterine cervix, incidence | Group (OR for firefighters vs non-firefighters): | | | Age, year of diagnosis | *Exposure assessment critique*: Satisfactory quality. Ever firefighter exposure only. May include municipal and rural firefighters.<br>*Strengths*: large study size (male firefighters); reliable information on firefighting status; includes female firefighters; assesses cancer incidence including tumour staging.<br>*Limitations*: few female firefighters; cancer cases selected as controls (numerator-based analysis); limited information on exposure and potential confounders. |
| | | | Women | < 10 | 0.41 (0.15–1.12) | | |
| | | Prostate, incidence | Group (OR for firefighters vs non-firefighters): | | | | |
| | | | Men | 1119 | 1.36 (1.27–1.46) | | |
| | | Prostate, incidence | Tumour stage (OR for firefighters vs non-firefighters): | | | | |
| | | | Early-stage | 916 | 1.13 (1.03–1.23) | | |
| | | | Late-stage | 148 | 1.42 (1.19–1.68) | | |
| | | Prostate, incidence | Age at diagnosis (OR for firefighters vs non-firefighters): | | | | |
| | | | < 50 yr | 92 | 1.88 (1.49–2.36) | | |
| | | | ≥ 50 yr | 1027 | 1.36 (1.26–1.47) | | |
| | | Testis, incidence | Group (OR for firefighters vs non-firefighters): | | | | |
| | | | Men | 101 | 1.66 (1.34–2.07) | | |
| | | Testis, incidence | Tumour stage (OR for firefighters vs non-firefighters): | | | | |
| | | | Early-stage | 72 | 1.39 (1.07–1.82) | | |
| | | | Late-stage | 27 | 1.69 (1.12–2.54) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Lee et al. (2020) (cont.) | | Testis, incidence | Age at diagnosis (OR for firefighters vs non-firefighters): | | | Age, year of diagnosis | |
| | | | < 50 yr | NR | 1.60 (1.28–2.01) | | |
| | | | ≥ 50 yr | NR | 1.47 (0.73–2.94) | | |
| | | Penis, incidence | Group (OR for firefighters vs non-firefighters): | | | | |
| | | | Men | < 10 | 0.79 (0.33–1.90) | | |
| | | Penis, incidence | Tumour stage (OR for firefighters vs non-firefighters): | | | | |
| | | | Early-stage | < 10 | 0.95 (0.36–2.55) | | |
| | | | Late-stage | 0 | 0 (NR) | | |
| | | Penis, incidence | Age at diagnosis (OR for firefighters vs non-firefighters): | | | | |
| | | | < 50 yr | < 10 | 0.88 (0.22–3.54) | | |
| | | | ≥ 50 yr | < 10 | 0.71 (0.23–2.21) | | |
| | | Kidney (urinary pelvis/UUT), incidence | Group (OR for firefighters vs non-firefighters): | | | | |
| | | | Men | 150 | 1.06 (0.90–1.24) | | |
| | | | Women | < 10 | 0.59 (0.15–2.36) | | |
| | | Kidney (urinary pelvis/UUT), incidence | Tumour stage, men (OR for firefighters vs non-firefighters): | | | | |
| | | | Early-stage | 106 | 0.97 (0.79–1.18) | | |
| | | | Late-stage | 40 | 1.04 (0.76–1.43) | | |
| | | Kidney (urinary pelvis/UUT), incidence | Age at diagnosis, men (OR for firefighters vs non-firefighters): | | | | |
| | | | < 50 yr | 47 | 1.19 (0.88–1.60) | | |
| | | | ≥ 50 yr | 103 | 0.98 (0.80–1.19) | | |
| | | Urinary bladder, incidence | Group (OR for firefighters vs non-firefighters): | | | | |
| | | | Men | 112 | 0.91 (0.75–1.10) | | |
| | | | Women | 10 | 1.88 (0.47–7.59) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Lee et al. (2020) (cont.) | | Urinary bladder, incidence | Tumour stage, men (OR for firefighters vs non-firefighters): | | | Age, year of diagnosis | |
| | | | Early-stage | 83 | 0.81 (0.65–1.02) | | |
| | | | Late-stage | 21 | 1.03 (0.67–1.58) | | |
| | | Urinary bladder, incidence | Age at diagnosis, men (OR for firefighters vs non-firefighters): | | | | |
| | | | < 50 yr | 19 | 1.13 (0.72–1.79) | | |
| | | | ≥ 50 yr | 93 | 0.87 (0.71–1.08) | | |
| McClure et al. (2021) Florida, USA 1981–2014 Case–control | Cases: firefighters, 3760; non-firefighters, NR; male cancer patients identified via linkage of FCDS and FMO records on firefighter certification and employment Controls: varies by cancer site; control patients are all other cancer types except the cancer of interest Exposure assessment method: employment as firefighter from cancer registry records and employment and professional certification records | Urinary system, incidence | Occupation (OR): | | | Age, year of diagnosis | *Exposure assessment critique:* Minimal quality. Ever firefighter exposure only. Incorporation of employment and certification records improvement for method 2. May include municipal and rural firefighters. *Strengths*: large study size; assesses cancer incidence. *Limitations*: broad genitourinary cancer groupings; cancer cases selected as controls (numerator-based analysis); minimal information on exposure and potential confounders; completeness of occupation data (from registry records) varied by sociodemographic and diagnostic characteristics. |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters, FMO employment certification records | 267 | 1.00 (0.88–1.13) | | |
| | | | Firefighters, FCDS occupational data | 138 | 1.01 (0.85–1.20) | | |
| | | Genital system, incidence | Occupation (OR): | | | | |
| | | | Non-firefighters | NR | 1 | | |
| | | | Firefighters, FMO employment certification records | 1228 | 1.37 (1.28–1.47) | | |
| | | | Firefighters, FCDS occupational data | 534 | 1.10 (0.99–1.22) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Muegge et al. (2018)<br>Indiana, USA<br>1985–2013<br>Case–control | Cases: 857 firefighters, 11 272 non-firefighters; cancer as the underlying cause of death in state death registry among registrants with complete information on year of death, age at time of death, sex, race, ethnicity, industry code, and occupation code; all firefighter cancers were included, but non-firefighter cancers only observed among non-firefighter decedents matched 4:1 on firefighter decedents on age at death, sex, race, ethnicity, and year of death<br>Controls: varied by cancer site; decedents with a cause of death other than the one under study among all firefighter decedents and a sample of non-firefighter decedents matched 4:1 on firefighter decedents on age at death, sex, race, ethnicity, and year of death<br>Exposure assessment method: death certificate coding of usual occupation | Kidney, mortality | Death certificate occupation (OR):<br>Non-firefighters<br>Firefighters | <br>70<br>32 | <br>1<br>1.84 (1.17–2.83) | Sex, race, ethnicity, age at death, year of death | *Exposure assessment critique:* Minimal quality. Crude, relying on knowledge of usual occupation by death certifier. Possible differential misclassification from missing occupation on death certificates. May include municipal and rural firefighters.<br>*Strengths*: large study size.<br>*Limitations*: deaths used as controls (numerator-based analysis); lack of information on exposure and potential confounders. |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Tsai et al. (2015)<br>California, USA<br>1988–2007<br>Case–control | Cases: 678 132 (all cancers); all first malignant primary cancers in the registry restricted to adult male participants (aged 18–97 yr) with industry and occupation information available; sites must have ≥ 10 firefighters among the cases to be analysed<br>Controls: 48 725 cancers of the pharynx, stomach, liver, and pancreas in the registry, restricted to adult male participants (aged 18–97 yr) with industry and occupation information available<br>Exposure assessment method: employment as firefighter, coded as longest job held from cancer registry records | Prostate, incidence | Race (OR, firefighters vs non-firefighters): | | | Age, year of diagnosis, race | *Exposure assessment critique:* Minimal quality. Ever firefighter exposure only. May include municipal and rural firefighters.<br>*Strengths*: large study size; assesses incident cancers; findings stratified by race/ethnicity.<br>*Limitations*: no information on the population at risk (numerator-based analysis); occupation missing from nearly 50% of registry cases and more likely for people who were older or of Hispanic ethnicity; lack of information on exposure and potential confounders. |
| | | | White | 1256 | 1.40 (1.19–1.64) | | |
| | | | Other | 125 | 2.42 (1.53–3.84) | | |
| | | | Overall | 1397 | 1.45 (1.25–1.69) | | |
| | | Testis, incidence | Race (OR, firefighters vs non-firefighters)\|: | | | | |
| | | | White | 70 | 0.91 (0.58–1.44) | | |
| | | | Other | 15 | 3.73 (1.26–11.02) | | |
| | | | Overall | 85 | 1.10 (0.73–1.66) | | |
| | | Kidney, incidence | Race (OR, firefighters vs non-firefighters): | | | | |
| | | | White | 96 | 1.16 (0.91–1.49) | | |
| | | | Other | 18 | 2.59 (1.40–4.80) | | |
| | | | Overall | 115 | 1.27 (1.01–1.59) | | |
| | | Urinary bladder, incidence | Race (OR, firefighters vs non-firefighters): | | | | |
| | | | White | 98 | 0.94 (0.73–1.21) | | |
| | | | Other | 8 | 2.37 (1.05–5.33) | | |
| | | | Overall | 106 | 0.99 (0.78–1.26) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Kang et al. (2008)<br>Massachusetts, USA<br>1987–2003<br>Case–control | Cases: NR overall (firefighters, 1881; non-firefighters, NR); White male residents of Massachusetts aged ≥ 18 yr with complete information on "usual occupation" and a diagnosis of one of 25 "cancers of concern" in the MCR<br>Controls: NR overall (firefighters, 244; non-firefighters, NR); White male residents of Massachusetts aged ≥ 18 yr with complete information on "usual occupation" and a cancer diagnosis not on the list of 25 "cancers of concern" in the MCR<br>Exposure assessment method: employment as firefighter coded from longest job held from cancer registry records | Prostate, incidence | Referent (SMBOR): | | | Age, smoking status | *Exposure assessment critique:* Minimal quality. Ever firefighter exposure only. May include municipal and rural firefighters.<br>*Strengths*: large size; long study period; assesses incident cancers; smoking information available.<br>*Limitations*: cancer cases used as controls (numerator-based analysis); Incomplete information on occupation (38% missing); lacking information on exposure and potential confounders. |
| | | | Firefighters (police referent) | 577 | 0.98 (0.78–1.23) | | |
| | | | Firefighters (all other occupations referent) | 577 | 1.05 (0.88–1.24) | | |
| | | Testis, incidence | Referent (SMBOR): | | | | |
| | | | Firefighters (police referent) | 25 | 1.53 (0.75–3.14) | | |
| | | | Firefighters (all other occupations referent) | 25 | 1.48 (0.88–2.48) | | |
| | | Kidney, incidence | Referent (SMBOR): | | | | |
| | | | Firefighters (police referent) | 64 | 1.34 (0.90–2.01) | | |
| | | | Firefighters (all other occupations referent) | 64 | 1.01 (0.74–1.38) | | |
| | | Urinary bladder, incidence | Referent (SMBOR): | | | | |
| | | | Firefighters (police referent) | 113 | 1.22 (0.89–1.69) | | |
| | | | Firefighters (all other occupations referent) | 113 | 1.19 (0.93–1.52) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Sama et al. (1990)<br>Massachusetts, USA<br>1982–1986<br>Case–control | Cases: NR; White men aged ≥ 18 yr with information on usual occupation and a diagnosis with one of nine cancers of concern in the MCR<br>Controls: NR; White men aged ≥ 18 yr with information on usual occupation and a cancer diagnosis for all other cancers, except those of the organ systems of concern (digestive, respiratory, and lymphatic/haematopoietic)<br>Exposure assessment method: employment as firefighter or fire chief from cancer registry records | Urinary bladder, incidence | Referent (SMBOR): | | | Age | *Exposure assessment critique:* Minimal quality. Ever firefighter exposure only. Use of secondary data sources confirmed occupation for some firefighters. May include municipal and rural firefighters.<br>*Strengths*: assesses incident cancers; smoking information available.<br>*Limitations*: small study; cancer cases used as controls (numerator-based analysis); incomplete information on occupation; crude smoking status information; no smoking adjustment; lack of information on exposure and potential confounders. |
| | | | Firefighters (police referent) | 26 | 2.11 (1.07–4.14) | | |
| | | | Firefighters (state referent) | 26 | 1.59 (1.02–2.50) | | |
| | | Urinary bladder, incidence | Age at diagnosis (SMBOR, firefighters vs police): | | | | |
| | | | 18–54 yr | 4 | 1.25 (0.26–5.88) | | |
| | | | 55–74 yr | 18 | 2.19 (0.99–4.84) | | |
| | | | ≥ 75 yr | 4 | 4.40 (0.42–46.26) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Ma et al. (1998)<br>USA<br>1984–1993<br>Case–control | Cases: NR; all male cancer deaths with coded industry and occupation on death certificates from 24 states captured in a NIOSH database<br>Controls: NR; all male non-cancer deaths in the NIOSH database<br>Exposure assessment method: death certificate coding of usual occupation | Prostate, mortality | Group (MOR): | | | Year of death, age at death | *Exposure assessment critique:* Minimal quality. Crude, relying on knowledge of usual occupation by death certifier. Possible differential misclassification from missing occupation on death certificates. May include municipal and rural firefighters.<br>*Strengths*: large study size (includes 6607 male firefighter deaths); broad geographical population coverage.<br>*Limitations*: non-cancer deaths used as controls (numerator-based analysis); lack of information on exposure and potential confounders. |
| | | | White firefighters | 189 | 1.2 (1.0–1.3) | | |
| | | | Black firefighters | 16 | 1.9 (1.2–3.2) | | |
| | | Testis, mortality | Group (MOR): | | | | |
| | | | White firefighters | 1 | 0.6 (NR) | | |
| | | | Black firefighters | 0 | 0 (NR) | | |
| | | Kidney (urinary pelvis/UUT), mortality | Group (MOR): | | | | |
| | | | White firefighters | 49 | 1.3 (1.0–1.7) | | |
| | | | Black firefighters | 0 | 0 (NR) | | |
| | | Urinary bladder, mortality | Group (MOR): | | | | |
| | | | White firefighters | 48 | 1.2 (0.9–1.6) | | |
| | | | Black firefighters | 1 | 1.3 (NR) | | |
| | | Ureter, mortality | Group (MOR): | | | | |
| | | | White firefighters | 1 | 1 (NR) | | |
| | | | Black firefighters | 0 | 0 (NR) | | |

**Table S2.4 (continued)**

| Reference, location enrolment/ follow-up period, study design | Population size, description, exposure assessment method | Cancer type (histopathology), incidence or mortality | Exposure category or level | Exposed cases or deaths | Risk estimate (95% CI) | Covariates controlled | Comments |
|---|---|---|---|---|---|---|---|
| Burnett et al. (1994)<br>USA<br>1984–1990<br>Mortality surveillance | 5744 deaths; White male firefighters identified by evaluation of coded occupation on death certificates from 27 states<br>Exposure assessment method: death certificate coding of usual occupation | Kidney, mortality | Group (PMR): | | | Age | *Exposure assessment critique:* Minimal quality. Crude, relying on knowledge of usual occupation by death certifier. Possible differential misclassification from missing occupation on death certificates. May include municipal and rural firefighters.<br>*Strengths*: large number of deaths; broad geographical population coverage.<br>*Limitations*: numerator-only (PMR) analysis; errors in death-certificate occupation; lack of information on exposure or potential confounders. |
| | | | Firefighters | 53 | 1.44 (1.08–1.89) | | |
| | | | Firefighters, age < 65 yr at death | 24 | 1.41 (0.90–2.10) | | |
| | | Urinary bladder, mortality | Group (PMR): | | | | |
| | | | Firefighters | 37 | 0.99 (0.70–1.37) | | |
| | | | Firefighters, age < 65 yr at death | 9 | 1.01 (0.46–1.93) | | |

CanCHEC, Canadian Census Health and Environment Cohort; CI, confidence interval; FCDS, Florida Cancer Data System; FMO, office of the Florida State Marshal; HR, hazard ratio; ICD, International Classification of Diseases; MCR, Massachusetts Cancer Registry; MOR, mortality odds ratio; MRR, mortality rate ratio; NOCCA, Nordic Occupational Cancer study; NR, not reported; OR, odds ratio; PMR, proportionate mortality ratio; SCC, squamous cell carcinoma; SIR, standardized incidence ratio; SMBOR, standardized morbidity odds ratio; SMR, standardized mortality ratio; UUT, upper urogenital tract; vs, versus; yr, year.

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