

Cancer incidence and HWSE path analysis

GM-UAW Cohort Study

July 6, 2020

This packet summarizes Cox proportional hazard model results relating cumulative exposure to straight, soluble, and synthetic metalworking fluids (MWF) to cancer incidence of 14 types and for all sites combined (includes types not shown here) in the UAW-GM Cohort. The types are colon, rectal, pancreatic, esophageal, stomach, laryngeal, lung & bronchial, breast, prostate, kidney and renal pelvic, bladder, melanoma, leukemia, and non-Hodgkin lymphoma. In addition, path analyses testing for the presence of healthy worker survivor effect are presented. These include Cox models relating employment status to cancer incidence and one Cox model relating cumulative MWF exposure to leaving work. The path analyses largely follow the methods outlined in Garcia et al.¹

The study population, summarized in Table 1, includes subjects from the UAW-GM Cohort who were still alive at the start of cancer incidence follow-up. Cancer incidence data were abstracted from Michigan Cancer Registry for all plants from years 1985 onward. Cancer incidence data for plants 1 and 2 were supplemented with data from the Surveillance, Epidemiology, and End Results Program (SEER). Follow-up begins three years after hire and no earlier than 1973 for plants 1 and 2 or 1985 for plant 3. Follow-up ends upon reaching the oldest observed age at death (considered lost to follow-up), death, cancer incidence, or the year 2015, whichever comes first. In the path analyses for employment status and cancer incidence, subjects were also censored upon reaching their 80th birthday.

Table 1: Summary of population characteristics. Follow-up for cancer incidence extends from 1985 through 2015.

| | <i>n</i> | <i>p</i> | |
|---|----------|------------------------|------------------------|
| Study population size (<i>N</i>) | 39 770 | 100% | |
| Race | | | |
| White | 25 612 | 64% | |
| Black | 6 890 | 17% | |
| Unknown | 7 268 | 18% | |
| Sex | | | |
| Male | 35 099 | 88% | |
| Female | 4 671 | 12% | |
| Plant [‡] | | | |
| Plant 1 | 11 481 | 29% | |
| Plant 2 | 15 922 | 40% | |
| Plant 3 | 12 367 | 31% | |
| Ever exposed to MWFs | | | |
| Straight | 21 589 | 54% | |
| Soluble | 34 406 | 87% | |
| Synthetic | 12 587 | 32% | |
| Diagnosed with cancer by end of follow-up | 7 945 | 20% | |
| | Median | 25 th %tile | 75 th %tile |
| Years of follow-up | 39.34 | 34.19 | 46.81 |
| Years at work [*] | 15.71 | 7.66 | 27.02 |
| Year of hire | 1964 | 1951 | 1973 |
| Age at hire (years) | 24 | 20 | 31 |
| Year of birth | 1936 | 1920 | 1948 |
| Year of first cancer diagnosis | 1999 | 1991 | 2007 |
| Age at first cancer diagnosis (years) | 67 | 59 | 74 |
| Cumulative exposure [‡] to MWFs (mg/m ³ ·y) | | | |
| Straight | 0.7 | 0.22 | 2.61 |
| Soluble | 4.94 | 1.93 | 13.33 |
| Synthetic | 0.45 | 0.15 | 1.58 |

[‡] Some individuals worked at several sites; plant indicates the site of longest work record time.

^{*} Among those with known date of worker exit.

[‡] Summary statistics calculated for ever-exposed individuals at end of follow-up only. Exposures were lagged 21 years.

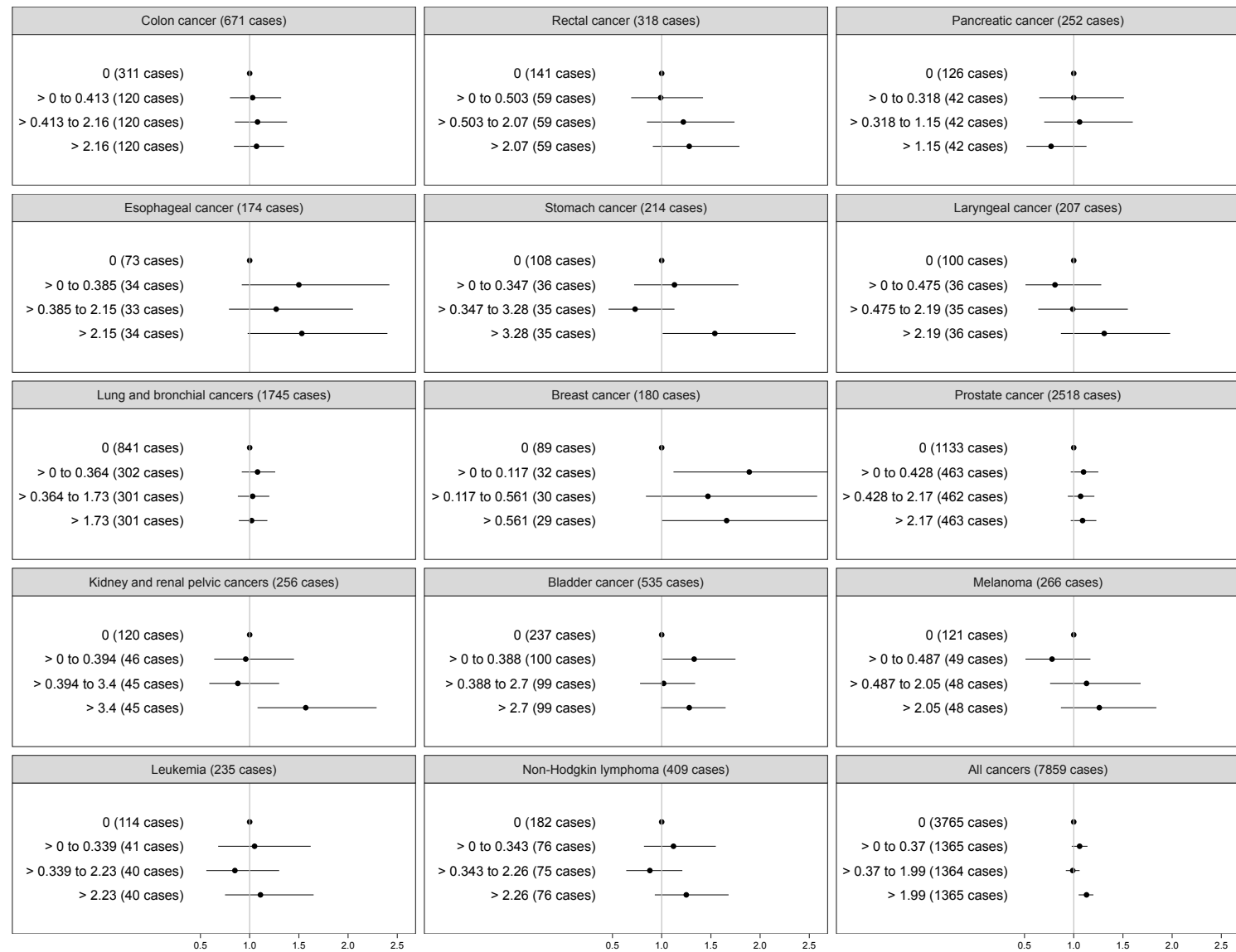
Figure 1: Adjusted hazard ratios associated with exposure to straight metal working fluids in the **UAW-GM Cohort**.

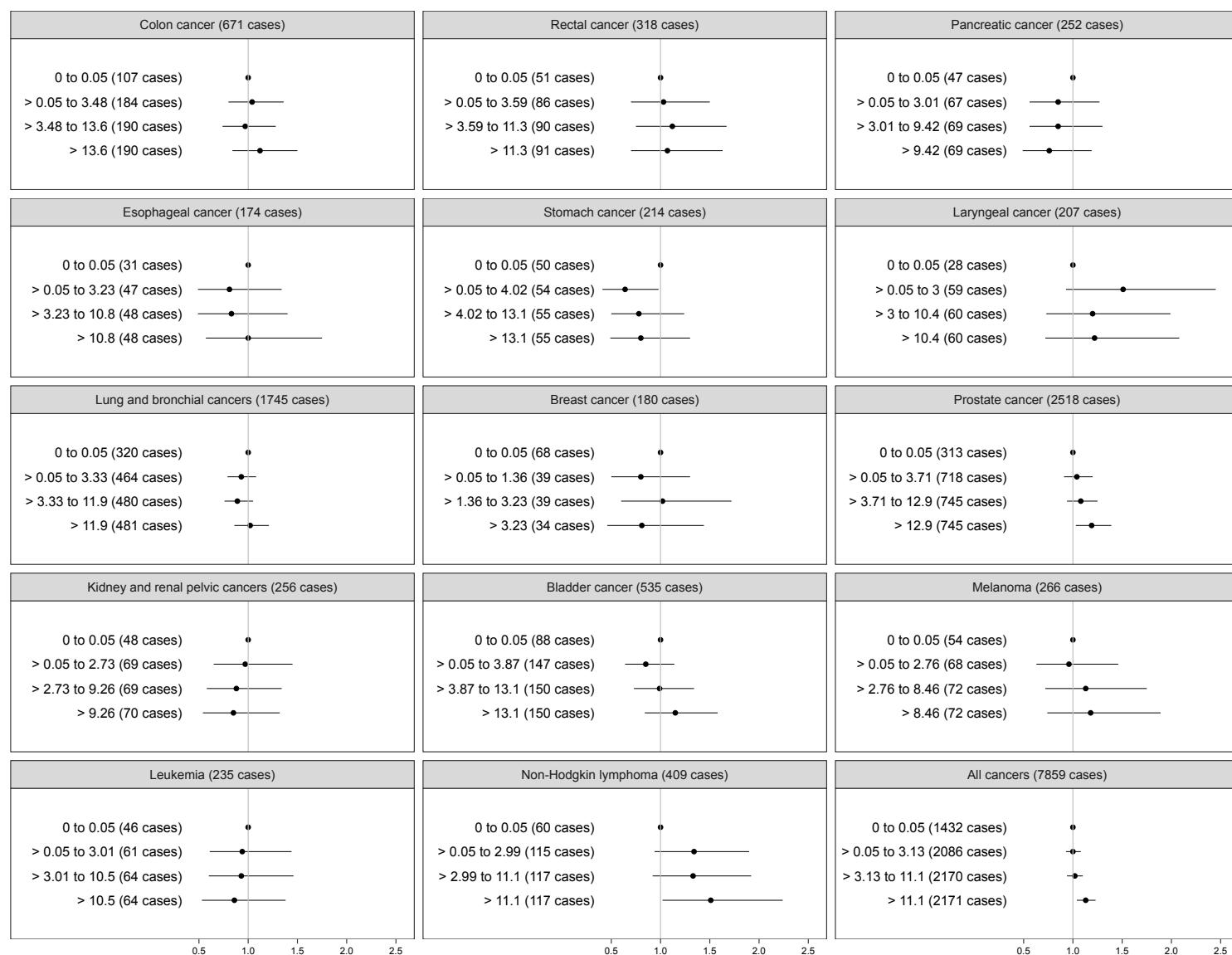
Figure 2: Adjusted hazard ratios associated with exposure to soluble metal working fluids in the **UAW-GM Cohort**.

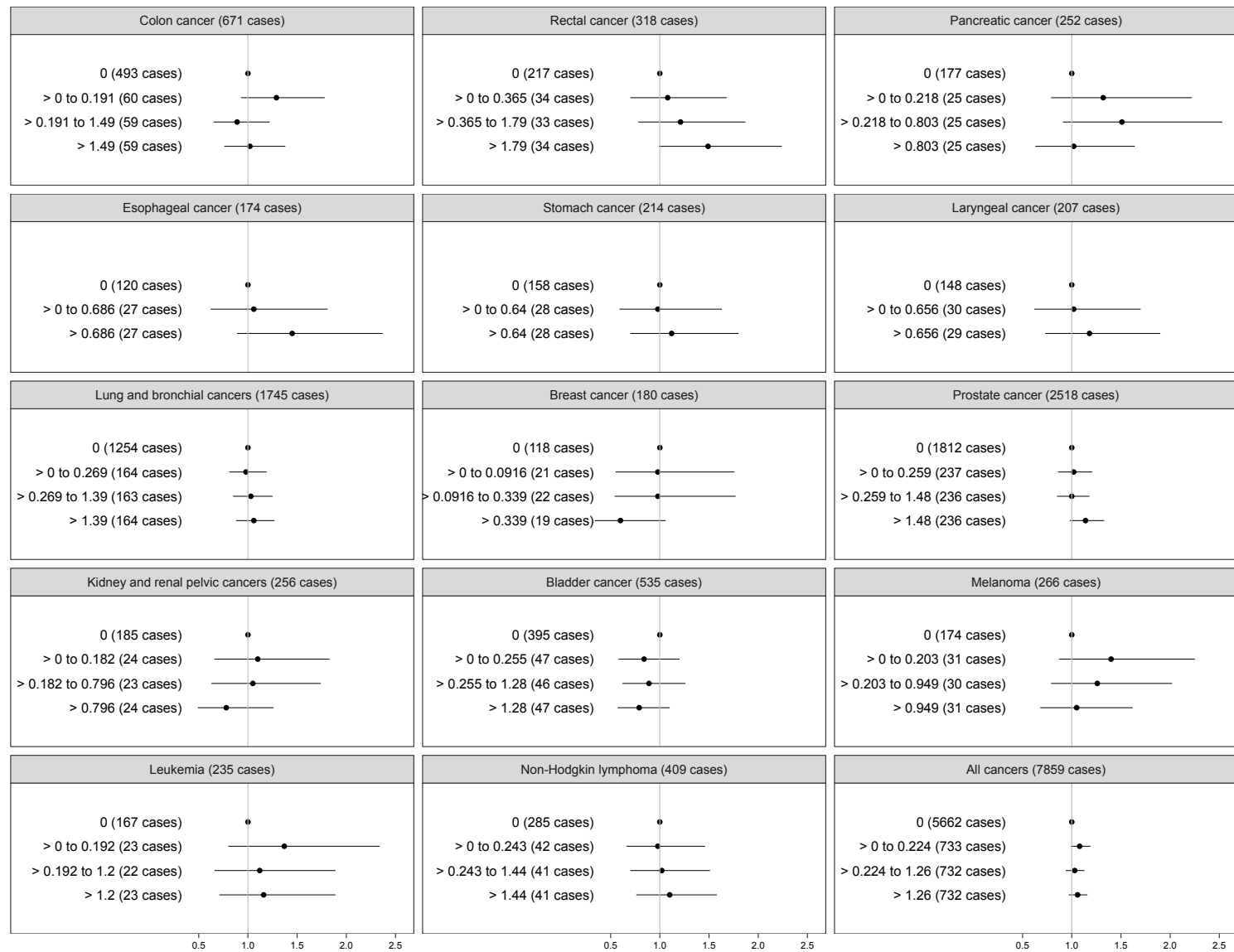
Figure 3: Adjusted hazard ratios associated with exposure to synthetic metal working fluids in the **UAW-GM Cohort**.

Figure 4: Adjusted hazard ratios for cancer incidence associated with leaving work in the **UAW-GM Cohort** (HWSE Condition 2).

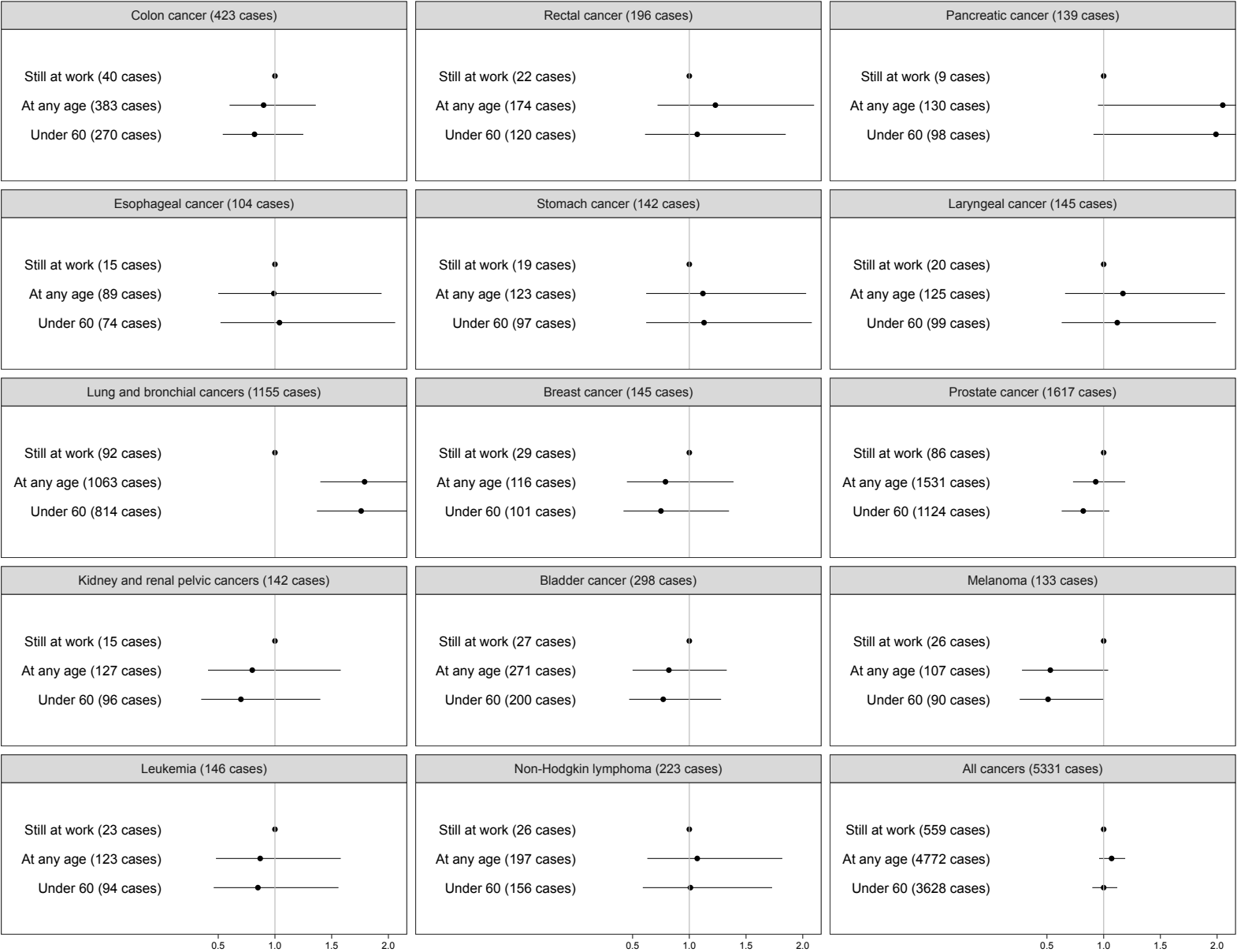


Table 2: Adjusted HR estimates for cancer incidence and employment status.

| | <i>n</i> | HR | (95% CI) | <i>p</i> | |
|--------------------------------|----------|------|--------------|----------|---|
| Colon cancer (423 events) | | | | | |
| Still employed | 40 | 1.00 | — | | |
| Not employed | 383 | 0.90 | (0.60, 1.36) | 0.61 | |
| Left work (under 50) | 159 | 0.76 | (0.50, 1.18) | 0.22 | |
| Left work (50 or older) | 224 | 1.07 | (0.69, 1.65) | 0.76 | |
| Left work (under 55) | 207 | 0.80 | (0.52, 1.22) | 0.30 | |
| Left work (55 or older) | 176 | 1.09 | (0.70, 1.70) | 0.70 | |
| Left work (under 60) | 270 | 0.82 | (0.54, 1.25) | 0.35 | |
| Left work (60 or older) | 113 | 1.14 | (0.72, 1.79) | 0.58 | |
| Rectal cancer (196 events) | | | | | |
| Still employed | 22 | 1.00 | — | | |
| Not employed | 174 | 1.23 | (0.72, 2.10) | 0.45 | |
| Left work (under 50) | 66 | 0.92 | (0.52, 1.63) | 0.76 | |
| Left work (50 or older) | 108 | 1.82 | (1.01, 3.27) | 0.05 | |
| Left work (under 55) | 96 | 1.07 | (0.61, 1.87) | 0.81 | |
| Left work (55 or older) | 78 | 1.65 | (0.90, 3.00) | 0.10 | |
| Left work (under 60) | 120 | 1.07 | (0.61, 1.85) | 0.82 | |
| Left work (60 or older) | 54 | 1.97 | (1.05, 3.70) | 0.03 | * |
| Pancreatic cancer (139 events) | | | | | |
| Still employed | 9 | 1.00 | — | | |
| Not employed | 130 | 2.05 | (0.95, 4.42) | 0.07 | |
| Left work (under 50) | 55 | 1.74 | (0.79, 3.87) | 0.17 | |
| Left work (50 or older) | 75 | 2.50 | (1.12, 5.61) | 0.03 | * |
| Left work (under 55) | 73 | 1.82 | (0.83, 4.00) | 0.14 | |
| Left work (55 or older) | 57 | 2.58 | (1.13, 5.87) | 0.02 | * |

| | | | | |
|--------------------------------|-----|------|--------------|------|
| Left work (under 60) | 98 | 1.99 | (0.91, 4.34) | 0.08 |
| Left work (60 or older) | 32 | 2.23 | (0.95, 5.25) | 0.07 |
| Esophageal cancer (104 events) | | | | |
| Still employed | 15 | 1.00 | — | |
| Not employed | 89 | 0.99 | (0.50, 1.94) | 0.97 |
| Left work (under 50) | 47 | 0.98 | (0.49, 1.99) | 0.96 |
| Left work (50 or older) | 42 | 0.99 | (0.48, 2.07) | 0.99 |
| Left work (under 55) | 63 | 1.08 | (0.54, 2.15) | 0.83 |
| Left work (55 or older) | 26 | 0.80 | (0.37, 1.74) | 0.58 |
| Left work (under 60) | 74 | 1.04 | (0.52, 2.06) | 0.92 |
| Left work (60 or older) | 15 | 0.81 | (0.34, 1.93) | 0.64 |
| Stomach cancer (142 events) | | | | |
| Still employed | 19 | 1.00 | — | |
| Not employed | 123 | 1.12 | (0.62, 2.03) | 0.72 |
| Left work (under 50) | 57 | 0.99 | (0.53, 1.86) | 0.99 |
| Left work (50 or older) | 66 | 1.33 | (0.69, 2.55) | 0.39 |
| Left work (under 55) | 77 | 1.09 | (0.59, 2.02) | 0.78 |
| Left work (55 or older) | 46 | 1.17 | (0.60, 2.30) | 0.64 |
| Left work (under 60) | 97 | 1.13 | (0.62, 2.08) | 0.69 |
| Left work (60 or older) | 26 | 1.07 | (0.52, 2.20) | 0.86 |
| Laryngeal cancer (145 events) | | | | |
| Still employed | 20 | 1.00 | — | |
| Not employed | 125 | 1.17 | (0.66, 2.07) | 0.59 |
| Left work (under 50) | 54 | 0.89 | (0.49, 1.65) | 0.72 |
| Left work (50 or older) | 71 | 1.69 | (0.91, 3.16) | 0.10 |
| Left work (under 55) | 75 | 1.00 | (0.56, 1.81) | 0.99 |
| Left work (55 or older) | 50 | 1.72 | (0.89, 3.31) | 0.11 |

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|--|------|------|--------------|---------|---|
| Left work (under 60) | 99 | 1.12 | (0.63, 1.99) | 0.71 | |
| Left work (60 or older) | 26 | 1.43 | (0.70, 2.92) | 0.32 | |
| Lung and bronchial cancers (1155 events) | | | | | |
| Still employed | 92 | 1.00 | — | | |
| Not employed | 1063 | 1.79 | (1.40, 2.29) | < 0.005 | * |
| Left work (under 50) | 480 | 1.57 | (1.22, 2.03) | < 0.005 | * |
| Left work (50 or older) | 583 | 2.16 | (1.66, 2.81) | < 0.005 | * |
| Left work (under 55) | 635 | 1.68 | (1.30, 2.16) | < 0.005 | * |
| Left work (55 or older) | 428 | 2.08 | (1.59, 2.72) | < 0.005 | * |
| Left work (under 60) | 814 | 1.76 | (1.37, 2.25) | < 0.005 | * |
| Left work (60 or older) | 249 | 1.91 | (1.44, 2.54) | < 0.005 | * |
| Breast cancer (145 events) | | | | | |
| Still employed | 29 | 1.00 | — | | |
| Not employed | 116 | 0.79 | (0.45, 1.39) | 0.41 | |
| Left work (under 50) | 71 | 0.72 | (0.39, 1.31) | 0.28 | |
| Left work (50 or older) | 45 | 0.90 | (0.48, 1.70) | 0.75 | |
| Left work (under 55) | 86 | 0.73 | (0.41, 1.32) | 0.30 | |
| Left work (55 or older) | 30 | 0.95 | (0.48, 1.86) | 0.88 | |
| Left work (under 60) | 101 | 0.75 | (0.42, 1.35) | 0.34 | |
| Left work (60 or older) | 15 | 0.99 | (0.46, 2.13) | 0.97 | |
| Prostate cancer (1617 events) | | | | | |
| Still employed | 86 | 1.00 | — | | |
| Not employed | 1531 | 0.93 | (0.73, 1.19) | 0.57 | |
| Left work (under 50) | 679 | 0.82 | (0.63, 1.06) | 0.13 | |
| Left work (50 or older) | 852 | 1.02 | (0.79, 1.32) | 0.86 | |
| Left work (under 55) | 884 | 0.82 | (0.63, 1.06) | 0.13 | |
| Left work (55 or older) | 647 | 1.08 | (0.84, 1.40) | 0.54 | |

| | | | | | |
|--|------|------|--------------|------|---|
| Left work (under 60) | 1124 | 0.82 | (0.63, 1.05) | 0.12 | |
| Left work (60 or older) | 407 | 1.21 | (0.93, 1.58) | 0.16 | |
| Kidney and renal pelvic cancers (142 events) | | | | | |
| Still employed | 15 | 1.00 | — | | |
| Not employed | 127 | 0.80 | (0.41, 1.58) | 0.53 | |
| Left work (under 50) | 58 | 0.62 | (0.30, 1.26) | 0.19 | |
| Left work (50 or older) | 69 | 1.13 | (0.54, 2.34) | 0.74 | |
| Left work (under 55) | 81 | 0.72 | (0.36, 1.46) | 0.36 | |
| Left work (55 or older) | 46 | 0.98 | (0.47, 2.06) | 0.96 | |
| Left work (under 60) | 96 | 0.70 | (0.35, 1.40) | 0.31 | |
| Left work (60 or older) | 31 | 1.17 | (0.54, 2.55) | 0.69 | |
| Bladder cancer (298 events) | | | | | |
| Still employed | 27 | 1.00 | — | | |
| Not employed | 271 | 0.82 | (0.50, 1.33) | 0.42 | |
| Left work (under 50) | 117 | 0.70 | (0.42, 1.16) | 0.17 | |
| Left work (50 or older) | 154 | 0.96 | (0.58, 1.61) | 0.89 | |
| Left work (under 55) | 153 | 0.73 | (0.44, 1.21) | 0.22 | |
| Left work (55 or older) | 118 | 0.97 | (0.58, 1.64) | 0.92 | |
| Left work (under 60) | 200 | 0.77 | (0.47, 1.28) | 0.31 | |
| Left work (60 or older) | 71 | 0.93 | (0.54, 1.60) | 0.80 | |
| Melanoma (133 events) | | | | | |
| Still employed | 26 | 1.00 | — | | |
| Not employed | 107 | 0.53 | (0.28, 1.04) | 0.06 | |
| Left work (under 50) | 58 | 0.49 | (0.25, 0.97) | 0.04 | * |
| Left work (50 or older) | 49 | 0.70 | (0.33, 1.49) | 0.35 | |
| Left work (under 55) | 74 | 0.50 | (0.25, 0.99) | 0.05 | |
| Left work (55 or older) | 33 | 0.69 | (0.31, 1.51) | 0.35 | |

| | | | | |
|-------------------------------------|-----|------|--------------|------|
| Left work (under 60) | 90 | 0.51 | (0.26, 1.00) | 0.05 |
| Left work (60 or older) | 17 | 0.68 | (0.29, 1.61) | 0.38 |
| Leukemia (146 events) | | | | |
| Still employed | 23 | 1.00 | — | |
| Not employed | 123 | 0.87 | (0.48, 1.58) | 0.65 |
| Left work (under 50) | 65 | 0.88 | (0.48, 1.62) | 0.68 |
| Left work (50 or older) | 58 | 0.86 | (0.45, 1.67) | 0.66 |
| Left work (under 55) | 83 | 0.92 | (0.51, 1.69) | 0.80 |
| Left work (55 or older) | 40 | 0.74 | (0.37, 1.47) | 0.39 |
| Left work (under 60) | 94 | 0.85 | (0.46, 1.56) | 0.60 |
| Left work (60 or older) | 29 | 0.97 | (0.47, 2.01) | 0.95 |
| Non-Hodgkin's lymphoma (223 events) | | | | |
| Still employed | 26 | 1.00 | — | |
| Not employed | 197 | 1.07 | (0.63, 1.82) | 0.79 |
| Left work (under 50) | 109 | 1.06 | (0.62, 1.82) | 0.83 |
| Left work (50 or older) | 88 | 1.10 | (0.62, 1.96) | 0.74 |
| Left work (under 55) | 125 | 0.98 | (0.57, 1.69) | 0.94 |
| Left work (55 or older) | 72 | 1.37 | (0.76, 2.48) | 0.30 |
| Left work (under 60) | 156 | 1.01 | (0.59, 1.73) | 0.97 |
| Left work (60 or older) | 41 | 1.36 | (0.73, 2.55) | 0.34 |

Table 3: Adjusted HR estimates for **leaving work**.

| Covariate | level | <i>n</i> | HR | (95% CI) | <i>p</i> | |
|--|-----------------|----------|-----|------------|----------|---|
| Cumulative straight | 0 | 10718 | 1.0 | — | | |
| | > 0 to 0.364 | 4350 | 1.1 | (1.1, 1.2) | < 0.005 | * |
| | > 0.364 to 1.79 | 4587 | 1.0 | (1.0, 1.1) | 0.05 | |
| | > 1.79 | 4757 | 1.0 | (1.0, 1.1) | 0.05 | |
| Cumulative soluble | 0 | 2506 | 1.0 | — | | |
| | > 0 to 3.13 | 6730 | 1.1 | (1.1, 1.2) | < 0.005 | * |
| | > 3.13 to 11.5 | 7330 | 1.0 | (1.0, 1.1) | 0.09 | |
| | > 11.5 | 7846 | 1.0 | (0.9, 1.0) | 0.21 | |
| Cumulative synthetic | 0 | 16896 | 1.0 | — | | |
| | > 0 to 0.26 | 2418 | 0.9 | (0.9, 1.0) | < 0.005 | * |
| | > 0.26 to 1.47 | 2520 | 0.9 | (0.9, 1.0) | 0.01 | * |
| | > 1.47 | 2578 | 1.0 | (1.0, 1.1) | 0.22 | |
| Race | White | 19975 | 1.0 | — | | |
| | Black | 4437 | 0.7 | (0.7, 0.7) | < 0.005 | * |
| Plant | 1 | 7982 | 1.0 | — | | |
| | 2 | 9976 | 0.7 | (0.7, 0.7) | < 0.005 | * |
| | 3 | 6454 | 0.5 | (0.5, 0.6) | < 0.005 | * |
| P-spline of calendar year (<i>df</i> = 16.99) | | 27380 | | — | < 0.005 | * |
| P-spline of year of hire (<i>df</i> = 16.82) | | 27380 | | — | < 0.005 | * |

Table 4: Adjusted HR estimates for incidence of **colon cancer** ($n = 671$).

| Covariate | level | n | HR | (95% CI) | p |
|--|-----------------|-----|------|--------------|-----------|
| Cumulative straight | 0 | 311 | 1.00 | — | |
| | > 0 to 0.413 | 120 | 1.03 | (0.80, 1.32) | 0.82 |
| | > 0.413 to 2.16 | 120 | 1.08 | (0.85, 1.38) | 0.53 |
| | > 2.16 | 120 | 1.07 | (0.84, 1.35) | 0.59 |
| Cumulative soluble | 0 to 0.05 | 107 | 1.00 | — | |
| | > 0.05 to 3.48 | 184 | 1.04 | (0.80, 1.36) | 0.75 |
| | > 3.48 to 13.6 | 190 | 0.97 | (0.74, 1.28) | 0.83 |
| | > 13.6 | 190 | 1.12 | (0.84, 1.50) | 0.43 |
| Cumulative synthetic | 0 | 493 | 1.00 | — | |
| | > 0 to 0.191 | 60 | 1.29 | (0.93, 1.78) | 0.13 |
| | > 0.191 to 1.49 | 59 | 0.89 | (0.65, 1.22) | 0.46 |
| | > 1.49 | 59 | 1.02 | (0.76, 1.38) | 0.88 |
| Race | White | 508 | 1.00 | — | |
| | Black | 163 | 1.79 | (1.45, 2.22) | < 0.005 * |
| Plant | 1 | 226 | 1.00 | — | |
| | 2 | 244 | 0.97 | (0.74, 1.27) | 0.82 |
| | 3 | 201 | 1.11 | (0.86, 1.43) | 0.43 |
| Sex | Male | 593 | 1.00 | — | |
| | Female | 78 | 0.90 | (0.69, 1.16) | 0.40 |
| P-spline of calendar year ($df = 12.54$) | | 671 | | — | 0.05 |
| P-spline of year of hire ($df = 13.03$) | | 671 | | — | 0.46 |

Table 5: Adjusted HR estimates for incidence of **rectal cancer** ($n = 318$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|-----------------|-----|------|--------------|------|---|
| Cumulative straight | 0 | 141 | 1.00 | — | | |
| | > 0 to 0.503 | 59 | 0.99 | (0.69, 1.42) | 0.96 | |
| | > 0.503 to 2.07 | 59 | 1.22 | (0.85, 1.74) | 0.28 | |
| | > 2.07 | 59 | 1.28 | (0.91, 1.79) | 0.15 | |
| Cumulative soluble | 0 to 0.05 | 51 | 1.00 | — | | |
| | > 0.05 to 3.59 | 86 | 1.03 | (0.70, 1.50) | 0.90 | |
| | > 3.59 to 11.3 | 90 | 1.12 | (0.75, 1.67) | 0.59 | |
| | > 11.3 | 91 | 1.07 | (0.70, 1.63) | 0.75 | |
| Cumulative synthetic | 0 | 217 | 1.00 | — | | |
| | > 0 to 0.365 | 34 | 1.08 | (0.70, 1.68) | 0.73 | |
| | > 0.365 to 1.79 | 33 | 1.21 | (0.78, 1.87) | 0.40 | |
| | > 1.79 | 34 | 1.49 | (0.99, 2.24) | 0.05 | |
| Race | White | 267 | 1.00 | — | | |
| | Black | 51 | 0.89 | (0.63, 1.24) | 0.49 | |
| Plant | 1 | 98 | 1.00 | — | | |
| | 2 | 128 | 0.78 | (0.54, 1.12) | 0.17 | |
| | 3 | 92 | 0.79 | (0.56, 1.12) | 0.18 | |
| Sex | Male | 293 | 1.00 | — | | |
| | Female | 25 | 0.60 | (0.39, 0.92) | 0.02 | * |
| P-spline of calendar year ($df = 7.17$) | | 318 | | — | 0.12 | |
| P-spline of year of hire ($df = 6$) | | 318 | | — | 0.03 | * |

Table 6: Adjusted HR estimates for incidence of **pancreatic cancer** ($n = 252$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|------------------|-----|------|--------------|------|---|
| Cumulative straight | 0 | 126 | 1.00 | – | | |
| | > 0 to 0.318 | 42 | 1.00 | (0.65, 1.51) | 0.98 | |
| | > 0.318 to 1.15 | 42 | 1.06 | (0.70, 1.60) | 0.80 | |
| | > 1.15 | 42 | 0.77 | (0.52, 1.13) | 0.18 | |
| Cumulative soluble | 0 to 0.05 | 47 | 1.00 | – | | |
| | > 0.05 to 3.01 | 67 | 0.85 | (0.56, 1.27) | 0.42 | |
| | > 3.01 to 9.42 | 69 | 0.85 | (0.56, 1.30) | 0.45 | |
| | > 9.42 | 69 | 0.76 | (0.49, 1.19) | 0.24 | |
| Cumulative synthetic | 0 | 177 | 1.00 | – | | |
| | > 0 to 0.218 | 25 | 1.32 | (0.79, 2.22) | 0.29 | |
| | > 0.218 to 0.803 | 25 | 1.51 | (0.91, 2.53) | 0.11 | |
| | > 0.803 | 25 | 1.02 | (0.63, 1.64) | 0.94 | |
| Race | White | 187 | 1.00 | – | | |
| | Black | 65 | 1.46 | (1.05, 2.04) | 0.02 | * |
| Plant | 1 | 85 | 1.00 | – | | |
| | 2 | 99 | 0.74 | (0.49, 1.13) | 0.16 | |
| | 3 | 68 | 0.75 | (0.51, 1.12) | 0.16 | |
| Sex | Male | 221 | 1.00 | – | | |
| | Female | 31 | 0.89 | (0.59, 1.35) | 0.60 | |
| P-spline of calendar year ($df = 9.07$) | | 252 | | – | 0.36 | |
| P-spline of year of hire ($df = 10.15$) | | 252 | | – | 0.99 | |

Table 7: Adjusted HR estimates for incidence of **esophageal cancer** ($n = 174$).

| Covariate | level | n | HR | (95% CI) | p |
|---|-----------------|-----|------|--------------|-----------|
| Cumulative straight | 0 | 73 | 1.00 | — | |
| | > 0 to 0.385 | 34 | 1.50 | (0.92, 2.42) | 0.10 |
| | > 0.385 to 2.15 | 33 | 1.27 | (0.79, 2.05) | 0.32 |
| | > 2.15 | 34 | 1.53 | (0.98, 2.40) | 0.06 |
| Cumulative soluble | 0 to 0.05 | 31 | 1.00 | — | |
| | > 0.05 to 3.23 | 47 | 0.81 | (0.49, 1.34) | 0.41 |
| | > 3.23 to 10.8 | 48 | 0.83 | (0.49, 1.40) | 0.48 |
| | > 10.8 | 48 | 1.00 | (0.57, 1.75) | 1.00 |
| Cumulative synthetic | 0 | 120 | 1.00 | — | |
| | > 0 to 0.686 | 27 | 1.06 | (0.62, 1.81) | 0.82 |
| | > 0.686 | 27 | 1.45 | (0.89, 2.37) | 0.14 |
| Race | White | 134 | 1.00 | — | |
| | Black | 40 | 1.39 | (0.93, 2.08) | 0.11 |
| Plant | 1 | 54 | 1.00 | — | |
| | 2 | 55 | 0.70 | (0.42, 1.16) | 0.16 |
| | 3 | 65 | 0.96 | (0.62, 1.49) | 0.86 |
| Sex | Male | 169 | 1.00 | — | |
| | Female | 5 | 0.19 | (0.08, 0.48) | < 0.005 * |
| P-spline of calendar year ($df = 6.02$) | | 174 | | — | 0.88 |
| P-spline of year of hire ($df = 6.12$) | | 174 | | — | 0.01 * |

Table 8: Adjusted HR estimates for incidence of **stomach cancer** ($n = 214$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|-----------------|-----|------|--------------|---------|---|
| Cumulative straight | 0 | 108 | 1.00 | — | | |
| | > 0 to 0.347 | 36 | 1.13 | (0.72, 1.78) | 0.60 | |
| | > 0.347 to 3.28 | 35 | 0.73 | (0.46, 1.13) | 0.16 | |
| | > 3.28 | 35 | 1.54 | (1.01, 2.36) | 0.05 | |
| Cumulative soluble | 0 to 0.05 | 50 | 1.00 | — | | |
| | > 0.05 to 4.02 | 54 | 0.64 | (0.41, 0.98) | 0.04 | * |
| | > 4.02 to 13.1 | 55 | 0.78 | (0.50, 1.24) | 0.30 | |
| | > 13.1 | 55 | 0.80 | (0.49, 1.30) | 0.37 | |
| Cumulative synthetic | 0 | 158 | 1.00 | — | | |
| | > 0 to 0.64 | 28 | 0.98 | (0.59, 1.63) | 0.95 | |
| | > 0.64 | 28 | 1.12 | (0.70, 1.80) | 0.63 | |
| Race | White | 159 | 1.00 | — | | |
| | Black | 55 | 1.70 | (1.18, 2.45) | < 0.005 | * |
| Plant | 1 | 73 | 1.00 | — | | |
| | 2 | 91 | 1.18 | (0.76, 1.84) | 0.47 | |
| | 3 | 50 | 0.78 | (0.49, 1.23) | 0.28 | |
| Sex | Male | 198 | 1.00 | — | | |
| | Female | 16 | 0.49 | (0.28, 0.83) | 0.01 | * |
| P-spline of calendar year ($df = 8.19$) | | 214 | | — | 0.84 | |
| P-spline of year of hire ($df = 11.35$) | | 214 | | — | 0.80 | |

Table 9: Adjusted HR estimates for incidence of **laryngeal cancer** ($n = 207$).

| Covariate | level | n | HR | (95% CI) | p |
|--|-----------------|-----|------|--------------|-----------|
| Cumulative straight | 0 | 100 | 1.00 | — | |
| | > 0 to 0.475 | 36 | 0.81 | (0.51, 1.28) | 0.37 |
| | > 0.475 to 2.19 | 35 | 0.99 | (0.64, 1.55) | 0.98 |
| | > 2.19 | 36 | 1.31 | (0.87, 1.98) | 0.20 |
| Cumulative soluble | 0 to 0.05 | 28 | 1.00 | — | |
| | > 0.05 to 3 | 59 | 1.51 | (0.93, 2.45) | 0.10 |
| | > 3 to 10.4 | 60 | 1.20 | (0.73, 1.99) | 0.47 |
| | > 10.4 | 60 | 1.22 | (0.72, 2.08) | 0.45 |
| Cumulative synthetic | 0 | 148 | 1.00 | — | |
| | > 0 to 0.656 | 30 | 1.02 | (0.62, 1.70) | 0.93 |
| | > 0.656 | 29 | 1.18 | (0.73, 1.90) | 0.50 |
| Race | White | 148 | 1.00 | — | |
| | Black | 59 | 1.74 | (1.22, 2.48) | < 0.005 * |
| Plant | 1 | 80 | 1.00 | — | |
| | 2 | 81 | 0.95 | (0.61, 1.46) | 0.81 |
| | 3 | 46 | 0.57 | (0.37, 0.89) | 0.01 * |
| Sex | Male | 203 | 1.00 | — | |
| | Female | 4 | 0.15 | (0.06, 0.42) | < 0.005 * |
| P-spline of calendar year ($df = 1$) | | 207 | | — | 0.45 |
| P-spline of year of hire ($df = 5.18$) | | 207 | | — | 0.61 |

Table 10: Adjusted HR estimates for incidence of **lung and bronchial cancers** ($n = 1745$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|-----------------|------|------|--------------|---------|---|
| Cumulative straight | 0 | 841 | 1.00 | — | | |
| | > 0 to 0.364 | 302 | 1.08 | (0.92, 1.26) | 0.36 | |
| | > 0.364 to 1.73 | 301 | 1.03 | (0.88, 1.20) | 0.70 | |
| | > 1.73 | 301 | 1.02 | (0.89, 1.18) | 0.74 | |
| Cumulative soluble | 0 to 0.05 | 320 | 1.00 | — | | |
| | > 0.05 to 3.33 | 464 | 0.93 | (0.79, 1.08) | 0.34 | |
| | > 3.33 to 11.9 | 480 | 0.89 | (0.76, 1.05) | 0.18 | |
| | > 11.9 | 481 | 1.02 | (0.86, 1.21) | 0.84 | |
| Cumulative synthetic | 0 | 1254 | 1.00 | — | | |
| | > 0 to 0.269 | 164 | 0.98 | (0.81, 1.19) | 0.85 | |
| | > 0.269 to 1.39 | 163 | 1.03 | (0.85, 1.25) | 0.76 | |
| | > 1.39 | 164 | 1.06 | (0.88, 1.27) | 0.56 | |
| Race | White | 1395 | 1.00 | — | | |
| | Black | 350 | 1.18 | (1.03, 1.35) | 0.02 | * |
| Plant | 1 | 549 | 1.00 | — | | |
| | 2 | 712 | 0.93 | (0.80, 1.09) | 0.38 | |
| | 3 | 484 | 0.87 | (0.75, 1.01) | 0.07 | |
| Sex | Male | 1557 | 1.00 | — | | |
| | Female | 188 | 0.81 | (0.69, 0.95) | 0.01 | * |
| P-spline of calendar year ($df = 7.67$) | | 1745 | | — | 0.04 | * |
| P-spline of year of hire ($df = 5.74$) | | 1745 | | — | < 0.005 | * |

Table 11: Adjusted HR estimates for incidence of **breast cancer** ($n = 180$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|-------------------|-----|------|--------------|------|---|
| Cumulative straight | 0 | 89 | 1.00 | — | | |
| | > 0 to 0.117 | 32 | 1.89 | (1.12, 3.21) | 0.02 | * |
| | > 0.117 to 0.561 | 30 | 1.47 | (0.84, 2.58) | 0.18 | |
| | > 0.561 | 29 | 1.66 | (1.00, 2.78) | 0.05 | |
| Cumulative soluble | 0 to 0.05 | 68 | 1.00 | — | | |
| | > 0.05 to 1.36 | 39 | 0.80 | (0.50, 1.30) | 0.37 | |
| | > 1.36 to 3.23 | 39 | 1.02 | (0.60, 1.72) | 0.95 | |
| | > 3.23 | 34 | 0.81 | (0.46, 1.44) | 0.48 | |
| Cumulative synthetic | 0 | 118 | 1.00 | — | | |
| | > 0 to 0.0916 | 21 | 0.98 | (0.55, 1.76) | 0.95 | |
| | > 0.0916 to 0.339 | 22 | 0.98 | (0.54, 1.77) | 0.94 | |
| | > 0.339 | 19 | 0.60 | (0.34, 1.06) | 0.08 | |
| Race | White | 113 | 1.00 | — | | |
| | Black | 67 | 1.33 | (0.92, 1.93) | 0.13 | |
| Plant | 1 | 31 | 1.00 | — | | |
| | 2 | 149 | 1.32 | (0.81, 2.16) | 0.26 | |
| P-spline of calendar year ($df = 3.84$) | | 180 | | — | 0.12 | |
| P-spline of year of hire ($df = 2.69$) | | 180 | | — | 0.95 | |

Table 12: Adjusted HR estimates for incidence of **prostate cancer** ($n = 2518$).

| Covariate | level | n | HR | (95% CI) | p | |
|--|-----------------|------|------|--------------|---------|---|
| Cumulative straight | 0 | 1133 | 1.00 | — | | |
| | > 0 to 0.428 | 463 | 1.10 | (0.97, 1.25) | 0.14 | |
| | > 0.428 to 2.17 | 462 | 1.07 | (0.94, 1.21) | 0.30 | |
| | > 2.17 | 463 | 1.09 | (0.97, 1.23) | 0.14 | |
| Cumulative soluble | 0 to 0.05 | 313 | 1.00 | — | | |
| | > 0.05 to 3.71 | 718 | 1.04 | (0.91, 1.20) | 0.54 | |
| | > 3.71 to 12.9 | 745 | 1.08 | (0.94, 1.25) | 0.28 | |
| | > 12.9 | 745 | 1.19 | (1.03, 1.39) | 0.02 | * |
| Cumulative synthetic | 0 | 1812 | 1.00 | — | | |
| | > 0 to 0.259 | 237 | 1.02 | (0.86, 1.21) | 0.79 | |
| | > 0.259 to 1.48 | 236 | 1.00 | (0.85, 1.18) | 0.98 | |
| | > 1.48 | 236 | 1.14 | (0.98, 1.33) | 0.09 | |
| Race | White | 1799 | 1.00 | — | | |
| | Black | 722 | 2.20 | (1.99, 2.44) | < 0.005 | * |
| Plant | 1 | 918 | 1.00 | — | | |
| | 2 | 802 | 0.94 | (0.82, 1.08) | 0.40 | |
| | 3 | 801 | 1.02 | (0.90, 1.15) | 0.79 | |
| P-spline of calendar year ($df = 16.65$) | | 2518 | | — | 0.05 | |
| P-spline of year of hire ($df = 14.14$) | | 2518 | | — | < 0.005 | * |

Table 13: Adjusted HR estimates for incidence of **kidney and renal pelvic cancers** ($n = 256$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|------------------|-----|------|--------------|------|---|
| Cumulative straight | 0 | 120 | 1.00 | — | | |
| | > 0 to 0.394 | 46 | 0.96 | (0.64, 1.45) | 0.85 | |
| | > 0.394 to 3.4 | 45 | 0.88 | (0.59, 1.30) | 0.51 | |
| | > 3.4 | 45 | 1.57 | (1.08, 2.29) | 0.02 | * |
| Cumulative soluble | 0 to 0.05 | 48 | 1.00 | — | | |
| | > 0.05 to 2.73 | 69 | 0.97 | (0.65, 1.45) | 0.88 | |
| | > 2.73 to 9.26 | 69 | 0.88 | (0.58, 1.34) | 0.55 | |
| | > 9.26 | 70 | 0.85 | (0.54, 1.32) | 0.47 | |
| Cumulative synthetic | 0 | 185 | 1.00 | — | | |
| | > 0 to 0.182 | 24 | 1.10 | (0.66, 1.83) | 0.72 | |
| | > 0.182 to 0.796 | 23 | 1.05 | (0.63, 1.74) | 0.86 | |
| | > 0.796 | 24 | 0.78 | (0.49, 1.26) | 0.31 | |
| Race | White | 215 | 1.00 | — | | |
| | Black | 41 | 0.93 | (0.64, 1.35) | 0.70 | |
| Plant | 1 | 67 | 1.00 | — | | |
| | 2 | 98 | 1.04 | (0.68, 1.57) | 0.87 | |
| | 3 | 91 | 1.00 | (0.68, 1.46) | 0.99 | |
| Sex | Male | 235 | 1.00 | — | | |
| | Female | 21 | 0.58 | (0.36, 0.94) | 0.03 | * |
| P-spline of calendar year ($df = 9.72$) | | 256 | | — | 0.03 | * |
| P-spline of year of hire ($df = 7.44$) | | 256 | | — | 0.26 | |

Table 14: Adjusted HR estimates for incidence of **bladder cancer** ($n = 535$).

| Covariate | level | n | HR | (95% CI) | p | |
|--|-----------------|-----|------|--------------|---------|---|
| Cumulative straight | 0 | 237 | 1.00 | — | | |
| | > 0 to 0.388 | 100 | 1.33 | (1.01, 1.75) | 0.04 | * |
| | > 0.388 to 2.7 | 99 | 1.02 | (0.78, 1.34) | 0.86 | |
| | > 2.7 | 99 | 1.28 | (0.99, 1.65) | 0.06 | |
| Cumulative soluble | 0 to 0.05 | 88 | 1.00 | — | | |
| | > 0.05 to 3.87 | 147 | 0.85 | (0.64, 1.14) | 0.28 | |
| | > 3.87 to 13.1 | 150 | 0.99 | (0.73, 1.34) | 0.96 | |
| | > 13.1 | 150 | 1.15 | (0.84, 1.58) | 0.38 | |
| Cumulative synthetic | 0 | 395 | 1.00 | — | | |
| | > 0 to 0.255 | 47 | 0.84 | (0.58, 1.20) | 0.33 | |
| | > 0.255 to 1.28 | 46 | 0.89 | (0.62, 1.26) | 0.51 | |
| | > 1.28 | 47 | 0.79 | (0.57, 1.10) | 0.17 | |
| Race | White | 481 | 1.00 | — | | |
| | Black | 54 | 0.55 | (0.41, 0.75) | < 0.005 | * |
| Plant | 1 | 144 | 1.00 | — | | |
| | 2 | 187 | 0.95 | (0.71, 1.27) | 0.73 | |
| | 3 | 204 | 1.14 | (0.88, 1.48) | 0.31 | |
| Sex | Male | 512 | 1.00 | — | | |
| | Female | 23 | 0.30 | (0.20, 0.46) | < 0.005 | * |
| P-spline of calendar year ($df = 8.9$) | | 535 | | — | 0.55 | |
| P-spline of year of hire ($df = 7.96$) | | 535 | | — | < 0.005 | * |

Table 15: Adjusted HR estimates for incidence of **melanoma** ($n = 266$).

| Covariate | level | n | HR | (95% CI) | p | |
|--|------------------|-----|------|--------------|---------|---|
| Cumulative straight | 0 | 121 | 1.00 | — | | |
| | > 0 to 0.487 | 49 | 0.78 | (0.51, 1.17) | 0.23 | |
| | > 0.487 to 2.05 | 48 | 1.13 | (0.76, 1.68) | 0.55 | |
| | > 2.05 | 48 | 1.26 | (0.87, 1.84) | 0.22 | |
| Cumulative soluble | 0 to 0.05 | 54 | 1.00 | — | | |
| | > 0.05 to 2.76 | 68 | 0.96 | (0.63, 1.46) | 0.85 | |
| | > 2.76 to 8.46 | 72 | 1.13 | (0.72, 1.75) | 0.60 | |
| | > 8.46 | 72 | 1.18 | (0.74, 1.89) | 0.49 | |
| Cumulative synthetic | 0 | 174 | 1.00 | — | | |
| | > 0 to 0.203 | 31 | 1.40 | (0.87, 2.25) | 0.16 | |
| | > 0.203 to 0.949 | 30 | 1.26 | (0.79, 2.02) | 0.34 | |
| | > 0.949 | 31 | 1.05 | (0.68, 1.62) | 0.83 | |
| Race | White | 262 | 1.00 | — | | |
| | Black | 4 | 0.08 | (0.03, 0.21) | < 0.005 | * |
| Plant | 1 | 44 | 1.00 | — | | |
| | 2 | 115 | 1.16 | (0.75, 1.81) | 0.50 | |
| | 3 | 107 | 1.06 | (0.71, 1.58) | 0.78 | |
| Sex | Male | 247 | 1.00 | — | | |
| | Female | 19 | 0.60 | (0.37, 0.98) | 0.04 | * |
| P-spline of calendar year ($df = 2.7$) | | 266 | | — | < 0.005 | * |
| P-spline of year of hire ($df = 6.89$) | | 266 | | — | 0.90 | |

Table 16: Adjusted HR estimates for incidence of **leukemia** ($n = 235$).

| Covariate | level | n | HR | (95% CI) | p | |
|---|-----------------|-----|------|--------------|------|---|
| Cumulative straight | 0 | 114 | 1.00 | — | | |
| | > 0 to 0.339 | 41 | 1.05 | (0.68, 1.62) | 0.82 | |
| | > 0.339 to 2.23 | 40 | 0.85 | (0.56, 1.30) | 0.45 | |
| | > 2.23 | 40 | 1.11 | (0.75, 1.65) | 0.60 | |
| Cumulative soluble | 0 to 0.05 | 46 | 1.00 | — | | |
| | > 0.05 to 3.01 | 61 | 0.94 | (0.61, 1.44) | 0.77 | |
| | > 3.01 to 10.5 | 64 | 0.93 | (0.60, 1.46) | 0.75 | |
| | > 10.5 | 64 | 0.86 | (0.53, 1.38) | 0.53 | |
| Cumulative synthetic | 0 | 167 | 1.00 | — | | |
| | > 0 to 0.192 | 23 | 1.37 | (0.80, 2.34) | 0.25 | |
| | > 0.192 to 1.2 | 22 | 1.12 | (0.66, 1.89) | 0.68 | |
| | > 1.2 | 23 | 1.16 | (0.71, 1.89) | 0.56 | |
| Race | White | 190 | 1.00 | — | | |
| | Black | 45 | 1.21 | (0.83, 1.75) | 0.32 | |
| Plant | 1 | 71 | 1.00 | — | | |
| | 2 | 89 | 0.90 | (0.58, 1.40) | 0.64 | |
| | 3 | 75 | 1.00 | (0.66, 1.50) | 0.99 | |
| Sex | Male | 215 | 1.00 | — | | |
| | Female | 20 | 0.61 | (0.37, 0.99) | 0.04 | * |
| P-spline of calendar year ($df = 2.44$) | | 235 | | — | 0.66 | |
| P-spline of year of hire ($df = 7.12$) | | 235 | | — | 0.45 | |

Table 17: Adjusted HR estimates for incidence of **non-hodgkin's lymphoma** ($n = 409$).

| Covariate | level | n | HR | (95% CI) | p | |
|--|-----------------|-----|------|--------------|------|---|
| Cumulative straight | 0 | 182 | 1.00 | — | | |
| | > 0 to 0.343 | 76 | 1.12 | (0.82, 1.55) | 0.47 | |
| | > 0.343 to 2.26 | 75 | 0.88 | (0.64, 1.21) | 0.43 | |
| | > 2.26 | 76 | 1.25 | (0.93, 1.68) | 0.14 | |
| Cumulative soluble | 0 to 0.05 | 60 | 1.00 | — | | |
| | > 0.05 to 2.99 | 115 | 1.34 | (0.94, 1.90) | 0.10 | |
| | > 2.99 to 11.1 | 117 | 1.33 | (0.92, 1.92) | 0.13 | |
| | > 11.1 | 117 | 1.51 | (1.02, 2.24) | 0.04 | * |
| Cumulative synthetic | 0 | 285 | 1.00 | — | | |
| | > 0 to 0.243 | 42 | 0.98 | (0.66, 1.46) | 0.93 | |
| | > 0.243 to 1.44 | 41 | 1.02 | (0.70, 1.51) | 0.90 | |
| | > 1.44 | 41 | 1.10 | (0.76, 1.58) | 0.62 | |
| Race | White | 358 | 1.00 | — | | |
| | Black | 51 | 0.68 | (0.49, 0.95) | 0.02 | * |
| Plant | 1 | 107 | 1.00 | — | | |
| | 2 | 163 | 1.09 | (0.77, 1.54) | 0.62 | |
| | 3 | 139 | 0.99 | (0.72, 1.36) | 0.96 | |
| Sex | Male | 362 | 1.00 | — | | |
| | Female | 47 | 0.91 | (0.65, 1.26) | 0.56 | |
| P-spline of calendar year ($df = 13.16$) | | 409 | | — | 0.07 | |
| P-spline of year of hire ($df = 12.37$) | | 409 | | — | 0.41 | |

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