# Tables and Figures

**Table 1.** Summary of study population characteristics (; million person-years). The cohort was restricted to individuals who were hired in or after 1938 and for whom at least half of their work history data was available. Individuals were considered lost to follow-up once they reach the maximum observed age at death.

|  |  |  |
| --- | --- | --- |
|  |  | (%) |
| Study population size () |  |  |
| Race |  |  |
| White |  |  |
| Black |  |  |
| Unknown |  |  |
| Sex |  |  |
| Male |  |  |
| Female |  |  |
| Plant |  |  |
| Plant 1 |  |  |
| Plant 2 |  |  |
| Plant 3 |  |  |
| Ever exposed to MWFs |  |  |
| Straight |  |  |
| Soluble |  |  |
| Synthetic |  |  |
| Deceased by end of follow-up |  |  |
|  | Median | (Q1, Q3) |
| Years of follow-up |  | ( |
| Years at work |  |  |
| Year of hire |  | ) |
| Age at hire (years) |  |  |
| Year of birth |  |  |
| Year of death among deceased |  |  |
| Age at death (years) among deceased |  |  |
| Cumulative exposure to MWFs (mg/my) |  |  |
| Straight |  |  |
| Soluble |  |  |
| Synthetic |  |  |
| For individuals who worked at several plants, plant was taken to be the site where they accrued the most work record time. | | |
| Among those with known date of leaving work. | | |
| Summary statistics calculated for exposed individuals at end of follow-up only. Exposures were lagged 21 years. | | |

**Table 2.** Standardized mortality ratios calculated for the GM-UAW cohort followed from 1941 to 2015. NIOSH LTAS-extracted reference rates were used for the years 1940 through 2009. CDC Mortality data were used as reference rates for 2010 onwards.

|  |  |  |  |
| --- | --- | --- | --- |
| Cause of death |  | SMR | (95% CI) |
| All causes |  |  |  |
| All natural causes |  |  |  |
| All cancers |  |  |  |
| Esophageal cancer |  |  |  |
| Stomach cancer |  |  |  |
| Intestinal cancer |  |  |  |
| Rectal cancer |  |  |  |
| Bladder and urinary organ cancers |  |  |  |
| Bile duct, liver, and gallbladder cancers |  |  |  |
| Pancreatic cancer |  |  |  |
| Laryngeal cancer |  |  |  |
| Lung cancer |  |  |  |
| Skin cancer |  |  |  |
| Prostate cancer |  |  |  |
| Brain and nervous system cancers |  |  |  |
| Leukemia |  |  |  |
| Breast cancer |  |  |  |
| All nonmalignant respiratory diseases |  |  |  |
| Chronic obstructive pulmonary disease |  |  |  |
| Cirrhosis and other chronic liver disease |  |  |  |
| All heart diseases |  |  |  |
| Ischemic heart disease |  |  |  |
| Cerebrovascular disease |  |  |  |
| All external causes |  |  |  |
| Variance estimates assume Poisson-distributed rates in the observed population. Reference rates were assumed to be parameters. | | | |

**Figure 1.** Adjusted hazard ratio estimates for cancers and cumulative exposure to straight metalworking fluids.

Figure 1. Adjusted hazard ratio estimates for cancers and cumulative exposure to straight metalworking fluids.

**Figure 2.** Adjusted hazard ratio estimates for cancers and cumulative exposure to soluble metalworking fluids.

Figure 2. Adjusted hazard ratio estimates for cancers and cumulative exposure to soluble metalworking fluids.

**Figure 3.** Adjusted hazard ratio estimates for cancers and cumulative exposure to synthetic metalworking fluids.

Figure 3. Adjusted hazard ratio estimates for cancers and cumulative exposure to synthetic metalworking fluids.

# Appendix 1

**Table A1.1.** International Classification of Diseases (ICD) codes used to define cases. Deaths prior to 1999 were defined with respect to the 9th revision. Deaths in or after 1999 were defined with respect to the 10th.

|  |  |  |
| --- | --- | --- |
| Cause of death | ICD 9 | ICD 10 |
| All causes | – | – |
| All natural causes | 001–799 | A00–R99, U00–Z99 |
| All cancers | 140–239 | C00–C99, D00–D49 |
| Esophageal cancer | 150 | C15 |
| Stomach cancer | 151 | C16 |
| Intestinal cancer | 152–153 | C17–C18 |
| Rectal cancer | 154 | C19–C21 |
| Kidney cancer | 189.0, 189.2 | C64–C66 |
| Bladder and urinary organ cancers | 188, 189.3–189.9 | C67–C68 |
| Bile duct, liver, and gallbladder cancers | 155–156 | C22–C24 |
| Pancreatic cancer | 157 | C25 |
| Laryngeal cancer | 161 | C32 |
| Lung cancer | 162 | C33–C34 |
| Skin cancer | 172–173 | C43–C44, C46.0, C46.9 |
| Prostate cancer | 185 | C61 |
| Brain and nervous system cancers | 191–192 | C47, C70–C72 |
| Leukemia | 204–208 | C91.0–C91.3, C91.5–C91.9, C92–C95 |
| Breast cancer | 174–175 | C50 |
| All nonmalignant respiratory diseases | 460–466, 470–478, 480–487, 490–495, 496–519 | A48.1, J00–J01, J02.8–J02.9, J03.8–J03.9, J04–J06, J10–J18, J20–J22, J40–J46, J30–J33, J34.1–J34.8, J35–J39, J47, J60:J95, J98, R09.1 |
| Chronic obstructive pulmonary disease | 490–492, 496 | J40–J44 |
| Pneumonia | 480–486 | A48.1, J12–J18 |
| Cirrhosis and other chronic liver disease | 571 | K70, K73–K74, K76.0 |
| All heart diseases | 390–398, 402, 404, 410–414, 420–429 | I00–I09, I11–I13, I20–I22, I24–I25, I30–I38, I40, I42, I44–I52, I97.0–I97.1, I97.8–I97.9, R00.1, R00.8 |
| Ischemic heart disease | 410–414 | I20–I22, I24–I25, I51.3, I51.6 |
| Rheumatic heart disease | 390–398 | I00–I09 |
| Cerebrovascular disease | 430–438 | G45.0–G45.2, G45.4–G45.9, I60–I69 |
| All external causes | E800–E848, E850–E888, E929–E978, E980–E999 | V00–V99, W00-W99, X00–X84, X85–X99, Y00–Y36, Y40–Y89 |

# Appendix 2

**Table A2.1.** Cox model estimates of the hazard ratio for selected cancer outcomes associated with exposure to **straight** metalworking fluids, controlling for other fluid types, calendar year, calendar year of hire, age, race, sex, and plant, when possible.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Number of cases | HR | 95% CI |  |
| Laryngeal cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Lung cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Esophageal cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Stomach cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Colon cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Rectal cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Bladder cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Liver cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Pancreatic cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Skin cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Prostate cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Brain and nervous system cancers ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Leukemia ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Breast cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |

**Table A2.2.** Cox model estimates of the hazard ratio for selected cancer outcomes associated with exposure to **soluble** metalworking fluids, controlling for other fluid types, calendar year, calendar year of hire, age, race, sex, and plant, when possible.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Number of cases | HR | 95% CI |  |
| Laryngeal cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Lung cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Esophageal cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Stomach cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Colon cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Rectal cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Bladder cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Liver cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Pancreatic cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Skin cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Prostate cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Brain and nervous system cancers ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Leukemia ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Breast cancer ( cases) | | | | | | |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |

**Table A2.3.** Cox model estimates of the hazard ratio for selected cancer outcomes associated with exposure to **synthetic** metalworking fluids, controlling for other fluid types, calendar year, calendar year of hire, age, race, sex, and plant, when possible.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Number of cases | HR | 95% CI |  |
| Laryngeal cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Lung cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Esophageal cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Stomach cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Colon cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Rectal cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Bladder cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Liver cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Pancreatic cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Skin cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Prostate cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Brain and nervous system cancers ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Leukemia ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  | to | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |
| Breast cancer ( cases) | | | | | | |
|  |  | mg/m3·years |  |  |  |  |
|  |  | mg/m3·years |  |  |  |  |