Cancer incidence and HWSE path analysis

GM-UAW Cohort Study

July 20, 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 ar presented. These include Cox models relating emloyment 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 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 80^{th} birthday.

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

	n	p	
Study population size (N)	39 132	100%	
Race			
White	25 119	64%	
Black	6 862	18%	
Unknown	7 151	18%	
Sex			
Male	34 498	88%	
Female	4 634	12%	
Plant[♮]			
Plant 1	11 467	29%	
Plant 2	15 910	41%	
Plant 3	11 755	30%	
Ever exposed to MWFs			
Straight	21 294	54%	
Soluble	34 055	87%	
Synthetic	12 530	32%	
Diagnosed with cancer by end of follow-up	7 894	20%	
	Median	25^{th} %tile	75^{th} %tile
Years of follow-up	39.5	34.3	46.98
Years at work[*]	15.73	7.65	27.06
Year of hire	1965	1951	1973
Age at hire (years)	24	20	31
Year of birth	1937	1921	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	0.69	0.21	2.53
Soluble	4.93	1.93	13.31
Synthetic	0.44	0.15	1.56

[♮] 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**.

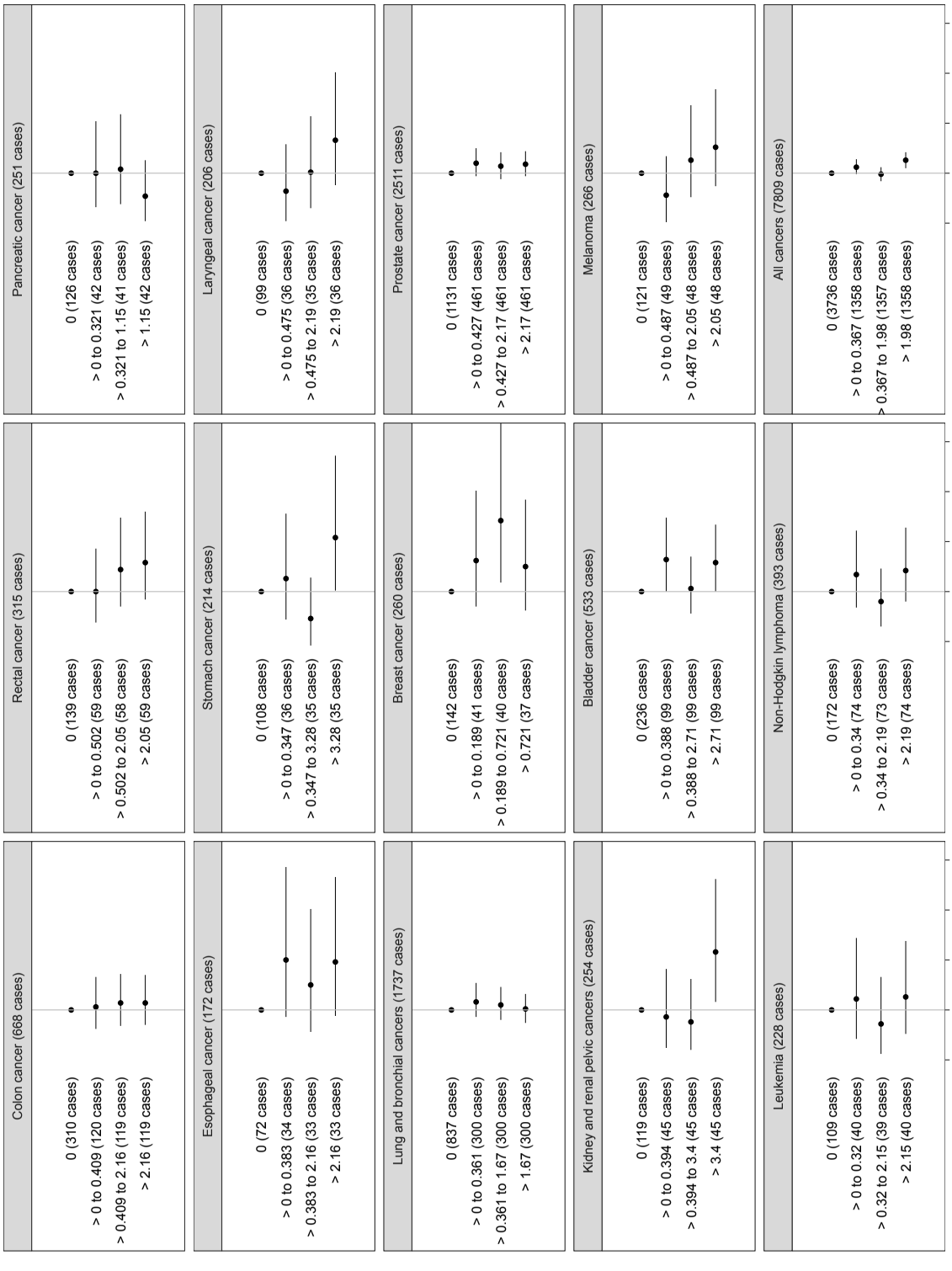

Figure 2: Adjusted hazard ratios associated with exposure to soluble metal working fluids in the **UAW-GM Cohort**.

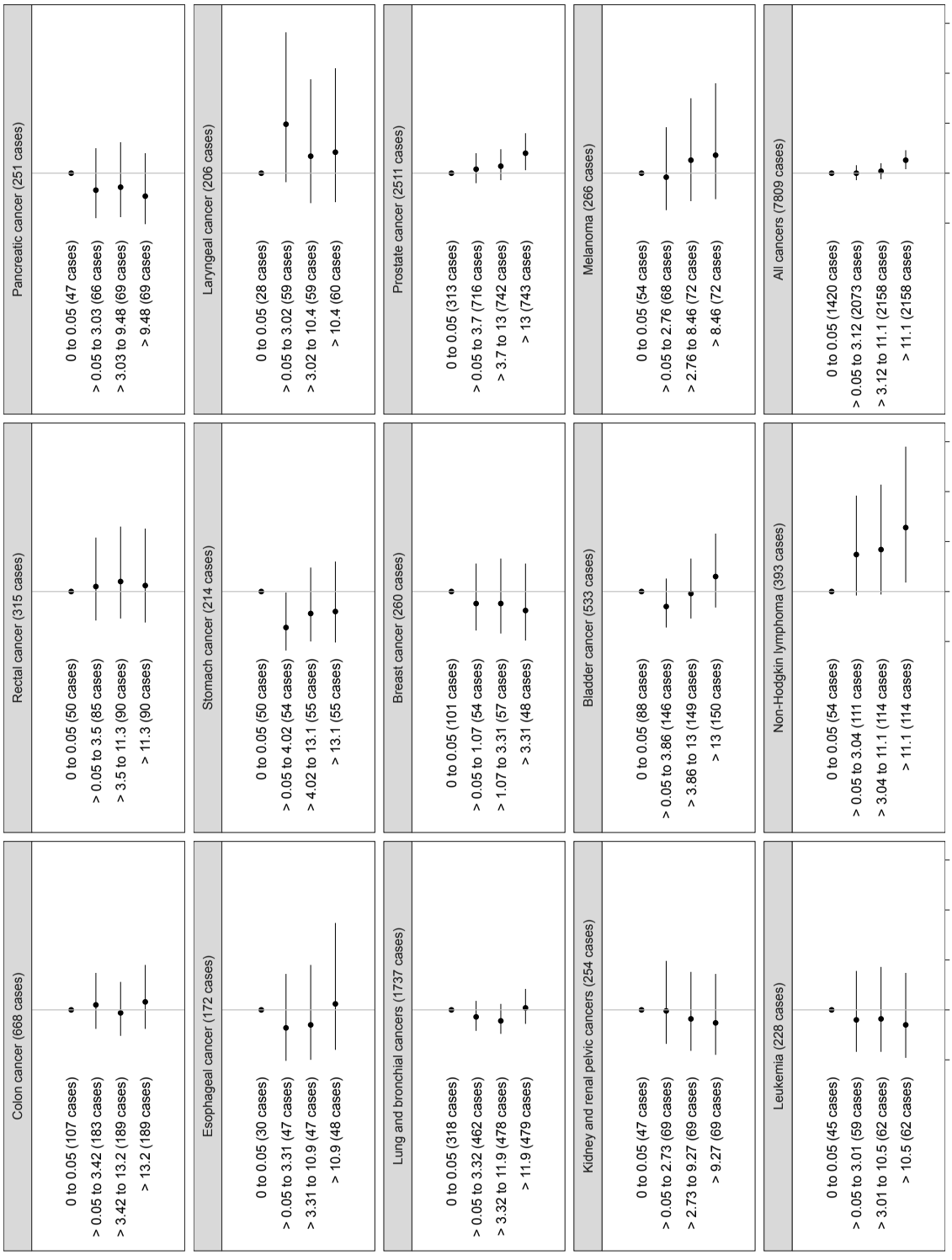

Figure 3: Adjusted hazard ratios associated with exposure to synthetic metal working fluids in the **UAW-GM Cohort**.

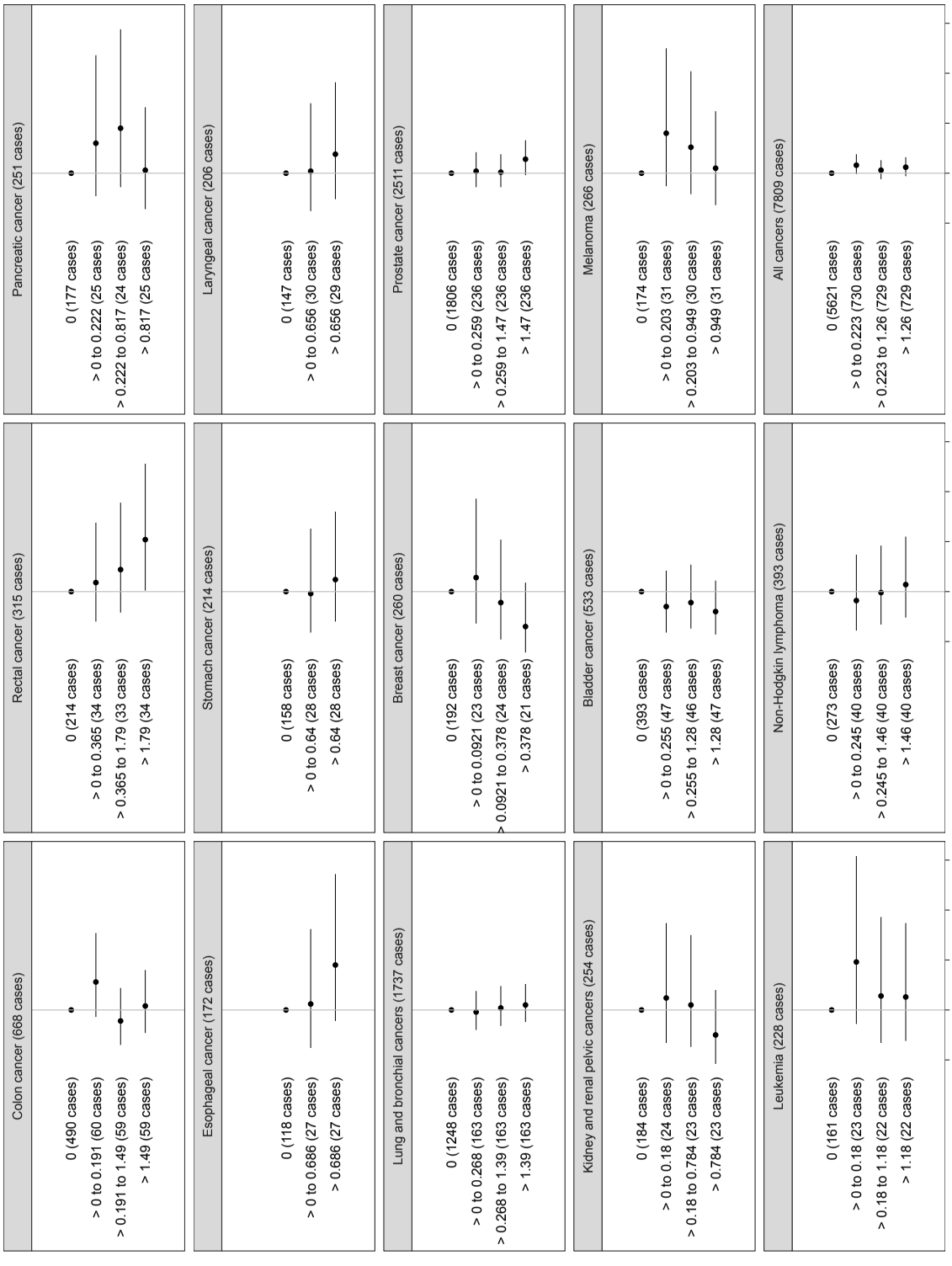

Figure 4: Adjusted hazard ratios for cancer incidence associated with leaving work in the **UAW-GM Cohort** (HWSE Condition 2).

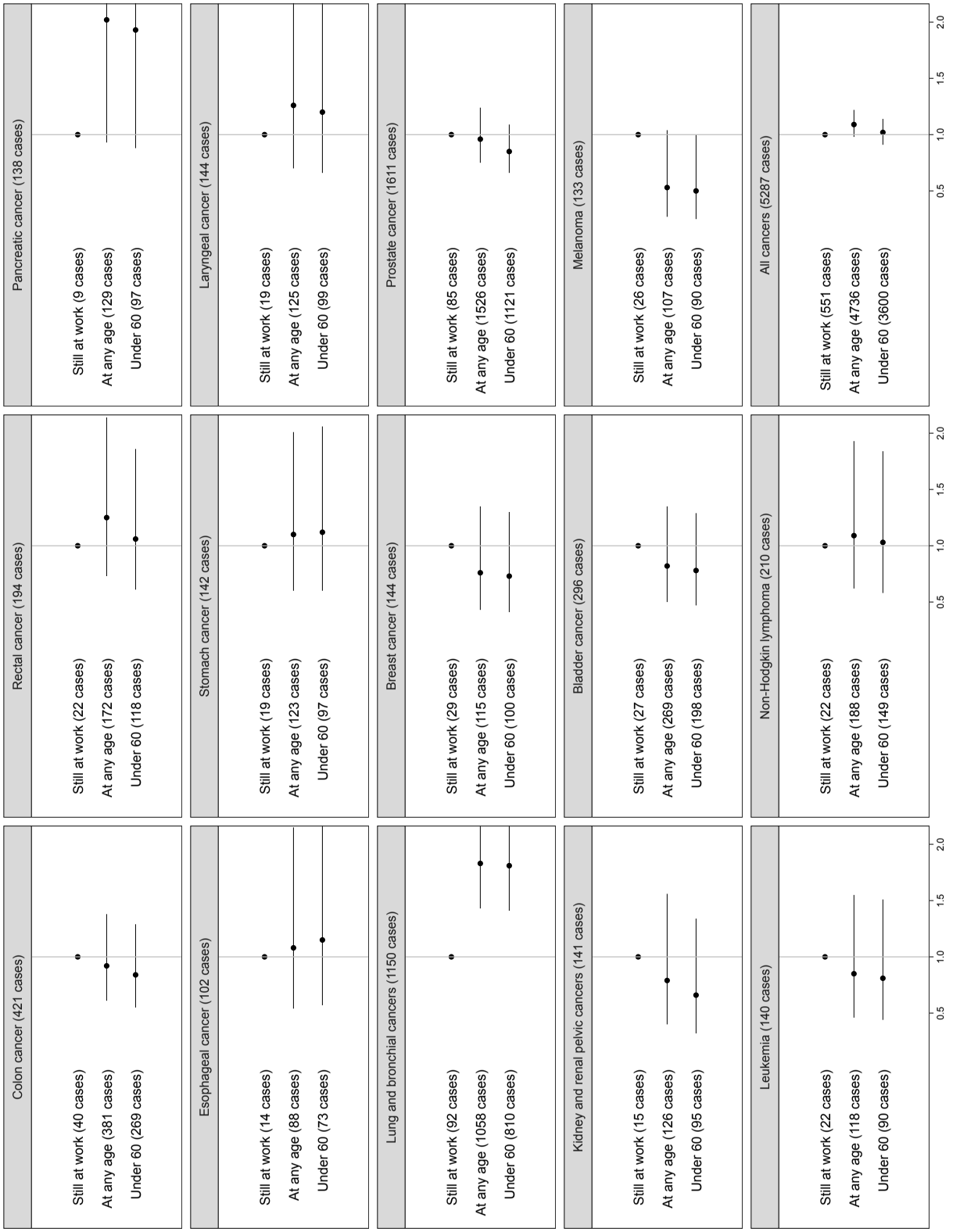

Table 2: Adjusted HR estimates for cancer incidence and employment status.

	n	HR	(95% CI)	p	
Colon cancer (421 events)					
Still employed	40	1.00	–		
Not employed	381	0.92	(0.61, 1.38)	0.68	
Left work (under 50)	158	0.79	(0.51, 1.22)	0.29	
Left work (50 or older)	223	1.06	(0.68, 1.63)	0.81	
Left work (under 55)	206	0.82	(0.54, 1.26)	0.37	
Left work (55 or older)	175	1.07	(0.69, 1.67)	0.75	
Left work (under 60)	269	0.84	(0.55, 1.29)	0.43	
Left work (60 or older)	112	1.11	(0.70, 1.75)	0.66	
Rectal cancer (194 events)					
Still employed	22	1.00	–		
Not employed	172	1.25	(0.73, 2.14)	0.42	
Left work (under 50)	65	0.90	(0.50, 1.62)	0.73	
Left work (50 or older)	107	1.78	(0.99, 3.20)	0.05	
Left work (under 55)	95	1.09	(0.62, 1.91)	0.77	
Left work (55 or older)	77	1.59	(0.87, 2.89)	0.13	
Left work (under 60)	118	1.06	(0.61, 1.86)	0.83	
Left work (60 or older)	54	1.95	(1.04, 3.65)	0.04	*
Pancreatic cancer (138 events)					
Still employed	9	1.00	–		
Not employed	129	2.02	(0.93, 4.36)	0.07	
Left work (under 50)	54	1.61	(0.72, 3.61)	0.25	
Left work (50 or older)	75	2.55	(1.14, 5.74)	0.02	*
Left work (under 55)	72	1.71	(0.77, 3.79)	0.19	
Left work (55 or older)	57	2.65	(1.16, 6.05)	0.02	*

Left work (under 60)	97	1.93	(0.88, 4.23)	0.10
Left work (60 or older)	32	2.27	(0.96, 5.35)	0.06
Esophageal cancer (102 events)				
Still employed	14	1.00	–	
Not employed	88	1.08	(0.54, 2.15)	0.84
Left work (under 50)	46	1.11	(0.53, 2.33)	0.77
Left work (50 or older)	42	1.03	(0.49, 2.18)	0.93
Left work (under 55)	62	1.23	(0.60, 2.53)	0.56
Left work (55 or older)	26	0.82	(0.37, 1.82)	0.63
Left work (under 60)	73	1.15	(0.57, 2.34)	0.70
Left work (60 or older)	15	0.85	(0.35, 2.03)	0.71
Stomach cancer (142 events)				
Still employed	19	1.00	–	
Not employed	123	1.10	(0.60, 2.01)	0.75
Left work (under 50)	57	0.93	(0.49, 1.77)	0.83
Left work (50 or older)	66	1.35	(0.70, 2.59)	0.37
Left work (under 55)	77	1.06	(0.57, 1.98)	0.85
Left work (55 or older)	46	1.18	(0.60, 2.31)	0.64
Left work (under 60)	97	1.12	(0.60, 2.06)	0.73
Left work (60 or older)	26	1.05	(0.51, 2.18)	0.89
Laryngeal cancer (144 events)				
Still employed	19	1.00	–	
Not employed	125	1.26	(0.70, 2.25)	0.44
Left work (under 50)	54	0.89	(0.47, 1.68)	0.73
Left work (50 or older)	71	1.83	(0.97, 3.44)	0.06
Left work (under 55)	75	1.04	(0.56, 1.92)	0.90
Left work (55 or older)	50	1.83	(0.94, 3.57)	0.07

Left work (under 60)	99	1.20	(0.66, 2.18)	0.55	
Left work (60 or older)	26	1.49	(0.72, 3.06)	0.28	
Lung and bronchial cancers (1150 events)					
Still employed	92	1.00	–		
Not employed	1058	1.83	(1.43, 2.35)	< 0.005	*
Left work (under 50)	479	1.61	(1.24, 2.08)	< 0.005	*
Left work (50 or older)	579	2.16	(1.66, 2.80)	< 0.005	*
Left work (under 55)	634	1.73	(1.34, 2.23)	< 0.005	*
Left work (55 or older)	424	2.06	(1.57, 2.69)	< 0.005	*
Left work (under 60)	810	1.81	(1.41, 2.33)	< 0.005	*
Left work (60 or older)	248	1.91	(1.44, 2.53)	< 0.005	*
Breast cancer (144 events)					
Still employed	29	1.00	–		
Not employed	115	0.76	(0.43, 1.35)	0.36	
Left work (under 50)	71	0.69	(0.38, 1.27)	0.23	
Left work (50 or older)	44	0.88	(0.47, 1.66)	0.69	
Left work (under 55)	86	0.71	(0.40, 1.29)	0.26	
Left work (55 or older)	29	0.91	(0.46, 1.80)	0.79	
Left work (under 60)	100	0.73	(0.41, 1.30)	0.28	
Left work (60 or older)	15	0.99	(0.46, 2.14)	0.98	
Prostate cancer (1611 events)					
Still employed	85	1.00	–		
Not employed	1526	0.96	(0.75, 1.24)	0.78	
Left work (under 50)	678	0.86	(0.66, 1.12)	0.25	
Left work (50 or older)	848	1.04	(0.81, 1.35)	0.75	
Left work (under 55)	882	0.85	(0.66, 1.10)	0.22	
Left work (55 or older)	644	1.10	(0.85, 1.43)	0.46	

Left work (under 60)	1121	0.85	(0.66, 1.09)	0.21	
Left work (60 or older)	405	1.23	(0.94, 1.61)	0.13	
Kidney and renal pelvic cancers (141 events)					
Still employed	15	1.00	–		
Not employed	126	0.79	(0.40, 1.56)	0.49	
Left work (under 50)	57	0.56	(0.27, 1.15)	0.11	
Left work (50 or older)	69	1.17	(0.56, 2.44)	0.68	
Left work (under 55)	80	0.68	(0.33, 1.38)	0.28	
Left work (55 or older)	46	1.01	(0.48, 2.13)	0.98	
Left work (under 60)	95	0.66	(0.32, 1.34)	0.25	
Left work (60 or older)	31	1.20	(0.55, 2.61)	0.65	
Bladder cancer (296 events)					
Still employed	27	1.00	–		
Not employed	269	0.82	(0.50, 1.35)	0.44	
Left work (under 50)	115	0.69	(0.41, 1.16)	0.16	
Left work (50 or older)	154	0.97	(0.58, 1.63)	0.92	
Left work (under 55)	151	0.72	(0.43, 1.21)	0.21	
Left work (55 or older)	118	0.98	(0.58, 1.66)	0.94	
Left work (under 60)	198	0.78	(0.47, 1.29)	0.33	
Left work (60 or older)	71	0.93	(0.54, 1.61)	0.81	
Melanoma (133 events)					
Still employed	26	1.00	–		
Not employed	107	0.53	(0.27, 1.04)	0.07	
Left work (under 50)	58	0.47	(0.23, 0.94)	0.03	*
Left work (50 or older)	49	0.76	(0.35, 1.62)	0.47	
Left work (under 55)	74	0.48	(0.24, 0.96)	0.04	*
Left work (55 or older)	33	0.75	(0.34, 1.65)	0.47	

Left work (under 60)	90	0.50	(0.25, 1.00)	0.05
Left work (60 or older)	17	0.72	(0.30, 1.72)	0.46
Leukemia (140 events)				
Still employed	22	1.00	–	
Not employed	118	0.85	(0.46, 1.55)	0.59
Left work (under 50)	62	0.85	(0.45, 1.61)	0.62
Left work (50 or older)	56	0.83	(0.43, 1.63)	0.59
Left work (under 55)	79	0.90	(0.48, 1.67)	0.73
Left work (55 or older)	39	0.73	(0.36, 1.48)	0.39
Left work (under 60)	90	0.81	(0.44, 1.51)	0.51
Left work (60 or older)	28	0.97	(0.47, 2.04)	0.94
Non-Hodgkin's lymphoma (210 events)				
Still employed	22	1.00	–	
Not employed	188	1.09	(0.62, 1.93)	0.76
Left work (under 50)	104	1.13	(0.63, 2.03)	0.68
Left work (50 or older)	84	1.03	(0.56, 1.91)	0.91
Left work (under 55)	119	1.00	(0.56, 1.80)	1.00
Left work (55 or older)	69	1.33	(0.71, 2.49)	0.38
Left work (under 60)	149	1.03	(0.58, 1.84)	0.92
Left work (60 or older)	39	1.33	(0.68, 2.59)	0.40

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

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	15241	1.00	–		
	> 0 to 0.402	5984	1.13	(1.09, 1.16)	< 0.005	*
	> 0.402 to 2.07	5984	1.04	(1.01, 1.08)	0.02	*
	> 2.07	5984	1.04	(1.00, 1.07)	0.03	*
Cumulative soluble	0 to 0.05	3822	1.00	–		
	> 0.05 to 3.86	9576	1.18	(1.14, 1.23)	< 0.005	*
	> 3.86 to 16.1	9897	1.09	(1.05, 1.14)	< 0.005	*
	> 16.1	9898	1.00	(0.96, 1.04)	1.00	
Cumulative synthetic	0	24584	1.00	–		
	> 0 to 0.261	2870	0.91	(0.87, 0.95)	< 0.005	*
	> 0.261 to 1.48	2869	0.94	(0.89, 0.98)	0.01	*
	> 1.48	2870	0.99	(0.95, 1.04)	0.74	
Race	White	27973	1.00	–		
	Black	5220	0.69	(0.67, 0.72)	< 0.005	*
Plant	1	14028	1.00	–		
	2	11826	0.70	(0.67, 0.73)	< 0.005	*
	3	7339	0.52	(0.50, 0.54)	< 0.005	*
Sex	Male	30254	1.00	–		
	Female	2939	1.43	(1.37, 1.49)	< 0.005	*
P-spline of calendar year (df = 16.99)		33193		–	< 0.005	*
P-spline of year of hire (df = 16.21)		33193		–	< 0.005	*

Table 4: Adjusted HR estimates for incidence of **colon cancer** ($n = 668$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	310	1.00	–		
	> 0 to 0.409	120	1.03	(0.81, 1.33)	0.79	
	> 0.409 to 2.16	119	1.07	(0.84, 1.36)	0.59	
	> 2.16	119	1.07	(0.85, 1.35)	0.58	
Cumulative soluble	0 to 0.05	107	1.00	–		
	> 0.05 to 3.42	183	1.05	(0.81, 1.37)	0.71	
	> 3.42 to 13.2	189	0.97	(0.74, 1.28)	0.85	
	> 13.2	189	1.08	(0.81, 1.45)	0.59	
Cumulative synthetic	0	490	1.00	–		
	> 0 to 0.191	60	1.28	(0.93, 1.77)	0.13	
	> 0.191 to 1.49	59	0.89	(0.65, 1.22)	0.47	
	> 1.49	59	1.04	(0.77, 1.40)	0.82	
Race	White	506	1.00	–		
	Black	162	1.78	(1.44, 2.20)	< 0.005	*
Plant	1	224	1.00	–		
	2	244	0.97	(0.74, 1.26)	0.81	
	3	200	1.10	(0.86, 1.41)	0.45	
Sex	Male	590	1.00	–		
	Female	78	0.90	(0.69, 1.16)	0.41	
P-spline of calendar year ($df = 11.58$)		668		–	0.06	
P-spline of year of hire ($df = 9.65$)		668		–	0.48	

Table 5: Adjusted HR estimates for incidence of **rectal cancer** ($n = 315$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	139	1.00	–		
	> 0 to 0.502	59	1.00	(0.69, 1.43)	0.99	
	> 0.502 to 2.05	58	1.22	(0.85, 1.74)	0.29	
	> 2.05	59	1.29	(0.92, 1.80)	0.14	
Cumulative soluble	0 to 0.05	50	1.00	–		
	> 0.05 to 3.5	85	1.05	(0.71, 1.54)	0.82	
	> 3.5 to 11.3	90	1.10	(0.73, 1.65)	0.65	
	> 11.3	90	1.06	(0.69, 1.63)	0.78	
Cumulative synthetic	0	214	1.00	–		
	> 0 to 0.365	34	1.09	(0.70, 1.69)	0.71	
	> 0.365 to 1.79	33	1.22	(0.79, 1.89)	0.37	
	> 1.79	34	1.52	(1.01, 2.28)	0.05	
Race	White	264	1.00	–		
	Black	51	0.89	(0.64, 1.25)	0.51	
Plant	1	97	1.00	–		
	2	127	0.77	(0.53, 1.11)	0.16	
	3	91	0.78	(0.55, 1.11)	0.16	
Sex	Male	291	1.00	–		
	Female	24	0.58	(0.37, 0.89)	0.01	*
P-spline of calendar year ($df = 7.15$)		315		–	0.11	
P-spline of year of hire ($df = 5.95$)		315		–	0.03	*

Table 6: Adjusted HR estimates for incidence of **pancreatic cancer** ($n = 251$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	126	1.00	–		
	> 0 to 0.321	42	1.00	(0.66, 1.52)	0.99	
	> 0.321 to 1.15	41	1.04	(0.69, 1.59)	0.84	
	> 1.15	42	0.77	(0.52, 1.13)	0.18	
Cumulative soluble	0 to 0.05	47	1.00	–		
	> 0.05 to 3.03	66	0.83	(0.55, 1.25)	0.38	
	> 3.03 to 9.48	69	0.86	(0.56, 1.31)	0.47	
	> 9.48	69	0.77	(0.49, 1.20)	0.25	
Cumulative synthetic	0	177	1.00	–		
	> 0 to 0.222	25	1.30	(0.77, 2.18)	0.32	
	> 0.222 to 0.817	24	1.45	(0.86, 2.44)	0.16	
	> 0.817	25	1.03	(0.64, 1.66)	0.91	
Race	White	186	1.00	–		
	Black	65	1.47	(1.06, 2.05)	0.02	*
Plant	1	85	1.00	–		
	2	98	0.75	(0.49, 1.14)	0.18	
	3	68	0.76	(0.51, 1.13)	0.17	
Sex	Male	221	1.00	–		
	Female	30	0.86	(0.57, 1.31)	0.49	
P-spline of calendar year ($df = 9.07$)		251		–	0.31	
P-spline of year of hire ($df = 10.17$)		251		–	0.99	

Table 7: Adjusted HR estimates for incidence of **esophageal cancer** ($n = 172$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	72	1.00	–		
	> 0 to 0.383	34	1.50	(0.93, 2.43)	0.10	
	> 0.383 to 2.16	33	1.25	(0.78, 2.01)	0.36	
	> 2.16	33	1.48	(0.94, 2.33)	0.09	
Cumulative soluble	0 to 0.05	30	1.00	–		
	> 0.05 to 3.31	47	0.82	(0.49, 1.36)	0.44	
	> 3.31 to 10.9	47	0.85	(0.50, 1.45)	0.56	
	> 10.9	48	1.06	(0.60, 1.87)	0.84	
Cumulative synthetic	0	118	1.00	–		
	> 0 to 0.686	27	1.06	(0.62, 1.81)	0.83	
	> 0.686	27	1.45	(0.89, 2.36)	0.14	
Race	White	133	1.00	–		
	Black	39	1.40	(0.93, 2.10)	0.11	
Plant	1	52	1.00	–		
	2	55	0.73	(0.43, 1.22)	0.22	
	3	65	1.02	(0.65, 1.59)	0.94	
Sex	Male	167	1.00	–		
	Female	5	0.19	(0.08, 0.48)	< 0.005	*
P-spline of calendar year ($df = 6.66$)		172		–	0.87	
P-spline of year of hire ($df = 6.15$)		172		–	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, 1.14)	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, 0.99)	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)	0.46	
	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		–	0.81	

Table 9: Adjusted HR estimates for incidence of **laryngeal cancer** (n = 206).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	99	1.00	–		
	> 0 to 0.475	36	0.82	(0.52, 1.29)	0.39	
	> 0.475 to 2.19	35	1.01	(0.65, 1.57)	0.97	
	> 2.19	36	1.33	(0.88, 2.01)	0.17	
Cumulative soluble	0 to 0.05	28	1.00	–		
	> 0.05 to 3.02	59	1.49	(0.91, 2.41)	0.11	
	> 3.02 to 10.4	59	1.17	(0.70, 1.94)	0.55	
	> 10.4	60	1.21	(0.71, 2.05)	0.48	
Cumulative synthetic	0	147	1.00	–		
	> 0 to 0.656	30	1.02	(0.62, 1.70)	0.93	
	> 0.656	29	1.19	(0.74, 1.91)	0.48	
Race	White	147	1.00	–		
	Black	59	1.74	(1.22, 2.48)	< 0.005	*
Plant	1	80	1.00	–		
	2	81	0.94	(0.61, 1.45)	0.79	
	3	45	0.56	(0.36, 0.86)	0.01	*
Sex	Male	202	1.00	–		
	Female	4	0.15	(0.06, 0.42)	< 0.005	*
P-spline of calendar year (df = 1.03)		206		–	0.39	
P-spline of year of hire (df = 5.12)		206		–	0.57	

Table 10: Adjusted HR estimates for incidence of **lung and bronchial cancers** ($n = 1737$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	837	1.00	–		
	> 0 to 0.361	300	1.08	(0.93, 1.27)	0.31	
	> 0.361 to 1.67	300	1.05	(0.90, 1.23)	0.53	
	> 1.67	300	1.01	(0.87, 1.16)	0.92	
Cumulative soluble	0 to 0.05	318	1.00	–		
	> 0.05 to 3.32	462	0.93	(0.79, 1.09)	0.36	
	> 3.32 to 11.9	478	0.89	(0.76, 1.06)	0.19	
	> 11.9	479	1.02	(0.86, 1.21)	0.84	
Cumulative synthetic	0	1248	1.00	–		
	> 0 to 0.268	163	0.98	(0.80, 1.19)	0.81	
	> 0.268 to 1.39	163	1.02	(0.84, 1.24)	0.82	
	> 1.39	163	1.05	(0.88, 1.26)	0.59	
Race	White	1387	1.00	–		
	Black	350	1.19	(1.04, 1.36)	0.01	*
Plant	1	546	1.00	–		
	2	709	0.93	(0.80, 1.09)	0.38	
	3	482	0.87	(0.75, 1.02)	0.08	
Sex	Male	1550	1.00	–		
	Female	187	0.81	(0.69, 0.95)	0.01	*
P-spline of calendar year ($df = 7.62$)		1737		–	0.04	*
P-spline of year of hire ($df = 5.91$)		1737		–	< 0.005	*

Table 11: Adjusted HR estimates for incidence of **breast cancer** (n = 260).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	142	1.00	–		
	> 0 to 0.189	41	1.31	(0.85, 2.01)	0.22	
	> 0.189 to 0.721	40	1.71	(1.09, 2.69)	0.02	*
	> 0.721	37	1.25	(0.81, 1.92)	0.32	
Cumulative soluble	0 to 0.05	101	1.00	–		
	> 0.05 to 1.07	54	0.88	(0.61, 1.28)	0.51	
	> 1.07 to 3.31	57	0.88	(0.58, 1.33)	0.55	
	> 3.31	48	0.81	(0.51, 1.28)	0.36	
Cumulative synthetic	0	192	1.00	–		
	> 0 to 0.0921	23	1.14	(0.68, 1.93)	0.62	
	> 0.0921 to 0.378	24	0.89	(0.52, 1.52)	0.68	
	> 0.378	21	0.65	(0.39, 1.09)	0.10	
Race	White	177	1.00	–		
	Black	83	1.21	(0.89, 1.66)	0.22	
Plant	1	31	1.00	–		
	2	148	1.21	(0.74, 1.97)	0.45	
	3	81	1.22	(0.76, 1.95)	0.42	
P-spline of calendar year (df = 2.46)		260		–	0.03	*
P-spline of year of hire (df = 5.61)		260		–	0.26	

Table 12: Adjusted HR estimates for incidence of **prostate cancer** (n = 2511).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	1131	1.00	–		
	> 0 to 0.427	461	1.10	(0.97, 1.25)	0.14	
	> 0.427 to 2.17	461	1.07	(0.94, 1.21)	0.32	
	> 2.17	461	1.09	(0.97, 1.22)	0.16	
Cumulative soluble	0 to 0.05	313	1.00	–		
	> 0.05 to 3.7	716	1.04	(0.90, 1.20)	0.57	
	> 3.7 to 13	742	1.07	(0.93, 1.24)	0.33	
	> 13	743	1.20	(1.03, 1.40)	0.02	*
Cumulative synthetic	0	1806	1.00	–		
	> 0 to 0.259	236	1.02	(0.86, 1.21)	0.80	
	> 0.259 to 1.47	236	1.01	(0.86, 1.19)	0.91	
	> 1.47	236	1.14	(0.98, 1.33)	0.09	
Race	White	1794	1.00	–		
	Black	720	2.21	(1.99, 2.45)	< 0.005	*
Plant	1	914	1.00	–		
	2	800	0.95	(0.82, 1.09)	0.43	
	3	800	1.02	(0.90, 1.16)	0.72	
P-spline of calendar year (df = 16.65)		2511		–	0.04	*
P-spline of year of hire (df = 14.14)		2511		–	< 0.005	*

Table 13: Adjusted HR estimates for incidence of **kidney and renal pelvic cancers** ($n = 254$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	119	1.00	–		
	> 0 to 0.394	45	0.93	(0.62, 1.41)	0.75	
	> 0.394 to 3.4	45	0.88	(0.60, 1.31)	0.54	
	> 3.4	45	1.58	(1.08, 2.31)	0.02	*
Cumulative soluble	0 to 0.05	47	1.00	–		
	> 0.05 to 2.73	69	0.99	(0.66, 1.49)	0.97	
	> 2.73 to 9.27	69	0.91	(0.59, 1.38)	0.65	
	> 9.27	69	0.87	(0.55, 1.36)	0.53	
Cumulative synthetic	0	184	1.00	–		
	> 0 to 0.18	24	1.12	(0.67, 1.87)	0.66	
	> 0.18 to 0.784	23	1.05	(0.63, 1.75)	0.85	
	> 0.784	23	0.75	(0.46, 1.20)	0.23	
Race	White	213	1.00	–		
	Black	41	0.94	(0.65, 1.37)	0.75	
Plant	1	66	1.00	–		
	2	97	1.05	(0.69, 1.60)	0.82	
	3	91	1.02	(0.70, 1.50)	0.91	
Sex	Male	233	1.00	–		
	Female	21	0.59	(0.37, 0.94)	0.03	*
P-spline of calendar year ($df = 9.34$)		254		–	0.03	*
P-spline of year of hire ($df = 7.42$)		254		–	0.27	

Table 14: Adjusted HR estimates for incidence of **bladder cancer** (n = 533).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	236	1.00	–		
	> 0 to 0.388	99	1.32	(1.00, 1.74)	0.05	
	> 0.388 to 2.71	99	1.03	(0.78, 1.35)	0.84	
	> 2.71	99	1.29	(1.00, 1.67)	0.05	
Cumulative soluble	0 to 0.05	88	1.00	–		
	> 0.05 to 3.86	146	0.85	(0.64, 1.13)	0.27	
	> 3.86 to 13	149	0.98	(0.73, 1.33)	0.92	
	> 13	150	1.15	(0.84, 1.58)	0.39	
Cumulative synthetic	0	393	1.00	–		
	> 0 to 0.255	47	0.85	(0.59, 1.21)	0.36	
	> 0.255 to 1.28	46	0.89	(0.63, 1.27)	0.54	
	> 1.28	47	0.80	(0.57, 1.11)	0.18	
Race	White	479	1.00	–		
	Black	54	0.56	(0.41, 0.76)	< 0.005	*
Plant	1	144	1.00	–		
	2	186	0.94	(0.70, 1.26)	0.69	
	3	203	1.13	(0.87, 1.47)	0.35	
Sex	Male	510	1.00	–		
	Female	23	0.30	(0.20, 0.47)	< 0.005	*
P-spline of calendar year (df = 9.01)		533		–	0.53	
P-spline of year of hire (df = 7.93)		533		–	< 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, 1.90)	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, 1.57)	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		–	0.91	

Table 16: Adjusted HR estimates for incidence of **leukemia** ($n = 228$).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	109	1.00	–		
	> 0 to 0.32	40	1.11	(0.71, 1.72)	0.65	
	> 0.32 to 2.15	39	0.86	(0.56, 1.33)	0.50	
	> 2.15	40	1.13	(0.76, 1.69)	0.54	
Cumulative soluble	0 to 0.05	45	1.00	–		
	> 0.05 to 3.01	59	0.90	(0.58, 1.39)	0.62	
	> 3.01 to 10.5	62	0.91	(0.58, 1.43)	0.68	
	> 10.5	62	0.85	(0.52, 1.37)	0.50	
Cumulative synthetic	0	161	1.00	–		
	> 0 to 0.18	23	1.48	(0.86, 2.54)	0.15	
	> 0.18 to 1.18	22	1.14	(0.67, 1.93)	0.64	
	> 1.18	22	1.13	(0.69, 1.87)	0.63	
Race	White	184	1.00	–		
	Black	44	1.23	(0.84, 1.79)	0.29	
Plant	1	68	1.00	–		
	2	85	0.89	(0.57, 1.39)	0.61	
	3	75	1.03	(0.68, 1.55)	0.89	
Sex	Male	209	1.00	–		
	Female	19	0.60	(0.36, 0.98)	0.04	*
P-spline of calendar year ($df = 2.36$)		228		–	0.52	
P-spline of year of hire ($df = 7$)		228		–	0.41	

Table 17: Adjusted HR estimates for incidence of **non-hodgkin's lymphoma** (n = 393).

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	172	1.00	–		
	> 0 to 0.34	74	1.17	(0.84, 1.61)	0.35	
	> 0.34 to 2.19	73	0.90	(0.65, 1.23)	0.51	
	> 2.19	74	1.21	(0.90, 1.64)	0.21	
Cumulative soluble	0 to 0.05	54	1.00	–		
	> 0.05 to 3.04	111	1.37	(0.96, 1.96)	0.08	
	> 3.04 to 11.1	114	1.42	(0.97, 2.07)	0.07	
	> 11.1	114	1.64	(1.09, 2.45)	0.02	*
Cumulative synthetic	0	273	1.00	–		
	> 0 to 0.245	40	0.91	(0.61, 1.37)	0.66	
	> 0.245 to 1.46	40	0.99	(0.67, 1.46)	0.95	
	> 1.46	40	1.07	(0.74, 1.55)	0.72	
Race	White	347	1.00	–		
	Black	46	0.64	(0.46, 0.90)	0.01	*
Plant	1	99	1.00	–		
	2	156	1.10	(0.78, 1.56)	0.60	
	3	138	1.01	(0.73, 1.38)	0.96	
Sex	Male	348	1.00	–		
	Female	45	0.93	(0.66, 1.29)	0.65	
P-spline of calendar year (df = 10.4)		393		–	0.02	*
P-spline of year of hire (df = 9)		393		–	0.41	

Table 18: Adjusted HR estimates for incidence of the indicated outcome, associated with race. Caution: these estimates are simply the conditional estimates from the previous table.

Outcome	level	n	HR	(95% CI)	p	
Colon cancer	White	506	1.00	–		
	Black	162	1.78	(1.44, 2.20)	< 0.005	$*$
Rectal cancer	White	264	1.00	–		
	Black	51	0.89	(0.64, 1.25)	0.51	
Pancreatic cancer	White	186	1.00	–		
	Black	65	1.47	(1.06, 2.05)	0.02	$*$
Esophageal cancer	White	133	1.00	–		
	Black	39	1.40	(0.93, 2.10)	0.11	
Stomach cancer	White	159	1.00	–		
	Black	55	1.70	(1.18, 2.45)	< 0.005	$*$
Laryngeal cancer	White	147	1.00	–		
	Black	59	1.74	(1.22, 2.48)	< 0.005	$*$
Lung and bronchial cancers	White	1387	1.00	–		
	Black	350	1.19	(1.04, 1.36)	0.01	$*$
Breast cancer	White	177	1.00	–		
	Black	83	1.21	(0.89, 1.66)	0.22	
Prostate cancer	White	1794	1.00	–		
	Black	720	2.21	(1.99, 2.45)	< 0.005	$*$
Kidney and renal pelvic cancers	White	213	1.00	–		
	Black	41	0.94	(0.65, 1.37)	0.75	
Bladder cancer	White	479	1.00	–		
	Black	54	0.56	(0.41, 0.76)	< 0.005	$*$
Melanoma	White	262	1.00	–		
	Black	4	0.08	(0.03, 0.21)	< 0.005	$*$
Leukemia	White	184	1.00	–		
	Black	44	1.23	(0.84, 1.79)	0.29	
Non-Hodgkin's lymphoma	White	347	1.00	–		
	Black	46	0.64	(0.46, 0.90)	0.01	$*$

1. Garcia E, Picciotto S, Costello S, Bradshaw PT, Eisen EA. Assessment of the healthy worker survivor effect in cancer studies of the united autoworkers-general motors cohort. *Occupational and environmental medicine*. 2017;74(4):294-300.