Cancer incidence and HWSE path analysis

GM-UAW Cohort Study

March 4, 2021

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 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 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	1952	1973
Age at hire (years)	24	20	31
Year of birth	1937	1921	1949
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**.

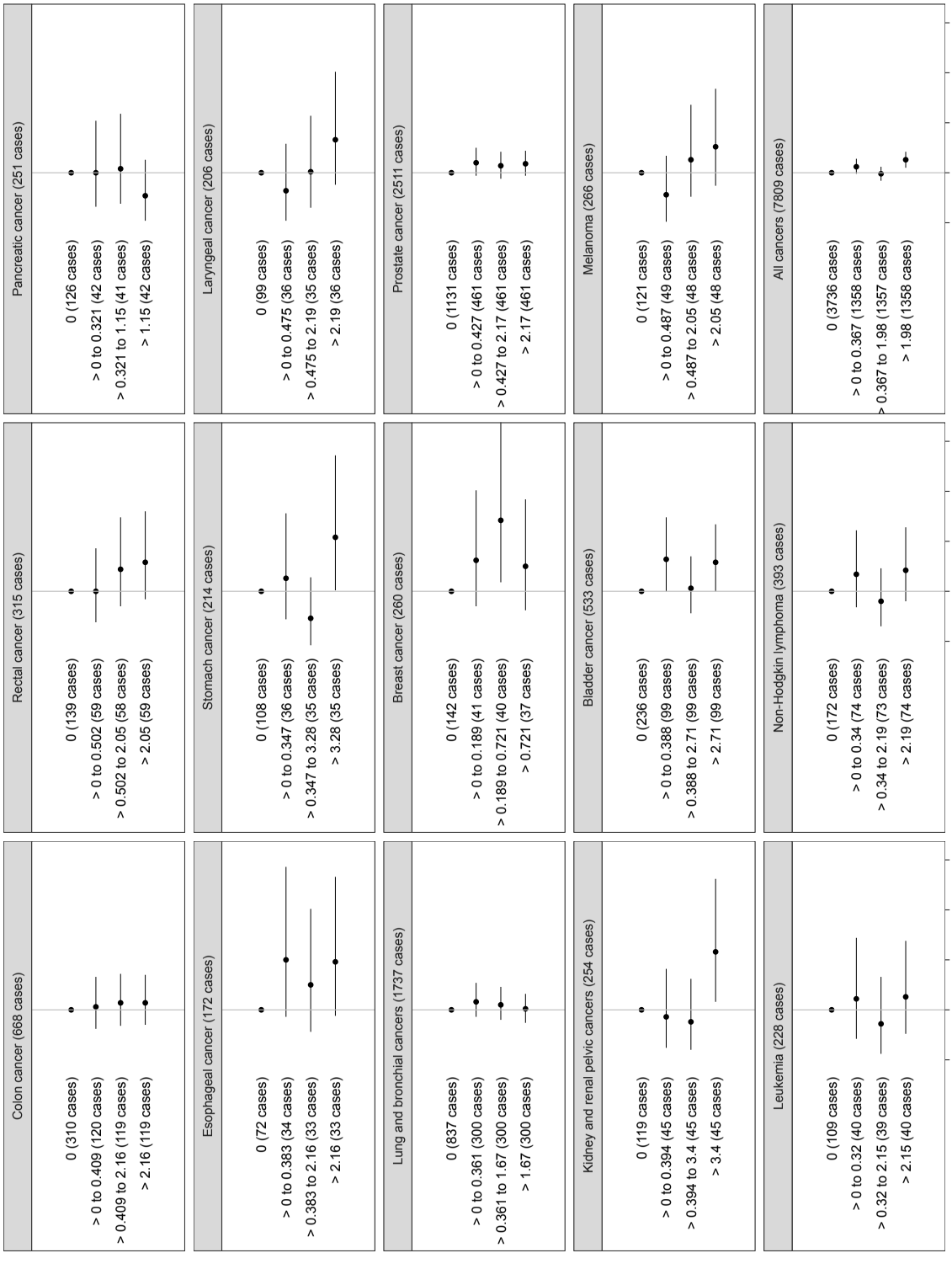

Figure 2: Adjusted hazard ratios associated with exposure to soluble metal working fluids in the **UAW-GM Cohort**.

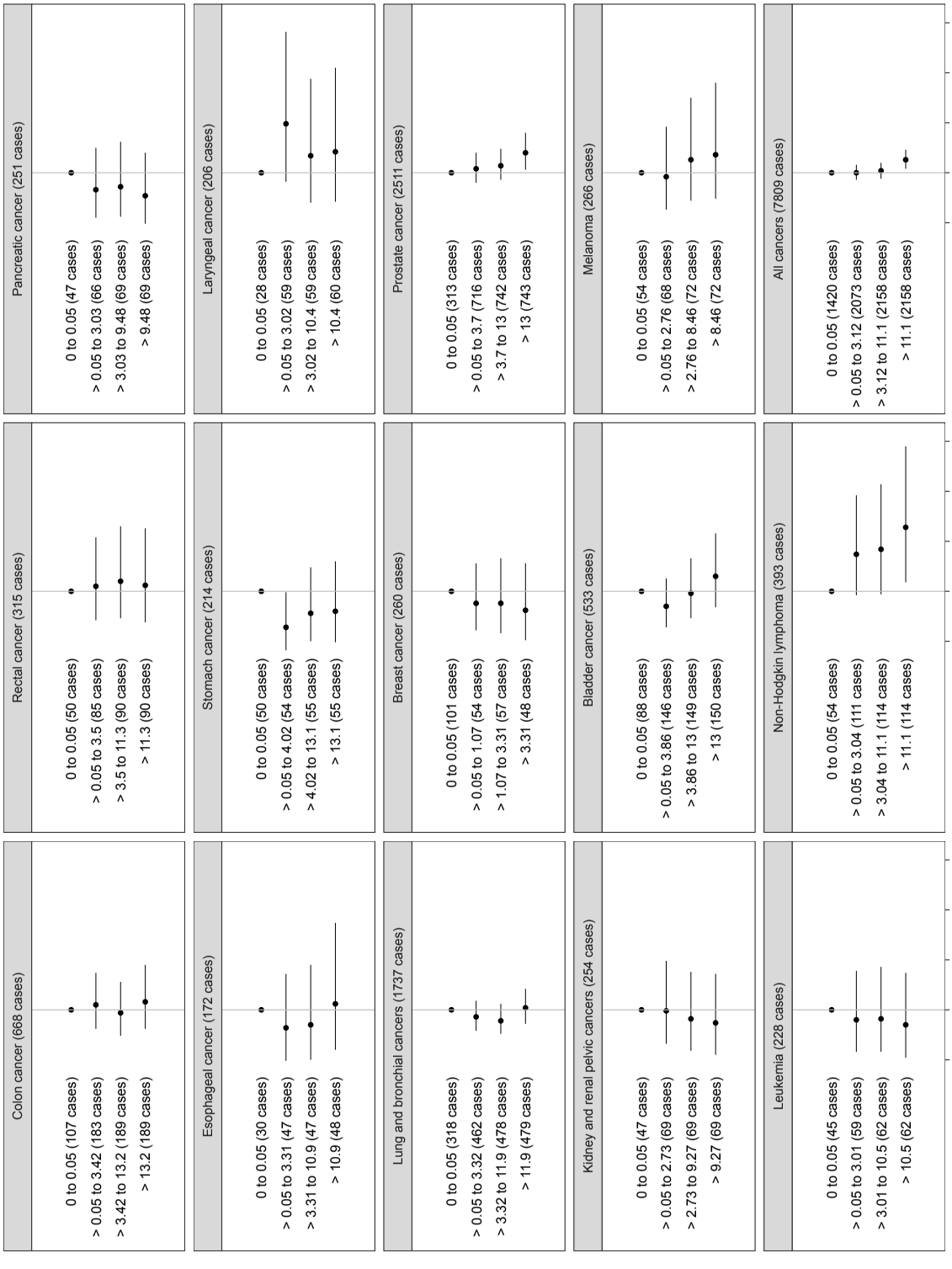

Figure 3: Adjusted hazard ratios associated with exposure to synthetic metal working fluids in the **UAW-GM Cohort**.

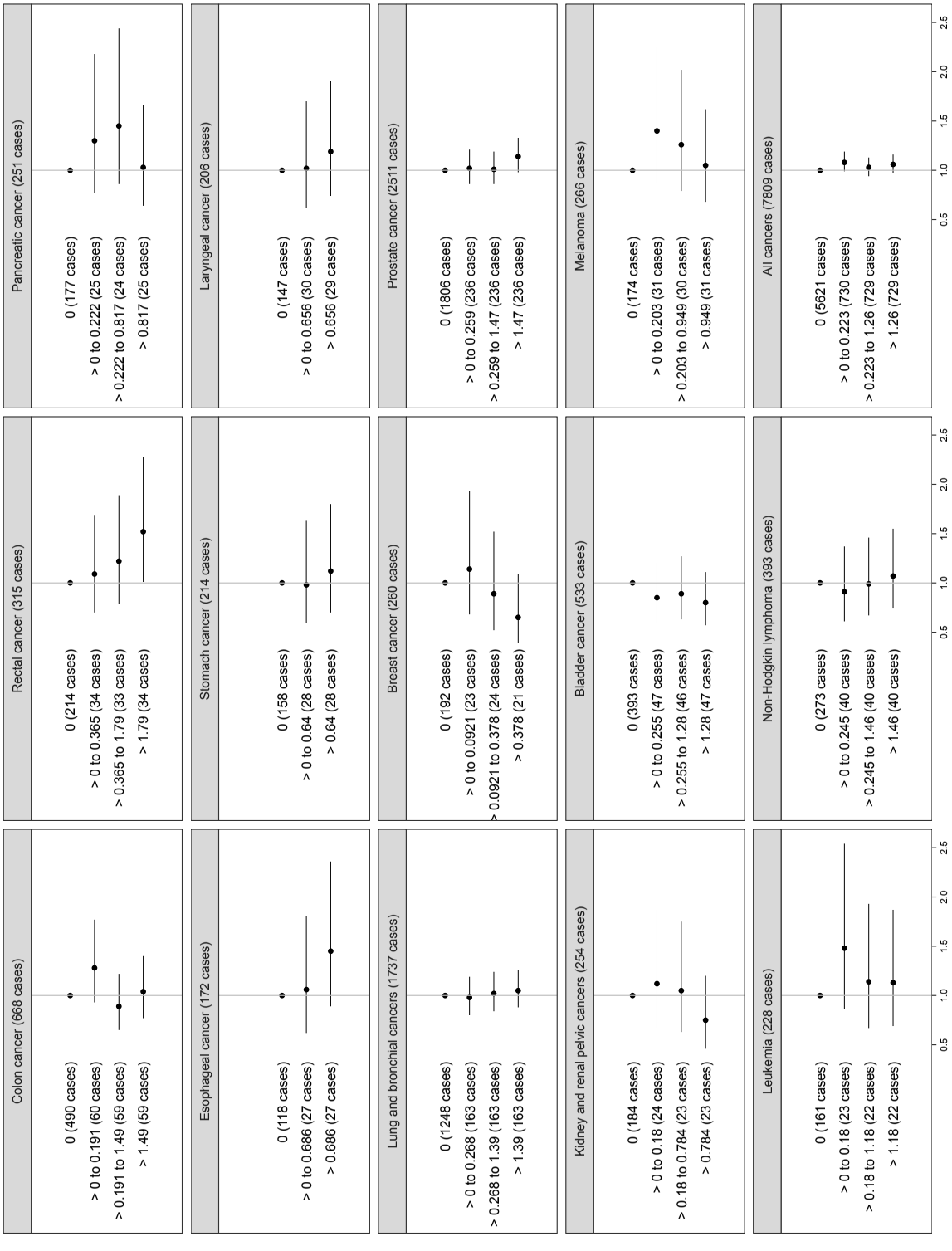

Figure 4: Adjusted hazard ratios for cancer incidence associated with leaving work in the **UAW-GM Cohort** (HWSE Condition 2).

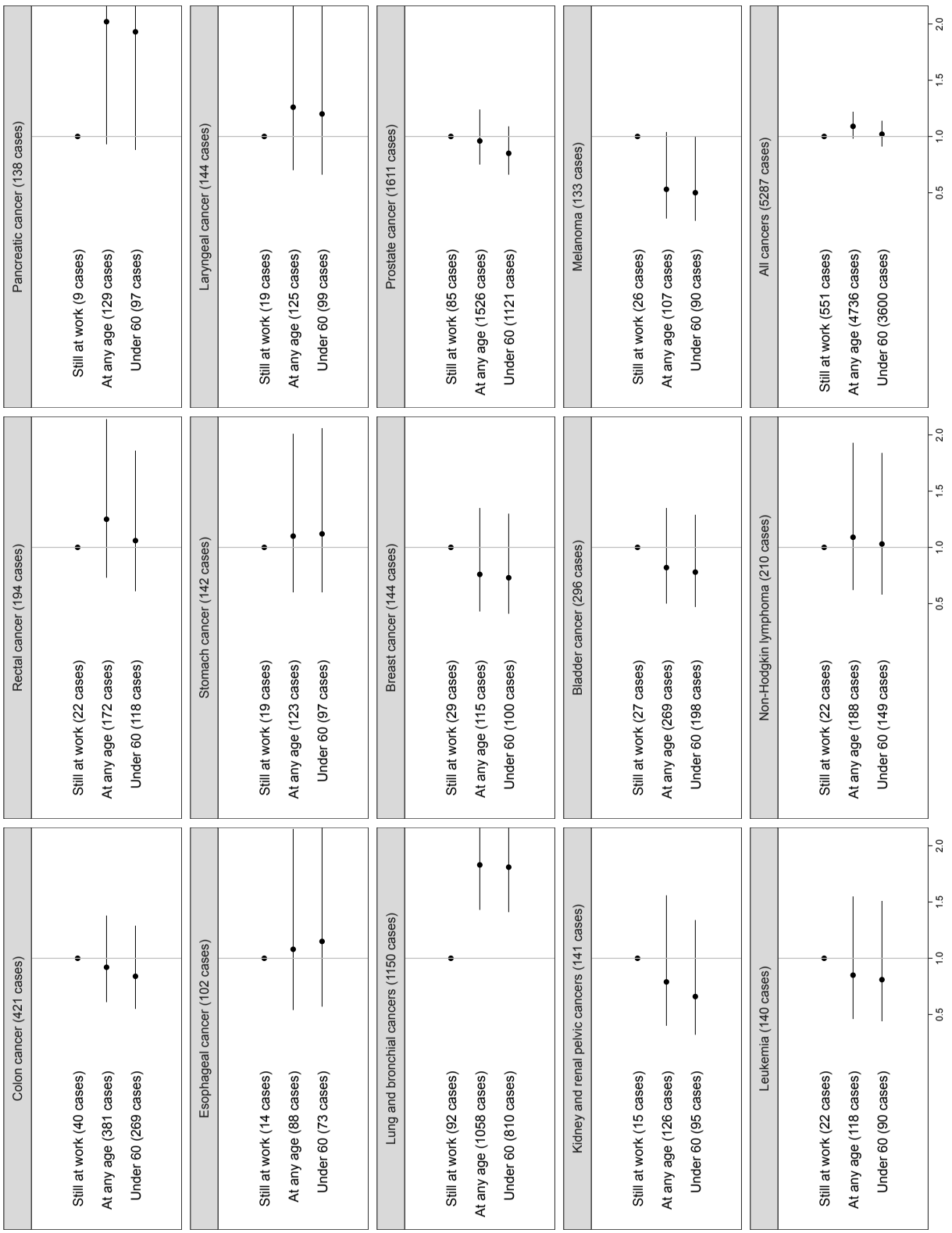

Table 2: Adjusted HR estimates for cancer incidence and employment status.

	n	HR	(95% CI)	p	
Colon cancer (421 events)					
Still employed	40	1.00	–		
Not employed	381	0.89	(0.59, 1.35)	0.59	
Left work (under 50)	158	0.74	(0.48, 1.14)	0.17	
Left work (50 or older)	223	1.07	(0.70, 1.66)	0.75	
Left work (under 55)	206	0.78	(0.51, 1.19)	0.25	
Left work (55 or older)	175	1.09	(0.70, 1.70)	0.70	
Left work (under 60)	269	0.81	(0.53, 1.23)	0.32	
Left work (60 or older)	112	1.12	(0.71, 1.76)	0.62	
Rectal cancer (194 events)					
Still employed	22	1.00	–		
Not employed	172	1.20	(0.70, 2.06)	0.51	
Left work (under 50)	65	0.84	(0.47, 1.50)	0.55	
Left work (50 or older)	107	1.80	(1.00, 3.24)	0.05	
Left work (under 55)	95	1.02	(0.58, 1.79)	0.95	
Left work (55 or older)	77	1.61	(0.88, 2.92)	0.12	
Left work (under 60)	118	1.01	(0.58, 1.76)	0.98	
Left work (60 or older)	54	1.95	(1.04, 3.66)	0.04	$*$
Pancreatic cancer (138 events)					
Still employed	9	1.00	–		
Not employed	129	1.85	(0.86, 4.00)	0.12	
Left work (under 50)	54	1.33	(0.59, 3.00)	0.49	
Left work (50 or older)	75	2.64	(1.17, 5.95)	0.02	$*$
Left work (under 55)	72	1.46	(0.66, 3.25)	0.35	
Left work (55 or older)	57	2.75	(1.20, 6.27)	0.02	$*$

Left work (under 60)	97	1.71	(0.78, 3.74)	0.18
Left work (60 or older)	32	2.30	(0.98, 5.40)	0.06
Esophageal cancer (102 events)				
Still employed	14	1.00	–	
Not employed	88	0.99	(0.49, 1.97)	0.97
Left work (under 50)	46	0.93	(0.44, 1.93)	0.84
Left work (50 or older)	42	1.06	(0.50, 2.24)	0.87
Left work (under 55)	62	1.07	(0.52, 2.18)	0.86
Left work (55 or older)	26	0.85	(0.39, 1.87)	0.68
Left work (under 60)	73	1.03	(0.51, 2.08)	0.94
Left work (60 or older)	15	0.85	(0.36, 2.04)	0.72
Stomach cancer (142 events)				
Still employed	19	1.00	–	
Not employed	123	1.04	(0.57, 1.90)	0.89
Left work (under 50)	57	0.83	(0.43, 1.57)	0.56
Left work (50 or older)	66	1.41	(0.73, 2.71)	0.31
Left work (under 55)	77	0.96	(0.51, 1.79)	0.90
Left work (55 or older)	46	1.23	(0.63, 2.41)	0.55
Left work (under 60)	97	1.03	(0.56, 1.90)	0.92
Left work (60 or older)	26	1.09	(0.53, 2.24)	0.82
Laryngeal cancer (144 events)				
Still employed	19	1.00	–	
Not employed	125	1.22	(0.68, 2.19)	0.50
Left work (under 50)	54	0.85	(0.45, 1.60)	0.61
Left work (50 or older)	71	1.84	(0.97, 3.46)	0.06
Left work (under 55)	75	1.00	(0.54, 1.84)	0.99
Left work (55 or older)	50	1.85	(0.95, 3.61)	0.07

Left work (under 60)	99	1.16	(0.64, 2.10)	0.63	
Left work (60 or older)	26	1.50	(0.73, 3.08)	0.27	
Lung and bronchial cancers (1150 events)					
Still employed	92	1.00	–		
Not employed	1058	1.73	(1.35, 2.21)	< 0.005	$*$
Left work (under 50)	479	1.40	(1.08, 1.82)	0.01	$*$
Left work (50 or older)	579	2.24	(1.73, 2.92)	< 0.005	$*$
Left work (under 55)	634	1.55	(1.20, 2.00)	< 0.005	$*$
Left work (55 or older)	424	2.14	(1.64, 2.81)	< 0.005	$*$
Left work (under 60)	810	1.66	(1.29, 2.13)	< 0.005	$*$
Left work (60 or older)	248	1.96	(1.48, 2.59)	< 0.005	$*$
Breast cancer (144 events)					
Still employed	29	1.00	–		
Not employed	115	0.76	(0.43, 1.34)	0.34	
Left work (under 50)	71	0.69	(0.38, 1.27)	0.23	
Left work (50 or older)	44	0.86	(0.46, 1.62)	0.64	
Left work (under 55)	86	0.71	(0.39, 1.28)	0.25	
Left work (55 or older)	29	0.89	(0.45, 1.75)	0.74	
Left work (under 60)	100	0.72	(0.40, 1.29)	0.27	
Left work (60 or older)	15	0.98	(0.45, 2.11)	0.96	
Prostate cancer (1611 events)					
Still employed	85	1.00	–		
Not employed	1526	0.96	(0.74, 1.23)	0.72	
Left work (under 50)	678	0.84	(0.65, 1.10)	0.21	
Left work (50 or older)	848	1.04	(0.80, 1.34)	0.77	
Left work (under 55)	882	0.84	(0.65, 1.09)	0.19	
Left work (55 or older)	644	1.10	(0.85, 1.43)	0.47	

Left work (under 60)	1121	0.84	(0.65, 1.08)	0.18	
Left work (60 or older)	405	1.23	(0.94, 1.60)	0.13	
Kidney and renal pelvic cancers (141 events)					
Still employed	15	1.00	–		
Not employed	126	0.77	(0.39, 1.52)	0.45	
Left work (under 50)	57	0.53	(0.26, 1.11)	0.09	
Left work (50 or older)	69	1.17	(0.56, 2.44)	0.68	
Left work (under 55)	80	0.65	(0.32, 1.33)	0.24	
Left work (55 or older)	46	1.01	(0.48, 2.13)	0.98	
Left work (under 60)	95	0.64	(0.31, 1.30)	0.21	
Left work (60 or older)	31	1.19	(0.55, 2.58)	0.66	
Bladder cancer (296 events)					
Still employed	27	1.00	–		
Not employed	269	0.82	(0.50, 1.34)	0.43	
Left work (under 50)	115	0.68	(0.40, 1.14)	0.14	
Left work (50 or older)	154	0.98	(0.58, 1.64)	0.93	
Left work (under 55)	151	0.71	(0.43, 1.19)	0.20	
Left work (55 or older)	118	0.99	(0.58, 1.67)	0.96	
Left work (under 60)	198	0.77	(0.46, 1.27)	0.31	
Left work (60 or older)	71	0.94	(0.55, 1.62)	0.83	
Melanoma (133 events)					
Still employed	26	1.00	–		
Not employed	107	0.53	(0.27, 1.04)	0.06	
Left work (under 50)	58	0.47	(0.23, 0.94)	0.03	*
Left work (50 or older)	49	0.75	(0.35, 1.60)	0.45	
Left work (under 55)	74	0.48	(0.24, 0.96)	0.04	*
Left work (55 or older)	33	0.74	(0.33, 1.63)	0.45	

Left work (under 60)	90	0.50	(0.25, 0.99)	0.05
Left work (60 or older)	17	0.71	(0.30, 1.69)	0.44
Leukemia (140 events)				
Still employed	22	1.00	–	
Not employed	118	0.80	(0.43, 1.46)	0.46
Left work (under 50)	62	0.77	(0.41, 1.45)	0.41
Left work (50 or older)	56	0.84	(0.43, 1.65)	0.62
Left work (under 55)	79	0.82	(0.44, 1.52)	0.53
Left work (55 or older)	39	0.74	(0.37, 1.49)	0.40
Left work (under 60)	90	0.75	(0.40, 1.40)	0.37
Left work (60 or older)	28	0.96	(0.46, 2.01)	0.92
Non-Hodgkin's lymphoma (210 events)				
Still employed	22	1.00	–	
Not employed	188	1.05	(0.60, 1.85)	0.86
Left work (under 50)	104	1.05	(0.59, 1.89)	0.87
Left work (50 or older)	84	1.05	(0.57, 1.94)	0.87
Left work (under 55)	119	0.94	(0.52, 1.69)	0.84
Left work (55 or older)	69	1.34	(0.71, 2.52)	0.36
Left work (under 60)	149	0.98	(0.55, 1.75)	0.95
Left work (60 or older)	39	1.32	(0.68, 2.56)	0.42

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

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	6956	1.00	–		
	>0 to 0.314	2493	1.04	(0.98, 1.10)	0.19	
	>0.314 to 1.66	2492	0.94	(0.89, 0.99)	0.01	$*$
	>1.66	2492	0.96	(0.91, 1.01)	0.10	
Cumulative soluble	0 to 0.05	2555	1.00	–		
	>0.05 to 2.7	3842	0.84	(0.80, 0.89)	<0.005	$*$
	>2.7 to 12.2	4018	0.74	(0.70, 0.78)	<0.005	$*$
	>12.2	4018	0.74	(0.69, 0.78)	<0.005	$*$
Cumulative synthetic	0	9812	1.00	–		
	>0 to 0.187	1541	0.91	(0.85, 0.97)	<0.005	$*$
	>0.187 to 1.14	1540	0.91	(0.85, 0.97)	<0.005	$*$
	>1.14	1540	0.92	(0.86, 0.98)	0.01	$*$
Race	White	10370.5	1.00	–		
	Black	4062.5	0.90	(0.86, 0.94)	<0.005	$*$
Plant	1	5247	1.00	–		
	2	6380	0.69	(0.66, 0.73)	<0.005	$*$
	3	2806	0.61	(0.57, 0.64)	<0.005	$*$
Sex	Male	12587	1.00	–		
	Female	1846	1.13	(1.07, 1.19)	<0.005	$*$
P-spline of calendar year ($df = 17.00$)			NA	–		
P-spline of year of hire ($df = 16.97$)			NA	–		

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	(0.14, 7.74)	0.98
	>0.409 to 2.16	119	1.07	(0.13, 8.64)	0.95
	>2.16	119	1.09	(0.13, 9.30)	0.94
Cumulative soluble	0 to 0.05	107	1.00	–	
	>0.05 to 3.42	183	1.05	(0.13, 8.14)	0.97
	>3.42 to 13.2	189	0.97	(0.14, 6.59)	0.98
	>13.2	189	1.08	(0.13, 8.94)	0.94
Cumulative synthetic	0	490	1.00	–	
	>0 to 0.191	60	1.27	(0.11, 15.33)	0.85
	>0.191 to 1.49	59	0.85	(0.16, 4.56)	0.85
	>1.49	59	1.02	(0.14, 7.59)	0.98
Year	1973 to 1987	115	1.00	–	
	1988 to 1992	117	2.01	(0.04, 104.16)	0.73
	1993 to 1998	120	1.53	(0.08, 30.36)	0.78
	1999 to 2003	106	1.45	(0.08, 24.64)	0.80
	2004 to 2008	104	1.29	(0.10, 15.99)	0.84
	>2008	106	0.85	(0.16, 4.46)	0.85
Year of hire	1938 to 1945	108	1.00	–	
	1946 to 1951	102	0.84	(0.16, 4.37)	0.84
	1952 to 1955	121	0.83	(0.16, 4.28)	0.83
	1956 to 1965	111	1.06	(0.13, 8.54)	0.95
	1966 to 1971	112	1.00	(0.14, 7.12)	1.00
	>1971	114	0.99	(0.14, 6.83)	0.99
Race	White	491.98	1.00	–	
	Black	176.02	1.78	(0.05, 58.12)	0.75
Plant	1	224	1.00	–	
	2	244	1.17	(0.12, 11.55)	0.89
	3	200	1.30	(0.10, 16.59)	0.84
Sex	Male	590	1.00	–	
	Female	78	0.91	(0.15, 5.46)	0.92

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	0.99	(0.14, 6.94)	0.99
	>0.502 to 2.05	58	1.22	(0.11, 13.16)	0.87
	>2.05	59	1.29	(0.10, 16.23)	0.84
Cumulative soluble	0 to 0.05	50	1.00	–	
	>0.05 to 3.5	85	1.03	(0.14, 7.83)	0.97
	>3.5 to 11.3	90	1.09	(0.13, 9.36)	0.93
	>11.3	90	1.02	(0.14, 7.43)	0.99
Cumulative synthetic	0	214	1.00	–	
	>0 to 0.365	34	1.07	(0.13, 8.70)	0.95
	>0.365 to 1.79	33	1.21	(0.11, 13.10)	0.87
	>1.79	34	1.52	(0.08, 30.07)	0.78
Year	1973 to 1986	60	1.00	–	
	1987 to 1992	53	1.28	(0.10, 15.80)	0.85
	1993 to 1998	50	1.04	(0.14, 7.92)	0.97
	1999 to 2004	52	0.93	(0.15, 5.84)	0.94
	2005 to 2008	53	1.30	(0.10, 16.77)	0.84
	>2008	47	0.61	(0.18, 2.03)	0.42
Year of hire	1938 to 1947	46	1.00	–	
	1948 to 1952	51	1.69	(0.06, 46.03)	0.76
	1953 to 1958	60	1.37	(0.09, 19.95)	0.82
	1959 to 1965	45	1.85	(0.05, 69.91)	0.74
	1966 to 1971	54	1.68	(0.06, 45.15)	0.76
	>1971	59	1.90	(0.05, 78.94)	0.74
Race	White	257.8	1.00	–	
	Black	57.2	0.91	(0.15, 5.34)	0.91
Plant	1	97	1.00	–	
	2	127	0.86	(0.16, 4.66)	0.86
	3	91	0.86	(0.16, 4.71)	0.87
Sex	Male	291	1.00	–	
	Female	24	0.60	(0.18, 1.97)	0.40

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	0.99	(0.14, 6.85)	0.99
	>0.321 to 1.15	41	1.03	(0.14, 7.77)	0.98
	>1.15	42	0.77	(0.17, 3.54)	0.74
Cumulative soluble	0 to 0.05	47	1.00	–	
	>0.05 to 3.03	66	0.82	(0.16, 4.12)	0.81
	>3.03 to 9.48	69	0.86	(0.16, 4.64)	0.86
	>9.48	69	0.75	(0.17, 3.25)	0.70
Cumulative synthetic	0	177	1.00	–	
	>0 to 0.222	25	1.28	(0.10, 15.90)	0.85
	>0.222 to 0.817	24	1.42	(0.09, 23.27)	0.80
	>0.817	25	1.03	(0.14, 7.70)	0.98
Year	1973 to 1988	46	1.00	–	
	1989 to 1994	38	1.60	(0.07, 36.81)	0.77
	1995 to 2001	47	1.52	(0.08, 29.53)	0.78
	2002 to 2006	44	1.81	(0.05, 63.46)	0.74
	2007 to 2011	45	1.72	(0.06, 50.02)	0.75
	>2011	31	1.42	(0.09, 22.77)	0.81
Year of hire	1938 to 1948	41	1.00	–	
	1949 to 1952	28	1.01	(0.14, 7.32)	0.99
	1953 to 1961	56	0.94	(0.15, 5.96)	0.95
	1962 to 1966	34	1.10	(0.13, 9.57)	0.93
	1967 to 1973	48	0.94	(0.15, 5.91)	0.95
	>1973	44	0.92	(0.15, 5.60)	0.93
Race	White	180	1.00	–	
	Black	71	1.58	(0.07, 34.69)	0.77
Plant	1	85	1.00	–	
	2	98	0.91	(0.15, 5.45)	0.92
	3	68	0.91	(0.15, 5.50)	0.92
Sex	Male	221	1.00	–	
	Female	30	0.89	(0.16, 5.13)	0.90

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	1.49	(0.08, 27.79)	0.79	
	$>$ 0.383 to 2.16	33	1.23	(0.11, 13.69)	0.87	
	$>$ 2.16	33	1.47	(0.08, 26.28)	0.79	
Cumulative soluble	0 to 0.05	30	1.00	–		
	$>$ 0.05 to 3.31	47	0.81	(0.17, 3.90)	0.79	
	$>$ 3.31 to 10.9	47	0.85	(0.16, 4.52)	0.85	
	$>$ 10.9	48	1.04	(0.14, 7.93)	0.97	
Cumulative synthetic	0	118	1.00	–		
	$>$ 0 to 0.686	27	1.06	(0.13, 8.42)	0.96	
	$>$ 0.686	27	1.47	(0.08, 26.18)	0.79	
Year	1973 to 1988	29	1.00	–		
	1989 to 1995	32	1.45	(0.08, 24.76)	0.80	
	1996 to 2002	28	1.01	(0.14, 7.23)	1.00	
	2003 to 2006	26	1.37	(0.09, 20.29)	0.82	
	2007 to 2012	34	1.08	(0.13, 9.02)	0.94	
	$>$ 2012	23	1.41	(0.09, 22.16)	0.81	
Year of hire	1938 to 1951	29	1.00	–		
	1952 to 1956	27	1.17	(0.12, 11.71)	0.89	
	1957 to 1965	29	1.80	(0.05, 61.13)	0.74	
	1966 to 1968	29	2.06	(0.04, 117.10)	0.73	
	1969 to 1973	29	2.53	(0.02, 362.31)	0.71	
	$>$ 1973	29	2.01	(0.04, 103.25)	0.73	
Race	White	128	1.00	–		
	Black	44	1.49	(0.08, 27.45)	0.79	
Plant	1	52	1.00	–		
	2	55	0.88	(0.16, 4.95)	0.89	
	3	65	1.14	(0.12, 10.70)	0.91	
Sex	Male	167	1.00	–		
	Female	5	0.20	(0.14, 0.30)	$<$ 0.005	$*$

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	(0.12, 10.26)	0.92
	$>$ 0.347 to 3.28	35	0.71	(0.18, 2.88)	0.63
	$>$ 3.28	35	1.54	(0.08, 31.67)	0.78
Cumulative soluble	0 to 0.05	50	1.00	–	
	$>$ 0.05 to 4.02	54	0.65	(0.18, 2.30)	0.50
	$>$ 4.02 to 13.1	55	0.81	(0.17, 3.96)	0.79
	$>$ 13.1	55	0.81	(0.17, 4.00)	0.80
Cumulative synthetic	0	158	1.00	–	
	$>$ 0 to 0.64	28	0.98	(0.14, 6.61)	0.98
	$>$ 0.64	28	1.13	(0.12, 10.47)	0.91
Year	1973 to 1986	42	1.00	–	
	1987 to 1991	30	1.32	(0.10, 17.47)	0.83
	1992 to 1997	45	1.49	(0.08, 27.31)	0.79
	1998 to 2003	26	0.82	(0.16, 4.10)	0.81
	2004 to 2010	43	1.10	(0.13, 9.61)	0.93
	$>$ 2010	28	0.99	(0.14, 6.89)	0.99
Year of hire	1938 to 1946	31	1.00	–	
	1947 to 1952	37	1.05	(0.13, 8.22)	0.96
	1953 to 1955	34	1.09	(0.13, 9.15)	0.94
	1956 to 1965	37	1.31	(0.10, 17.23)	0.84
	1966 to 1972	35	0.98	(0.14, 6.74)	0.99
	$>$ 1972	40	1.15	(0.12, 11.00)	0.90
Race	White	149	1.00	–	
	Black	65	2.19	(0.03, 159.88)	0.72
Plant	1	73	1.00	–	
	2	91	1.60	(0.07, 37.10)	0.77
	3	50	1.07	(0.13, 8.75)	0.95
Sex	Male	198	1.00	–	
	Female	16	0.49	(0.19, 1.28)	0.14

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	0.81	(0.17, 4.02)	0.80	
	>0.475 to 2.19	35	1.00	(0.14, 7.09)	1.00	
	>2.19	36	1.34	(0.10, 18.40)	0.83	
Cumulative soluble	0 to 0.05	28	1.00	–		
	>0.05 to 3.02	59	1.51	(0.08, 28.90)	0.79	
	>3.02 to 10.4	59	1.20	(0.11, 12.65)	0.88	
	>10.4	60	1.22	(0.11, 13.23)	0.87	
Cumulative synthetic	0	147	1.00	–		
	>0 to 0.656	30	1.03	(0.14, 7.69)	0.98	
	>0.656	29	1.20	(0.11, 12.62)	0.88	
Year	1973 to 1985	36	1.00	–		
	1986 to 1991	35	1.60	(0.07, 36.89)	0.77	
	1992 to 1996	32	1.67	(0.06, 44.10)	0.76	
	1997 to 2004	42	1.31	(0.10, 17.20)	0.84	
	2005 to 2009	29	1.47	(0.08, 26.03)	0.79	
	>2009	32	1.44	(0.09, 23.95)	0.80	
Year of hire	1938 to 1948	29	1.00	–		
	1949 to 1952	26	1.11	(0.13, 9.74)	0.93	
	1953 to 1959	41	1.14	(0.12, 10.68)	0.91	
	1960 to 1965	36	1.46	(0.08, 25.82)	0.79	
	1966 to 1969	37	1.11	(0.13, 9.86)	0.92	
	>1969	37	0.76	(0.17, 3.36)	0.72	
Race	White	141	1.00	–		
	Black	65	1.74	(0.06, 52.39)	0.75	
Plant	1	80	1.00	–		
	2	81	1.10	(0.13, 9.43)	0.93	
	3	45	0.62	(0.18, 2.08)	0.44	
Sex	Male	202	1.00	–		
	Female	4	0.16	(0.12, 0.21)	<0.005	$*$

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	1.07	(0.13, 8.71)	0.95
	>0.361 to 1.67	300	1.03	(0.14, 7.85)	0.97
	>1.67	300	1.01	(0.14, 7.21)	1.00
Cumulative soluble	0 to 0.05	318	1.00	–	
	>0.05 to 3.32	462	0.92	(0.15, 5.64)	0.93
	>3.32 to 11.9	478	0.90	(0.15, 5.26)	0.91
	>11.9	479	1.00	(0.14, 7.19)	1.00
Cumulative synthetic	0	1248	1.00	–	
	>0 to 0.268	163	0.97	(0.15, 6.41)	0.97
	>0.268 to 1.39	163	1.01	(0.14, 7.33)	0.99
	>1.39	163	1.06	(0.13, 8.41)	0.96
Year	1973 to 1986	304	1.00	–	
	1987 to 1992	290	1.43	(0.09, 23.61)	0.80
	1993 to 1997	278	1.46	(0.08, 25.66)	0.80
	1998 to 2003	300	1.20	(0.11, 12.50)	0.88
	2004 to 2009	287	1.05	(0.13, 8.27)	0.96
	>2009	278	0.95	(0.15, 6.18)	0.96
Year of hire	1938 to 1948	273	1.00	–	
	1949 to 1952	221	1.31	(0.10, 17.24)	0.84
	1953 to 1958	368	1.34	(0.10, 18.43)	0.83
	1959 to 1965	231	1.52	(0.08, 29.60)	0.78
	1966 to 1972	346	1.45	(0.08, 25.10)	0.80
	>1972	298	1.34	(0.10, 18.28)	0.83
Race	White	1321.88	1.00	–	
	Black	415.12	1.37	(0.09, 20.22)	0.82
Plant	1	546	1.00	–	
	2	709	1.14	(0.12, 10.56)	0.91
	3	482	1.03	(0.14, 7.67)	0.98
Sex	Male	1550	1.00	–	
	Female	187	0.82	(0.16, 4.11)	0.81

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	1.33	(0.10, 17.99)	0.83
	$>$ 0.189 to 0.721	40	1.78	(0.05, 58.23)	0.75
	$>$ 0.721	37	1.34	(0.10, 18.74)	0.83
Cumulative soluble	0 to 0.05	101	1.00	–	
	$>$ 0.05 to 1.07	54	0.93	(0.15, 5.69)	0.93
	$>$ 1.07 to 3.31	57	0.94	(0.15, 5.87)	0.94
	$>$ 3.31	48	0.86	(0.16, 4.68)	0.86
Cumulative synthetic	0	192	1.00	–	
	$>$ 0 to 0.0921	23	1.15	(0.12, 10.85)	0.91
	$>$ 0.0921 to 0.378	24	0.88	(0.16, 4.91)	0.88
	$>$ 0.378	21	0.62	(0.18, 2.06)	0.43
Year	1973 to 1990	45	1.00	–	
	1991 to 1996	53	1.92	(0.04, 82.84)	0.73
	1997 to 2001	37	1.36	(0.09, 19.46)	0.82
	2002 to 2006	39	1.27	(0.11, 15.39)	0.85
	2007 to 2011	47	1.59	(0.07, 36.15)	0.77
	$>$ 2011	39	1.81	(0.05, 62.22)	0.74
Year of hire	1938 to 1953	40	1.00	–	
	1954 to 1968	36	0.96	(0.15, 6.27)	0.96
	1969 to 1972	18	1.29	(0.10, 16.14)	0.84
	1973 to 1976	67	1.12	(0.12, 10.05)	0.92
	1977 to 1977	47	1.07	(0.13, 8.62)	0.95
	$>$ 1977	52	0.86	(0.16, 4.62)	0.86
Race	White	177	1.00	–	
	Black	83	1.23	(0.11, 13.80)	0.87
Plant	1	31	1.00	–	
	2	148	1.21	(0.11, 13.12)	0.87
	3	81	1.30	(0.10, 16.68)	0.84

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	1.09	(0.13, 9.15)	0.94
	$>$ 0.427 to 2.17	461	1.05	(0.13, 8.22)	0.96
	$>$ 2.17	461	1.11	(0.13, 9.66)	0.93
Cumulative soluble	0 to 0.05	313	1.00	–	
	$>$ 0.05 to 3.7	716	1.06	(0.13, 8.34)	0.96
	$>$ 3.7 to 13	742	1.11	(0.13, 9.71)	0.93
	$>$ 13	743	1.28	(0.10, 15.81)	0.85
Cumulative synthetic	0	1806	1.00	–	
	$>$ 0 to 0.259	236	1.01	(0.14, 7.29)	0.99
	$>$ 0.259 to 1.47	236	1.00	(0.14, 7.08)	1.00
	$>$ 1.47	236	1.16	(0.12, 11.26)	0.90
Year	1973 to 1991	445	1.00	–	
	1992 to 1996	421	2.50	(0.02, 335.59)	0.71
	1997 to 2001	473	2.51	(0.02, 347.70)	0.71
	2002 to 2005	387	2.29	(0.03, 204.44)	0.72
	2006 to 2010	408	1.68	(0.06, 45.62)	0.76
	$>$ 2010	380	1.41	(0.09, 22.49)	0.81
Year of hire	1938 to 1948	418	1.00	–	
	1949 to 1953	395	0.85	(0.16, 4.44)	0.84
	1954 to 1960	412	1.05	(0.13, 8.27)	0.96
	1961 to 1966	423	1.29	(0.10, 16.30)	0.84
	1967 to 1971	439	1.42	(0.09, 23.23)	0.80
	$>$ 1971	427	1.56	(0.07, 32.89)	0.78
Race	White	1714.04	1.00	–	
	Black	799.96	2.25	(0.03, 186.83)	0.72
Plant	1	914	1.00	–	
	2	800	1.09	(0.13, 9.14)	0.94
	3	800	1.19	(0.12, 12.36)	0.88

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	0.91	(0.15, 5.41)	0.92
	>0.394 to 3.4	45	0.87	(0.16, 4.78)	0.87
	>3.4	45	1.59	(0.07, 35.50)	0.77
Cumulative soluble	0 to 0.05	47	1.00	–	
	>0.05 to 2.73	69	0.99	(0.14, 6.82)	0.99
	>2.73 to 9.27	69	0.90	(0.15, 5.31)	0.91
	>9.27	69	0.86	(0.16, 4.60)	0.86
Cumulative synthetic	0	184	1.00	–	
	>0 to 0.18	24	1.10	(0.13, 9.39)	0.93
	>0.18 to 0.784	23	1.00	(0.14, 7.12)	1.00
	>0.784	23	0.74	(0.17, 3.14)	0.68
Year	1973 to 1988	43	1.00	–	
	1989 to 1997	46	1.19	(0.12, 12.29)	0.88
	1998 to 2003	45	1.53	(0.08, 30.64)	0.78
	2004 to 2007	36	1.71	(0.06, 49.26)	0.75
	2008 to 2011	42	1.91	(0.04, 81.35)	0.73
	>2011	42	1.90	(0.05, 78.59)	0.74
Year of hire	1938 to 1950	40	1.00	–	
	1951 to 1954	42	1.10	(0.13, 9.52)	0.93
	1955 to 1963	44	1.79	(0.05, 60.27)	0.74
	1964 to 1967	36	1.24	(0.11, 14.05)	0.86
	1968 to 1973	44	1.47	(0.08, 26.09)	0.79
	>1973	48	1.25	(0.11, 14.53)	0.86
Race	White	208	1.00	–	
	Black	46	0.95	(0.15, 6.08)	0.96
Plant	1	66	1.00	–	
	2	97	1.25	(0.11, 14.32)	0.86
	3	91	1.08	(0.13, 9.01)	0.94
Sex	Male	233	1.00	–	
	Female	21	0.60	(0.19, 1.96)	0.40

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	1.28	(0.10, 15.82)	0.85	
	>0.388 to 2.71	99	1.01	(0.14, 7.32)	0.99	
	>2.71	99	1.28	(0.10, 15.53)	0.85	
Cumulative soluble	0 to 0.05	88	1.00	–		
	>0.05 to 3.86	146	0.84	(0.16, 4.30)	0.83	
	>3.86 to 13	149	0.99	(0.14, 6.86)	0.99	
	>13	150	1.10	(0.13, 9.58)	0.93	
Cumulative synthetic	0	393	1.00	–		
	>0 to 0.255	47	0.83	(0.16, 4.17)	0.82	
	>0.255 to 1.28	46	0.88	(0.16, 4.89)	0.88	
	>1.28	47	0.81	(0.17, 4.00)	0.80	
Year	1973 to 1989	98	1.00	–		
	1990 to 1995	82	1.45	(0.08, 24.73)	0.80	
	1996 to 2000	95	1.73	(0.06, 51.89)	0.75	
	2001 to 2005	85	1.38	(0.09, 20.52)	0.82	
	2006 to 2010	87	1.22	(0.11, 13.39)	0.87	
	>2010	86	1.07	(0.13, 8.61)	0.95	
Year of hire	1938 to 1948	87	1.00	–		
	1949 to 1953	85	1.16	(0.12, 11.40)	0.90	
	1954 to 1960	92	1.45	(0.08, 24.78)	0.80	
	1961 to 1965	61	2.05	(0.04, 112.67)	0.73	
	1966 to 1971	107	1.89	(0.05, 76.39)	0.74	
	>1971	101	2.19	(0.03, 158.45)	0.72	
Race	White	468.94	1.00	–		
	Black	64.06	0.60	(0.19, 1.92)	0.39	
Plant	1	144	1.00	–		
	2	186	1.02	(0.14, 7.44)	0.99	
	3	203	1.20	(0.11, 12.71)	0.88	
Sex	Male	510	1.00	–		
	Female	23	0.30	(0.17, 0.54)	<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	(0.17, 3.63)	0.75	
	>0.487 to 2.05	48	1.15	(0.12, 10.84)	0.91	
	>2.05	48	1.27	(0.11, 15.38)	0.85	
Cumulative soluble	0 to 0.05	54	1.00	–		
	>0.05 to 2.76	68	0.98	(0.14, 6.60)	0.98	
	>2.76 to 8.46	72	1.17	(0.12, 11.51)	0.89	
	>8.46	72	1.19	(0.12, 12.12)	0.89	
Cumulative synthetic	0	174	1.00	–		
	>0 to 0.203	31	1.41	(0.09, 22.30)	0.81	
	>0.203 to 0.949	30	1.27	(0.11, 15.21)	0.85	
	>0.949	31	1.05	(0.13, 8.29)	0.96	
Year	1973 to 1993	51	1.00	–		
	1994 to 1999	46	2.23	(0.03, 176.39)	0.72	
	2000 to 2003	41	3.11	(0.01, 1380.57)	0.72	
	2004 to 2007	50	3.66	(0.00, 4768.21)	0.72	
	2008 to 2011	43	3.21	(0.01, 1723.03)	0.72	
	>2011	35	2.72	(0.01, 561.53)	0.71	
Year of hire	1938 to 1952	38	1.00	–		
	1953 to 1960	49	1.29	(0.10, 15.98)	0.84	
	1961 to 1965	36	2.19	(0.03, 159.94)	0.72	
	1966 to 1969	48	1.39	(0.09, 21.17)	0.81	
	1970 to 1976	39	1.57	(0.07, 34.12)	0.77	
	>1976	56	1.60	(0.07, 37.12)	0.77	
Race	White	255.72	1.00	–		
	Black	10.28	0.16	(0.12, 0.22)	<0.005	$*$
Plant	1	44	1.00	–		
	2	115	1.02	(0.14, 7.56)	0.98	
	3	107	1.05	(0.13, 8.18)	0.96	
Sex	Male	247	1.00	–		
	Female	19	0.56	(0.19, 1.68)	0.30	

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	1.12	(0.12, 10.00)	0.92
	$>$ 0.32 to 2.15	39	0.87	(0.16, 4.76)	0.87
	$>$ 2.15	40	1.15	(0.12, 11.08)	0.90
Cumulative soluble	0 to 0.05	45	1.00	–	
	$>$ 0.05 to 3.01	59	0.94	(0.15, 5.86)	0.94
	$>$ 3.01 to 10.5	62	0.95	(0.15, 6.11)	0.96
	$>$ 10.5	62	0.92	(0.15, 5.51)	0.92
Cumulative synthetic	0	161	1.00	–	
	$>$ 0 to 0.18	23	1.50	(0.08, 28.71)	0.79
	$>$ 0.18 to 1.18	22	1.14	(0.12, 10.51)	0.91
	$>$ 1.18	22	1.15	(0.12, 10.86)	0.90
Year	1973 to 1988	42	1.00	–	
	1989 to 1993	36	1.68	(0.06, 45.77)	0.76
	1994 to 1999	44	1.45	(0.08, 24.73)	0.80
	2000 to 2005	33	0.94	(0.15, 5.96)	0.95
	2006 to 2010	39	1.23	(0.11, 13.73)	0.87
	$>$ 2010	34	0.99	(0.14, 6.99)	1.00
Year of hire	1938 to 1948	32	1.00	–	
	1949 to 1953	40	1.47	(0.08, 26.22)	0.79
	1954 to 1962	41	1.60	(0.07, 37.23)	0.77
	1963 to 1967	38	1.99	(0.04, 97.60)	0.73
	1968 to 1972	37	2.58	(0.02, 404.12)	0.71
	$>$ 1972	40	1.68	(0.06, 44.97)	0.76
Race	White	176.84	1.00	–	
	Black	51.16	1.25	(0.11, 14.34)	0.86
Plant	1	68	1.00	–	
	2	85	0.95	(0.15, 6.03)	0.95
	3	75	1.11	(0.13, 9.85)	0.92
Sex	Male	209	1.00	–	
	Female	19	0.61	(0.18, 2.04)	0.43

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	1.18	(0.12, 11.78)	0.89
	>0.34 to 2.19	73	0.93	(0.15, 5.69)	0.93
	>2.19	74	1.24	(0.11, 13.98)	0.86
Cumulative soluble	0 to 0.05	54	1.00	–	
	>0.05 to 3.04	111	1.40	(0.09, 21.73)	0.81
	>3.04 to 11.1	114	1.49	(0.08, 27.70)	0.79
	>11.1	114	1.70	(0.06, 47.44)	0.76
Cumulative synthetic	0	273	1.00	–	
	>0 to 0.245	40	0.91	(0.15, 5.48)	0.92
	>0.245 to 1.46	40	0.98	(0.14, 6.70)	0.98
	>1.46	40	1.09	(0.13, 9.24)	0.94
Year	1973 to 1990	77	1.00	–	
	1991 to 1996	57	1.39	(0.09, 21.39)	0.81
	1997 to 2001	63	1.64	(0.07, 40.38)	0.76
	2002 to 2005	71	2.21	(0.03, 169.03)	0.72
	2006 to 2010	74	1.75	(0.06, 53.90)	0.75
	>2010	51	1.16	(0.12, 11.21)	0.90
Year of hire	1938 to 1949	64	1.00	–	
	1950 to 1953	60	1.26	(0.11, 14.96)	0.85
	1954 to 1962	70	1.31	(0.10, 17.18)	0.84
	1963 to 1967	63	1.46	(0.08, 25.61)	0.80
	1968 to 1973	66	1.82	(0.05, 64.21)	0.74
	>1973	70	1.51	(0.08, 29.19)	0.78
Race	White	337.96	1.00	–	
	Black	55.04	0.67	(0.18, 2.46)	0.54
Plant	1	99	1.00	–	
	2	156	1.02	(0.14, 7.45)	0.99
	3	138	1.04	(0.14, 8.04)	0.97
Sex	Male	348	1.00	–	
	Female	45	0.94	(0.15, 5.86)	0.94

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	491.98	1.00	–		
	Black	176.02	1.78	(0.05, 58.12)	0.75	
Rectal cancer	White	257.8	1.00	–		
	Black	57.2	0.91	(0.15, 5.34)	0.91	
Pancreatic cancer	White	180	1.00	–		
	Black	71	1.58	(0.07, 34.69)	0.77	
Esophageal cancer	White	128	1.00	–		
	Black	44	1.49	(0.08, 27.45)	0.79	
Stomach cancer	White	149	1.00	–		
	Black	65	2.19	(0.03, 159.88)	0.72	
Laryngeal cancer	White	141	1.00	–		
	Black	65	1.74	(0.06, 52.39)	0.75	
Lung and bronchial cancers	White	1321.88	1.00	–		
	Black	415.12	1.37	(0.09, 20.22)	0.82	
Breast cancer	White	177	1.00	–		
	Black	83	1.23	(0.11, 13.80)	0.87	
Prostate cancer	White	1714.04	1.00	–		
	Black	799.96	2.25	(0.03, 186.83)	0.72	
Kidney and renal pelvic cancers	White	208	1.00	–		
	Black	46	0.95	(0.15, 6.08)	0.96	
Bladder cancer	White	468.94	1.00	–		
	Black	64.06	0.60	(0.19, 1.92)	0.39	
Melanoma	White	255.72	1.00	–		
	Black	10.28	0.16	(0.12, 0.22)	< 0.005	$*$
Leukemia	White	176.84	1.00	–		
	Black	51.16	1.25	(0.11, 14.34)	0.86	
Non-Hodgkin's lymphoma	White	337.96	1.00	–		
	Black	55.04	0.67	(0.18, 2.46)	0.54	

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.