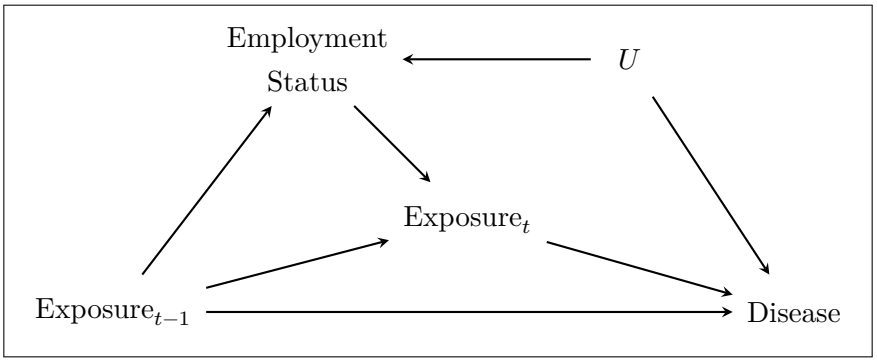
HWSE path analysis

February 3, 2022



The presence of the healthy worker survivor effect (HWSE) implies the presence of the following three conditions:[1]

1. Leaving work predicts (future) exposure
2. Leaving work is associated with the disease
3. Prior exposure predicts predicts leaving work

In occupational cohort studies of occupational exposure, the first condition readily satisfied. The presence of conditions 2 and 3 can be assessed by fitting Cox proportional hazards models.[1,2]

Data. The analytic data constitute a subset of the UAW-GM Cohort (about 35 thousand subjects). Person-time was accrued starting three years after hire or at the start of cancer registry, whichever came later. Cancer incidence follow-up began in 1985 for those at Plant 3 and in 1973 for those at Plants 1 and 2. Follow-up ended on the earlier of: December 31, 1994 or when a subject experienced the cancer incidence outcome of interest, died, or attained 75 years of age. Some subjects experienced the outcome of interest before completing their third year of employment. Those subjects were excluded from the analyses pertaining to that outcome. About 18% of subjects had missing race. Missing race was considered its own distinct category.

Cumulative exposure to the three metal working fluid types was lagged 1 year. Exposure was categorized into 4 levels including the referent group where possible, and 3 or 2 levels otherwise. The referent group for straight and synthetic metalworking fluids was 0 mg/m^3·years That for soluble metalworking fluids was 0–0.05 mg/m^3·years. Other covariates included in the models were splined calendar year, splined year of hire, race, plant, and sex. Risk sets were indexed by age.

For the evaluation of condition 2, leaving work predicts cancer incidence, the main exposure of interest was binary employment status with no lag. Note that exact cancer incidence dates are not known for all cases, even though year of incidence is known. For those cases, we used July 1 as the date of incidence. For this reason, there may have been employment status misclassification of person-time because some cases would have been inappropriately marked as "employed" when they received their cancer diagnosis while others would have been inappropriately marked as "not employed." Sensitivity analysis was conducted where employment status was updated each year, rather than each day. Results were largely the same except in the case of leukemia.

For the evaluation of condition 3, prior exposure predicts leaving work, the main exposures of interest were cumulative exposure to the three MWF types (in a single model). For consistency, follow-up for these models *also* began in 1985 or 1973, depending on the plant. The outcome of interest was binary employment status with no lag.

Table 1: Summary of population characteristics. Follow-up starts in 1973 for plants 1 and 2, and 1985 for plant 3. Follow-up ends in 1994.

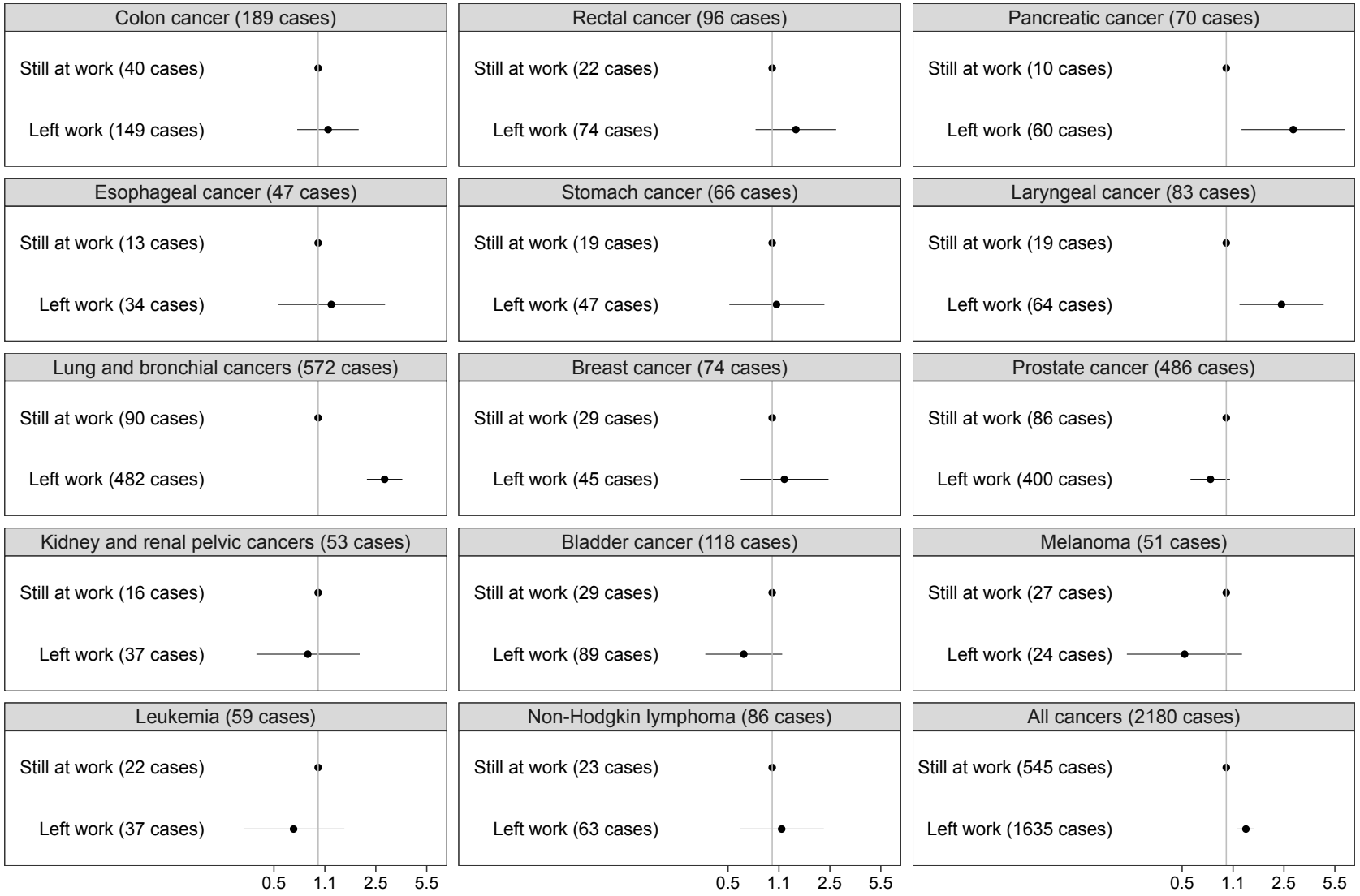
	n	p	
Study population size (person-years)	39,132	1,087,230	
Race			
White	25,119	64%	
Black	6,862	18%	
Unknown	7,151	18%	
Sex			
Male	34,498	88%	
Female	4,634	12%	
Plant[1]			
Plant 1	5,935	23%	
Plant 2	11,532	45%	
Plant 3	7,942	31%	
Ever exposed to MWFs			
Straight	21,282	54%	
Soluble	34,041	87%	
Synthetic	12,516	32%	
Employment status in 1995			
Left work	28,162	72%	
Still at work	10,970	28%	
Diagnosed with cancer by end of follow-up	7,894	20%	
	Median	25^{th} %tile	75^{th} %tile
Years of follow-up	31.0	20.0	36.0
Year of birth	1937	1921	1949
Year of hire	1965	1952	1973
Age at hire (years)	24.2	20.3	31.4
Year of leaving work[2]	1985	1970	1995
Age at leaving work (years)[2]	46.2	36.6	56.2
Years at work[2]	15.7	7.7	27.1
Year of first cancer diagnosis	1999	1991	2007
Age at first cancer diagnosis (years)	66.8	59.2	74.3
Cumulative exposure[3] to MWFs ($mg/m^3 \cdot y$)			
Straight	0.69	0.21	2.53
Soluble	4.93	1.93	13.32
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 leaving work.



Numeric results for condition 2

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

	n	HR	(95% CI)	p	
Colon cancer (189 events)					
Still employed	40	1.00	–		
Not employed	149	1.17	(0.72, 1.89)	0.53	
Rectal cancer (96 events)					
Still employed	22	1.00	–		
Not employed	74	1.45	(0.77, 2.73)	0.25	
Pancreatic cancer (70 events)					
Still employed	10	1.00	–		
Not employed	60	2.86	(1.27, 6.43)	0.01	$*$
Esophageal cancer (47 events)					
Still employed	13	1.00	–		
Not employed	34	1.23	(0.53, 2.86)	0.63	
Stomach cancer (66 events)					
Still employed	19	1.00	–		
Not employed	47	1.07	(0.51, 2.27)	0.85	
Laryngeal cancer (83 events)					
Still employed	19	1.00	–		
Not employed	64	2.38	(1.23, 4.61)	0.01	$*$
Lung and bronchial cancers (572 events)					
Still employed	90	1.00	–		
Not employed	482	2.84	(2.15, 3.75)	< 0.005	$*$
Breast cancer (74 events)					
Still employed	29	1.00	–		
Not employed	45	1.21	(0.61, 2.42)	0.59	
Prostate cancer (486 events)					
Still employed	86	1.00	–		

Not employed	400	0.78	(0.57, 1.06)	0.11
Kidney and renal pelvic cancers (53 events)				
Still employed	16	1.00	–	
Not employed	37	0.85	(0.38, 1.92)	0.70
Bladder cancer (118 events)				
Still employed	29	1.00	–	
Not employed	89	0.64	(0.35, 1.17)	0.15
Melanoma (51 events)				
Still employed	27	1.00	–	
Not employed	24	0.52	(0.21, 1.28)	0.16
Leukemia (59 events)				
Still employed	22	1.00	–	
Not employed	37	0.68	(0.31, 1.51)	0.34
Non-Hodgkin's lymphoma (86 events)				
Still employed	23	1.00	–	
Not employed	63	1.16	(0.60, 2.25)	0.66

Table 3: Adjusted HR estimates for **colon cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	40	1.00				
	Not employed	149	1.17	(0.72, 1.89)	0.53	0.246	
Duration of employment	3 to 10	38	1.00				
	$>$ 10 to 19	33	1.09	(0.65, 1.82)	0.75	0.262	
	$>$ 19 to 26	39	1.73	(1.00, 3.01)	0.05	0.282	
	$>$ 26 to 30	31	1.90	(1.04, 3.47)	0.04	0.309	
	$>$ 30	48	1.95	(1.08, 3.54)	0.03	0.304	
Cumulative straight	0	88	1.00				
	$>$ 0 to 0.8	34	0.70	(0.45, 1.10)	0.12	0.227	
	$>$ 0.8 to 2.85	33	0.88	(0.56, 1.40)	0.60	0.236	
	$>$ 2.85	34	0.83	(0.54, 1.29)	0.41	0.222	
Cumulative soluble 5	0 to 0.05	22	1.00				
	$>$ 0.05 to 6.15	56	0.90	(0.54, 1.51)	0.69	0.264	
	$>$ 6.15 to 18.1	55	1.12	(0.65, 1.93)	0.69	0.278	
	$>$ 18.1	56	0.98	(0.56, 1.72)	0.94	0.289	
Cumulative synthetic	0	133	1.00				
	$>$ 0 to 1.92	28	0.73	(0.44, 1.20)	0.22	0.254	
	$>$ 1.92	28	1.19	(0.73, 1.93)	0.49	0.248	
Race	White	112	1.00				
	Black	46	1.86	(1.22, 2.84)	0.00	0.215	
	Unknown	31	1.08	(0.64, 1.83)	0.77	0.269	
Plant	1	60	1.00				
	2	78	1.46	(0.90, 2.37)	0.13	0.247	
	3	51	1.81	(1.11, 2.93)	0.02	0.248	
Sex	Male	171	1.00				
	Female	18	0.72	(0.43, 1.21)	0.21	0.262	
P-spline of calendar year ($df = 3.06$)			1.02	(0.99, 1.06)	0.23	0.019	3.06
					0.03		3.06
P-spline of year of hire ($df = 3.01$)			1.02	(0.99, 1.04)	0.17	0.011	3.01
					0.05		3.01

Table 4: Adjusted HR estimates for **rectal cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	22	1.00				

	Not employed	74	1.45	(0.77, 2.73)	0.25	0.322	
Duration of employment	3 to 9	23	1.00				
	$>$ 9 to 20	25	1.51	(0.79, 2.89)	0.21	0.331	
	$>$ 20 to 28	22	1.43	(0.66, 3.10)	0.37	0.396	
	$>$ 28	26	1.48	(0.65, 3.36)	0.35	0.419	
Cumulative straight	0	49	1.00				
	$>$ 0 to 1.31	24	0.67	(0.38, 1.17)	0.16	0.289	
	$>$ 1.31	23	0.91	(0.53, 1.57)	0.73	0.279	
Cumulative soluble 5	0 to 0.05	10	1.00				
	$>$ 0.05 to 4.48	29	1.23	(0.58, 2.60)	0.59	0.383	
	$>$ 4.48 to 15.8	28	0.98	(0.46, 2.12)	0.97	0.390	
	$>$ 15.8	29	1.01	(0.45, 2.23)	0.99	0.406	
Cumulative synthetic	0	70	1.00				
	$>$ 0	26	0.79	(0.44, 1.43)	0.44	0.303	
Race	White	51	1.00				
	Black	20	0.92	(0.51, 1.66)	0.78	0.301	
	Unknown	25	0.97	(0.49, 1.91)	0.94	0.345	
Plant	1	40	1.00				
	2	44	0.98	(0.54, 1.79)	0.96	0.306	
	3	12	0.44	(0.21, 0.92)	0.03	0.377	
Sex	Male	92	1.00				
	Female	4	0.31	(0.11, 0.87)	0.03	0.525	
P-spline of calendar year ($df = 3.09$)			1.03	(0.98, 1.08)	0.23	0.023	3.09
					0.76		3.09
P-spline of year of hire ($df = 3.00$)			1.02	(0.98, 1.05)	0.32	0.017	3.00
					0.23		3.00

Table 5: Adjusted HR estimates for **pancreatic cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	10	1.00				
	Not employed	60	2.86	(1.27, 6.43)	0.01	0.414	
Duration of employment	3 to 13	23	1.00				
	$>$ 13 to 26	21	1.35	(0.67, 2.71)	0.40	0.356	
	$>$ 26	26	2.08	(0.94, 4.62)	0.07	0.408	
Cumulative straight	0	33	1.00				
	$>$ 0	37	1.11	(0.65, 1.90)	0.71	0.276	
Cumulative soluble 5	0 to 0.05	9	1.00				

	>0.05 to 3.88	21	1.00	(0.44, 2.26)	1.00	0.415	
	>3.88 to 13.3	20	0.75	(0.32, 1.72)	0.49	0.425	
	>13.3	20	0.49	(0.20, 1.16)	0.10	0.444	
Cumulative synthetic	0	53	1.00				
	>0	17	0.88	(0.43, 1.81)	0.73	0.367	
Race	White	34	1.00				
	Black	21	1.60	(0.83, 3.08)	0.16	0.334	
	Unknown	15	1.02	(0.46, 2.26)	0.96	0.404	
Plant	1	33	1.00				
	2	24	0.60	(0.28, 1.29)	0.19	0.389	
	3	13	0.69	(0.32, 1.52)	0.36	0.400	
Sex	Male	66	1.00				
	Female	4	0.43	(0.15, 1.24)	0.12	0.536	
P-spline of calendar year ($df = 3.05$)			1.00	(0.95, 1.06)	0.99	0.028	3.05
					0.23		3.05
P-spline of year of hire ($df = 3.00$)			1.04	(1.01, 1.08)	0.02	0.017	3.00
					0.85		3.00

Table 6: Adjusted HR estimates for **esophageal cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	13	1.00				
	Not employed	34	1.23	(0.53, 2.86)	0.63	0.430	
Duration of employment	3 to 18	22	1.00				
	>18	25	1.19	(0.52, 2.72)	0.69	0.423	
Cumulative straight	0	17	1.00				
	>0	30	1.58	(0.80, 3.09)	0.19	0.344	
Cumulative soluble 5	0 to 0.05	4	1.00				
	>0.05 to 6.03	22	1.32	(0.43, 4.02)	0.62	0.568	
	>6.03	21	0.80	(0.25, 2.50)	0.70	0.584	
Cumulative synthetic	0	33	1.00				
	>0	14	0.78	(0.35, 1.74)	0.54	0.411	
Race	White	22	1.00				
	Black	12	1.69	(0.74, 3.87)	0.21	0.423	
	Unknown	13	1.23	(0.47, 3.22)	0.67	0.488	
Plant	1	17	1.00				
	2	19	1.01	(0.40, 2.54)	0.99	0.472	
	3	11	1.26	(0.49, 3.26)	0.63	0.486	

Sex	Male	46	1.00				
	Female	1	0.15	(0.02, 1.09)	0.06	1.024	
P-spline of calendar year ($df = 3.09$)			1.00	(0.94, 1.06)	0.98	0.030	3.09
					0.23		3.09
P-spline of year of hire ($df = 2.97$)			1.05	(1.00, 1.10)	0.03	0.022	2.97
					0.16		2.97

Table 7: Adjusted HR estimates for **stomach cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	19	1.00				
	Not employed	47	1.07	(0.51, 2.27)	0.85	0.381	
Duration of employment	3 to 11	19	1.00				
	$>$ 11 to 23	23	1.51	(0.74, 3.10)	0.26	0.365	
	$>$ 23	24	1.20	(0.52, 2.78)	0.68	0.430	
Cumulative straight	0	30	1.00				
	$>$ 0	36	1.08	(0.62, 1.88)	0.79	0.283	
Cumulative soluble 5	0 to 0.05	7	1.00				
	$>$ 0.05 to 6.79	30	1.15	(0.49, 2.72)	0.75	0.440	
	$>$ 6.79	29	0.82	(0.33, 2.02)	0.66	0.463	
Cumulative synthetic	0	49	1.00				
	$>$ 0	17	0.73	(0.35, 1.50)	0.39	0.368	
Race	White	31	1.00				
	Black	20	1.79	(0.91, 3.49)	0.09	0.341	
	Unknown	15	1.07	(0.47, 2.46)	0.87	0.424	
Plant	1	28	1.00				
	2	27	0.94	(0.44, 2.01)	0.87	0.390	
	3	11	0.74	(0.32, 1.72)	0.49	0.428	
Sex	Male	62	1.00				
	Female	4	0.40	(0.14, 1.15)	0.09	0.535	
P-spline of calendar year ($df = 3.05$)			1.02	(0.96, 1.07)	0.59	0.028	3.05
					0.39		3.05
P-spline of year of hire ($df = 3.00$)			1.01	(0.98, 1.05)	0.46	0.019	3.00
					0.61		3.00

Table 8: Adjusted HR estimates for **laryngeal cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df

Employment status	Still employed	19	1.00				
	Not employed	64	2.38	(1.23, 4.61)	0.01	0.338	
Duration of employment	3 to 15	21	1.00				
	$>$ 15 to 24	14	2.07	(0.94, 4.56)	0.07	0.402	
	$>$ 24 to 29	24	5.17	(2.29, 11.69)	0.00	0.416	
	$>$ 29	24	3.24	(1.34, 7.82)	0.01	0.450	
Cumulative straight	0	30	1.00				
	$>$ 0 to 1.96	27	0.99	(0.53, 1.83)	0.97	0.316	
	$>$ 1.96	26	1.90	(1.07, 3.40)	0.03	0.296	
Cumulative soluble 5	0 to 0.05	9	1.00				
	$>$ 0.05 to 5.7	25	0.79	(0.36, 1.76)	0.57	0.408	
	$>$ 5.7 to 14.2	24	0.83	(0.36, 1.87)	0.65	0.418	
	$>$ 14.2	25	0.46	(0.20, 1.05)	0.07	0.426	
Cumulative synthetic	0	53	1.00				
	$>$ 0	30	1.28	(0.69, 2.35)	0.43	0.311	
Race	White	41	1.00				
	Black	24	1.97	(1.06, 3.64)	0.03	0.314	
	Unknown	18	1.59	(0.73, 3.48)	0.25	0.399	
Plant	1	31	1.00				
	2	37	1.04	(0.51, 2.11)	0.92	0.362	
	3	15	0.77	(0.36, 1.68)	0.52	0.396	
Sex	Male	81	1.00				
	Female	2	0.21	(0.05, 0.88)	0.03	0.728	
P-spline of calendar year ($df = 3.08$)			1.02	(0.97, 1.07)	0.52	0.026	3.08
					0.82		3.08
P-spline of year of hire ($df = 3.00$)			1.00	(0.96, 1.04)	0.95	0.021	3.00
					0.39		3.00

Table 9: Adjusted HR estimates for **lung and bronchial cancers**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	90	1.00				
	Not employed	482	2.84	(2.15, 3.75)	0.00	0.142	
Duration of employment	3 to 6	95	1.00				
	$>$ 6 to 16	127	0.89	(0.67, 1.18)	0.42	0.143	
	$>$ 16 to 24	120	1.44	(1.04, 1.99)	0.03	0.165	
	$>$ 24 to 30	113	1.55	(1.08, 2.21)	0.02	0.182	
	$>$ 30	117	1.88	(1.29, 2.75)	0.00	0.193	

Cumulative straight	0	253	1.00				
	>0 to 0.472	107	1.01	(0.78, 1.32)	0.92	0.133	
	>0.472 to 2.37	106	0.93	(0.71, 1.21)	0.59	0.135	
	>2.37	106	1.10	(0.86, 1.41)	0.44	0.126	
Cumulative soluble 5	0 to 0.05	70	1.00				
	>0.05 to 4.57	168	0.87	(0.65, 1.17)	0.36	0.150	
	>4.57 to 15.9	167	0.80	(0.59, 1.08)	0.14	0.155	
	>15.9	167	0.75	(0.55, 1.04)	0.08	0.163	
Cumulative synthetic	0	397	1.00				
	>0 to 0.522	59	0.88	(0.64, 1.23)	0.46	0.167	
	>0.522 to 1.97	58	1.20	(0.87, 1.67)	0.26	0.167	
	>1.97	58	1.06	(0.78, 1.45)	0.71	0.160	
Race	White	297	1.00				
	Black	128	1.34	(1.05, 1.71)	0.02	0.126	
	Unknown	147	1.18	(0.90, 1.56)	0.23	0.141	
Plant	1	212	1.00				
	2	247	0.85	(0.65, 1.10)	0.22	0.135	
	3	113	0.91	(0.69, 1.21)	0.53	0.144	
Sex	Male	517	1.00				
	Female	55	0.76	(0.56, 1.02)	0.06	0.150	
P-spline of calendar year ($df = 3.07$)			0.99	(0.97, 1.01)	0.16	0.010	3.07
					0.69		3.07
P-spline of year of hire ($df = 3.02$)			1.04	(1.03, 1.05)	0.00	0.007	3.02
					0.06		3.02

Table 10: Adjusted HR estimates for **breast cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	29	1.00				
	Not employed	45	1.21	(0.61, 2.42)	0.59	0.354	
Duration of employment	3 to 12	24	1.00				
	>12 to 19	25	1.34	(0.70, 2.54)	0.38	0.329	
	>19	25	1.86	(0.80, 4.32)	0.15	0.429	
Cumulative straight	0	38	1.00				
	>0	36	0.63	(0.36, 1.10)	0.10	0.286	
Cumulative soluble 5	0 to 0.05	16	1.00				
	>0.05 to 1.45	21	1.22	(0.62, 2.43)	0.56	0.351	
	>1.45 to 3.99	21	1.32	(0.63, 2.77)	0.45	0.376	

	> 3.99	16	0.75	(0.32, 1.77)	0.51	0.436	
Cumulative synthetic	0	46	1.00				
	> 0	28	1.33	(0.72, 2.45)	0.36	0.312	
Race	White	43	1.00				
	Black	16	1.27	(0.65, 2.47)	0.48	0.338	
	Unknown	15	1.03	(0.43, 2.49)	0.94	0.449	
Plant	1	4	1.00				
	2	49	2.20	(0.69, 7.03)	0.18	0.592	
	3	21	2.26	(0.71, 7.23)	0.17	0.593	
P-spline of calendar year ($df = 3.01$)			1.09	(1.02, 1.16)	0.01	0.033	3.01
					0.72		3.01
P-spline of year of hire ($df = 3.00$)			0.98	(0.94, 1.02)	0.40	0.022	3.00
					0.32		3.00

Table 11: Adjusted HR estimates for **prostate cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	86	1.00				
	Not employed	400	0.78	(0.57, 1.06)	0.11	0.156	
Duration of employment	3 to 10	94	1.00				
	$>$ 10 to 18	86	1.31	(0.95, 1.82)	0.10	0.167	
	$>$ 18 to 27	109	1.27	(0.90, 1.78)	0.17	0.173	
	$>$ 27 to 30	67	1.38	(0.94, 2.01)	0.10	0.195	
	> 30	130	1.30	(0.91, 1.86)	0.15	0.182	
Cumulative straight	0	226	1.00				
	$>$ 0 to 0.628	87	0.80	(0.60, 1.06)	0.12	0.143	
	$>$ 0.628 to 2.91	86	0.76	(0.57, 1.01)	0.06	0.147	
	> 2.91	87	0.89	(0.68, 1.16)	0.39	0.138	
Cumulative soluble 5	0 to 0.05	34	1.00				
	$>$ 0.05 to 6.52	151	1.25	(0.85, 1.83)	0.26	0.196	
	$>$ 6.52 to 20.1	150	1.34	(0.91, 1.98)	0.14	0.200	
	> 20.1	151	1.32	(0.89, 1.98)	0.17	0.205	
Cumulative synthetic	0	333	1.00				
	$>$ 0 to 0.656	51	1.13	(0.78, 1.63)	0.52	0.187	
	$>$ 0.656 to 2.47	51	1.27	(0.89, 1.83)	0.19	0.186	
	> 2.47	51	1.66	(1.18, 2.33)	0.00	0.173	
Race	White	257	1.00				
	Black	155	2.01	(1.56, 2.58)	0.00	0.127	

	Unknown	74	0.93	(0.67, 1.29)	0.66	0.169	
Plant	1	219	1.00				
	2	173	0.81	(0.59, 1.10)	0.17	0.157	
	3	94	0.86	(0.63, 1.18)	0.35	0.157	
Sex	Male	486	1.00				
	Female	0				0.000	
P-spline of calendar year ($df = 3.05$)			1.10	(1.07, 1.12)	0.00	0.011	3.05
					0.01		3.05
P-spline of year of hire ($df = 3.02$)			1.02	(1.00, 1.03)	0.02	0.007	3.02
					0.15		3.02

Table 12: Adjusted HR estimates for **kidney and renal pelvic cancers**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	16	1.00				
	Not employed	37	0.85	(0.38, 1.92)	0.70	0.416	
Duration of employment	3 to 25	26	1.00				
	> 25	27	2.91	(1.31, 6.50)	0.01	0.410	
Cumulative straight	0	21	1.00				
	> 0	32	1.48	(0.79, 2.79)	0.22	0.323	
Cumulative soluble 5	0 to 0.05	9	1.00				
	> 0.05 to 7.46	22	0.65	(0.28, 1.48)	0.30	0.425	
	> 7.46	22	0.43	(0.18, 1.03)	0.06	0.447	
Cumulative synthetic	0	40	1.00				
	> 0	13	0.49	(0.23, 1.06)	0.07	0.390	
Race	White	30	1.00				
	Black	10	1.25	(0.53, 2.92)	0.61	0.434	
	Unknown	13	1.52	(0.61, 3.77)	0.37	0.464	
Plant	1	15	1.00				
	2	25	1.59	(0.68, 3.74)	0.29	0.436	
	3	13	1.51	(0.59, 3.84)	0.38	0.476	
Sex	Male	51	1.00				
	Female	2	0.26	(0.06, 1.10)	0.07	0.736	
P-spline of calendar year ($df = 3.04$)			0.98	(0.93, 1.04)	0.59	0.029	3.04
					0.17		3.04
P-spline of year of hire ($df = 3.00$)			1.02	(0.98, 1.07)	0.39	0.023	3.00
					0.46		3.00

Table 13: Adjusted HR estimates for **bladder cancer**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	29	1.00				
	Not employed	89	0.64	(0.35, 1.17)	0.15	0.308	
Duration of employment	3 to 9	21	1.00				
	$>$ 9 to 18	23	1.47	(0.76, 2.83)	0.25	0.335	
	$>$ 18 to 23	21	2.67	(1.29, 5.49)	0.01	0.369	
	$>$ 23 to 29	29	2.40	(1.16, 4.98)	0.02	0.372	
	$>$ 29	24	1.35	(0.61, 2.99)	0.46	0.406	
Cumulative straight	0	52	1.00				
	$>$ 0 to 0.543	22	0.87	(0.50, 1.53)	0.63	0.288	
	$>$ 0.543 to 3.36	22	0.79	(0.44, 1.39)	0.41	0.293	
	$>$ 3.36	22	1.18	(0.69, 2.02)	0.55	0.275	
Cumulative soluble 5	0 to 0.05	10	1.00				
	$>$ 0.05 to 4.89	36	1.23	(0.59, 2.56)	0.58	0.374	
	$>$ 4.89 to 18.8	36	0.96	(0.46, 2.01)	0.91	0.378	
	$>$ 18.8	36	1.10	(0.51, 2.36)	0.80	0.389	
Cumulative synthetic	0	80	1.00				
	$>$ 0	38	1.23	(0.73, 2.07)	0.45	0.268	
Race	White	70	1.00				
	Black	21	0.82	(0.47, 1.43)	0.48	0.285	
	Unknown	27	1.41	(0.77, 2.56)	0.26	0.305	
Plant	1	47	1.00				
	2	48	0.69	(0.39, 1.23)	0.21	0.295	
	3	23	0.68	(0.37, 1.24)	0.21	0.306	
Sex	Male	116	1.00				
	Female	2	0.12	(0.03, 0.48)	0.00	0.720	
P-spline of calendar year ($df = 3.04$)			1.03	(0.99, 1.08)	0.14	0.022	3.04
					0.56		3.04
P-spline of year of hire ($df = 3.00$)			1.02	(0.99, 1.05)	0.16	0.014	3.00
					0.26		3.00

Table 14: Adjusted HR estimates for **melanoma**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	27	1.00				
	Not employed	24	0.52	(0.21, 1.28)	0.16	0.456	

Duration of employment	3 to 18	25	1.00				
	> 18	26	1.30	(0.54, 3.15)	0.56	0.453	
Cumulative straight	0	22	1.00				
	> 0	29	0.71	(0.38, 1.34)	0.29	0.324	
Cumulative soluble 5	0 to 0.05	3	1.00				
	> 0.05 to 4.8	24	2.53	(0.73, 8.76)	0.14	0.633	
	> 4.8	24	2.63	(0.72, 9.53)	0.14	0.657	
Cumulative synthetic	0	30	1.00				
	> 0	21	1.01	(0.49, 2.11)	0.97	0.375	
Race	White	41	1.00				
	Black	1	0.09	(0.01, 0.68)	0.02	1.029	
	Unknown	9	1.22	(0.43, 3.52)	0.71	0.538	
Plant	1	8	1.00				
	2	26	1.49	(0.57, 3.94)	0.42	0.494	
	3	17	1.24	(0.49, 3.14)	0.65	0.474	
Sex	Male	48	1.00				
	Female	3	0.45	(0.14, 1.50)	0.19	0.611	
P-spline of calendar year ($df = 3.05$)			1.14	(1.06, 1.23)	0.00	0.038	3.05
					0.31		3.05
P-spline of year of hire ($df = 2.99$)			1.00	(0.95, 1.05)	0.91	0.024	2.99
					0.43		2.99

Table 15: Adjusted HR estimates for **leukemia**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	22	1.00				
	Not employed	37	0.68	(0.31, 1.51)	0.34	0.408	
Duration of employment	3 to 20	28	1.00				
	> 20	31	1.15	(0.54, 2.48)	0.72	0.391	
Cumulative straight	0	18	1.00				
	> 0 to 1.32	21	1.60	(0.78, 3.29)	0.20	0.368	
	> 1.32	20	1.85	(0.91, 3.73)	0.09	0.359	
Cumulative soluble 5	0 to 0.05	5	1.00				
	> 0.05 to 8.91	27	0.94	(0.34, 2.56)	0.90	0.514	
	> 8.91	27	1.10	(0.38, 3.17)	0.86	0.540	
Cumulative synthetic	0	37	1.00				
	> 0	22	1.40	(0.70, 2.80)	0.34	0.353	
Race	White	35	1.00				

	Black	10	0.86	(0.39, 1.92)	0.72	0.408	
	Unknown	14	1.47	(0.62, 3.49)	0.38	0.441	
Plant	1	19	1.00				
	2	21	0.47	(0.20, 1.12)	0.09	0.445	
	3	19	0.90	(0.41, 2.01)	0.80	0.407	
Sex	Male	53	1.00				
	Female	6	1.09	(0.44, 2.67)	0.85	0.458	
P-spline of calendar year ($df = 3.04$)			1.06	(0.99, 1.12)	0.07	0.031	3.04
					0.60		3.04
P-spline of year of hire ($df = 3.00$)			1.00	(0.96, 1.04)	0.94	0.022	3.00
					0.55		3.00

Table 16: Adjusted HR estimates for **non-hodgkin's lymphoma**.

Covariate	level	n	HR	(95% CI)	p	SE	df
Employment status	Still employed	23	1.00				
	Not employed	63	1.16	(0.60, 2.25)	0.66	0.337	
Duration of employment	3 to 7	20	1.00				
	$>$ 7 to 20	23	0.65	(0.33, 1.28)	0.22	0.346	
	$>$ 20 to 29	21	0.69	(0.30, 1.61)	0.39	0.431	
	$>$ 29	22	0.76	(0.31, 1.90)	0.56	0.465	
Cumulative straight	0	36	1.00				
	$>$ 0 to 1.21	25	1.14	(0.64, 2.03)	0.66	0.295	
	$>$ 1.21	25	1.21	(0.69, 2.13)	0.50	0.287	
Cumulative soluble 5	0 to 0.05	9	1.00				
	$>$ 0.05 to 5.33	26	0.95	(0.43, 2.10)	0.89	0.406	
	$>$ 5.33 to 20.1	25	1.20	(0.52, 2.76)	0.67	0.426	
	$>$ 20.1	26	2.11	(0.86, 5.17)	0.10	0.457	
Cumulative synthetic	0	64	1.00				
	$>$ 0	22	0.67	(0.37, 1.22)	0.19	0.308	
Race	White	58	1.00				
	Black	7	0.33	(0.14, 0.76)	0.01	0.430	
	Unknown	21	0.85	(0.42, 1.75)	0.66	0.366	
Plant	1	27	1.00				
	2	33	0.84	(0.43, 1.65)	0.61	0.343	
	3	26	0.95	(0.50, 1.80)	0.88	0.326	
Sex	Male	76	1.00				
	Female	10	1.24	(0.61, 2.52)	0.56	0.363	

P-spline of calendar year ($df = 3.06$)	1.05	(1.00, 1.11)	0.06	0.027	3.06
			0.47		3.06
P-spline of year of hire ($df = 3.00$)	1.01	(0.98, 1.05)	0.49	0.017	3.00
			0.68		3.00

Numeric results for condition 3

Table 17: Adjusted HR estimates for **leaving work**.

Covariate	level	n	HR	(95% CI)	p	
Cumulative straight	0	11837	1.00	–		
	$>$ 0 to 0.363	4769	1.05	(1.01, 1.09)	0.01	$*$
	$>$ 0.363 to 1.9	4768	1.05	(1.01, 1.10)	0.01	$*$
	$>$ 1.9	4768	1.05	(1.01, 1.09)	0.02	$*$
Cumulative soluble	0 to 0.05	3337	1.00	–		
	$>$ 0.05 to 3.1	7602	1.07	(1.02, 1.12)	$<$ 0.005	$*$
	$>$ 3.1 to 11.6	7601	1.05	(1.00, 1.09)	0.04	$*$
	$>$ 11.6	7602	0.97	(0.93, 1.02)	0.26	
Cumulative synthetic	0	18458	1.00	–		
	$>$ 0 to 0.251	2562	1.02	(0.97, 1.07)	0.42	
	$>$ 0.251 to 1.45	2561	1.02	(0.97, 1.07)	0.46	
	$>$ 1.45	2561	1.12	(1.07, 1.17)	$<$ 0.005	$*$
Race	White	14319	1.00	–		
	Black	4777	1.02	(0.98, 1.05)	0.43	
	Unknown	7046	9.14	(8.79, 9.51)	$<$ 0.005	$*$
Plant	1	8652	1.00	–		
	2	10127	0.67	(0.64, 0.70)	$<$ 0.005	$*$
	3	7363	0.65	(0.62, 0.67)	$<$ 0.005	$*$
Sex	Male	23318	1.00	–		
	Female	2824	1.24	(1.18, 1.29)	$<$ 0.005	$*$
P-spline of calendar year ($df = 16.98$)			1.06	(1.06, 1.06)	$<$ 0.005	$*$
				–	$<$ 0.005	$*$
P-spline of year of hire ($df = 16.25$)			0.96	(0.96, 0.97)	$<$ 0.005	$*$
				–	$<$ 0.005	$*$

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