

## Results

Table 1 summaries of population characteristics among the full study population and among those diagnosed with non-Hodgkin lymphoma between 1985 and 2004. The cohort is predominantly white (66%) and male (87%). There were half as many workers employed at Plant 1 than at Plant 2 or Plant 3. The median year of hire among those diagnosed with NHL was 1959 whereas the median year of hire in the full study population was 1967. Age at hire was approximately the same among those with NHL and the full study population. Median lagged cumulative exposure to all three MWF types was higher among NHL cases. Soluble MWFs were the most widely used MWF type (with approximately 90% of workers ever exposed). Median cumulative exposure among exposed was 6.5 times higher for soluble than for straight MWFs. Median average annual exposure to the three MWF types among exposed workers over calendar time is presented in Figure 1.

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Table 1: Summary of population characteristics. Statistics shown above the horizontal line are count (%). Those shown below are median (quartile 1, quartile 3).

	Study population		NHL cases	
N (person-years)	34,734	(596,698)	231	(2,777)
Race				
White	22,789	(66%)	173	(75%)
Black	6,304	(18%)	21	(9%)
Unknown	5,641	(16%)	37	(16%)
Sex				
Male	30,235	(87%)	206	(89%)
Female	4,499	(13%)	25	(11%)
Plant <sup>a</sup>				
Plant 1	8,721	(25%)	68	(29%)
Plant 2	14,258	(41%)	90	(39%)
Plant 3	11,755	(34%)	73	(32%)
Ever exposed to MWFs <sup>b</sup>				
Straight	19,905	(57%)	133	(58%)
Soluble	31,044	(89%)	210	(91%)
Synthetic	12,262	(35%)	72	(31%)
Year of birth	1940	(1925, 1950)	1929	(1919, 1940)

NHL: non-Hodgkin lymphoma.

<sup>a</sup> Plant of longest employment duration among those who worked at multiple plants; <sup>b</sup> Lagged 10 years; <sup>c</sup> Among those who left work by December 31, 1994; <sup>d</sup> Among ever-exposed individuals, lagged 10 years.

	Study population		NHL cases	
Year of hire	1967	(1953, 1976)	1959	(1951, 1969)
Age at hire (years)	23.6	(20.0, 30.1)	25.4	(21.1, 33.6)
Year of leaving work <sup>c</sup>	1979	(1968, 1989)	1977	(1964, 1987)
Age at leaving work (years) <sup>c</sup>	45.0	(31.9, 57.7)	53.4	(36.5, 61.2)
Years at work <sup>c</sup>	15.3	(7.3, 27.1)	19.2	(8.0, 29.9)
Cumulative time off (years) <sup>b</sup>	1.05	(0.30, 1.80)	0.71	(0.14, 1.40)
Cumulative exposure to MWFs (mg/m <sup>3</sup> -years) <sup>d</sup>				
Straight	0.70	(0.22, 2.56)	0.93	(0.29, 3.30)
Soluble	4.65	(1.85, 12.13)	7.16	(2.86, 20.91)
Synthetic	0.45	(0.16, 1.64)	0.89	(0.29, 2.11)

NHL: non-Hodgkin lymphoma.

<sup>a</sup> Plant of longest employment duration among those who worked at multiple plants; <sup>b</sup> Lagged 10 years; <sup>c</sup> Among those who left work by December 31, 1994; <sup>d</sup> Among ever-exposed individuals, lagged 10 years.

The observed cause-specific cumulative incidence of NHL was 6.65 per 1000. The g-formula estimate of the cumulative incidence under no interventions on MWF exposure, but the elimination of competing risks was 9.56 (8.15, 10.89) per 1000. Table 2 presents the g-formula results for interventions on exposure to soluble MWFs. Those for straight and synthetic MWFs are presented in Tables S1 and S2 in the Appendix. Since exposure to soluble MWFs was greatest in prevalence and magnitude, limits on soluble MWF would result in interventions on a greater percentage of person-years than limits on straight or synthetic MWF. The intervention limiting average annual soluble MWF exposure at the REL affected 23.8% of the person-years in the follow-up period. Limiting straight and synthetic MWF exposure at the REL affected 3.2% and 1.1% of the person-years under follow-up, respectively.

Stronger limits on average annual exposure to soluble MWFs resulted in monotonic reductions in the cumulative incidence of NHL. Capping average annual exposure to soluble MWFs at the NIOSH REL of 0.5 mg/m<sup>3</sup> and a tenth of the REL resulted in a cumulative incidence of 8.30 (6.52, 10.19) and 7.52 (5.73, 9.51) per 1000, respectively. The risk ratios contrasting these interventions to the natural course were 0.87 (0.72, 1.02) and 0.79 (0.62, 0.97), respectively. Dynamic reductions in soluble exposure with the aim of reducing total MWF exposure to the REL and half the REL also yielded strong protective risk ratios 0.84 (0.69, 0.99) and 0.80 (0.64, 0.98), respectively. These interventions attain risk reductions of the same magnitude as those when setting exposure limits at 0.25 and 0.05 mg/m<sup>3</sup>, but do so while intervening on a smaller proportion of person-years.

The relative risks contrasting interventions on straight and synthetic MWF exposure to the natural course were much smaller in magnitude than those for soluble; none were statistically significant.

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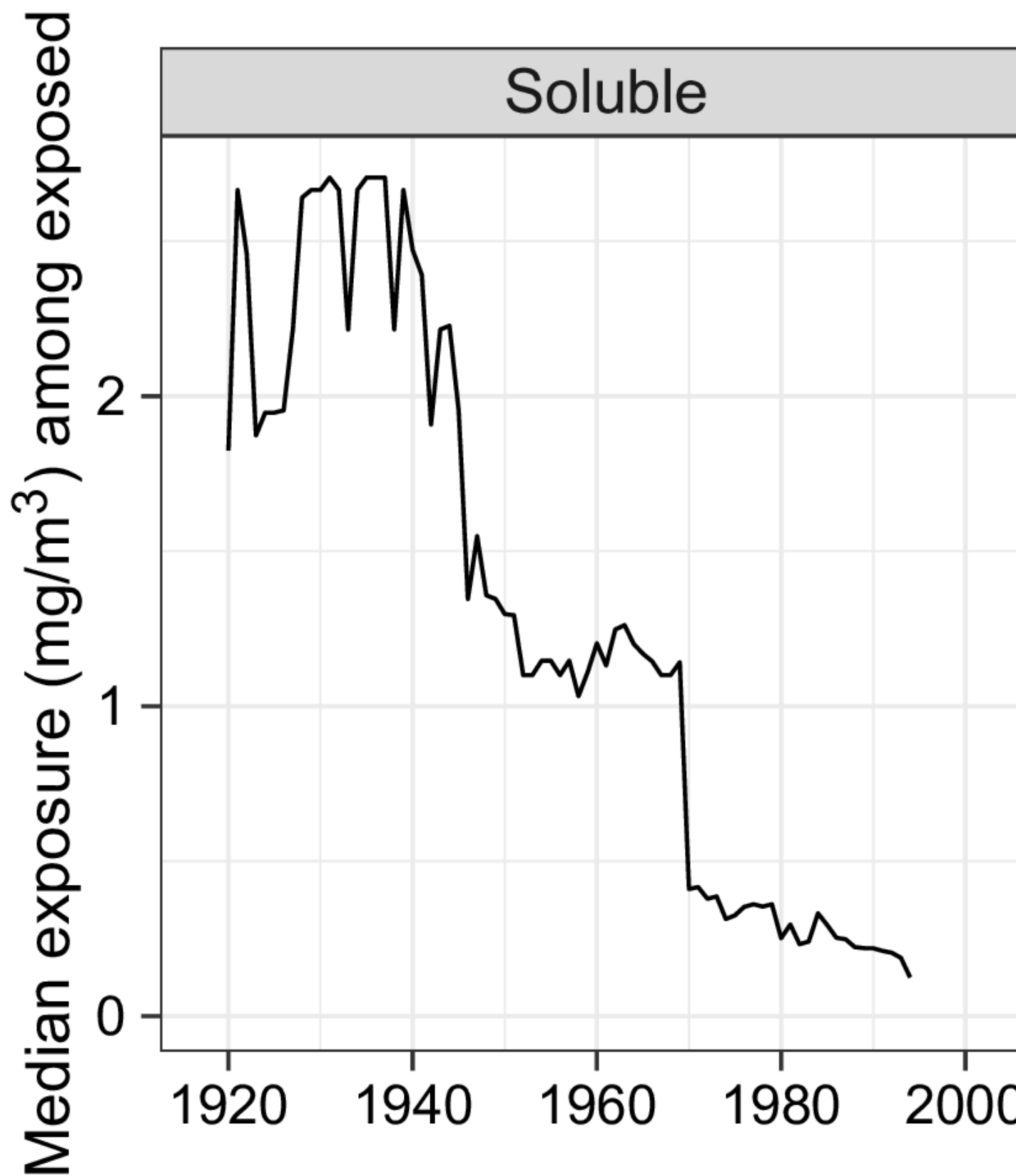


Figure 1: Median average annual exposure to straight, soluble, and synthetic metalworking fluids among exposed workers.

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Table 2: Counterfactual risks (per 1000) and risk ratios contrasting interventions on soluble MWF to the observed course.

Exposure limit on soluble MWF (mg/m <sup>3</sup> )	Person-years intervened (%)	Risk per 1000	(95% CI)	RR	(95% CI)
None	0.0	9.56	(8.15, 10.89)	1.00	
0.5	23.8	8.30	(6.52, 10.19)	0.87	(0.72, 1.02)
0.25	36.2	8.06	(6.15, 10.15)	0.84	(0.68, 1.01)
0.05	43.9	7.52	(5.73, 9.51)	0.79	(0.62, 0.97)
max(0, 0.5 - str - syn)	28.3	8.00	(6.27, 9.87)	0.84	(0.69, 0.99)
max(0, 0.25 - str - syn)	40.0	7.69	(5.88, 9.64)	0.80	(0.64, 0.98)

MWF: metalworking fluid;  
 str: exposure to straight metalworking fluids;  
 syn: exposure to synthetic metalworking fluids.