

**Table 2.1. Cohort studies of chromium IV and lung and respiratory cancer**

Author date/ Place	Characteristics of Cohort	Exposure Assessment	Comments	Exposure Category	n <sup>1</sup>	Relative Risk	95% CI	Type of estimate and reference population
<i>Chromate Production</i>								
Brinton, et al. (1952) US	5522 person-years in 7 chromate production plants; employed 1940–50, followed 1946–50			All workers	26	28.9	[18.87–42.35]	SMR ref US
Enterline, (1974) US	1200 workers in 3 chromate production plants employed 1937–40, followed 1941–60		All respiratory cancers	All workers	69	9.43	[7.34–11.93]	SMR ref US
Satoh, et al. (1981) Tokyo	896 chromium compound production workers employed 1918–75, followed 1918–78			All workers	26	9.5	[6.20–13.92]	SMR ref Japan
Korallus, et al. (1982) Germany	1140 workers in 2 chromate production plants employed > 1 year 1934–79			All workers	51	2.1	[1.56–2.76]	SMR ref North Rhine Westphalia
de Marco, et al. (1988) Italy	540 chromate production workers employed 10 years or more, employed and followed during 1948–85			All workers	14	2.17	1.18–3.63	SMR ref Italy
				High exposure to Cr VI	6	4.2	[1.53–9.14]	SMR ref Italy
Davies, et al. (1991) United Kingdom	2298 workers in 3 chromate production factories; exposed before 1976, followed-up 1950–88			All workers	175	1.97	[1.69–2.28]	SMR ref national
				High chromate exposure jobs	151	2.45	[2.07–2.87]	SMR ref national
				Post-process change	14	1.02	0.56–1.71	SMR ref national

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Korallus, et al. (1993) Germany	2 chromate-producing factories; 1 417 workers with ≥ 1 year of exposure. Exposure and follow-up periods 1948–88	Not used here <sup>2</sup>	Overlap with Birk <i>et al</i> cohort. Includes both pre- and post- process change workers.	All pre-process change workers	66	2.27	1.78–2.85	SMR ref North Rhine Westphalia
Rosenman and Stanbury (1996) New Jersey, US	3408 workers in 4 chromate production facilities, employed during 1937–71			All white males	170	1.95	1.67–2.27	PMR ref US
				All black males	54	1.88	1.41–2.45	PMR ref US
				White males, 20+ years duration	18	2.83	1.68–4.47	PMR ref US
				Black males, 20+ years duration	6	6.30	2.30–13.71	PMR ref US
Gibb, et al. (2000) Baltimore, US	2357 male workers at a chromium production plant, excluding those who began work before 1950; followed 1950–92	Exposure estimated for each worker; estimates assigned by job title, and JEM based on air measurements.	Smoking status available for most workers.	All workers	122	1.80	1.49–2.14	SMR ref Maryland
				Cumulative exposure: 0.077 – 5.25 mg CrO <sub>3</sub> .yrs/m <sup>3</sup>	38	2.24	1.60 – 3.03	SMR ref Maryland
Luippold, et al. (2003) Ohio, US	482 chromate production workers employed ≥ 1 year 1940–72, and followed 1941–97	JEM developed from hygiene surveys, used to derive cumulative exposure estimates		All workers	51	2.41	1.80 – 3.17	SMR ref Ohio
				Cumulative exposure: 2.70 – 23 mg.yr/m <sup>3</sup>	20	4.63	2.83 – 7.16	SMR ref Ohio
				Hired after 1959	6	0.92	0.34 – 2.01	SMR ref Ohio

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Luippold, et al. (2005) US	Two plants producing chromates; both using low exposure process; 430 men in Plant 1 employed 1971–98 and followed 1979–98, 187 men in Plant 2 employed 1979–98 and followed 1980–98	Not used here <sup>2</sup>		All workers	3	0.84	0.17 – 2.44	SMR ref state
Birk, et al. (2006) Germany	901 workers with > 1 year exposure at 2 low exposure chromate-production plants. Exposure period approximately 1960–98, followed for same period	Detailed employment histories reconstructed for each cohort member; industrial hygiene survey; more than 12 000 urinary chromium results collected during routine medical examinations	A subset of workers in the Korallus study – those exposed post-change in process. Smoking status available for most workers.	All workers  Cumulative exposure based on urine levels: > 200 ug.yr/l	22  12	1.48  2.09	0.93 – 2.25  1.08 – 3.65	SMR ref North Rhine Westphalia  SMR ref North Rhine Westphalia
<b><i>Chromate Paints and Pigments</i></b>								
Dalager, et al. (1980) US	977 spray painters using zinc chromate paints in aircraft maintenance at 2 US military bases, employed to 1959, followed 1959–77		All respiratory cancers	All workers	21	1.84	[1.14–2.81]	PMR ref US
Bertazzi, et al. (1981) Italy	427 workers in a plant manufacturing paint and coatings, employed 1946–77, followed 1954–78	Major exposure was chromate pigments	Documented co-exposure to asbestos	All workers	8	2.27	[0.98–4.47]	SMR ref local rates

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Frentzel-Beyme (1983) Germany and Holland	978 workers in 5 plants manufacturing zinc and lead chromates, 15 076 person- years		Dates of employment and follow-up unclear	All workers	19	2.0	[1.20–3.12]	SMR ref national rates
Langård and Vigander (1983) Norway	133 workers in a zinc chromate pigment production plant employed 1948–72, followed 1948–80	Not used here <sup>2</sup>		> 3 years’ employment	6	44	[16.07–95.77]	SIR ref Norway
Davies (1984) United Kingdom	1152 male workers in 3 lead and/or zinc chromate pigment factories employed 1930s to 1981, followed to 1981	Jobs were allocated to exposure grades high, medium and low. based on discussion with management		All workers	28	3.59	2.4–5.2	SMR ref England and Wales
				High exposure	12	4.00	2.1–7.0	SMR ref England and Wales
Hayes et al. (1989) New Jersey, US	1879 lead and zinc chromate pigment production workers employed 1940–69, followed to 1982	Not used here <sup>2</sup>	Lung and pleura	All workers	41	1.16	0.83 – 1.58	SMR ref US
				10 +years duration	8	1.94	0.83–3.83	SMR ref US
Deschamps et al. (1995) France	294 men in a chromate pigment production plant, employed and followed 1958–87			All workers	18	3.6	2.13–5.68	SMR ref local region
				Duration 20+ years	6	3.77	1.38–8.21	SMR ref local region
<b><i>Chromium electro-plating</i></b>								
Silverstein et al. (1981) US	238 workers in automative diecasting and Ni-Cr-plating plant employed before 1978, followed 1974–78			Men	28	1.9	[1.26–2.75]	PMR ref US
				Women	10	3.7	[1.77–6.80]	PMR ref US
Franchini et al. (1983) Parma, Italy	116 “thick” platers in nine plants employed and followed 1951–81			All workers, latency > 10 yrs	3	5.0	[1.03–14.61]	SMR ref Italy

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Itoh et al. (1996) Japan	1193 platers from 415 small-scale chrome plating plants employed 1970–76, followed 1976–92			All workers	14	1.81	0.99–3.04	SMR ref Japan
Sorahan et al. (1998) Midlands, United Kingdom	1762 workers in a large chrome plating plant employed 1946–76, followed 1946–95	list of jobs in cohort assessed for chrome exposure	All workers exposed to chromic acid mists.	All male platers	49	1.25	0.93–1.66	SMR ref England and Wales
				All female platers	16	1.24	0.71–2.01	SMR ref England and Wales
Sorahan and Harrington (2000) Yorkshire, United Kingdom	920 male chrome platers from 54 plants in Yorkshire. Employed before 1972, followed 1972–97	Industrial hygiene surveys carried out at 42 plants		Duration 5+ years, males	10	4.25	1.83–9.87	OR based on nested case-control
				All workers	60	1.85	1.41–2.38	SMR ref England and Wales
				Duration $\geq$ 5 years	19	1.41	0.85–2.20	SMR ref England and Wales
				Chrome platers	-	1.39	0.96–2.00	OR internal analysis includes an unexposed work group, adjusted for smoking
Roberti, et al. (2006) Italy	226 platers in a “bright” electroplating plant employed 1968–94, followed 1968–2003	Not used here <sup>2</sup>		All males	7	3.13	1.23–6.44	SMR ref Venice
<b><i>Cohorts in other industries</i></b>								
Axelsson, et al. (1980) Sweden	1876 workers in ferro-chromium plant employed > 1 year 1930–75, followed 1951–75			All workers	7	1.2	[0.48–2.47]	SIR ref county

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Langård et al. (1990) Norway	1235 ferro-chromium and ferro-silicon male workers employed 1928–65, followed 1953–85		Lung and pleura	All ferro-chromium workers	10	1.5	[0.72–2.76]	SMR ref Norway
Moulin, et al. (1990) France	2269 workers in a ferro-alloy and SS production plant employed and followed 1952–82. Nested case-control based on 12 cases and 58 controls	Job histories; expert assessment for PAH, Cr, Ni	Uncertain exposure to Cr VI	All workers > 1 year duration	11	2.04	1.02–3.64	SMR ref France
				Exposed to Cr and/or Ni	4	2.75	0.29–26.30	OR from nested case-control
Simonato, et al. (1991) 9 European countries	11 092 male welders from 135 companies in 9 European countries, variable periods of employment and follow-up across countries	Not used here <sup>2</sup>	Results for mild steel welders showed excess risk of lung cancer	Predominantly stainless steel welders	20	1.23	0.75–1.90	SMR ref national rates
				Duration 20+ years' predominantly stainless steel welding	13	1.74	0.93–2.97	SMR ref national rates
Gérin, et al. (1993) 9 European countries	JEM was applied to welders in the Simonato et al. cohort	JEM for exposure to Ni and Cr VI derived from measurements and expert opinion	All results shown are for Ever SS welders for > 5 yrs, analysed with 20 yrs latency	Cumulative Cr VI exposure 0.05 – 0.5 mg.yrs/m <sup>3</sup>	7	1.30	0.52 – 2.68	SMR ref national rates
				Cumulative exposure to Cr VI 0.5 – 1.5 mg.yrs/m <sup>3</sup>	9	1.93	0.88 – 3.66	SMR ref national rates
				Cumulative exposure to CrVI 1.5+ mg.yrs/m <sup>3</sup>	5	1.41	0.46 – 3.29	SMR ref national rates

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Hansen, et al. (1996) Denmark	10 059 welders, stainless steel grinders, and other metal workers from 79 welding companies, employed 1964–84; followed 1968–86	Mailed questionnaire on lifetime occupation, and smoking/drinking habits. 83% response	Cohort partly included in Simonato study. Results for mild steel welders showed similar excess risk of lung cancer	All SS welders	23	1.19	0.75–1.79	SMR ref Denmark
Lauritsen and Hansen (1996) Denmark	Nested case-control within cohort of 8 372 respondents of the Hansen et al. 1996 cohort; 94 lung cancer deaths occurring 1946–86, 439 controls	Occupation and smoking history based on mailed questionnaires	Overlap with Hansen et al. 1996 and with Simonato et al. 1991. Results for mild steel welders showed similar excess risk of lung cancer.	All SS welders	20	1.5	0.8–2.6	OR adjusted for smoking
Alexander, et al. (1996) Washington state	2429 aerospace workers with > 6 month's exposure to Cr VI, employed 1940–94 and followed 1974–94	Industrial hygiene data and work history records; available for all years of the study		All workers	15	0.8	0.4 – 1.3	SIR ref Puget Sound
				49.3 – 184.7 chromate-years	5	1.1	0.3 – 2.5	SIR ref Puget Sound
Milatou-Smith, et al. (1997) Sweden	233 stainless steel welders from 8 different companies employed > 5 years 1950–65, followed 1955–92	Air measurement for Cr VI		High exposure to CrVI	6	1.64	0.60–3.58	SMR ref Sweden
Rafnsson, et al. (1997) Iceland	1172 licensed stone masons, born after 1 880 and alive in 1955; followed 1955–93		It was shown that Icelandic cement dust contains Cr VI and that masons have measurable Cr VI in urine	All workers	25	1.69	1.09–2.49	SIR ref Iceland

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Boice et al. (1999) California	3634 workers who were exposed to chromates at an aircraft manufacturing plant employed > 1 year since 1960, followed 1960–96	Not used here <sup>2</sup>		All workers	87	1.02	0.82 – 1.26	SMR ref California for white workers and U.S. general population for non-white workers.
Moulin et al. (2000) France	4288 male workers in a SS and metallic alloy production plant employed > 1 year from before 1968 to 1991, followed 1968–92	No airborne measurements were available; exposure estimates were based on experts' JEM	Uncertain exposure to Cr VI	All workers	54	1.2	0.90–1.57	SMR ref region
				Exposed to chromium and/or nickel	33	0.72	0.32 – 1.62	OR based on internal analyses
Halasová, et al. (2005) Istbene, Slovak Republic	Workers in ferro-chromium plant followed 1985–99		Uncertain exposure to Cr VI. Number of workers unclear	Workers exposed to Cr	59	4.04	[3.08–5.21]	Ratio of directly standardised rates using local area rates

1 n: Number of exposed cases

2 Not used here: This signifies that the study did involve an exposure assessment protocol of some sort, but that the result presented in this table does not depend on that exposure assessment