

Table 2.8 Case-control studies on cancer of the haematopoietic system and welding/welding fumes (web only)

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Preston-Martin & Peters (1988) Los Angeles, USA 1979–1985	Cases: 130; histologically confirmed chronic myeloid leukaemia cases Controls: 130; individually matched neighbourhood controls (on sex, race, ± 5 year birth year) Exposure assessment method: Questionnaire; telephone questionnaire asking whether ever worked in eleven specific occupations or industries; same interviewer for case and control. These eleven were chosen because of their suggested possible relationship to leukaemia risk	Leukaemia (CML)	Welder (ever)	22	25.4 (2.78–232.54)	Diagnostic radiography dose, ever lived on farm, self or first degree relative with Down syndrome or thalassemia minor	Strengths: analyses were focused specifically on welding Limitations: small size. small number of exposed controls (4)
Persson et al. (1989) Sweden 1964–1986	Cases: 160; malignant lymphoma cases, both HD and NHL, were obtained from the register of the Department, at least 20 years old, hospital-based Controls: 275; population register for other studies, Exposure assessment method: Questionnaire; full occupational history and questions about specific exposures	NHL	Welding	7	1 (0.3–2.7)	Age, sex, farming, exposure to fresh wood	Strengths: full occupational history and self-report of specific exposures obtained Limitations: small size

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Persson et al. (1989) Sweden 1964–1986	Cases: 160; Hospital (106 NHL, 54 HL) cases Controls: 275; withdrawn from population registries Exposure assessment method: Questionnaire; Minimum duration of exposure: 1 year; minimum latency: 5 years	NHL	Welding	NR	1 (0.3–2.7)	Logistic odds ratio	Malignant histiocytosis and T-cell lymphoma were excluded Strengths: Pathology was available Limitations: Small size; only surviving cases included; reliance on self-reported exposure information
		HL	Welding	NR	5.4 (2–15)	Logistic odds ratio	
Siemiatycki (1991) Canada, Montreal 1979–1985	Cases: 215; Male residents of the Montreal metropolitan area with histologically confirmed incident NHL, age 35–70 Controls: 2890; 2357 study subjects with other cancers and 533 population-based controls Exposure assessment method: Expert judgement; full occupational history, specific job modules, expert assessment	NHL	Welders and flame cutters (any)	4	0.8 (0.4–2)	Age, family income, cigarette index	Strengths: expert assessment Limitations: cancer controls
			Arc welding fumes (any)	20	0.8 (0.6–1.2)		
			Arc welding fumes (substantial)	6	0.8 (0.4–1.7)		
			Gas welding fumes (any)	18	0.8 (0.5–1.2)		
			Gas welding fumes (substantial)	6	0.7 (0.4–1.5)		
Eriksson & Karlsson (1992) Sweden 1982–1986	Cases: 256; National Cancer Registry Controls: 256; National Population Registry, or National Death Registry of the Causes of Death, matched by age, sex, vital status, and county. Exposure assessment method: Questionnaire	MM (Multiple myeloma)	Welding	3	0.43 (0.14–1.12)	None	Strengths: Cases validated from cancer registry

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Heineman et al. (1992) Denmark 1970–1984	Cases: 835; men diagnosed with MM and reported to the Danish cancer registry Controls: 2979; population controls, matched on sex and year of birth Exposure assessment method: Questionnaire; occupation obtained through linkage with Danish Supplementary Pension Fund	MM	Men only: Welder	6	2 (0.6–5.7)	Age	Strengths: large size
Demers et al. (1993) USA (King and Pierce counties in Washington State; Davis, Salt Lake, Utah, and Weber Counties in Utah; five counties of metropolitan Atlanta; and the three metropolitan Detroit counties). 1977–1981	Cases: 692; Newly diagnosed MM cases under age 80 identified through tumour registries participating in SEER. For 32% interviews were conducted with a proxy. Controls: 1683; population controls, frequency matched to the cases on age and sex and resident in the same areas as the cases. Exposure assessment method: Questionnaire; lifetime work histories. Occupations and industries coded using the 1970 US Census codes	MM	Welders and cutters Welder and cutters (self-responding cases only)	22 14	1.2 (0.7–2) 1.3 (0.6–2.6)	Sex, race, age, study area	Strengths: large size, lifetime work histories collected through interview. Limitations: 32% of the case interview were with proxies, but results were also presented without these

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Keller & Howe (1993) Illinois, USA 1986–1989	Cases: 1034; newly diagnosed male leukaemia cases reported in Illinois by Illinois hospitals. Controls: 4396; random sample of approximately 10% of all other cancers Exposure assessment method: Questionnaire; job title recorded at cancer registration	Leukaemia	Men: Welder	NR	1.63 (0.72–3.7)	Age, history of tobacco use	This study reports on multiple cancer sites Limitations: only welders within the construction industry are selected in the exposed group. It is unclear how many welders (outside of the construction industry) are categorized as unexposed
Persson et al. (1993) Sweden 1975–1984	Cases: 93; NHL cases from cancer registry and hospital Controls: 204; randomly drawn from population registries Exposure assessment method: Questionnaire	NHL (Non-Hodgkin lymphoma)	Welding	15	2.3 (1–5.1)	Age	Strengths: study conducted to confirm/refute findings of earlier Persson study in an adjacent geographic region. Limitations: very small size
Persson et al. (1993) Sweden 1975–1984	Cases: 124; 31 cases of HD cases from cancer registry and 93 cases of NHL Controls: 204; population controls Exposure assessment method: Questionnaire	HL (Hodgkin lymphoma) NHL (Non-Hodgkin lymphoma)	Welding Welding	3 15	1.2 2.3 (1–5.1)	None Logistic odds ratio	Study too small, exclude. Overlap with Persson 1989? Limitations: small number of HD cases

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Figgs et al. (1995) USA (24 states) 1984–1989	Cases: 23 890; NHL deaths Controls: 119 450; noncancer controls deaths, similar distribution with cases in terms of residence (rural vs urban), autopsy status, and geographic region of residence Exposure assessment method: Questionnaire; job from death certificate	NHL (Non- Hodgkin lymphoma)	Black males: Welders	6	2.1 (0.8–5.8)	.	Strengths: very large size Limitations: no information on confounders. Only NHL deaths. Only occupation on death certificate
Costantini et al. (1998) Italy (multicentre) 1991–1993	Cases: 1388; hospital-based Controls: 1718; population-based Exposure assessment method: Questionnaire	NHL (Non- Hodgkin lymphoma)	Welders	28	1.7 (0.92–3.02)	To be extracted from paper	Included in the 't Mannetje et al. (2016) pooled analysis
Mao et al. (2000) Canada (8 provinces) 1994–1997	Cases: 1469; histologically confirmed incident NHL cases Controls: 5073; without cancer, having the same distribution of age/sex with cases, selected from a random sample of the provinces. Exposure assessment method: Questionnaire; occupation and self-report of 17 exposures including welding	NHL (Non- Hodgkin lymphoma)	Welding (men) Welding (women)	173 18	1.1 (0.9–1.3) 1.3 (0.7–2.3)	Age, province, BMI, milk consumption, education (women only)	Strengths: large size, specific question about welding Limitations: not entirely clear whether the full occupational history was collected

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Bethwaite et al. (2001) New Zealand 1989–1991	Cases: 110; incident leukaemia cases Controls: 199; general population controls Exposure assessment method: Questionnaire	Leukaemia: acute (AML and ALL combined)	Welders/flare cutters	14	2.79 (1.2–6.8)	Educational attainment, sex, age	Limitations: small size
Costantini et al. (2001) Italy (multicentre) 1991–1993	Cases: 1450; newly diagnosed cases, both male and female, aged 20– 74, population Controls: 1779; a random sample of the general population, stratified by sex and 5-year age groups Exposure assessment method: Questionnaire; Face-to-face interviews collecting entire working history, followed by exposure-specific questions on chemicals, solvents, and pesticides from a job-specific questionnaire developed by industrial hygienists and agronomists. Industrial hygienists and agronomists assisted in determining the occupational exposures of each subject	NHL (Non- Hodgkin lymphoma): includes CLL	Welders	19	1.2 (0.6–2.3)	Age	Same study population as Costantini et al. (1998)? Included in the ‘t Mannetje et al. (2016) pooled analysis. Strengths: detailed occupational history collected, as well as exposure specific questions and expert assessment. Large size

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Costantini et al. (2001) Italy (multicentre) 1991–1993	Cases: 652; leukaemia cases (ICD-9: 204–208) Controls: 1779; general population, stratified by sex and 5-year age groups Exposure assessment method: Questionnaire; Face to face interviews collecting entire working history, followed by exposure-specific questions on chemicals, solvents, and pesticides from a job-specific questionnaire developed by industrial hygienists and agronomists. Industrial hygienists and agronomists assisted in determining the occupational exposures of each subject	Leukaemia	Males only: Welder	6	0.9 (0.3–2.3)	Age	Strengths: detailed occupational history collected, as well as exposure specific questions and expert assessment. Large size
Costantini et al. (2001) Italy (multicentre) 1991–1993	Cases: 365; incident cases of malignancies of the haematolymphopoietic system Controls: 1779; general population, stratified by sex and 5-year age groups Exposure assessment method: Questionnaire	HL (Hodgkin lymphoma)	Welders	2	0.6 (0.1–2.9)	Age	
		MM (Multiple myeloma)	Welders	7	3.3 (1.3–8.5)	Age	

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Fabbro-Peray et al. (2001) France (Languedoc-Roussillon) 1992–1996	Cases: 445; incident cases of histologically confirmed malignant lymphomas, aged 18 years or older and had negative serology for HIV. Controls: 1025; randomly selected from electoral lists, at least age 18 years; cases and controls were unmatched Exposure assessment method: Questionnaire; full occupational history collected and also specific occupational exposures through questionnaire	NHL (Non-Hodgkin lymphoma)	Never /occasionally welding (ref)	404	1	Age, sex, urban setting, education	The authors discuss electromagnetic radiation exposure as a possible explanation for the elevated risk in welders. Strengths: relatively large number of exposed cases and controls, detailed information on occupational exposures from questionnaire, providing ability to adjust for these including benzene. Frequency of welding was assessed. Limitations: no detailed exposure assessment to welding fumes
			Welding (often)	17	1.7 (0.8–3.4)		
			Welding (daily)	23	2.6 (1.4–5.1)		
		NHL (Non-Hodgkin lymphoma)	Duration in years			Age, sex, urban setting, education	
			Welding: 0 (ref)	404	1		
			≤ 13	17	2.7 (1.3–5.5)		
			> 13	21	1.8 (0.9–3.5)		
NHL (Non-Hodgkin lymphoma)	Frequency			Age, sex, level of education, rural/urban setting, reported medical history, benzene, pesticides/agricultural occupation, radio operator occupation			
	Welding: Never/occasionally welding (ref)	404	1				
	Often	17	1.4 (0.7–2.9)				
		Daily	23	2.5 (1.2–5)			
Oppenheimer and Preston-Martin (2002) Los Angeles, USA 1987–1994	Cases: 412; Acute Myeloid Leukaemia cases Controls: 412; neighbourhood controls individually matched to cases on birth years (+/- 5 years), race, sex Exposure assessment method: Questionnaire	Leukaemia (AML)	Welder (ever)	17	0.8 (0.4–1.7)	None	
			Welding (ever) excluding proxy pairs	14	2.2 (0.8–7)		

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Zheng et al. (2002) USA (Kansas, Nebraska) 1979–1981	Cases: 611; incident (555 NHL, 56 CLL) from two studies, men and women included Controls: 2380; population (1673 men, 707) women, frequency matched to cases by sex, age (+/- 5 years), race, vital status and state of residence using approximately a 4:1 matching ratio Exposure assessment method: Questionnaire; usual occupation collected through the telephone interview	NHL (Non-Hodgkin lymphoma)	Welders and solderers	9	2.9 (1.2–6.9)	Age, state of residence, type of respondent, pesticides, first-degree relative with lymphatic or haematopoietic cancer	Strengths: population controls Limitations: only usual occupation collected
		NHL (DLBCL)	Welders and solderers	5	3.4 (1.2–9.8)	Age, state of residence, type of respondent, pesticides, first-degree relative with lymphatic or haematopoietic cancer	
		NHL (SLL/CLL)	Welders and solderers	1	3 (0.4–25.2)	Age, state of residence, type of respondent, pesticides, first-degree relative with lymphatic or haematopoietic cancer	
Adegoke et al. (2003) Shanghai, China 1987–1989	Cases: 486; leukaemia subjects Controls: 502; healthy controls residing in Shanghai Exposure assessment method: Questionnaire	Leukaemia	Welders and sheet metal	9	1.3 (0.5–3.6)	Age, sex, income	Occupational category too broad to be excluded?

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Band et al. (2004) Canada (BC) 1983–1990	Cases: 769; NHL cases, grouped by pathogenic type Controls: 9076; internal controls, consisting of all other cancer sites excluding lung cancer, and cancers of unknown primary site, having at least 1 matching control per case Exposure assessment method: Questionnaire; self-administered job descriptions of full occupational history	NHL (Non-Hodgkin lymphoma): Diffuse small cell cleaved	Welding and flame cutting (Diffuse small cleaved-cell lymphoma, <i>n</i> = 127)	4	3.6 (1.45–8.97)	Marital status, education, smoking, alcohol, self/proxy	ORs for other NHL subtypes were not reported, because for those a statistically significant OR for welding was not observed. NOTE: may be available online Strengths: large size Limitations: OR for all NHL not reported. small number of welder cases
Baris et al. (2004) USA (Atlanta, Detroit, New Jersey) 1986–1989	Cases: 573; newly diagnosed MM cases age 30–79 Controls: 2131; population controls from the same areas proportional to the expected race, sex and age of the 4 cancer sites included in the study. Exposure assessment method: Questionnaire; Personal interview at home, collecting full occupational history. For women only the usual occupation was collected	MM (Multiple myeloma)	Welders and solderers	10	0.82 (0.41–1.63)	Sex, race, state of residence, education	

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Dryver et al. (2004) Sweden 1990–1998	Cases: 859; NHL cases identified through cancer registry Controls: 1310; matched on sex, age and parish, population based Exposure assessment method: Questionnaire; The questionnaire collected the full occupational history, with specific focus on 25 industries including welding and 16 specific exposures including welding fumes. A job-exposure matrix was also applied (FINJEM), but for exposures other than welding fumes	NHL (Non-Hodgkin lymphoma)	Welding	73	1.42 (1.01–1.99)	Matching variables sex, age, parish	Strengths: detailed exposure assessment through self-report
			Welding fumes	101	0.98 (0.73–1.3)	Matching variables sex, age, parish	
			Welding fumes ≥ 5 vs < 5 years	49	0.96 (0.62–1.47)		
't Mannetje et al. (2008) New Zealand 2003–2004	Cases: 291; NHL cased from new Zealand cancer registry (aged 25–70) Controls: 471; randomly selected from the new Zealand electoral roll, frequency matched by age Exposure assessment method: Questionnaire; full occupational history collected through face to face interviews	NHL (Non-Hodgkin lymphoma)	Men only: Fitter and welder	5	0.99 (0.31–3.12)	Sex, age group, smoking status, Maori ethnicity, occupational status	Strengths: full occupational history Limitations: small size and small number of welder cases

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Karunanayake et al. (2008) Canada (6 provinces) 1991–1994	Cases: 513; incident male NHL cases, the mean age was 57.7 Controls: 1506; population-based controls. frequency matched on age (+/-) 2 years Exposure assessment method: Questionnaire; self-administered postal questionnaire also asking about specific exposures in the full occupational history	NHL (Non-Hodgkin lymphoma)	Only men: Welder	13	1.25 (0.64–2.44)	Age, province of residence	Strengths: large size, full occupational history Limitations: no specific welding fumes exposure assessment
Wong et al. (2010) Shanghai, China 2003–2007	Cases: 722; newly diagnosed AML cases Controls: 1298; hospital controls matched by age and sex Exposure assessment method: Questionnaire	Leukaemia (AML)	Welding	14	1.49 (0.74–3.02)	.	Results by AML subtype are also reported Strengths: large size
Luckhaupt et al. (2012) California, USA 1988–2007	Cases: 1703; male leukaemia cases (age 18–97) from the California Cancer Registry, that worked in the construction industry Controls: Up to 5 controls; cancer controls (with cancers not thought to be related to exposures common in construction), that worked in the construction industry Exposure assessment method: Questionnaire	Leukaemia Leukaemia (AML) Leukaemia (CML)	Men only: Welders Men only: Welders Men only: Welders	21 7 4	1.12 (0.7–1.81) 1.56 (0.67–3.66) 0.86 (0.29–2.53)	. . .	Strengths: large size, results presented for leukaemia subtypes Limitations: cancer controls

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't Mannetje et al. (2016) pooled analysis (10 studies from Europe, USA, Canada, Australia) 1988–2004	Cases: 10 046; incident histologically confirmed cases Controls: 12 025; hospital or population depending on study Exposure assessment method: Questionnaire; job title collected through interview. Full occupational history available for 8 out of 10 studies	NHL (Non-Hodgkin lymphoma)	Welders (ever)	174	1.03 (0.83–1.27)	Age, sex, study centre	Strengths: large size and analyses by subtype Limitations: specific exposure to welding fumes not assessed
			Welders male (ever)	141	1.01 (0.8–1.27)		
			Welders female (ever)	33	1.06 (0.66–1.71)		
			Welders (> 10 years)	53	1.01 (0.69–1.48)		
			Welders male (> 10 years)	46	0.91 (0.61–1.36)		
		NHL (DLBCL)	Welders (ever)	67	1.31 (0.99–1.74)	Age, sex, study centre	
			Welders (> 10 years)	18	1.2 (0.7–2.05)		
		NHL (Follicular)	Welders (ever)	26	0.81 (0.53–1.23)	Age, sex, study centre	
			Welders (> 10 years)	10	1.25 (0.63–2.49)		
		NHL (SLL/CLL)	Welders (ever)	19	0.97 (0.59–1.6)	Age, sex, study centre	

ALL, acute lymphoblastic leukaemia; AML, acute myeloid leukaemia; BMI, body mass index; CI, confidence interval; CLL, chronic lymphocytic leukaemia; CML, chronic myeloid leukaemia; DLBCL, diffuse large B-cell lymphoma; HL, Hodgkin lymphoma; MM, multiple myeloma; NHL, non-Hodgkin lymphoma; NR, not reported; OR, odds ratio; SEER, Surveillance, Epidemiology, and End Results Program; SLL, small lymphocytic lymphoma

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