

Table 2.1. Cohort studies of mustard gas and cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	Expected cases	Relative risk (95% CI)*	Adjustment for potential confounders	Comments
Case & Lea (1955), United Kingdom	1,267 men who were pensioned for the effects of mustard gas poisoning during World War I. Follow-up from 1930, until December 31, 1952	Questionnaire	Lung and pleura	Mustard gas exposure	29	14.0	SMR [2.1 (1.44-2.98)] (p<0.0001)	All male	Only ex-soldiers who were symptomatic in 1930 were eligible for pension. There may be a bias due to no control for smoking. Expected numbers are the numbers that would have occurred when the mortality that affects the general (male) population of the UK over the calendar period of observation is used.
				Neoplasms other than lung and pleura	50	46.8	SMR [1.07 (0.81-1.41)]		
Beebe (1960), USA (1919–1955)	3 groups of WW1 veterans. A– 1855 veterans who had pneumonia during the influenza pandemic	Medical records of the Armed Forces and the VA, for men (white) born between 1888 and 1893	Respiratory system	All respiratory cancer	39	26.6	SMR [1.47 (1.07-2.01)](p<0.01)		In order to ascertain that the cases were mustard gas cases the records had to show that the eyes and skin were affected and also some evidence of pulmonary injury. Mortality data were extracted from the VA files. Smoking history was available only for a small fraction of the study groups. USA white male population as reference population for SMR.
				Mustard gas	65	57.77	[1.13 (0.88-1.43)]		
Norman (1975) 1919–1965	B– 2718 veterans who were hospitalized for mustard gas poisoning in 1918 C– 2578 veterans who had wounds of the extremities (controls)		All respiratory cancer						

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Weiss & Weiss 1975, Germany	Of a total of 878 former workers (1935–1945) in a mustard gas factory, thereof 402 directly in production, 271 examined for mustard gas related symptoms between 1951–74, 245 could be traced and followed-up. Among 85 deaths, 32 were cancer deaths.	No information given	Bronchus	Not specified	11	4.95	2.22 (p<0.05)	none	
			Gastro-intestinal cancer		11	8.12	1.35		
			Urinary bladder		3	1.16	2.59		
			Leukemia		3	1.06	2.83 [0.91-8.78]		
Manning <i>et al</i> , (1981), United Kingdom	502 men and women who worked in manufacturing mustard gas during 1940–45 were traced until the end of 1974. (359 men, 143 women)	Gas factory workers	Larynx and trachea		3	0.4	7.5 p<0.02	Expected numbers were computed by calculating the follow-up years for each worker (to the end of 1974). The total number of men or women-years in each 5-year age group and in each 5-year calendar period were multiplied by the national death rates. The authors mention that there were 7 known cases of cancer of the larynx against 0.75 expected (but no comments why they were not included in the study).	
			Oesophagus		0	0.93	0		
			Stomach		1	5.21	0.2 [0.03-1.36]		
			Lung and pleura		21	13.43	1.6 [1.02-2.40]		
			Leukemia		0	0.80	0		

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Easton <i>et al.</i> (1988) United Kingdom	Cohort of 2498 men and 1032 women employed in the manufacture of mustard gas during the second world war (1938–1944), working for at least 1 year in gas production (for women) Follow-up until 1984 (92271 person-year)	Represented by duration of employment Less than 3 years 3 years over 3 years	Pharynx	< 3	2	1.24	SMR [1.61 (0.40-6.45)]	Sex, age	Other war gases were also manufactured in the concerned factory. Expected numbers were estimated by multiplying person-years at risk by the corresponding national death rates
				≥3	11	0.90	[12.22 (6.77-22.07)]		
			Larynx	All	15	2.73	5.49 [3.31-9.11]		
				< 3	5	2.10	[2.38 (0.99-5.72)]		
			Lung	≥3	5	1.55	[3.23 (1.34-7.75)]		
				All	11	4.04	2.72 [1.51-4.92]		
			Oesophagus	< 3	98	74.45	[1.32 (1.08-1.60)]		
				≥3	91	53.23	[1.71 (1.39-2.10)]		
			Stomach	All	200	138.39	1.45 [1.26-1.66]		
				< 3	12	5.02	[2.39 (1.36-4.21)]		
			Other cancers of buccal cavity and respiratory	≥3	4	3.63	[1.10 (0.41-2.94)]		
				All	20	10.7	1.87 [1.21-2.90]		
			Leukaemia (ICD-9 204-208)	< 3	30	23.88	[1.26 (0.88-1.80)]		
				≥3	23	17.56	[1.31 (0.87-1.97)]		
	All	70	49.57	1.41 [1.12-1.78]					
	< 3	6	2.08	[2.88 (1.30-6.42)]					
	≥3	6	1.54	[3.90 (1.75-8.67)]					
				13	8.51	[1.53 (0.87–2.6)]			

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Wada et al. (1968) Nishimoto et al. (1983, 1988) Yamakido et al. (1996) Okunojima, Japan	Cohort of 1632 male workers in poison-gas factories between 1927–1945. Follow-up between 1952 and 1992 Divided into 3 groups A–engaged in production (674) of war gases B–in contact with poison gases (598) C–engaged in production of other gases or administrative work (360)	Exposure was assessed by description of job and duration	Lung	A	72		SMR*		Reference population was the overall Japanese males Several war gases were produced in the concerned factory simultaneously * p<0.05
				≤0.5 yr		2.32			
				0.5–5 yr		3.24*			
				>5 yr		7.35*			
				B	51				
				≤0.5 yr		3.84			
				0.5–5 yr		2.53			
				>5 yr		4.92			
				C	13				
				≤0.5 yr		0			
0.5–5 yr		1.08							
>5 yr		1.5							
Gastro-intestinal tract	A	85							
	B	62							
	C	37							
	All	184		0.95					
exposed	62		Rate Ratio (adjusted) 0.98 (0.72–1.34)						

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Bullman & Kang (2000) USA	1545 Navy recruits who volunteered to be exposed to mustard gas while wearing protective clothing and wearing a mask (a single event). The non-exposed group included 2663 navy veterans who served in the same location but were not exposed to the mustard gas chamber test. The test was conducted during 1943–45 and the follow-up period lasted until	Military records at the National Personnel Record Center Exposure was considered low for all exposed	Respiratory cancer	not-exposed	127		0.70 (0.07–7.11)	Adjusted for age at entry to follow-up and length of stay in follow-up	No information on smoking and occupational exposures. [exposure probably low compared to other cohorts]
				exposed	1				
			Laryngeal cancer	not-exposed	3		0.99 (0.72–1.36)		
				exposed	61				
			Lung cancer	not-exposed	123		0.73 (0.14–3.77)		
				exposed	2				
Skin cancer	not-exposed	6		0.9 (0.8–1.12)					
	exposed	141							
All cancers	not-exposed	318							