

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments
Mancuso (1979) Lorain, OH, US Reading, PA, US Combined	Cohort of 3 266 men employed for at least 3 months during 1942–1948 at two beryllium processing, production and fabrication facilities (1 222 in Lorain, OH and 2044 in Reading PA); mortality follow-up through 1974 (Lorain, OH) and 1975 (Reading, PA); US mortality rates used as comparison	Dates of employment from plant records	Lung	Lorain, OH, US Reading, PA, US Combined	25 40 65	<i>RR</i> 1.8 ^a (1.2–2.7) 1.25 ^a (0.9–1.7) 1.42 ^a (1.1–1.8)	Age	^a Adjusted for 10% underestimate of expected deaths
Mancuso (1980) Lorain, OH, USA Reading, PA, USA Combined	Cohort of 3 685 men employed during 1937–1948 at two beryllium processing, production and fabrication facilities; mortality follow-up through 1976	Dates of employment from plant records	Lung	All 15+ years of latency	80 53	1.40 [1.1–1.7] 1.82 [1.4–2.4]	Age	Cohorts identified using Social Security Administration payroll records; viscose rayon industry workers used as comparison
Wagoner <i>et al.</i> (1980) Reading, PA, USA	Cohort of 3 055 men who worked at least 1 day during 1942–1967 at a beryllium processing, production and fabrication facility previously studied by Mancuso (1979, 1980); mortality follow-up through 1976; US death rates used as comparison	Dates of employment from plant records	Lung	All 25+ years of latency	47 20	1.25 ^a (0.9–1.7) 1.68 ^a (1.0–2.6)	Age	^a Adjusted for 10% underestimate of expected deaths
Infante <i>et al.</i> (1980) Beryllium Case Registry, USA	Cohort of 421 white men entered into the Beryllium Case Registry between July 1952 and December 1975, while alive, with a diagnosis of acute beryllium-related pneumonitis or chronic beryllium disease; follow-up through 1975; US death rates used as comparison		Lung	All Acute pneumonitis Chronic beryllium disease	7 6 1	[1.93] [0.8–4.0] 2.86 ^a (1.0–6.2) 0.66 ^a (0.1–3.7)	Age	Expected deaths for 1968–75 based on 1965–67 rates, resulting in a 10% underestimate of expected deaths

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments
Steenland and Ward (1991) US Beryllium Case Registry, USA	Cohort of 689 men and women entered into the Beryllium Case Registry between July 1952 and December 1980, while alive, with a diagnosis of acute beryllium-related pneumonitis or chronic beryllium disease; follow-up through 1988; vital status, 95%; US death rates used as comparison		Lung	All Acute pneumonitis Chronic beryllium disease 20+ years of latency	28 17 10 9	<i>SMR</i> 2.00 (1.33–2.89) 2.32 (1.35–3.72) 1.57 (0.75–2.89) 1.52 (0.70–2.89)	Age	
Ward <i>et al.</i> (1992) Seven beryllium processing plants, USA	Cohort of 9 225 men who worked at least 2 days between 1940 and 1969 at seven beryllium processing plants in Ohio and Pennsylvania, USA; two of the plants (in Lorain, OH and Reading, PA) previously studied by Mancuso (1979, 1980) and Wagoner <i>et al.</i> (1980); follow-up through 1988; vital status, 96.7%; cause of death, 98.6%; US and county death rates used as comparison	Dates of employment from plant records	Lung	All 30+ years of latency Lorain, OH, US Reading, PA, US Cleveland, OH Lucky, OH Elmore, OH Hazleton, OH Multiple plants Location unknown	280 134 57 120 44 9 15 13 13 9	1.26 ($P < 0.01$) 1.46 ($P < 0.01$) 1.69 ($P < 0.01$) 1.24 ($P < 0.05$) 0.82 1.08 0.99 1.39 1.67 1.33	Age	

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments
Sanderson <i>et al.</i> (2001) Reading, PA, USA	Nested case-control study within one beryllium processing plant previously studied Mancuso (1979, 1980), Wagoner <i>et al.</i> (1980) and Ward <i>et al.</i> , (1992); lung cancer cases ($n = 142$) and controls ($n = 710$) identified within a cohort of 3 569 workers employed at any time between 1940 and 1969 and followed through 1992; five controls selected for each lung cancer case by incidence density sampling; required to have survived to at least the age at which the index case died and to be of the same race	Work history records linked to quantitative, time-specific exposure estimates for each job; exposures truncated at the age of death of the case, minus any lag	Lung	<i>Geometric mean cumulative exposure ($\mu\text{g}/\text{m}^3$ days) (geometric standard deviation (GSD))</i>	<i>Cases</i> n=142	<i>RR</i> <i>Controls</i> n=710		
				GM (GSD)	4 606 (9.3)	6 328 (9.3)	0.123	
				Lagged 10 years	4 057 (38.9)	2036 (38.9)	0.041	
				Lagged 20 years	844 (134)	305 (134)	0.024	
				<i>Average exposure ($\mu\text{g}/\text{m}^3$) (GSD)</i>				
				Not lagged	22.8 (3.4)	19.3 (3.4)	0.142	
				Lagged 10 years	22.6 (6.6)	12.3 (6.6)	0.0005	
				Lagged 20 years	10.2 (11.9)	5.3 (11.9)	0.004	
				<i>Maximum exposure ($\mu\text{g}/\text{m}^3$) (GSD)</i>				
				Not lagged	32.4 (3.8)	27.1 (3.8)	0.150	
				Lagged 10 years	30.8 (7.6)	16.1 (7.6)	0.0005	
				Lagged 20 years	13.1 (13.9)	6.5 (13.9)	0.004	
				<i>Quartiles of cumulative exposure (quartile ranges)</i>				
				Not lagged		1.00		
				Q1 ($\leq 1\ 425$)		0.73		
Q2 (1 426–5600)		0.85						
Q3 (5 601–28 123)		0.57 ($P < 0.05$)						
Q4 ($> 28\ 123$)								
<i>Quartiles of cumulative exposure (quartile ranges)</i>								
10-Year lag								
Q1 (≤ 808)		1.00						
Q2 (809–3970)		1.38						
Q3 (3 971–20 996)		1.38						
Q4 ($> 20\ 996$)		0.92						

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments		
Sanderson <i>et al.</i> (2001) (contd)				<i>Quartiles of cumulative exposure (quartile ranges)</i>						
				20-Year lag						
				Q1 (≤ 20)			1.00			
				Q2 (21–2195)			2.18 ($P < 0.01$)			
				Q3 (2 196–12 376)			1.89 ($P < 0.05$)			
				Q4 ($> 12 376$)			1.89 ($P < 0.05$)			
				<i>Quartiles of average exposure (quartile ranges)</i>						
				Not lagged						
				Q1 (≤ 11.2)			1.00			
				Q2 (11.3–24.9)			1.61			
				Q3 (25.0–34.0)			1.75 ($P < 0.05$)			
				Q4 (> 34.0)			1.27			
				<i>Quartiles of average exposure (quartile ranges)</i>						
				10-Year lag						
				Q1 (≤ 9.5)			1.00			
				Q2 (9.6–23.6)			2.39 ($P < 0.01$)			
Q3 (23.7–32.8)			2.71 ($P < 0.01$)							
Q4 (> 32.8)			1.83 ($P < 0.05$)							
<i>Quartiles of average exposure (quartile ranges)</i>										
20-Year lag										
Q1 (≤ 1.0)			1.00							
Q2 (1.1–19.3)			1.92 ($P < 0.05$)							
Q3 (19.4–25.5)			3.06 ($P < 0.01$)							
Q4 (> 25.5)			1.70							

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments		
Sanderson <i>et al.</i> (2001) (contd)				<i>Quartiles of maximum exposure (quartile ranges)</i>						
				Not lagged						
				Q1 (≤ 17.0)			1.00			
				Q2 (17.1–25.0)			1.82 ($P < 0.05$)			
				Q3 (25.1–71.5)			1.08			
				Q4 (> 71.5)			1.14			
				<i>Quartiles of maximum exposure (quartile ranges)</i>						
				10-Year lag						
				Q1 (≤ 10.0)			1.00			
				Q2 (10.1–25.0)			3.34 ($P < 0.01$)			
				Q3 (25.1–70.0)			2.19 ($P < 0.05$)			
				Q4 (> 70.0)			1.92 ($P < 0.05$)			
<i>Quartiles of maximum exposure (quartile ranges)</i>										
20-Year lag										
Q1 (≤ 1.0)			1.00							
Q2 (1.1–23.0)			1.95 ($P < 0.05$)							
Q3 (23.1–56.0)			2.89 ($P < 0.01$)							
Q4 (> 56.0)			1.67							

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments
Sanderson <i>et al.</i> (2001) (contd)				<i>Conditional logistic regression analysis of logs of continuous exposure variables</i>	<i>Parameter estimate</i>	<i>Wald statistic</i>	<i>p-value</i>	
				<i>Log cumulative exposure (ug/m³)</i>	-0.064			
				Not lagged	0.060	2.38	0.123	
				Lagged 10 years	0.041	5.35	0.021	
				Lagged 20 years		5.62	0.018	
				<i>Log average exposure (ug/m³)</i>	0.110			
				Not lagged	0.184	2.14	0.143	
				Lagged 10 years	0.088	12.62	0.0004	
				Lagged 20 years		8.35	0.0039	
				<i>Log maximum exposure (ug/m³)</i>	0.098			
				Not lagged	0.171	2.06	0.151	
				Lagged 10 years	0.085	12.81	0.0003	
						8.63	0.0033	
				<i>Comparison of cases and controls by level of exposure</i>	< 2 µg/m ³	> 2–20 µg/m ³	> 20 µg/m ³	
					1.00	2.10	2.23	
				<i>Average exposure (ug/m³)</i>	1.00	4.07 (P < 0.01)	4.17 (P < 0.01)	
				Not lagged	1.00	2.30 (P < 0.01)	2.19 (P < 0.01)	
				Lagged 10 years				
				Lagged 20 years				
					1.00	1.85	2.22	
				<i>Maximum exposure (ug/m³)</i>	1.00	3.89 (P < 0.01)	4.58 (P < 0.01)	
				Not lagged	1.00	2.09 (P < 0.05)	2.34 (P < 0.01)	
				Lagged 10 years				
				Lagged 20 years				

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments
Schubauer-Berigan <i>et al.</i> (2008) Reading, PA, USA	Reanalysis of nested case-control study previously reported by Sanderson <i>et al.</i> (2001); with separate analyses controlling for birth cohort and age at hire and use of the lowest detectable exposure level divided by 2 as the minimal exposure value for continuous exposure-response analyses	Work history records linked to quantitative, time-specific exposure estimates for each job	Lung	<i>Quartiles of cumulative exposure (quartile ranges) adjusted for birth year</i>				
				Not lagged				
				Q1 ($\leq 1\ 425$)		1.00		
				Q2 (1 426–5600)		0.77 (0.47–1.27)		
				Q3 (5 601–28,123)		0.89 (0.55–1.44)		
				Q4 ($> 28\ 124$)		0.61 (0.36–1.02)		
				<i>Quartiles of cumulative exposure (quartile ranges) adjusted for birth year</i>				
				10-Year lag				
				Q1 (≤ 808)		1.00		
				Q2 (809–3970)		1.27 (0.76–2.11)		
				Q3 (3 971–20 996)		1.23 (0.73–2.05)		
				Q4 ($> 20\ 997$)		0.83 (0.48–1.46)		
				<i>Quartiles of cumulative exposure (quartile ranges) adjusted for birth year</i>				
				20-Year lag				
				Q1 (≤ 20)		1.00		
				Q2 (21–2195)		1.46 (0.72–2.97)		
Q3 (2 196–12 376)		1.29 (0.64–2.61)						
Q4 ($> 12\ 376$)		1.30 (0.64–2.65)						
<i>Quartiles of average exposure (quartile ranges) adjusted for birth year</i>								
Not lagged								
Q1 (≤ 11.2)		1.00						
Q2 (11.3–24.9)		1.68 (0.99–2.87)						
Q3 (25.0–34.0)		2.02 (1.16–3.51)						
Q4 (> 34.1)		1.33 (0.76–2.34)						

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments			
Schubauer-Berigan <i>et al.</i> (2008) (contd)				<i>Quartiles of average exposure (quartile ranges) adjusted for birth year</i>							
				10-Year lag							
				Q1 (≤ 9.5)			1.00				
				Q2 (9.6–23.6)			2.04 (1.14–3.66)				
				Q3 (23.7–32.8)			2.47 (1.38–4.42)				
				Q4 (> 32.9)			1.59 (0.87–2.91)				
				<i>Quartiles of average exposure (quartile ranges) adjusted for birth year</i>							
				20-Year lag							
				Q1 (≤ 1.0)			1.00				
				Q2 (1.1–19.3)			1.29 (0.61–2.71)				
				Q3 (19.4–25.5)			2.14 (1.07–4.28)				
				Q4 (> 25.6)			1.19 (0.58–2.44)				
				<i>Conditional logistic regression analysis of logs of continuous exposure variables</i>				<i>Parameter estimate (95% CI)</i>	<i>Wald statistic</i>	<i>p-value</i>	
				<i>Log cumulative exposure (ug/m³ days) unadjusted</i>							
Not lagged				-0.064 (-0.144–0.017)	2.38	0.123					
Lagged 10 years				0.060 (0.009–0.111)	5.35	0.021					
Lagged 20 years				0.041 (0.007–0.075)	5.61	0.018					
<i>Log cumulative exposure (ug/m³ days) birth year adjusted</i>											
Not lagged				-0.055 (-0.137–0.026)	1.79	0.181					
Lagged 10 years				0.038 (0.019–0.094)	1.71	0.192					
Lagged 20 years				0.012 (-0.031–0.055)	0.30	0.585					

Table 2.1. Cohort and nested case-control studies of beryllium and lung cancer

Reference, location, name of study	Cohort description	Exposure assessment	Organ site (ICD code)	Exposure categories	No. of cases/deaths	OR (95% CI)*	Adjustment for potential confounders	Comments
Schubauer-Berigan <i>et al.</i> (2008) (contd)				<i>Log cumulative exposure (ug/m³days) birth year adjusted and alternative factor used to allow taking log of 0 exposure category</i>	<i>Parameter estimate (95% CI)</i>	<i>Wald statistic</i>	<i>p value</i>	
				Not lagged	na	na	na	
				Lagged 10 years	0.018 (-0.051–0.086)	0.25	0.616	
				Lagged 20 years	0.00034 (-0.069–0.070)	0.001	0.992	
				<i>Log average exposure (ug/m³)</i>				
				Not lagged	0.110 (-0.037–0.256)	2.15	0.143	
				Lagged 10 years	0.184 (0.083–0.286)	12.62	0.0004	
				Lagged 20 years	0.088 (0.028–0.148)	8.35	0.0039	
				<i>Log average exposure (ug/m³) birth year adjusted</i>				
				Not lagged	0.119 (-0.025–0.264)	2.60	0.107	
				Lagged 10 years	0.159 (0.051–0.268)	8.25	0.0041	
				Lagged 20 years	0.048 (-0.026–0.123)	1.59	0.207	
				<i>Log average exposure (ug/m³) birth year adjusted and alternative factor used to allow taking log of 0 exposure category</i>				
				Not lagged	na	na	na	
				Lagged 10 years	0.164 (0.049–0.278)	7.79	0.0052	
				Lagged 20 years	0.069 (-0.048–0.186)	1.32	0.251	

^a with adjustment for use of 1965–1967 death rates to estimate number of expected deaths through 1975 used by IARC WG in 1992

[] confidence interval calculated by IARC WG in 1992