Table 2.9. Summary of epidemiological studies of arsenic in drinking-water and liver cancer

Reference	Location	End-point	Exposure	No. of cases		Study outcome	Comments
Ecological studies							
Taiwan							
Chen *et al.* (1985)	84 villages on the SW coast	Mortality 1968–82, all ages	Endemic area for chronic arsenic toxicity (Blackfoot disease)	Men Women	305 146	Age- and sex-adjusted SMR (95% CI) 1.7 (1.5–1.9) 2.3 (1.9–2.7)	Mid-year population: 141 733 in 1968, 120 607 in 1982; national rate in 1968–82 used as the standard for estimation of SMR

Chen *et al.* (1988a)	42 villages on the SW coast	Mortality 1973–86, all ages	Average arsenic (1962–64)
			
			General population
			  < 300 μg/L
			  300–590 μg/L
			  ≥ 600 μg/mL
			
			General population
			  < 300 μg/L
			  300–590 μg/L
			  ≥ 600 μg/mL
				
				Men
				
				Women
						Age standardized mortality rate per 100,000
						
						28.0
						32.6
						42.7
						68.8
						
						8.9
						14.2
						18.8
						31.8
							899 811 person–years, rate per 100 000, age-standardized to 1976 world population

Wu *et al.* (1989)	42 villages on the SW coast	Mortality 1973–86, age ≥ 20	Average arsenic (1962–64)
			  < 300 μg/L
			  300–590 μg/L
			  ≥ 600 μg/mL
			
			  < 300 μg/L
			  300–590 μg/L
			  ≥ 600 μg/mL
				
				Men
				
				Women
					
					54
					42
					27
					
					25
					16
					10
						Age-adjusted mortality rates per 100,000
						47.8
						67.7
						86.7
						p for trend < 0.05
						21.4
						24.2
						31.8
						p for trend < 0.05
							Men, 257 935 person–years; women, 234 519 person–years; rate per 100 000, age-standardized to 1976 world population

Table 2.9. Summary of epidemiological studies of arsenic in drinking-water and liver cancer

Reference	Location	End-point	Exposure	No. of cases		Study outcome	Comments
Chen & Wang (1990)	Taiwan	Mortality 1972–83, all ages	National survey of 83 656 wells (1974–76); average arsenic for each of 314 precincts or townships	Men Women		*β (SE) from regression* 6.8 (1.3) 2.0 (0.5) *Percentiles of age-adjusted mortality rate/100 000 person–years*	Regression coefficient (β) estimates increase in age-adjusted mortality per 100 000 per 100 μg/L arsenic increase in water
				Men		25th 21.8 50th 27.0 75th 34.1	
				Women		25th 7.0 50th 8.7 75th 11.6	
Tsai *et al.* (1999)	SW Taiwan, 4 townships	Mortality 1971–94, all ages	Arsenic-exposed area	Men Women	631 224	SMR (95% CI) 1.8 (1.7–1.98) 1.9 (1.6–2.1)	Men, 1 508 623 person–years; women, 1 404 759 person–years; national rates in 1971–94 used as the standard for estimation of SMR
South America							
Rivara *et al.* (1997)	Region II and VIII, northern Chile	Mortality 1976–92	Arsenic-contaminated Region II			Relative risk 1.2 (0.99–1.6)	Population: 411 000 in Region II, 1 700 000 in Region VIII. Antofagasta (Region II) versus Region VIII.
Hopenhayn-Rich *et al.* (1998)	Córdoba Province, Argentina, 26 counties	Mortality 1986–91, age ≥ 20	County group *Men* Low exposure (341 547) Medium exposure (201 546) High exposure (135 209) *Women* Low exposure (348 874) Medium exposure (204 454) High exposure (137 805)	 186 142 98 173 125 90		SMR 1.5 (1.3–1.8) 1.8 (1.5–2.1) 1.8 (1.5–2.2) 1.7 (1.4–1.96) 1.9 (1.6–2.2) 1.9 (1.5–2.4)	National rate in 1989 used as the standard for estimation of SMR

Table 2.9. Summary of epidemiological studies of arsenic in drinking-water and liver cancer

Reference	Location	End-point	Exposure	No. of cases		Study outcome	Comments
Smith *et al*. (1998)	Region II, Northern Chile	Mortality 1989–93, age ≥ 30	5-year intervals, 420 µg/L average	Men Women	48 37	SMR 1.1 (0.8–1.5) 1.1 (0.8–1.5)	National rates in 1991 used as the standard estimation of SMR; arsenic concentration is population-weighted average for major cities or towns in Region II, 1950–74
Liaw *et al*. (2008)	Region II, Northern Chile	Mortality, 1950-2000 among children (<20 yrs) during & after high exposure period (1958-1970)	In-utero & early life exposure to arsenic >800 µg/L during 1958-1970.	Year of birth 1930-'39 1940-'49 1950-'57 1958-'70 1971-'81 1982-2000	N 2 3 9 2 2 1	RR (95% CI) p 2.4 (0.4-14.4) 0.33 1.5 (0.4-5.9) 0.53 10.6 (2.9-39.3) <0.001 1.2 (0.2-5.9) 0.83 1.6 (0.3-8.8) 0.58 0.5 (0.1-4.2) 0.52	Poisson regression used to calculate RR between Region II and region V mortality. 8 of 9 deaths among 1957-1970 births were 10-19 yrs old.
Australia							
Hinwood *et al*. (1999)	Victoria	Incidence 1982–91	Median concentration of arsenic in drinking-water ranged 1–1077 µg/L	749		SIR (95% CI) 0.5 (0.3–0.8)	State rates in 1982–91 used as the standard for estimation of SIR
Cohort studies							
Chen *et al*. (1988b)	SW Taiwan	Mortality	Area endemic for Blackfoot disease	17		SMR: 4.66 (*p* < 0.001) compared with national standard; 2.48 (*p* < 0.01) compared with regional standard	789 patients with Blackfoot disease followed from 1968 to 1984. National and regional rates in 1968–83 used as the standard for estimation of SMR
Tsuda *et al*. (1995)	Niigata Prefecture, Japan	Mortality, 1959–92, all ages	Level of arsenic < 0.05 mg/L 0.05–0.99 mg/L ≥ 1.0 mg/L Total	 0 0 2 2		SMR 0.0 (0–4.4) 0.0 (0–15.1) 7.2 (1.3–26.1) 1.5 (0.3–5.5)	113 persons who drank from industrially contaminated wells in 1955–59, then followed for 33 years; rates in Niigata Prefecture in 1960–89 used as the standard for estimation of SMR
Lewis *et al*. (1999)	Millard County, UT, USA	Mortality	Arsenic in well-water ranged 3.5–620 µg/L	Men Women	3 7	SMR 0.9 (0.2–2.5) 1.4 (0.6–2.9)	State rates in 1950–92 used as the standard for estimation of SMR.

Table 2.9. Summary of epidemiological studies of arsenic in drinking-water and liver cancer

Reference	Location	End-point	Exposure	No. of cases	Study outcome	Comments
Nakadaira *et al.* (2002)	Niigata Prefecture, Japan	Mortality	Industrially contaminated well-water in the town of Nakajo	1	O/E = 0.7	86 patients with chronic arsenic poisoning. National rates in 1959–92 used as the standard for estimation of SMR
Case–control study						
Chen *et al.* (1986)	SW Taiwan, 4 townships	Mortality	Duration of consumption of artesian well-water containing high levels of arsenic	65 cases 368 controls	Age- and gender-adjusted ORs by years of consuming high-arsenic artesian well-water: Never 1.00 1–20 years 0.85 21–40 years 1.24 > 40 years 2.67	ORs calculated using subjects who never consumed artesian well-water as referent Mantel-Haenszel χ^2 value: 9.01 ($p < 0.01$)

SMR, standardized mortality ratio; CI, confidence interval; SIR, standardized incidence ratio; O/E, observed/expected; OR, odds ratio