Arsenic

An Invisible Poison in Drinking Water

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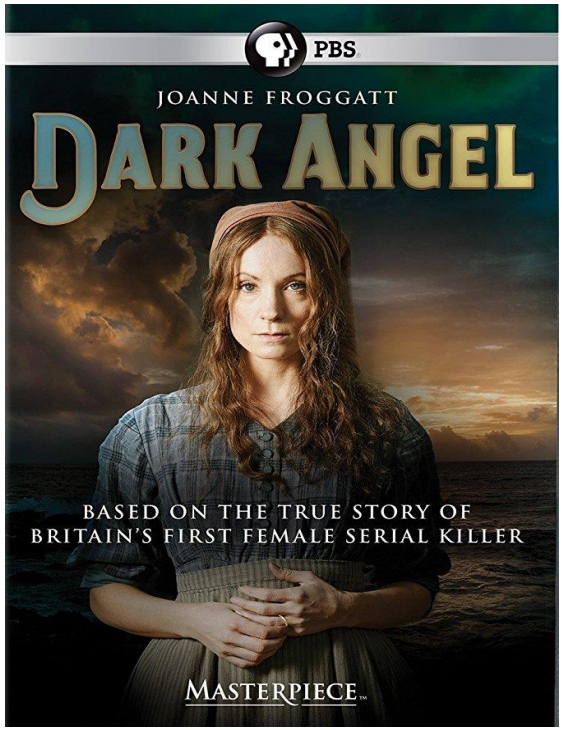
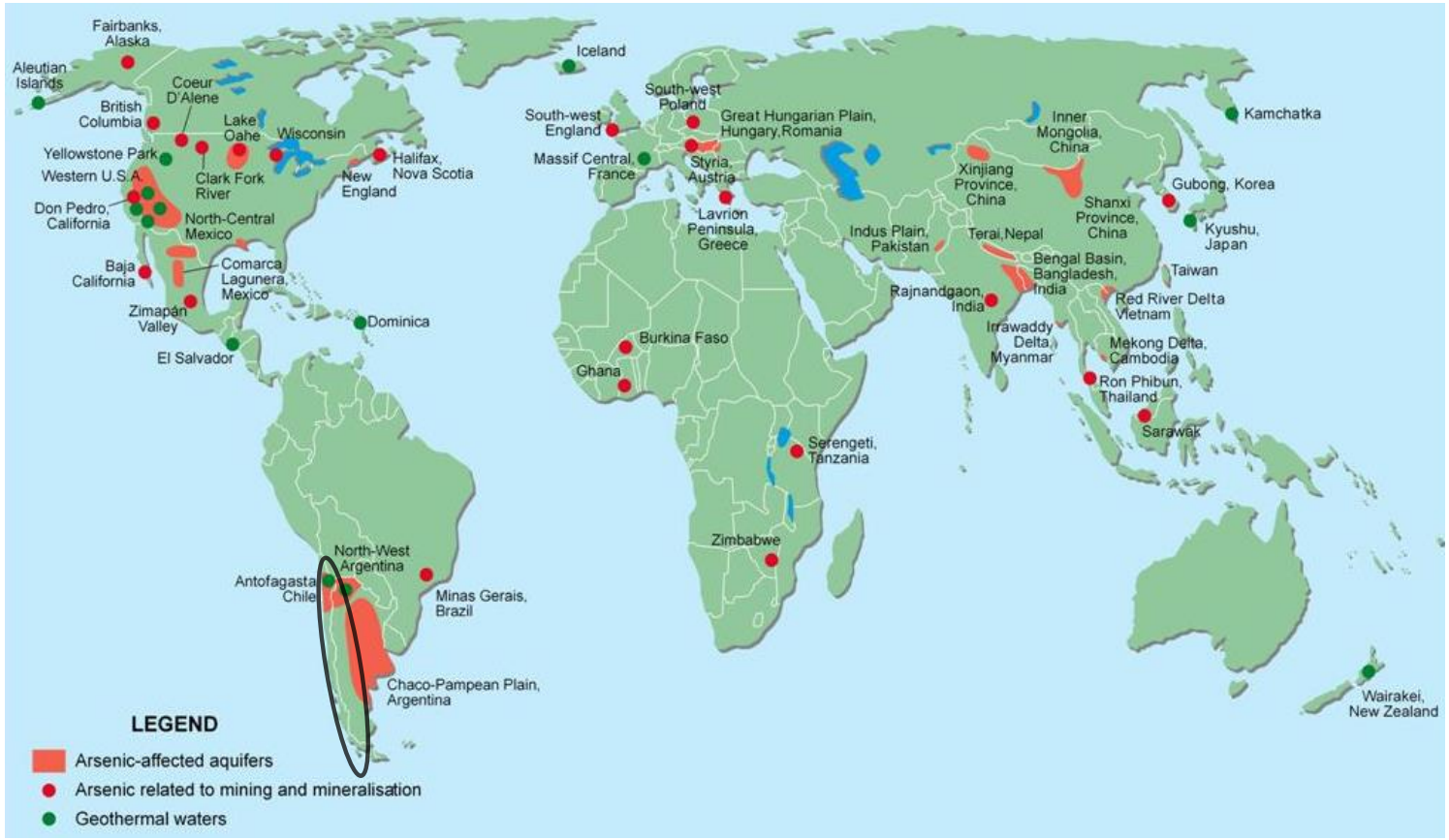
Arsenic



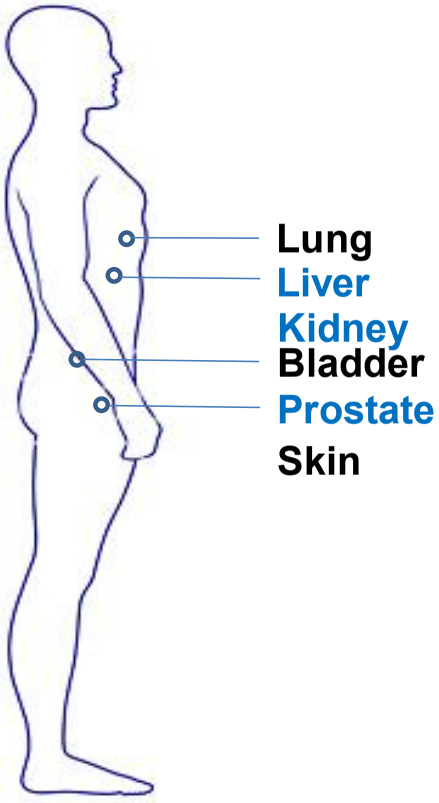
King of Poisons
Poison of Kings

No odor
No color
No taste

Arsenic in Groundwater



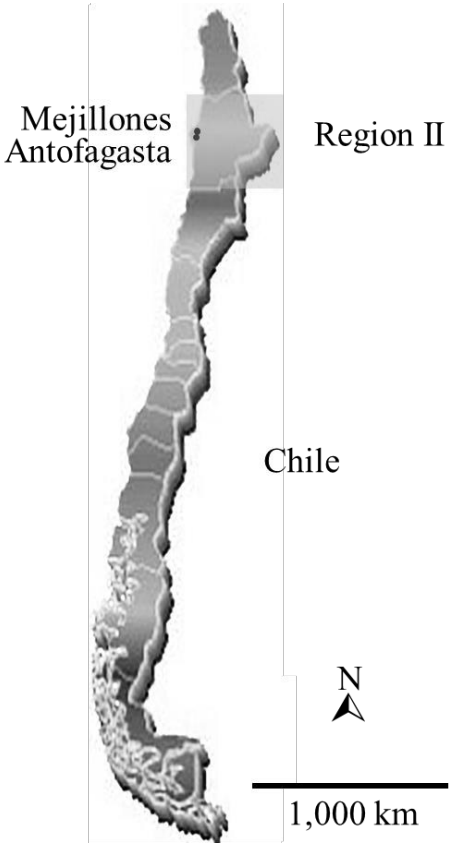
Arsenic and Cancer

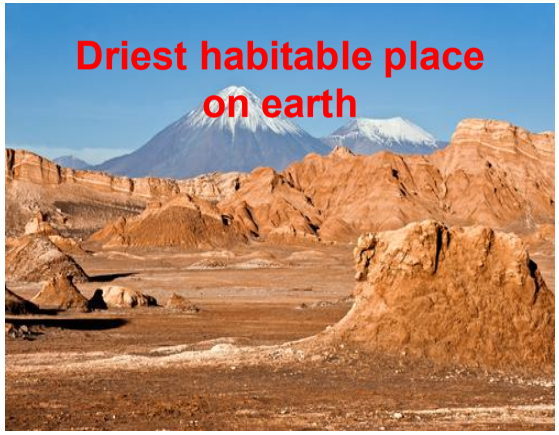


"Group1 Carcinogen"

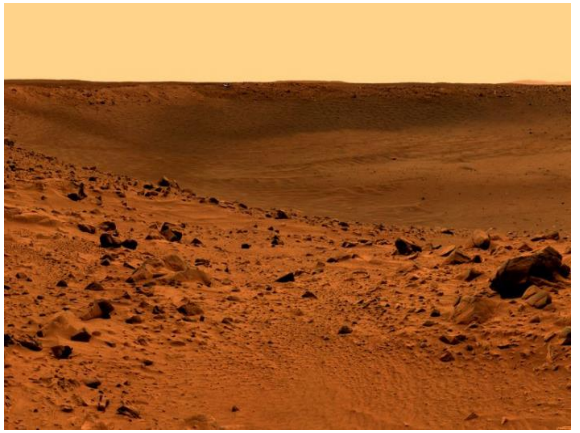
"There is **sufficient evidence** that inorganic arsenic causes cancers of the **urinary bladder, lung and skin**. Positive associations with cancer of kidney, liver, and prostate has been observed."
(IARC, 2004)

City of Antofagasta in Chile





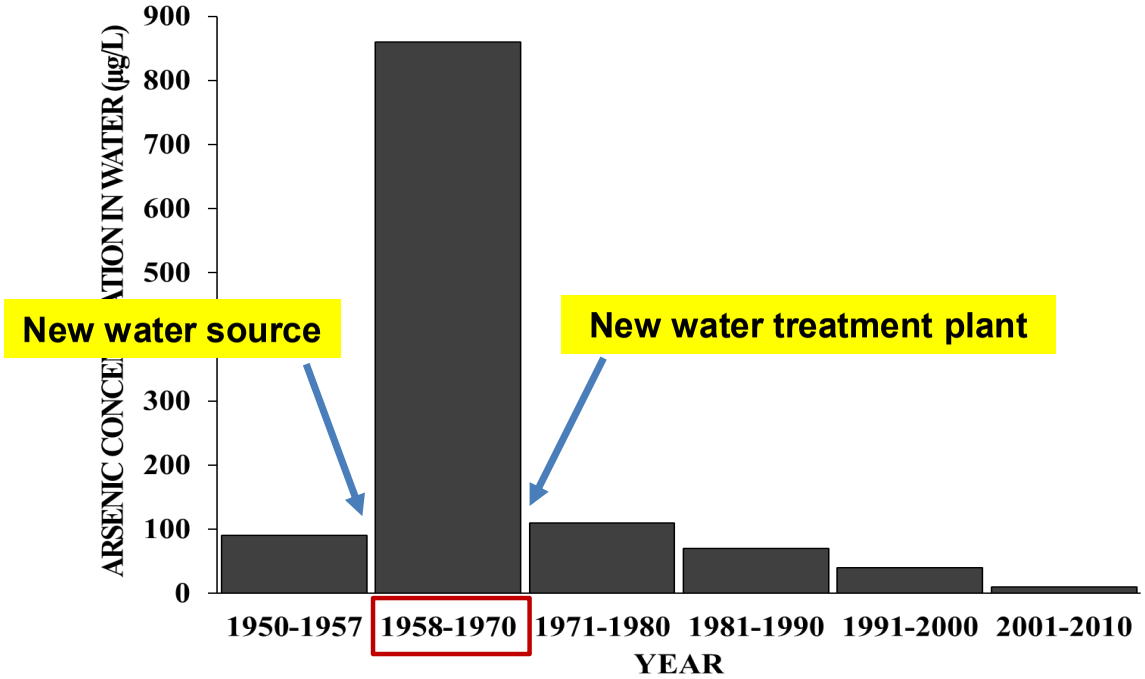
Region II (Antofagasta), Chile



Mars

- Development of mining industry ► Population growth ► Drinking water shortage ► Supplement with new water source (high arsenic level)

Arsenic in Drinking Water of Antofagasta



Average arsenic level in 1958-1970

870 µg/L

Current regulatory level: 10 µg/L

Unique Exposure Scenario

- **Distinct high exposure period:** sudden major increase and drop (1958-1970)
- **Limited water source:** whole population drank same municipal water in Antofagasta (> 125,000 people)
- **Good exposure record**
- **Adequate latency**

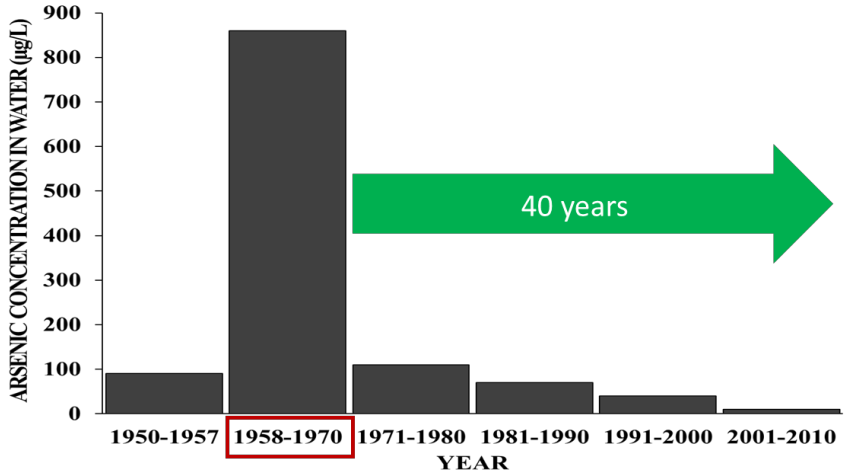
Questions

1. Is arsenic in drinking water associated with an increased cancer mortality up to the year 2010: 50 years after high exposures first began?

2. Is there an effect of age at first exposure on the association of arsenic in drinking water and bladder cancer mortality?

Question 1

Is arsenic in drinking water associated with an increased cancer mortality up to the year 2010: 40 years after high exposures stopped?



Smith et al. (2018). Lung, bladder, and kidney cancer mortality 40 years after arsenic exposure reduction. *Journal of the National Cancer Institute*, 110(3), 241-249.

Arsenic and Cancer Mortality in Antofagasta (2001-2010)

Standardized Mortality Ratio in Antofagasta, compared to the rest of Chile

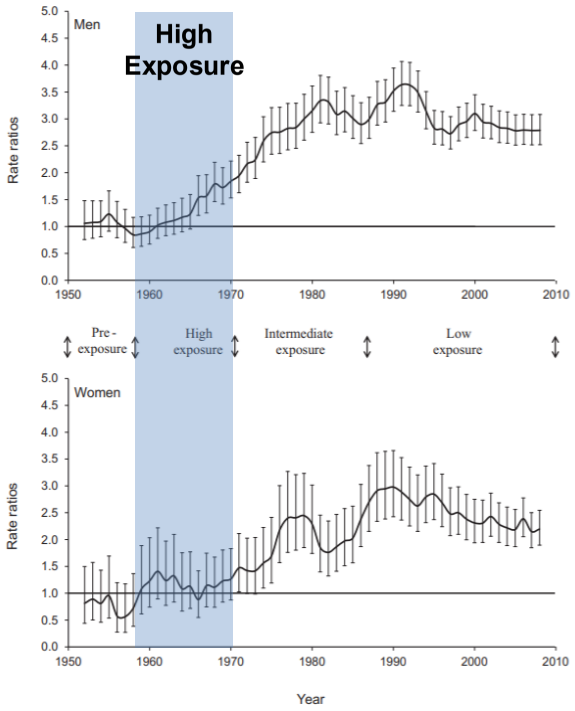
Type of disease and age, y	RR (95% CI)	Type of disease and age, y	RR (95% CI)	Type of disease and age, y	RR (95% CI)
Lung cancer: men		Bladder cancer: men		Kidney cancer: men	
30–39	0.96 (0.36 to 2.62)	30–39	2.19 (0.28 to 16.8)	30–39	0
40–49	2.35 (1.73 to 3.18)	40–49	13.0 (7.94 to 21.4)	40–49	0.99 (0.49 to 2.00)
50–59	4.00 (3.52 to 4.55)	50–59	5.68 (3.98 to 8.11)	50–59	1.52 (1.05 to 2.21)
60–69	3.58 (3.24 to 3.95)	60–69	4.18 (3.10 to 5.63)	60–69	1.74 (1.29 to 2.35)
70–79	3.15 (2.83 to 3.51)	70–79	4.74 (3.79 to 5.93)	70–79	1.95 (1.46 to 2.61)
80+	3.16 (2.67 to 3.76)	80+	4.07 (3.11 to 5.32)	80+	2.47 (1.65 to 3.70)
All	3.38* (3.19 to 3.58)	All	4.79* (4.20 to 5.46)	All	1.75* (1.49 to 2.05)
Lung cancer: women		Bladder cancer: women		Kidney cancer: women	
30–39	2.32 (0.93 to 5.76)	30–39	0	30–39	0
40–49	3.99 (2.90 to 5.50)	40–49	7.03 (2.90 to 17.0)	40–49	1.55 (0.63 to 3.81)
50–59	2.19 (1.72 to 2.79)	50–59	9.58 (5.83 to 15.7)	50–59	1.80 (1.00 to 3.21)
60–69	2.30 (1.92 to 2.76)	60–69	7.25 (5.05 to 10.4)	60–69	1.81 (1.13 to 2.90)
70–79	2.54 (2.17 to 2.99)	70–79	7.47 (5.74 to 9.74)	70–79	2.32 (1.61 to 3.33)
80+	2.10 (1.69 to 2.62)	80+	4.78 (3.58 to 6.38)	80+	2.60 (1.75 to 3.86)
All	2.41* (2.20 to 2.64)	All	6.43* (5.49 to 7.54)	All	2.09* (1.69 to 2.57)

Arsenic-related cancer mortality due to arsenic exposure can have **very long latencies**, with increased risks manifesting 50 years after first exposure.

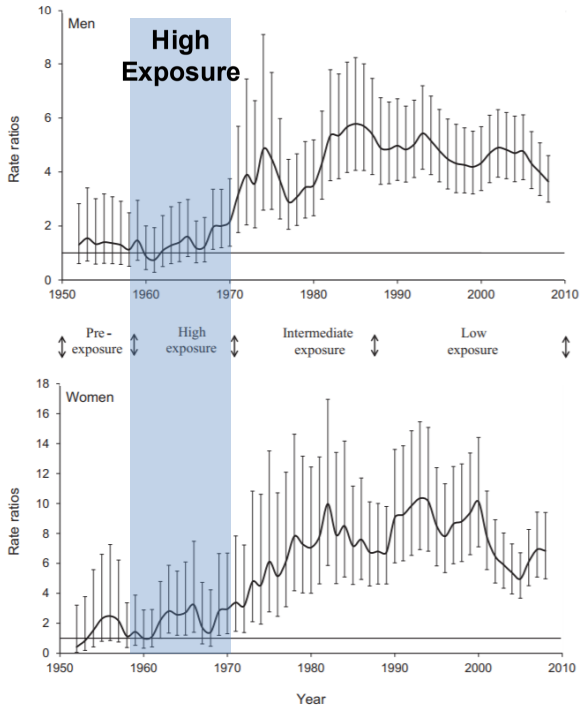
Latency of Arsenic-Related Cancers in Antofagasta

Age-adjusted rate ratios for cancer mortality for Region II (arsenic-exposed), compared with Region V (unexposed), Chile (1950–2010)

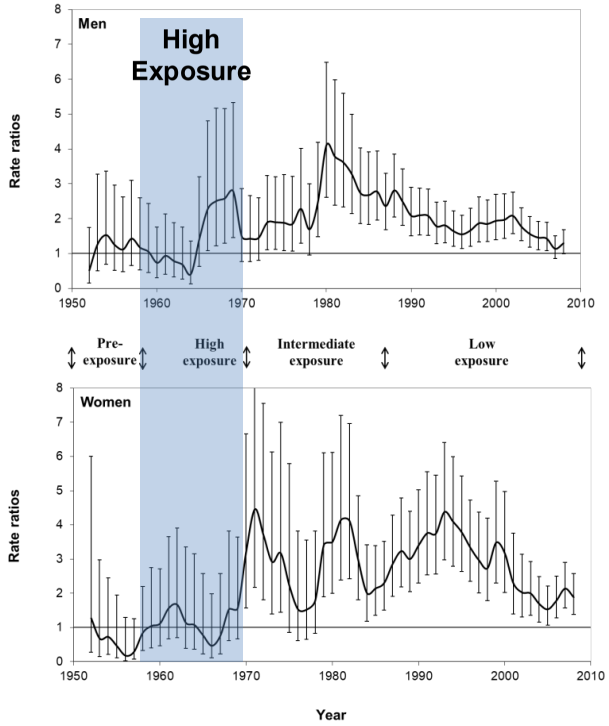
Lung Cancer



Bladder Cancer

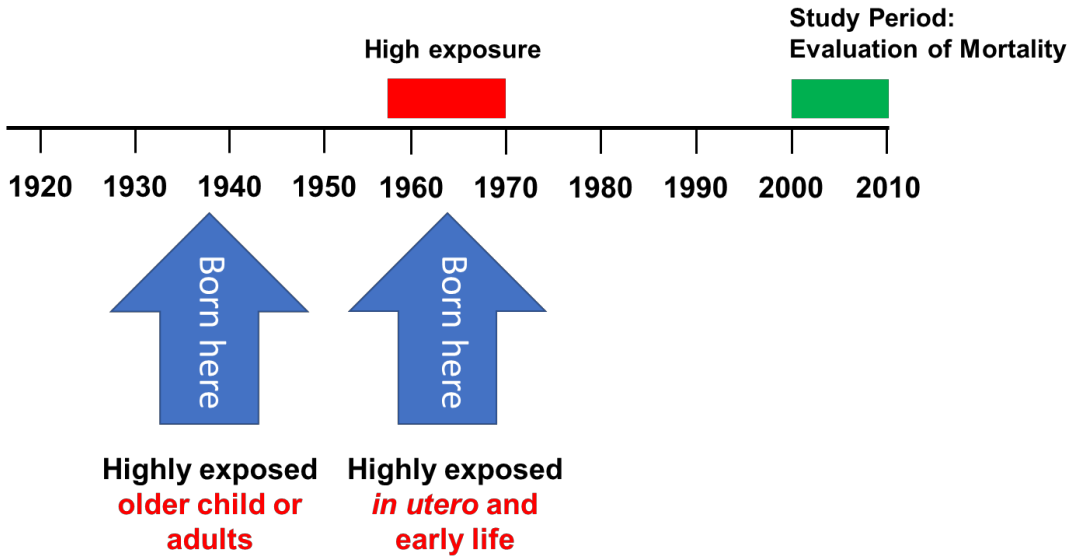


Kidney Cancer



Question 2

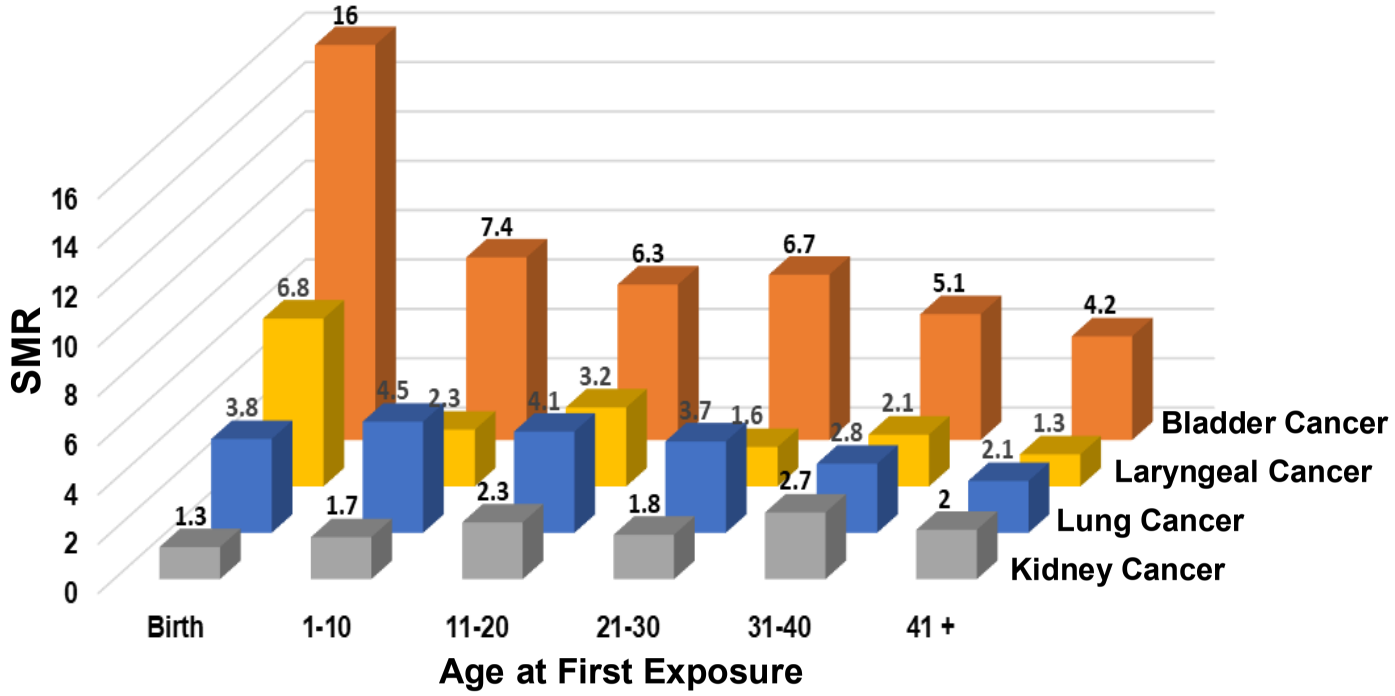
Is there an effect of age at first exposure on the association of arsenic in drinking water and bladder cancer mortality?

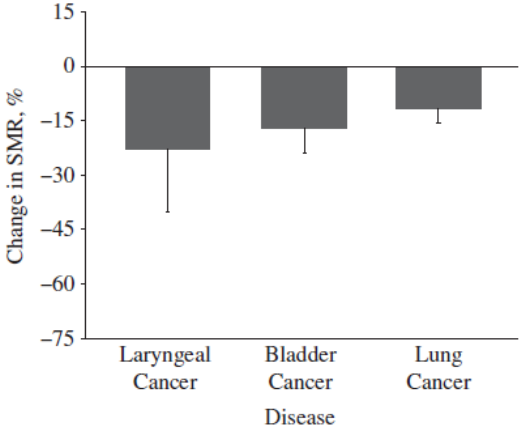


Roh et al. (2018). Age at exposure to arsenic in water and mortality 30–40 years after exposure cessation. *American journal of epidemiology*, *187*(11), 2297-2305.

Early-Life Exposure to Arsenic and Cancer Mortality

Effect of Age at First Exposure to Arsenic on Cancer Mortality





Demographic, Lifestyle-Related, and Medical Risk Factors of Antofagasta

Demographic, Lifestyle-Related, and Medical Risk Factors of Antofagasta and all of Chile

Characteristic[b]	Region II	All of Chile
Demographic risk factors		
Female sex	48.1	51.1
Urban residence	97.7	91.6
Higher education (university/ professional)	17.0	14.0
Poverty-level SES	11.4	18.8
Lifestyle-related risk factors		
Current smoking (yes/no)	42.8	40.5
Passive tobacco smoke exposure	7.1	9.6
Tobacco smoking, cigarettes/day	7.7	10.4
Alcohol consumption, g/day	41.5	55.6
Fruit/vegetable consumption, g/day	174.0	186.0
Salt consumption, g/day	9.6	9.8
Regular physical activity[c]	13.8	10.6
Medical risk factors		
Average BMI[d]	27.2	27.4
Obesity (BMI ≥30)	24.7	25.1
Hypertension (BP ≥140/90 mm Hg)	21.1	26.9
Diabetes mellitus	9.3	9.4

Demographic, Lifestyle-Related, and Medical Risk Factors of Antofagasta

Smoking rate of Antofagasta and the rest of Chile

Categories	Smoking rates, %		
	Region II	Region V	All of Chile
1990 CASEN*: smoking in the past year			
Status			
Nonsmokers	78.0	74.8	78.6
Moderate smokers (>0 to 1 pack/d)	20.8	22.8	19.7
Heavy smokers (>1 pack/d)	1.0	1.2	1.1
Sex			
Men who smoked	27.5	28.8	25.3
Women who smoked	16.8	19.5	16.5
1992 CASEN*: smoking in the past year			
Status			
Nonsmokers	74.8	73.7	76.7
Moderate smokers (>0 to 1 pack/d)	23.6	24.5	21.9
Heavy smokers (>1 pack/d)	1.2	1.1	1.0
Sex			
Men who smoked	30.9	30.7	28.0
Women who smoked	19.0	20.8	18.0
2006 CONACE†: Did you smoke in the past month? Yes			
Year			
1994	38.2	40.1	38.9
1996	34.9	40.2	39.5
1998	36.8	42.8	40.1
2000	39.5	43.5	42.7
2002	39.6	45.6	42.4
2004	40.2	45.2	42.5
2015 SENDA‡: Do you smoke daily? Yes			
Year			
2002	28.3	31.2	30.6
2004	29.3	31.7	30.5
2006	25.5	30.5	28.8
2008	24.4	27.0	28.2
2010	23.3	21.4	24.5
2012	21.9	24.6	21.9
2014	14.6	22.4	22.7

Bladder cancer-specific relative risk by smoking = 1.5 (Cumberbatch et al., 2016)

Conclusion

- Arsenic-related cancer mortality is still very high even 40 years after the high exposure stopped
- Major impacts on people who probably experienced early life exposure

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NIH National Institute of Environmental Health Sciences

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Thank you!