

**High concentrations of arsenic in drinking water  
result in the highest known increases in mortality  
attributable to any environmental exposure**

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# Some of our key collaborators:

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- Bangladesh, Dr Md. Yunus
- Argentina, Dr. Omar Rey
- University of Washington, Dr. David Kalman
- UCSF (San Francisco), Dr. John Balmes
- UC Berkeley, Dr. Martyn Smith

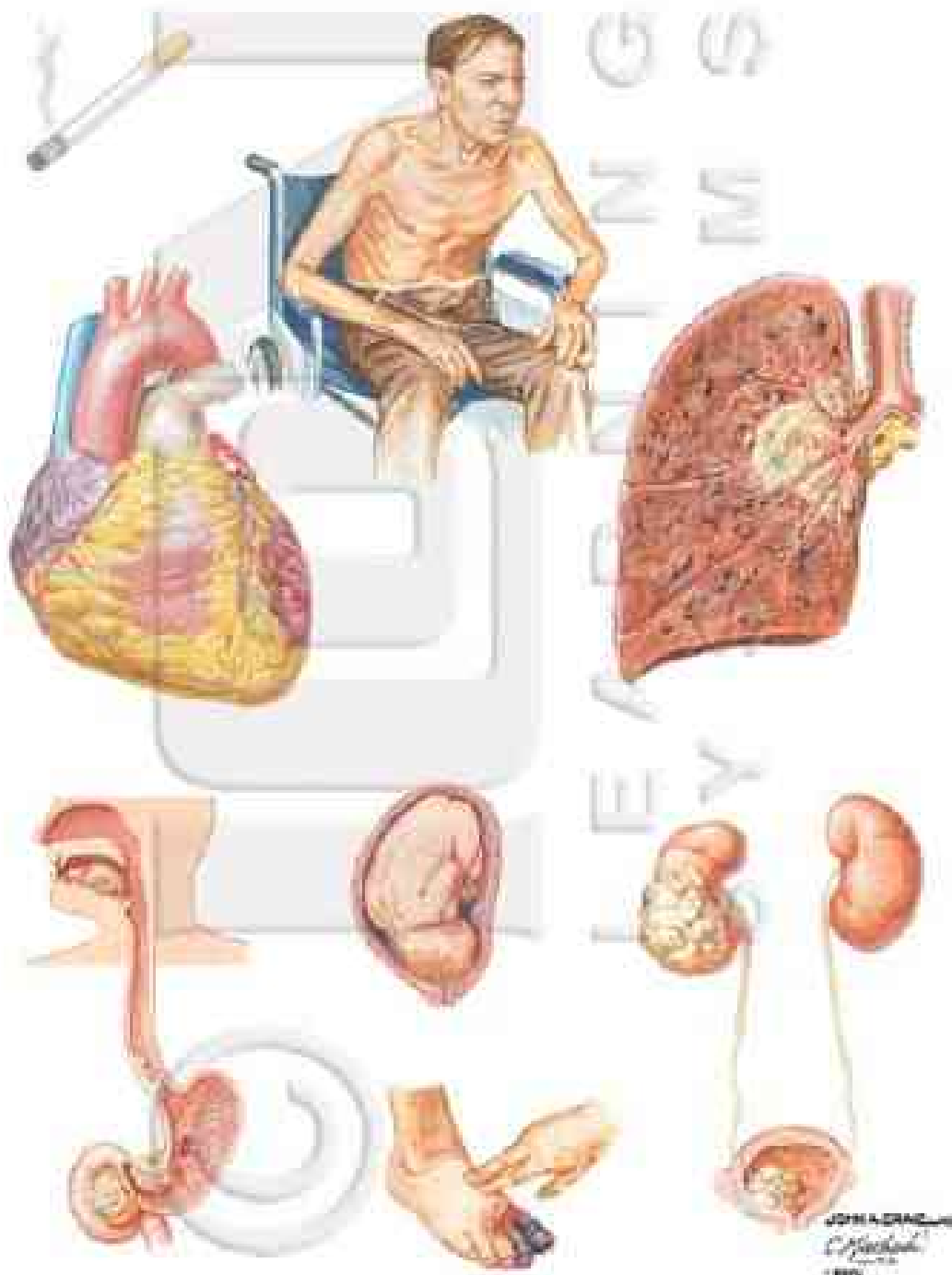
**The idea that something in drinking water  
might have major impacts in the lung is:**

**A little?**

**incredible**

**Could invisible tasteless and odorless  
arsenic in drinking water really affect  
the lungs?**





JOHN A. CHAMBERLAIN  
C. Mackintosh  
1889





# Known causes of lung cancer involve inhalation

- smoking
- passive smoking
- asbestos
- radon
- silica
- chromium
- diesel exhaust
- coke oven PAHs
- bischlormethyl ether
- nickel
- arsenic

# Arsenic in drinking water

- It is ingested, not inhaled
- Could it possibly affect the lungs and other organs like cigarette smoking?
- And could the risks be compared to those from smoking cigarettes?

**Incredible!**

# Map of Chile

 <http://www.ine.cl/Territoriales/chile.jpg>

← Region II

← Region V

**CHILE**

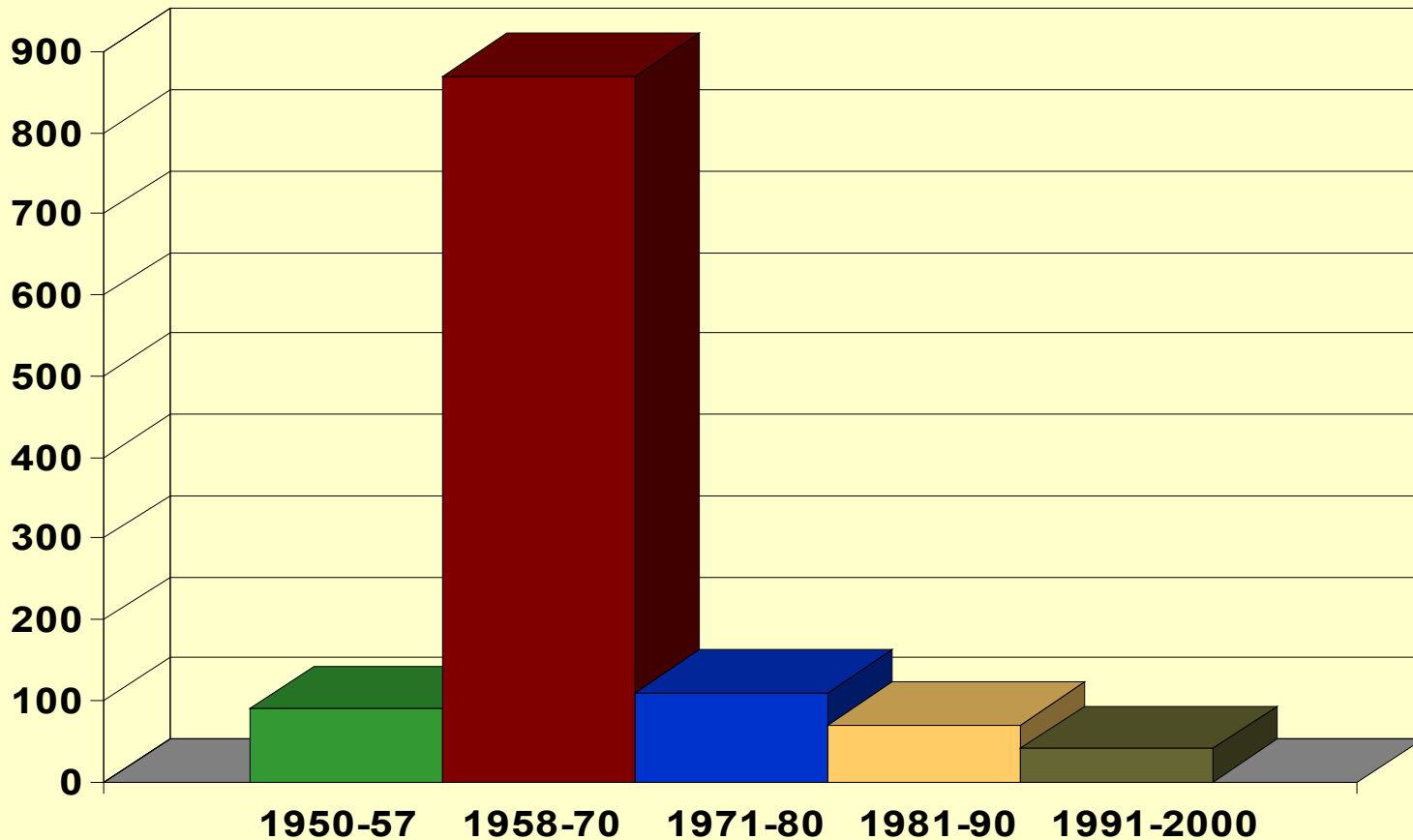






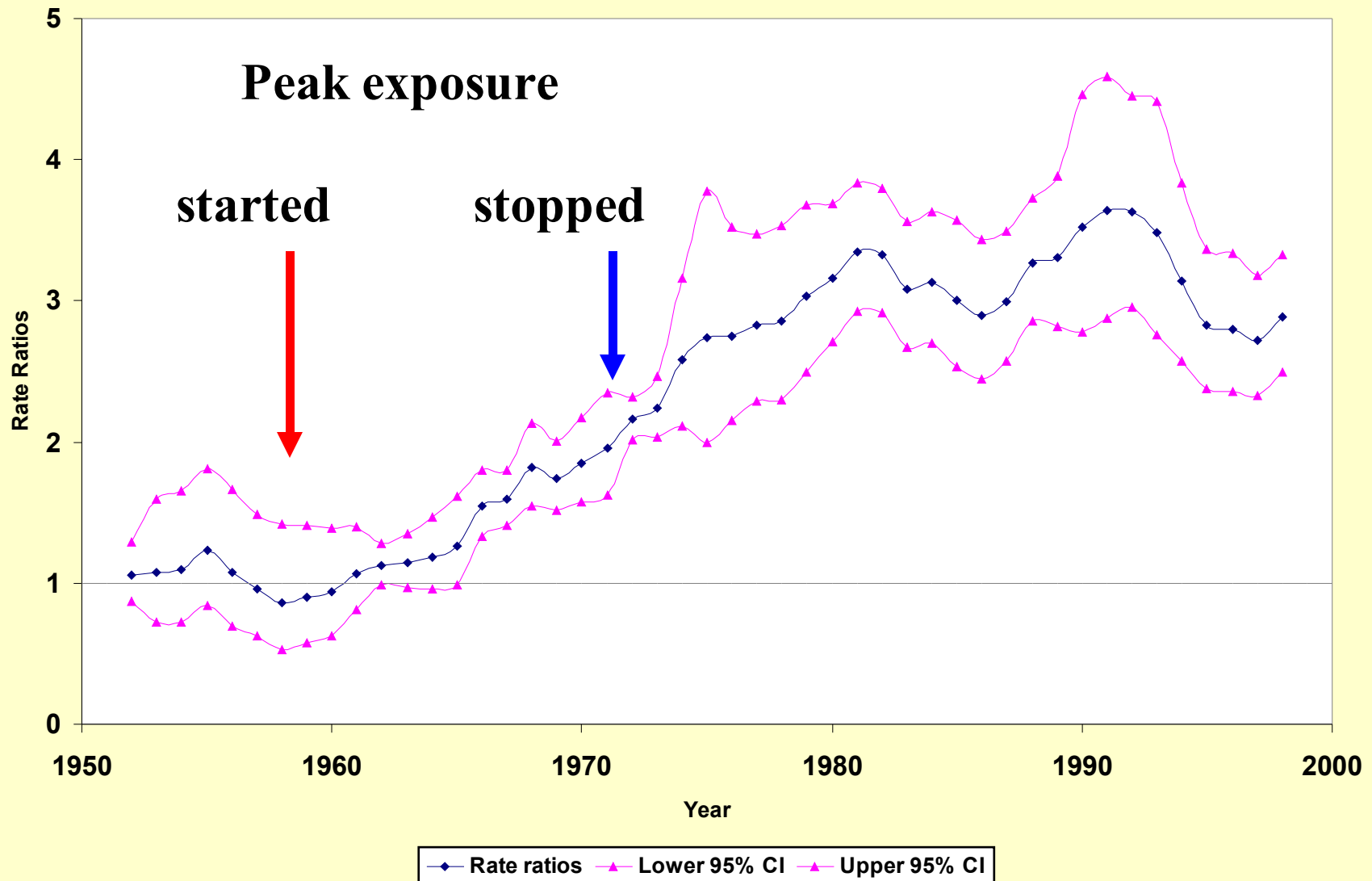


**Arsenic concentrations in Antofagasta and Mejillones water by year. Arsenic contaminated water sources were used from 1958, and an arsenic removal plant was installed in 1971.**



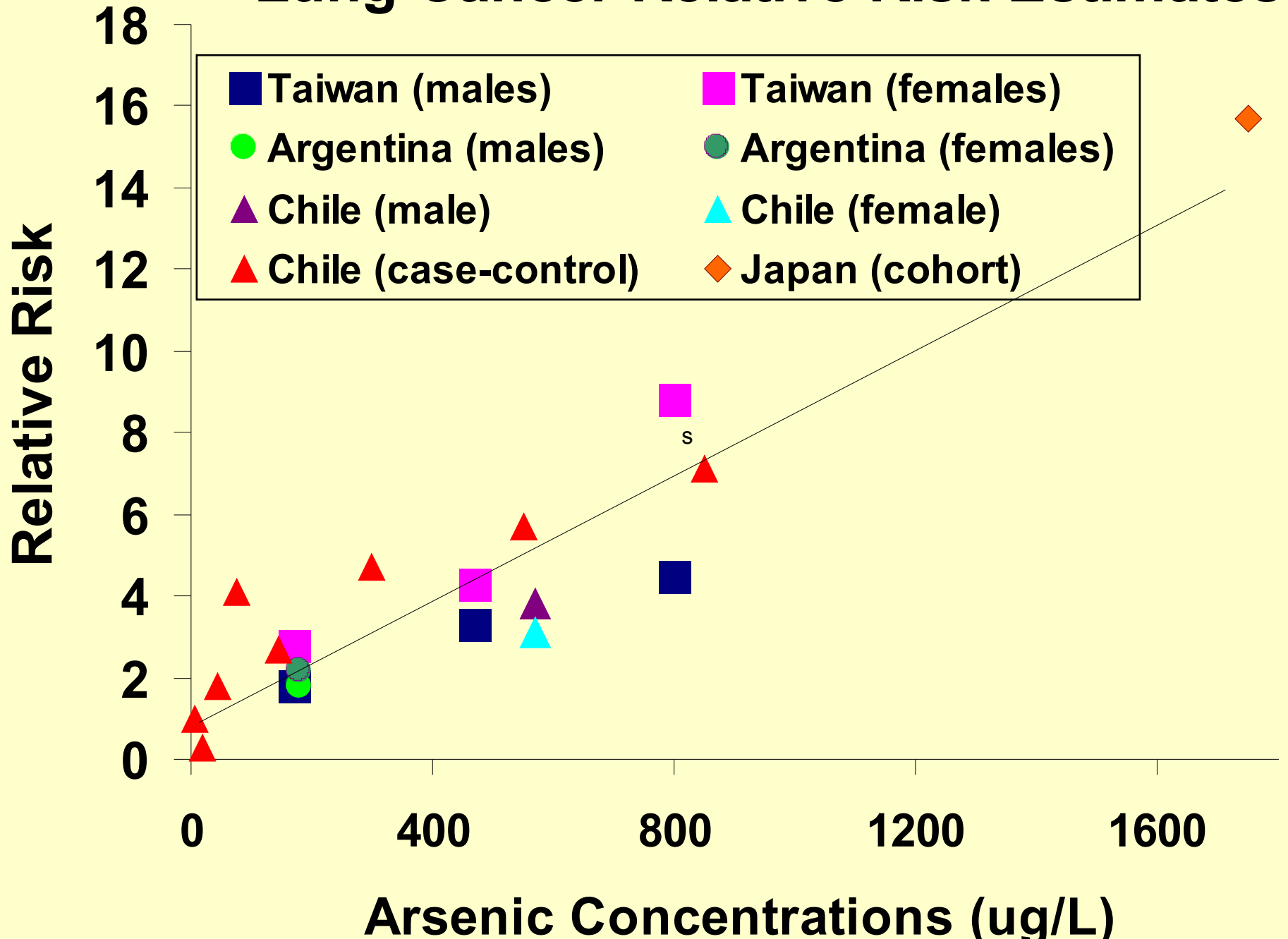


# Mortality from lung cancer among men, Region II Chile Marshall et al, J. Natl Cancer Inst, 2007





# Lung Cancer Relative Risk Estimates

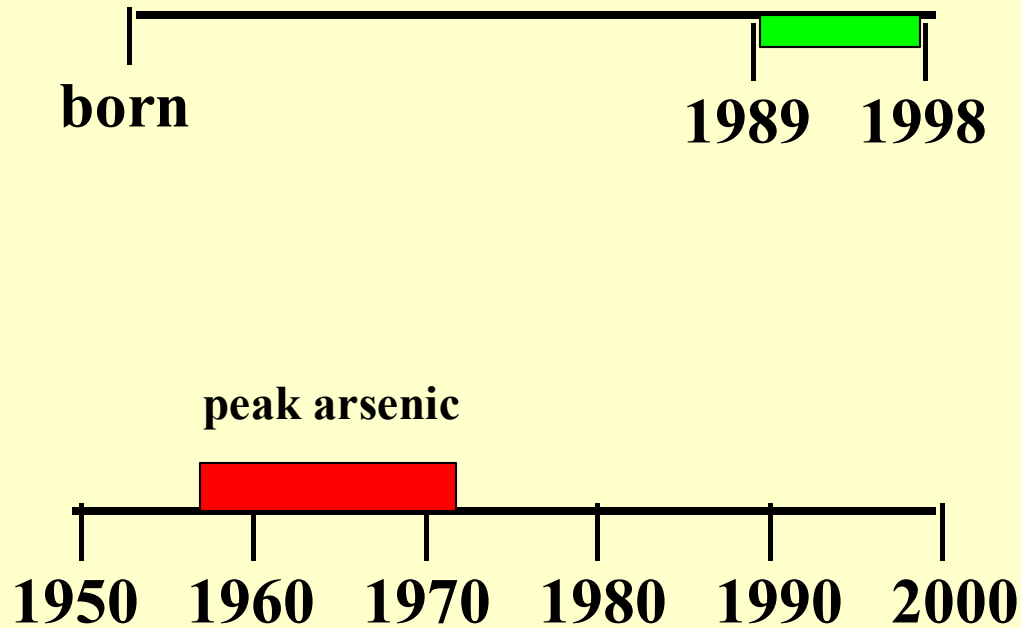


## IARC classification, 2002

Arsenic in drinking-water was evaluated as *carcinogenic to humans* (Group 1) on the basis of *sufficient evidence* for an increased risk for cancer of the urinary bladder, **lung** and skin.

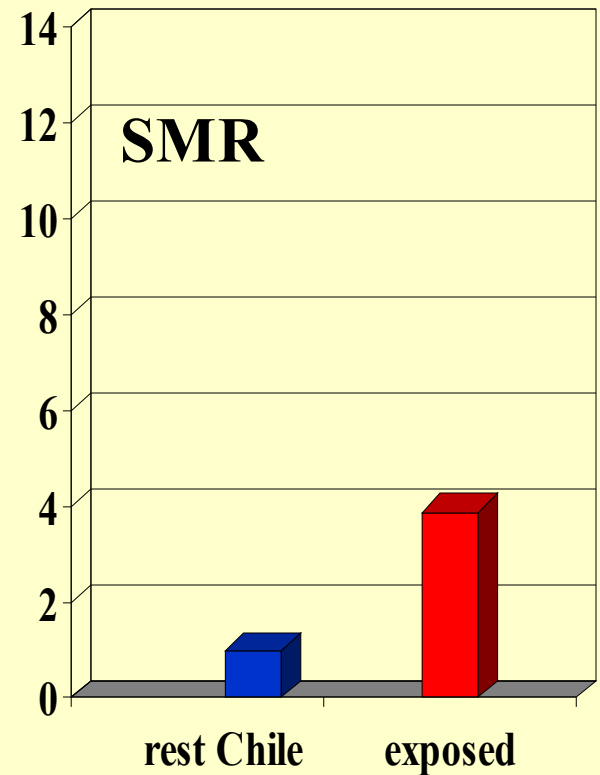
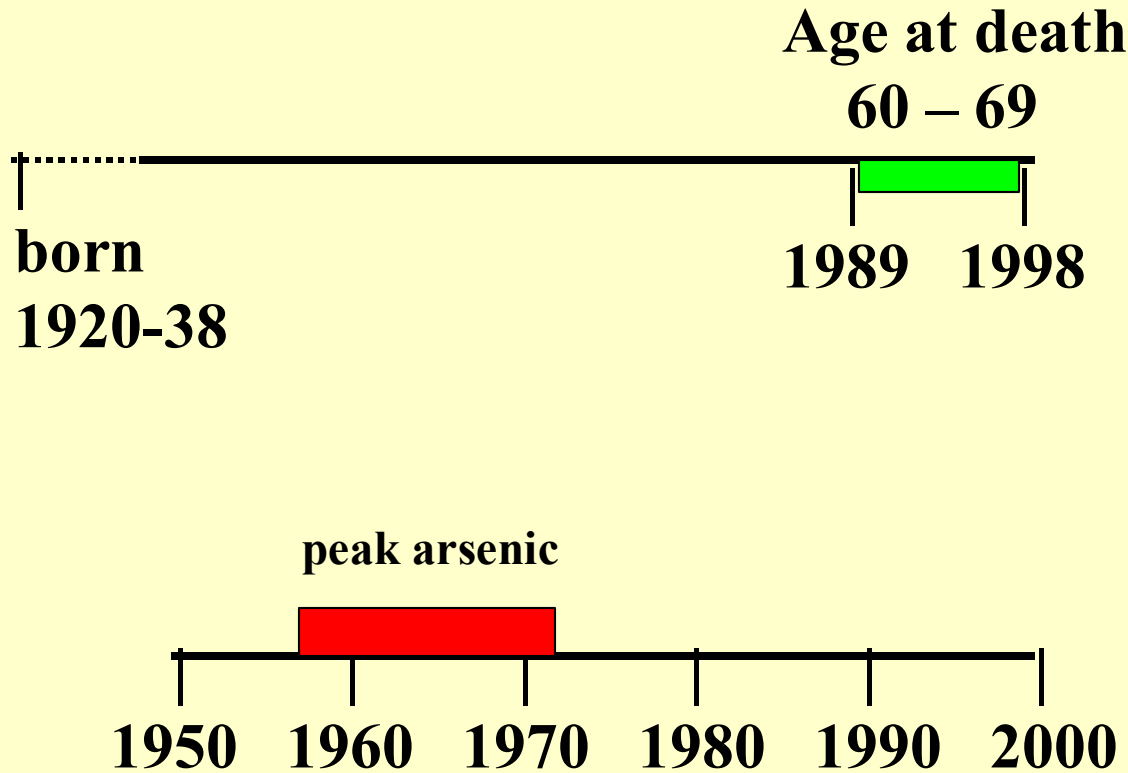
# Childhood exposure

# Lung cancer mortality in men according to exposure in childhood



# Lung cancer mortality in older men

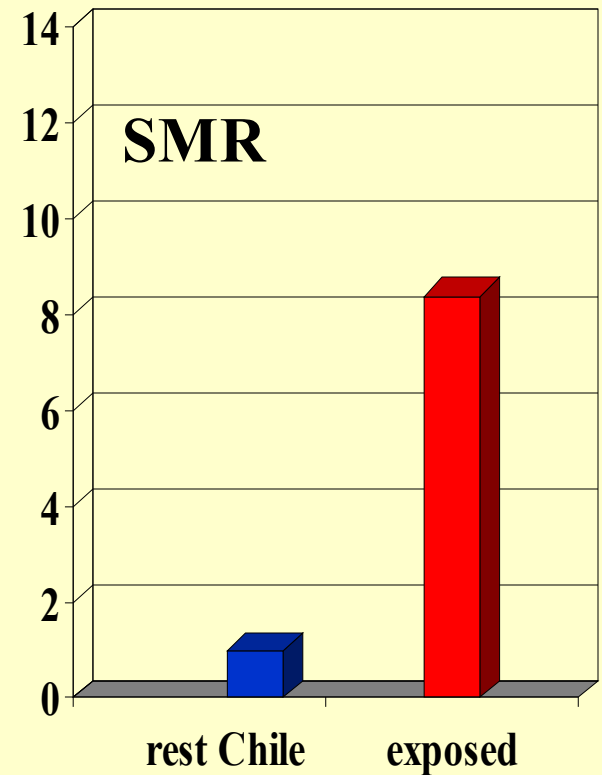
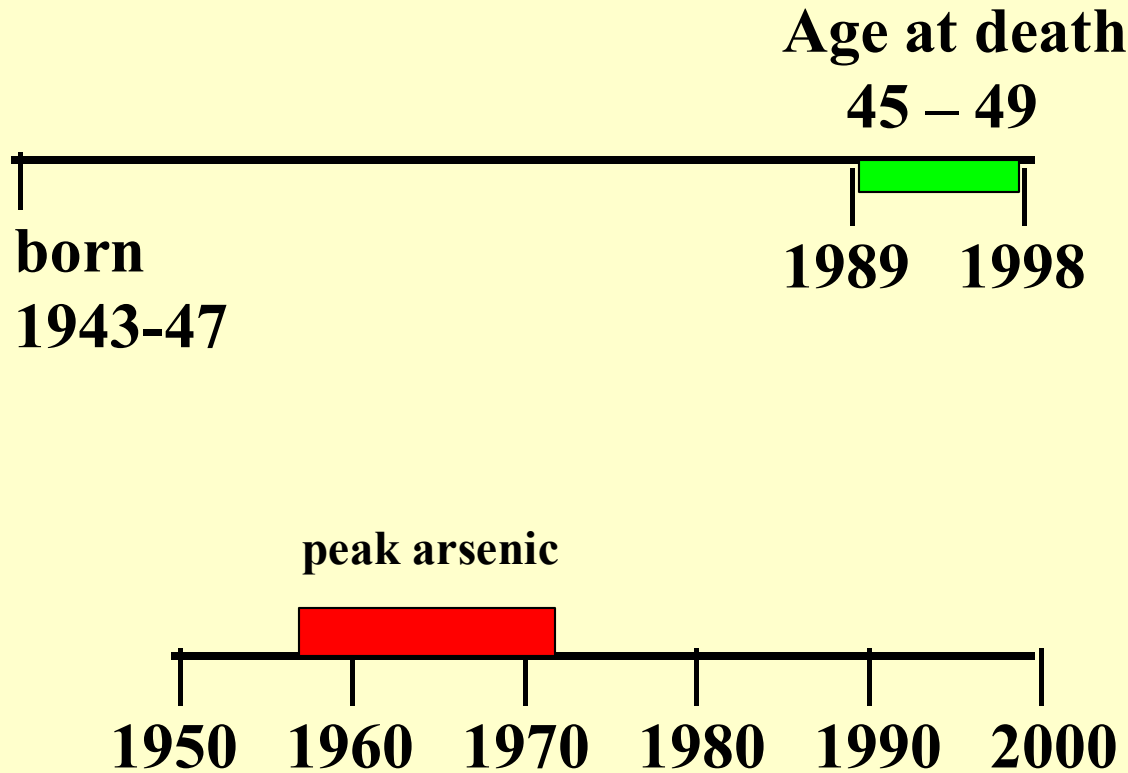
(SMR = standardized mortality ratio = observed/expected deaths)



$p < 0.001$

# Lung cancer mortality in older men

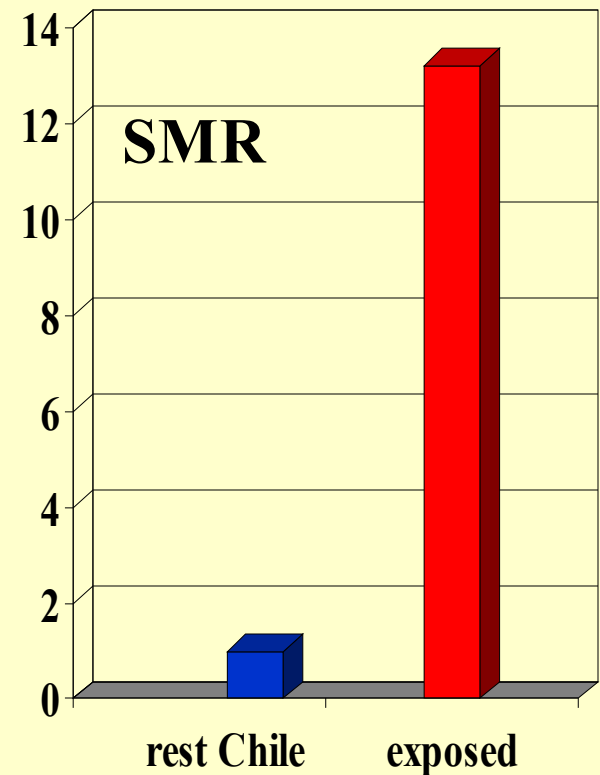
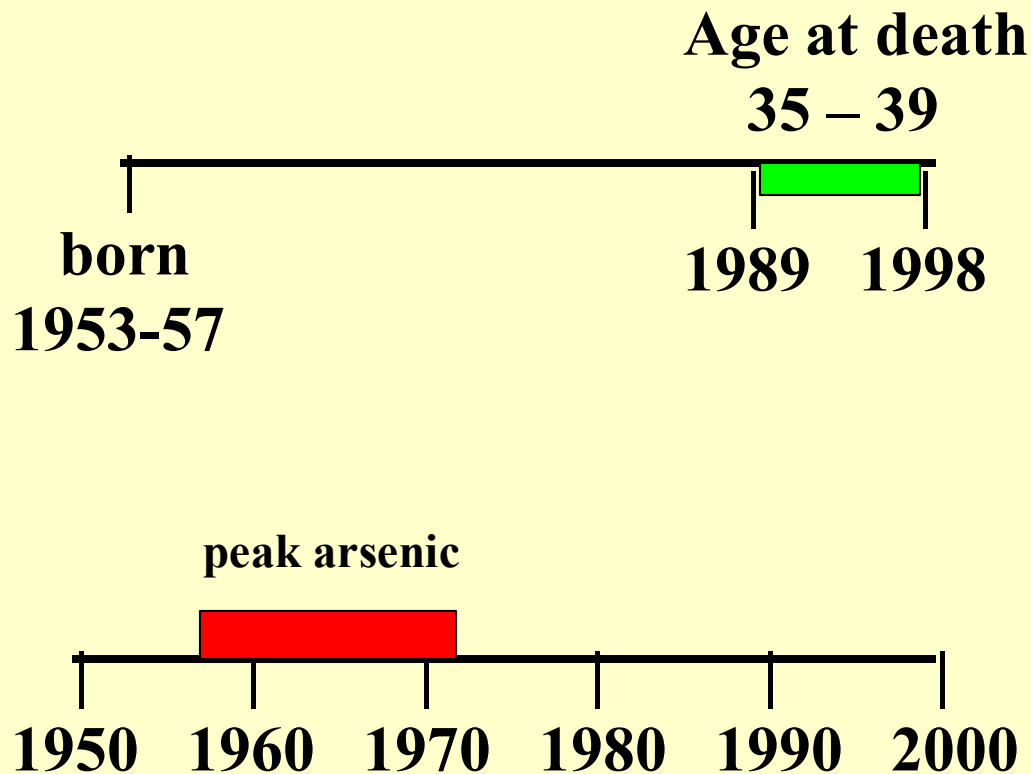
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# Lung cancer mortality in men according to exposure in childhood

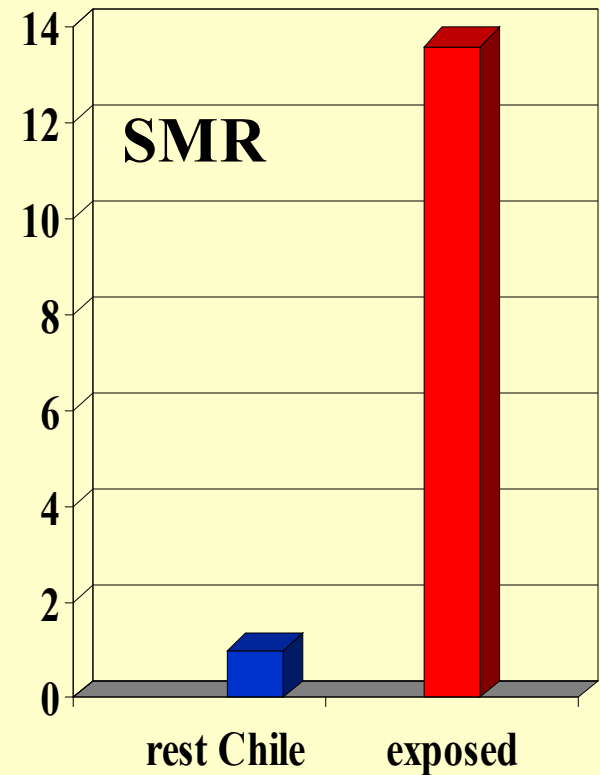
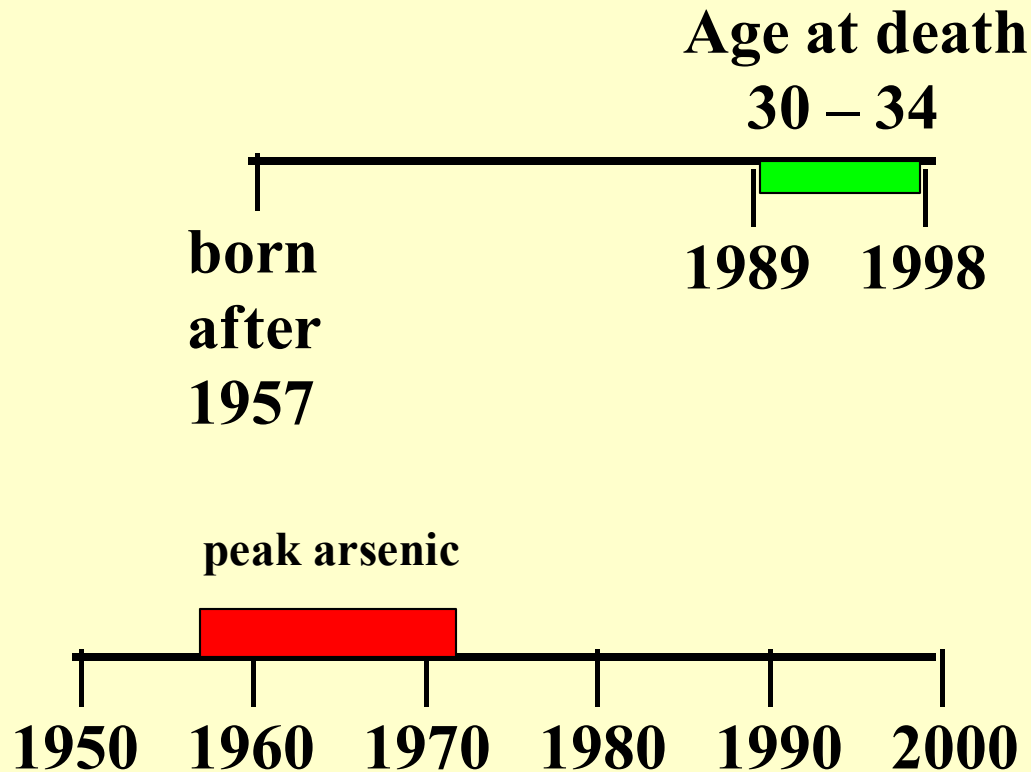
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# Lung cancer mortality in men according to exposure in childhood

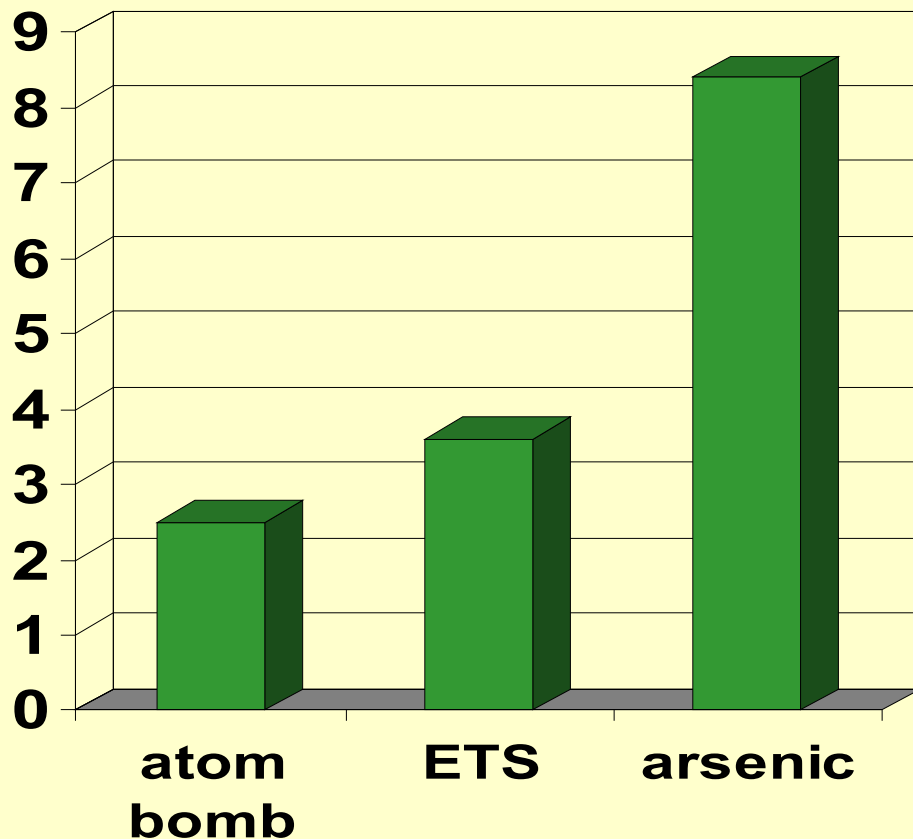
(SMR = standardized mortality ratio = observed/expected deaths)



$p < 0.001$



## Childhood exposures and young adult lung cancer relative risks



- Atomic bomb survivors Hiroshima and Nagasaki aged 10-20 in 1945. No cases in those exposed *in utero* or under age 10.
- A study giving lung cancer relative risks in the age range 30-39 following many hours of daily passive smoking as children (only four cases).
- Lung cancer relative risks in age range 30-39 in Region II of Chile following early life exposure to arsenic in water. There were 32 lung cancer deaths with 3.8 expected (RR=8.4,  $p < 0.001$ ).

**Arsenic in drinking water results  
in the highest known adult cancer risks  
from any childhood exposure**





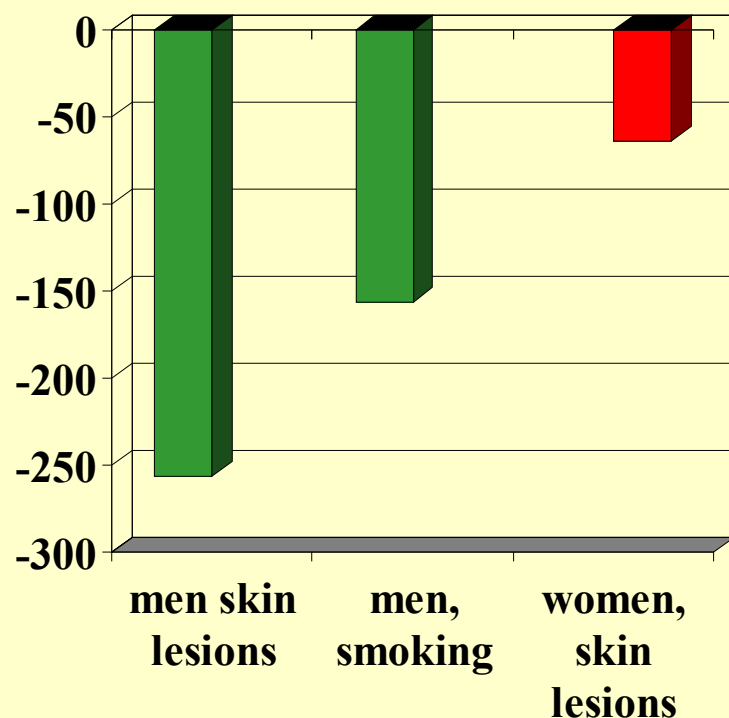


# Overall respiratory study design

- Initial survey in 1995/96 of 7,600 people
- 415 were found to have arsenic skin lesions
- We selected persons with skin lesions living in 21 villages whose primary drinking water sources contained up to 500  $\mu\text{g}/\text{L}$ .

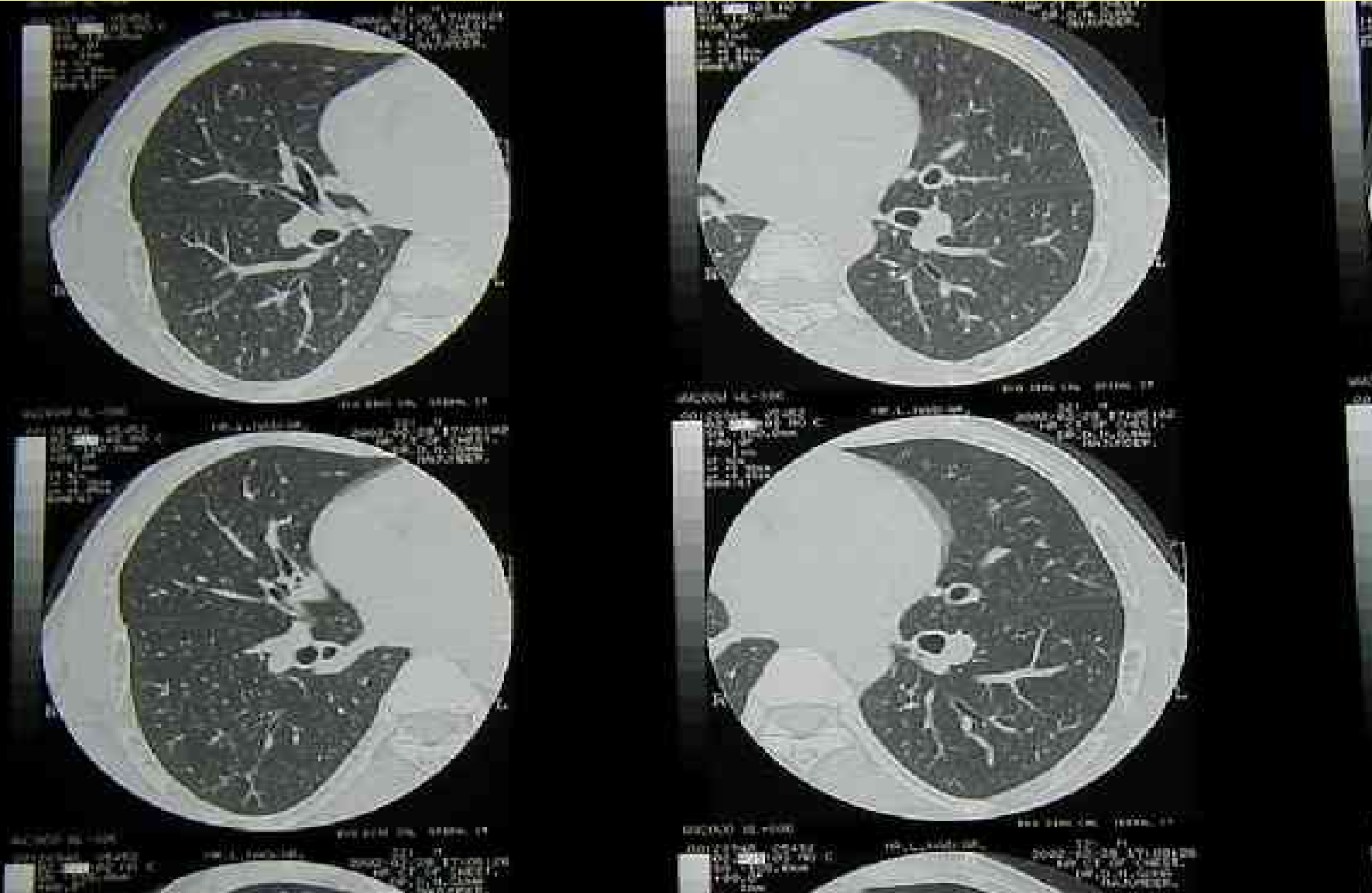


## Lung function findings of reduced FEV1 adjusted for age and height



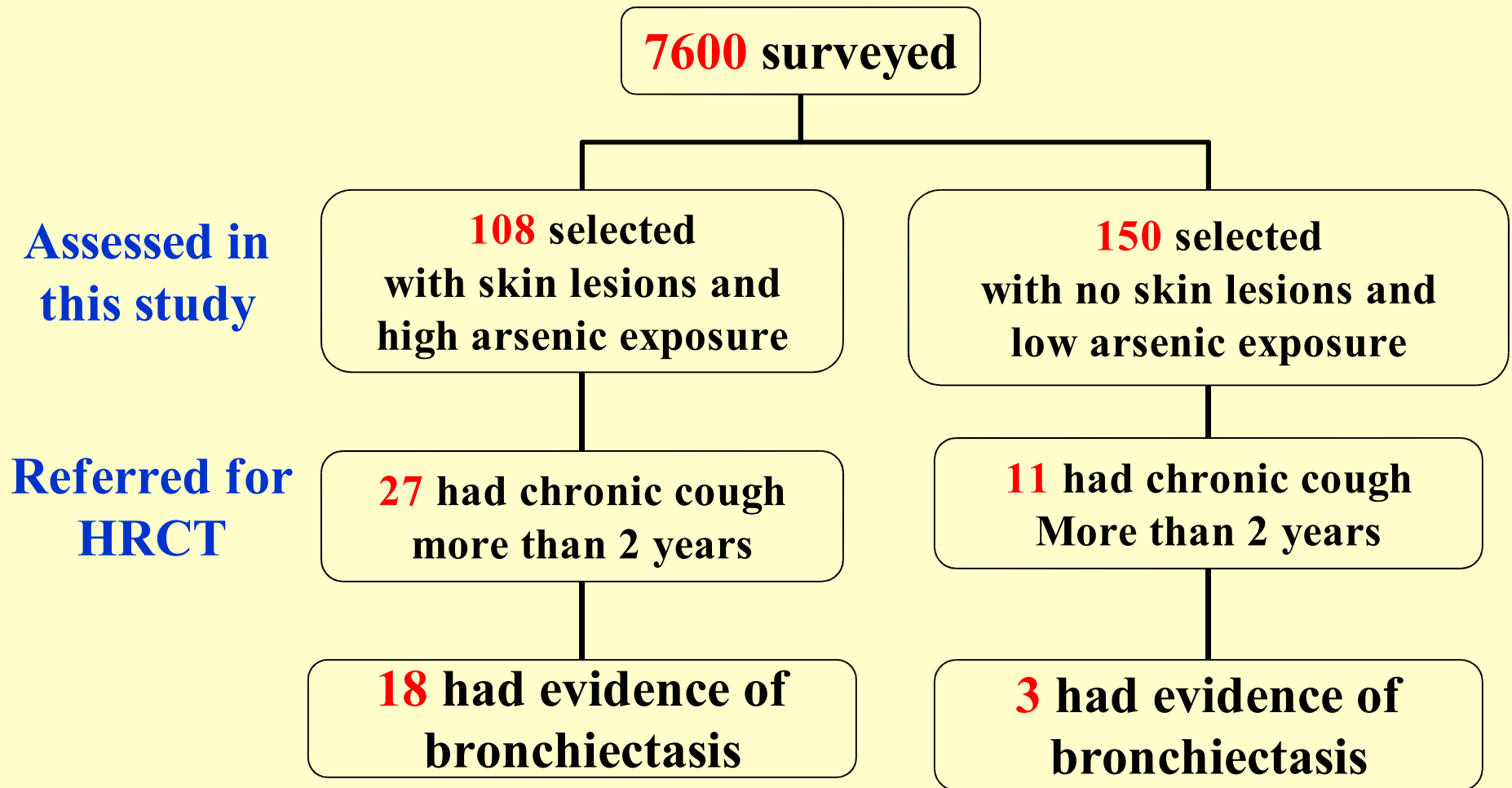
- For all men combined  
**P=0.007**
- Among men in this population, arsenic- caused skin lesions were associated with a greater FEV1 reduction (-256ml) than from smoking (-156ml)

**High resolution computed tomography (HRCT) with readings in India and the United States without knowing who had skin lesions.**





# Study design, x-ray (HRCT) study in West Bengal, India

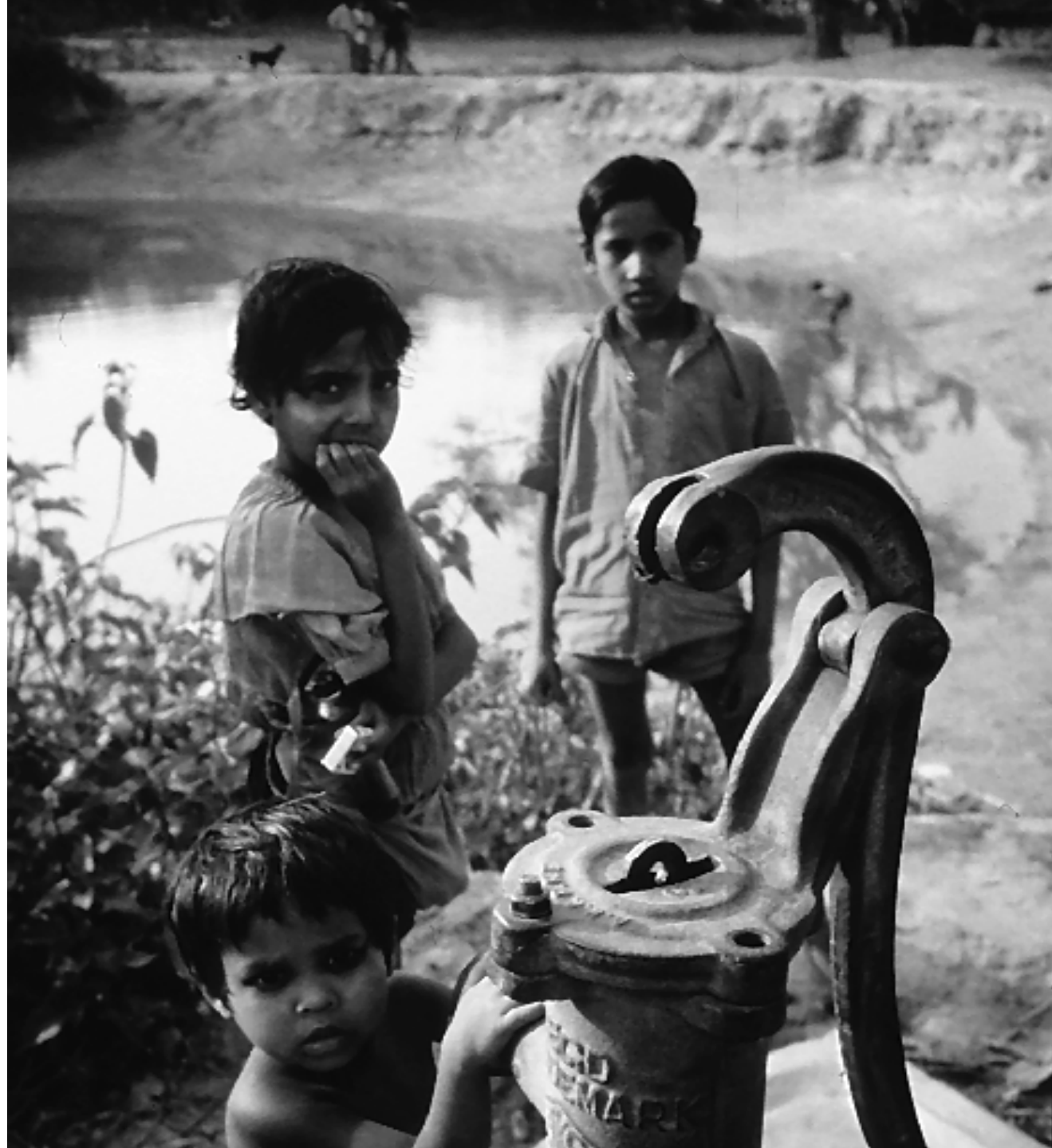


**10-fold increased prevalence of bronchiectasis OR=10.1,  $p < 0.01$**

# End Stage Lung Disease

**Obstruction, Infection, Hemoptysis, Bronchiectasis**







Source: Project Well, West  
Bengal, India, 2003



# **Arsenic in Drinking Water and Skin Lesions: Dose-Response Data from West Bengal, India**

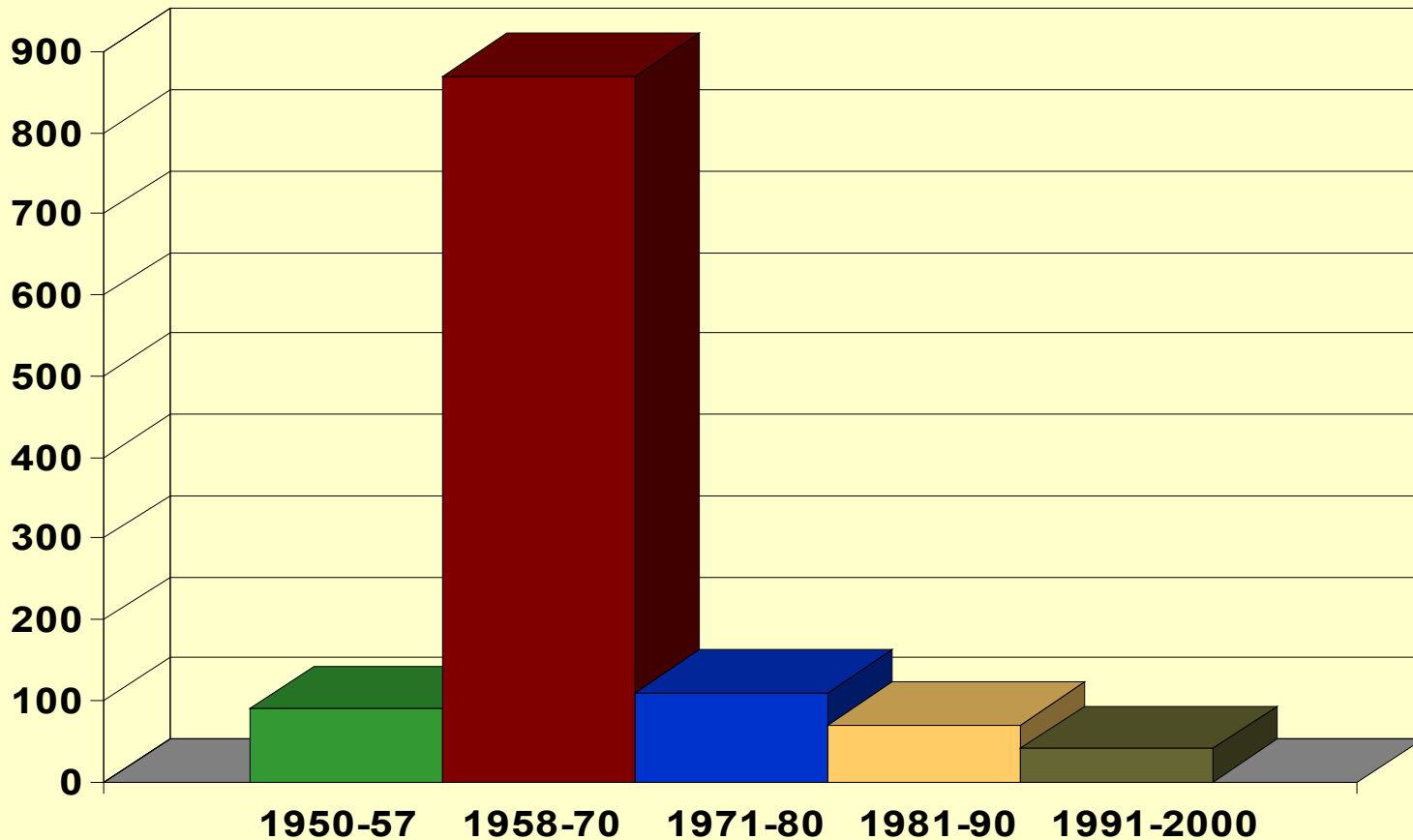
*Haque R et al. Epidemiology 2003*

The lowest peak arsenic water concentration ingested by a confirmed case was 115 ug/liter.

All other cases had peak water concentrations of at least 150 ug/L

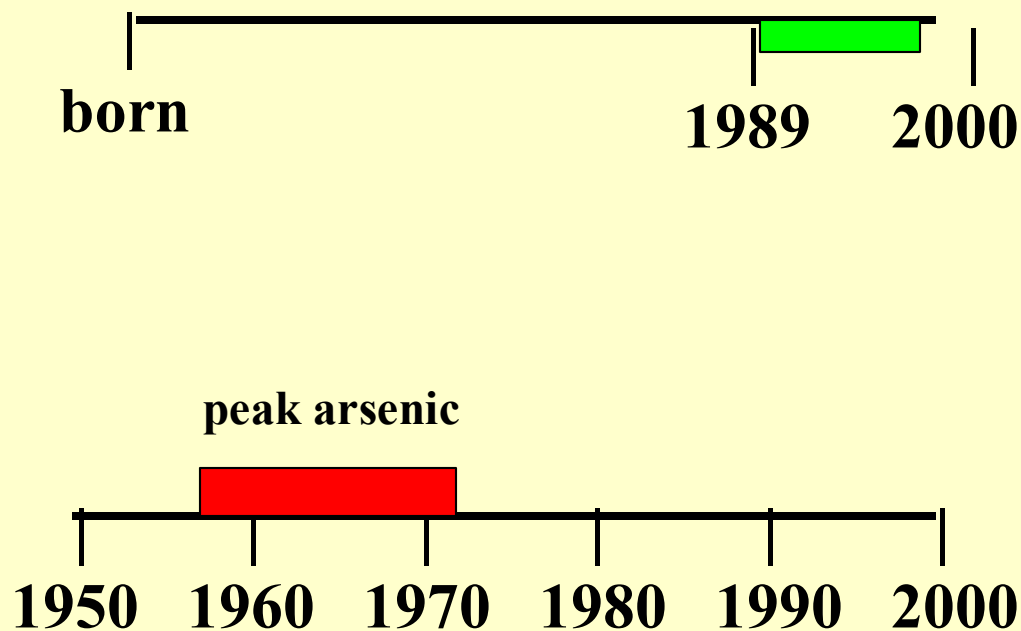
Note: Detailed exposure assessment is essential

**Arsenic concentrations in Antofagasta and Mejillones water by year. Arsenic contaminated water sources were used from 1958, and an arsenic removal plant was installed in 1971.**



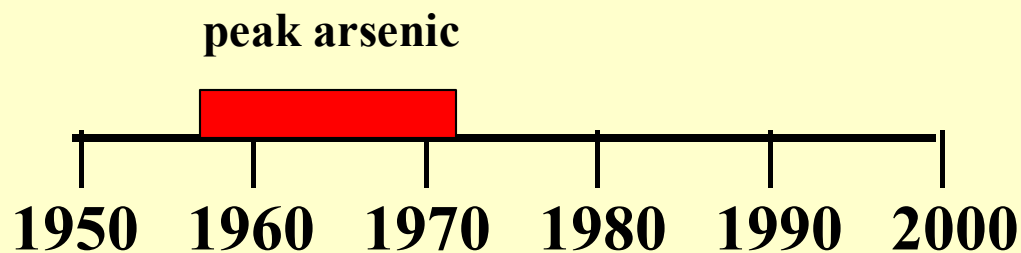
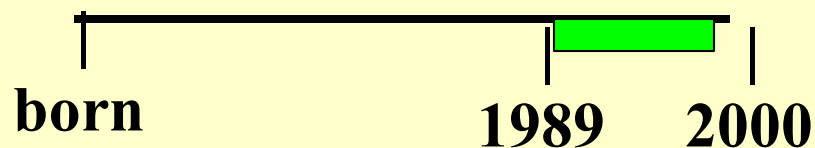
# Chronic obstructive pulmonary disease (COPD) mortality in young men according to exposure in childhood

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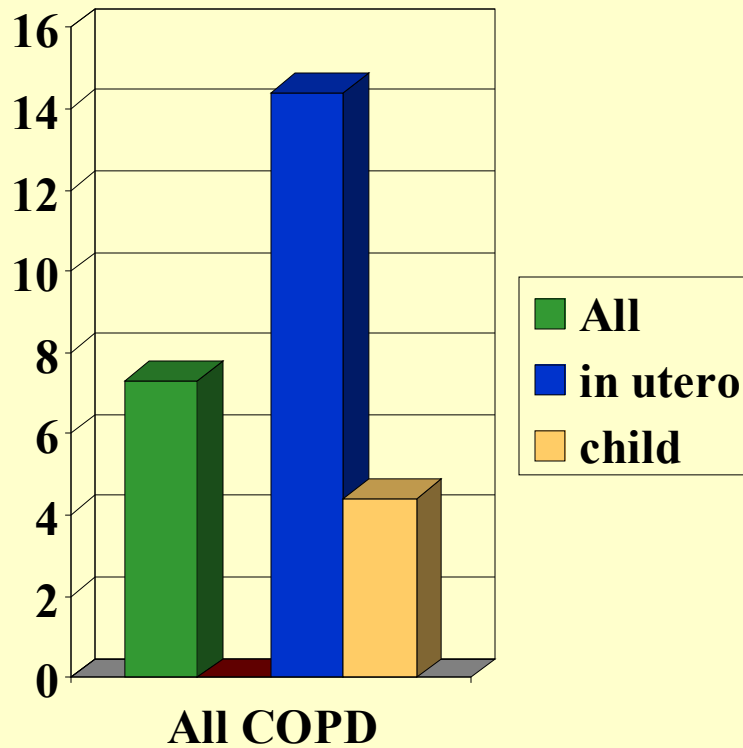
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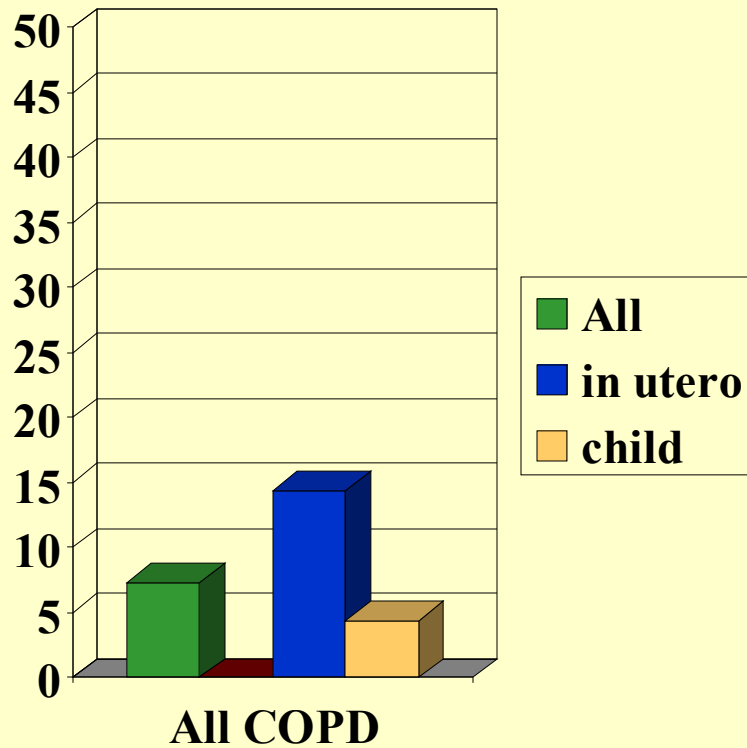


# Mortality (SMRs) from Chronic Obstructive Pulmonary Disease, age 30-49, for those born in the very high exposure period (*in utero*) or just before (*child*)

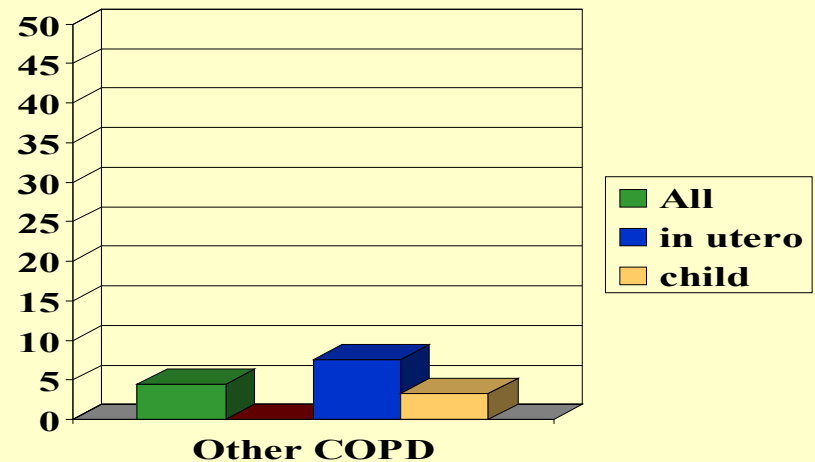
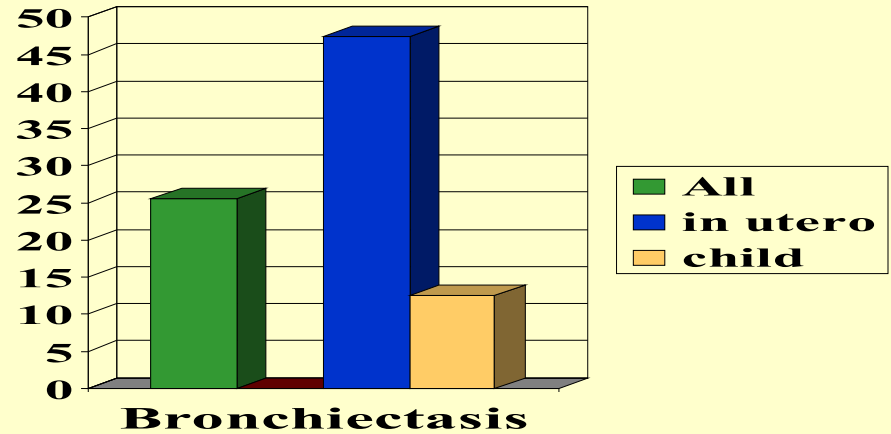
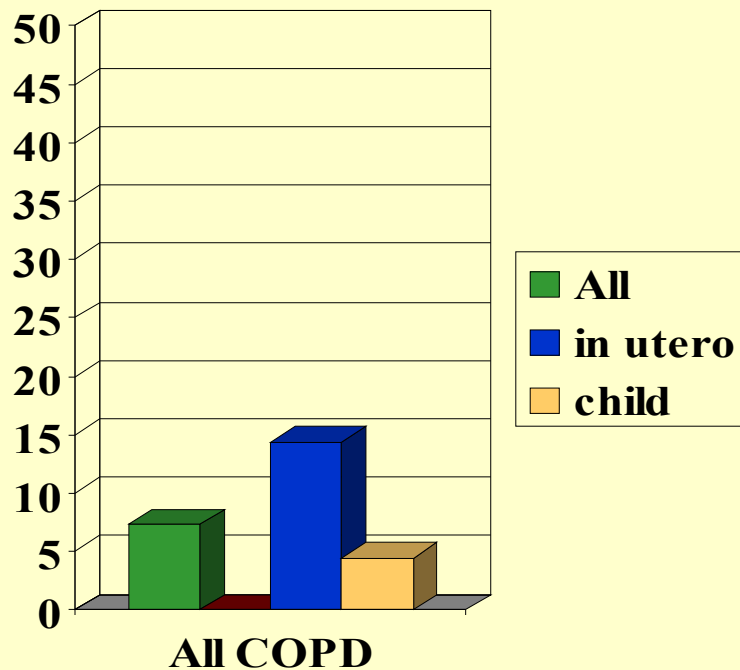


**$P < 0.001$**

# Mortality (SMRs) from Chronic Obstructive Pulmonary Disease, age 30-49, for those born in the very high exposure period (*in utero*) or just before (*child*)



# Mortality (SMRs) from Chronic Obstructive Pulmonary Disease, age 30-49, for those born in the very high exposure period (in utero exposure) or just before (child)



**$p < 0.001$  except other  
COPD  $p = 0.004$**



# Map of Chile

 <http://www.ine.cl/Territoriales/chile.jpg>

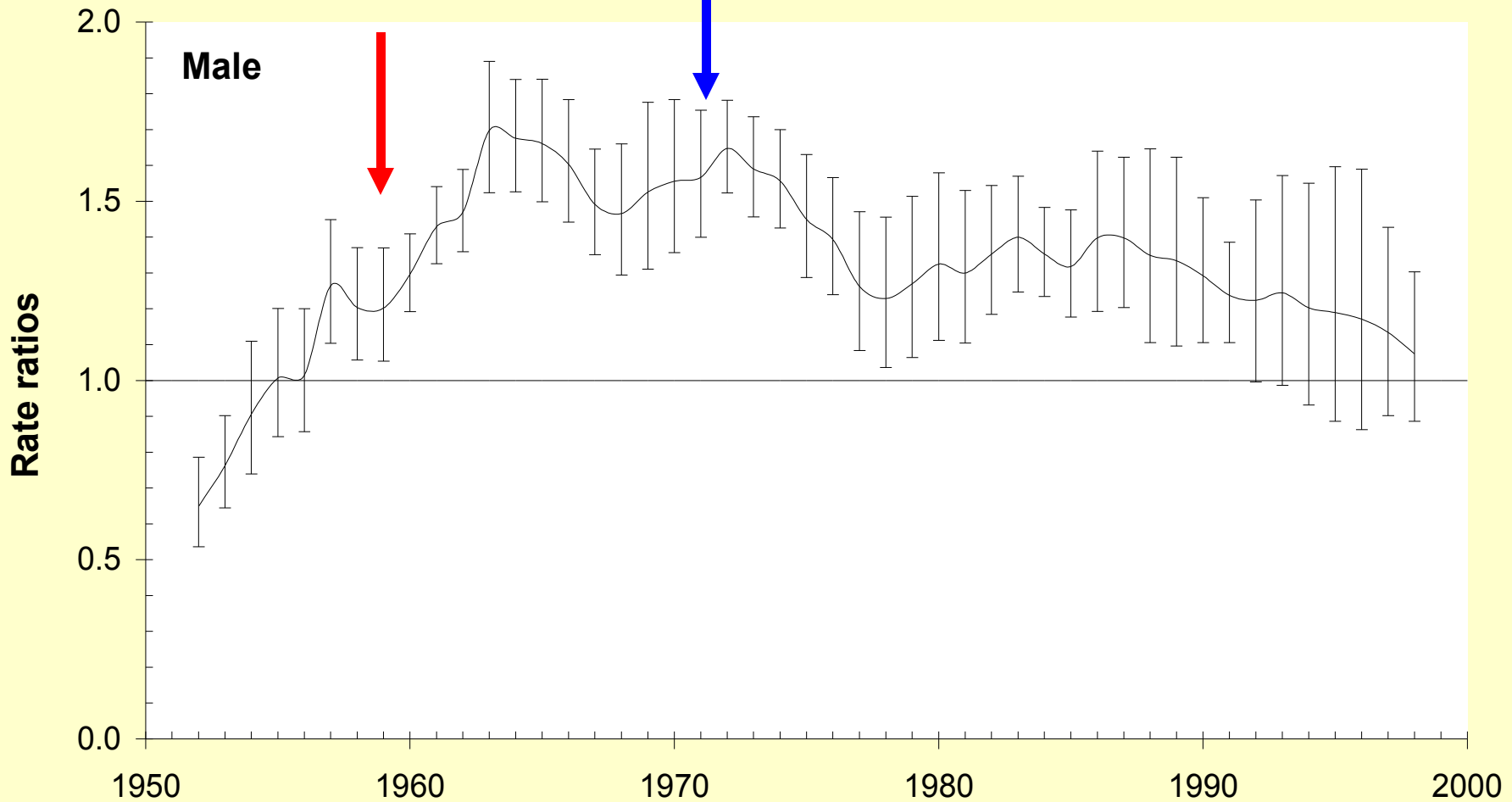
← Region II

← Region V

**CHILE**

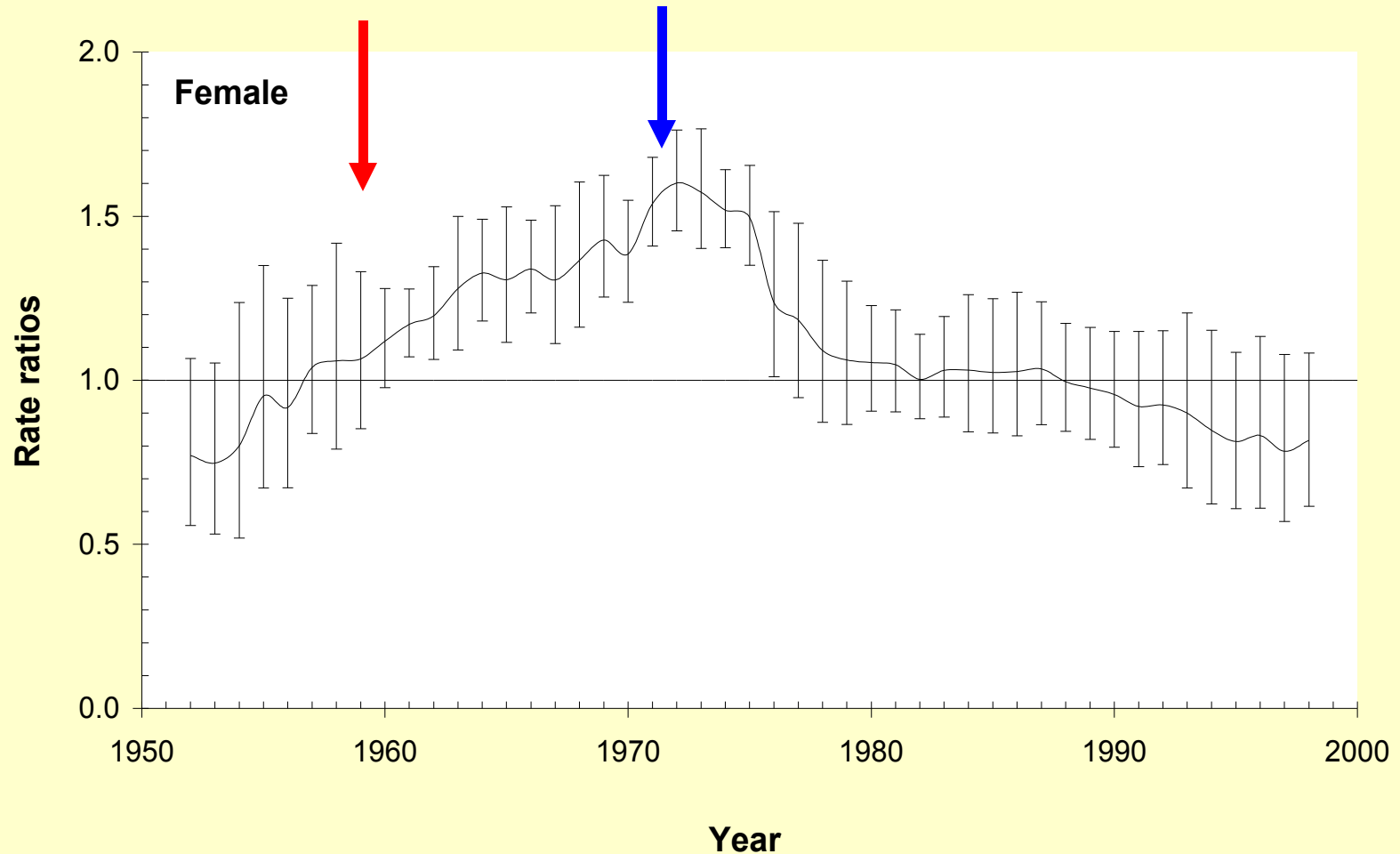
# Male mortality from acute myocardial infarction

Peak exposure started stopped



# Female mortality from acute myocardial infarction

**Peak exposure    started    stopped**



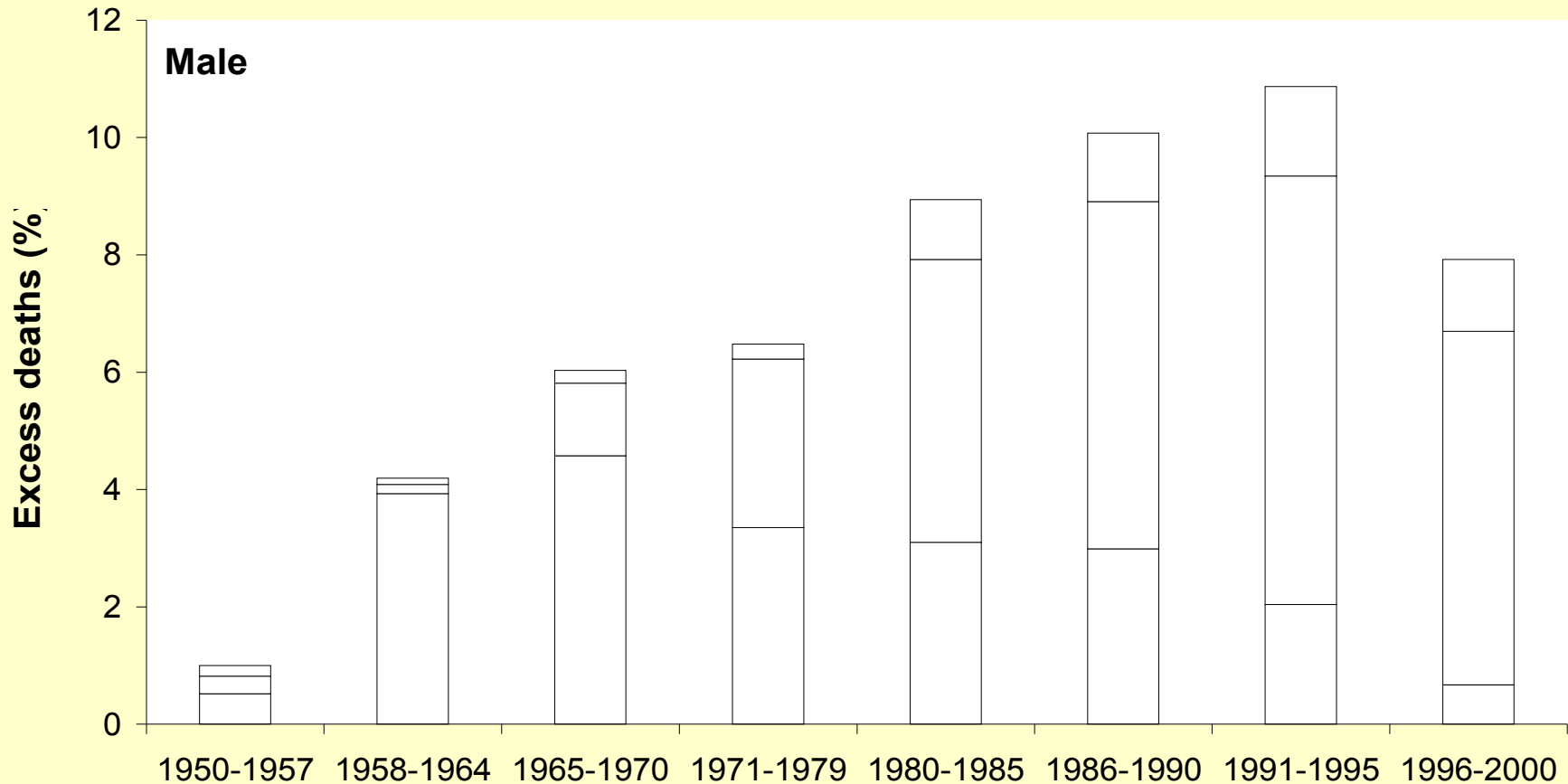


## Excess deaths attributable to arsenic in Region II Chile

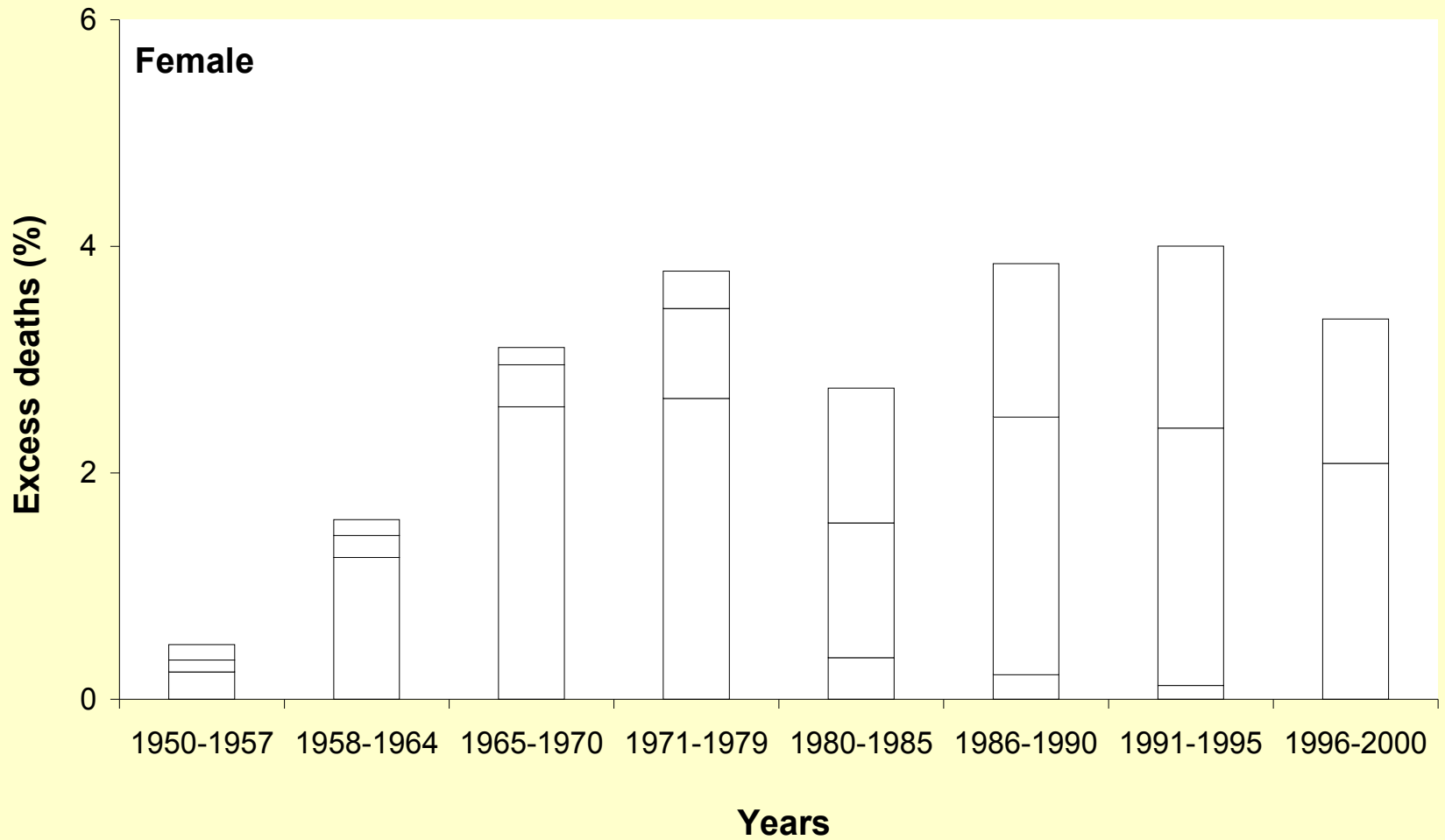
Years	Total Deaths	Excess Deaths Due to Acute Myocardial Infarction	Excess Deaths Due to Lung Cancer	Excess Deaths Due to Bladder Cancer	Total Excess Deaths	Excess Deaths as a Percentage of Total Deaths (%)
<b>Male:</b>						
1950-1957	5,604	29	17	10	56	1.00
1958-1964	5,650	222	9	6	237	4.19
1965-1970	5,025	230	62	11	303	6.03
1971-1979*	7,966	267	229	20	516	6.48
1980-1985	6,285	195	303	64	562	8.94
1986-1990	5,152	154	305	60	519	10.07
1991-1995	5,639	115	412	86	613	10.87
1996-2000	5,944	40	358	73	471	7.92
Total	47,265	1,252	1,695	330	3,277	6.93
<b>Female:</b>						
1950-1957	3,722	9	4	5	18	0.48
1958-1964	3,596	45	7	5	57	1.59
1965-1970	3,251	84	12	5	101	3.11
1971-1979*	5,158	137	41	17	195	3.78
1980-1985	3,998	12	39	39	90	2.75
1986-1990	3,793	8	84	50	142	3.85
1991-1995	4,079	5	92	65	162	4.00
1996-2000	4,568	0	113	69	182	3.36
Total	32,165	300	392	255	947	2.94

# Acute myocardial infarction, lung cancer and bladder cancer mortality after exposure to arsenic

□ Acute Myocardial Infarction □ Lung Cancer □ Bladder Cancer



# Acute myocardial infarction, lung cancer and bladder cancer mortality after exposure to arsenic

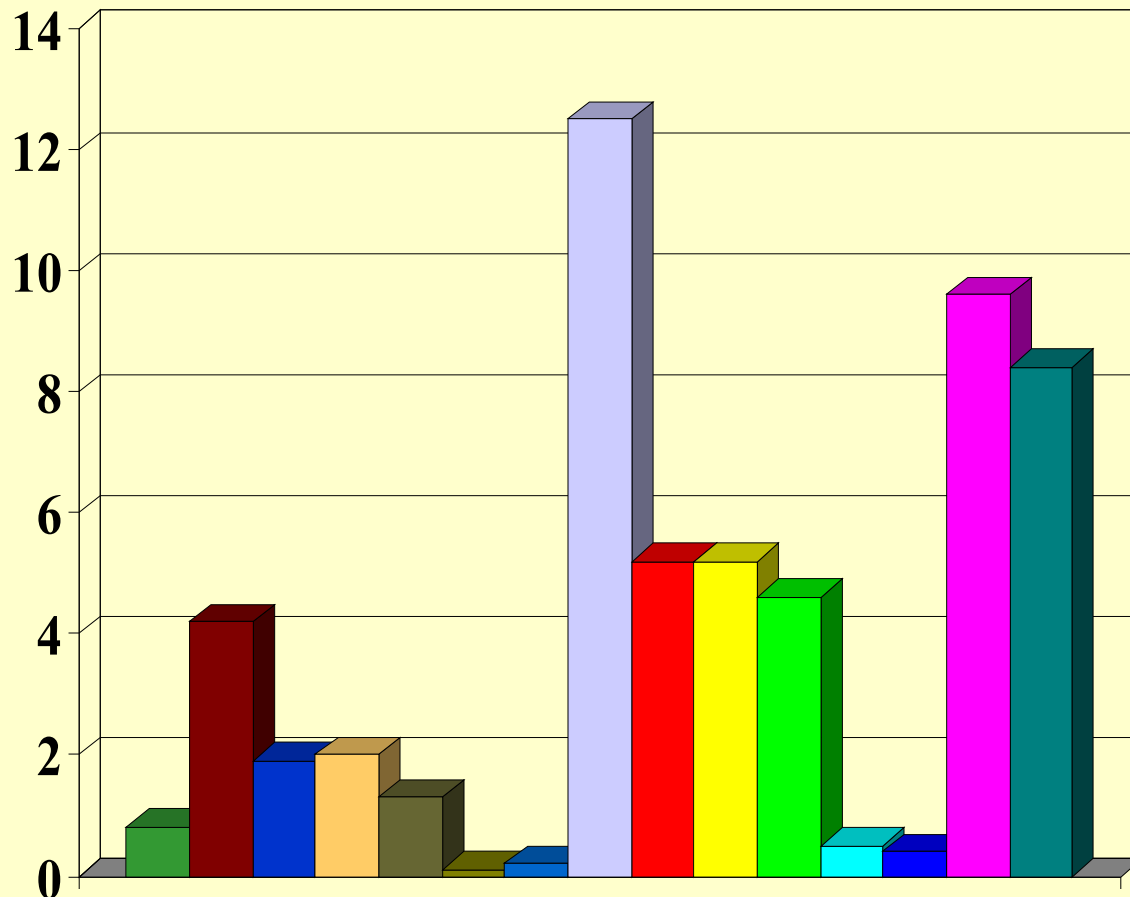


**The estimated cancer risk at the drinking water standard of 50 µg/L for arsenic is more than 100 times greater than that for any other drinking water contaminant**

**Smith AH, Lopipero PA, Bates MN, Steinmaus CM.  
Arsenic epidemiology and drinking water standards.  
Science 296: 2145-6, 2002**

# Cancer risk from contaminants in drinking water other than arsenic

**Per 100,000**

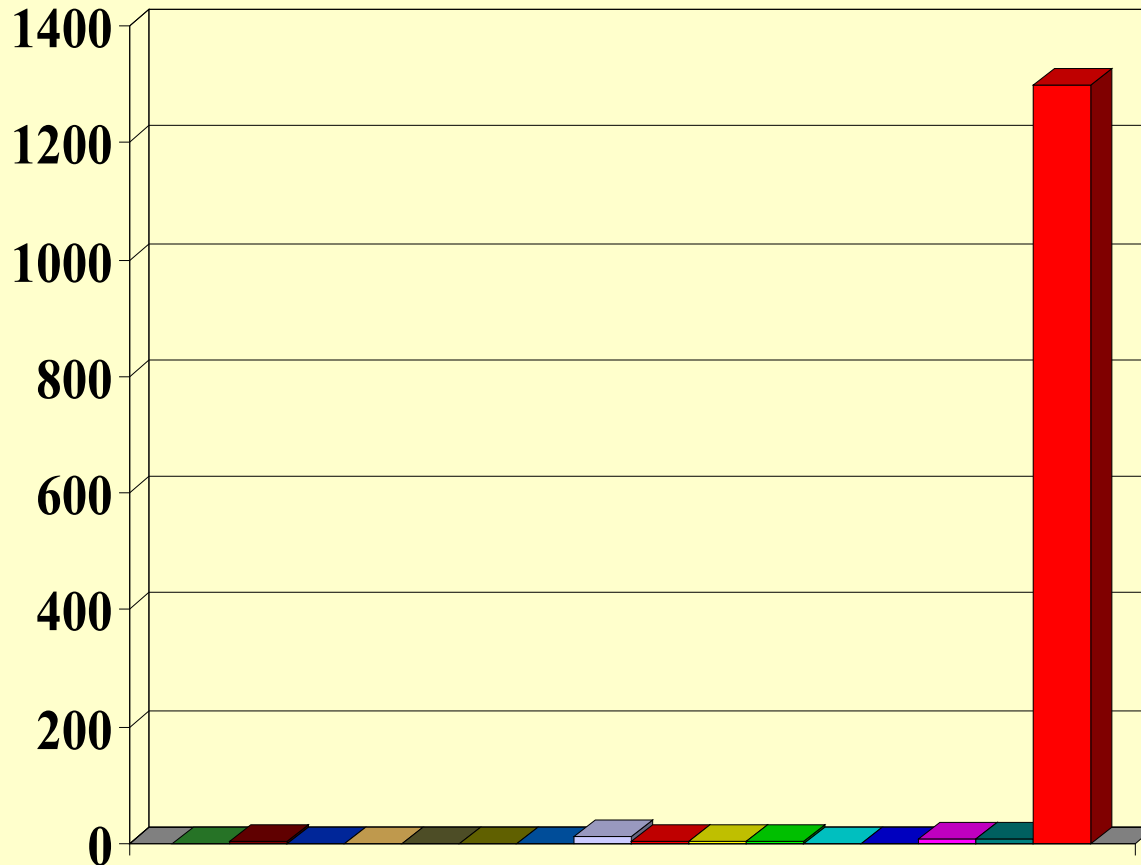


**Top of the list:**

**Ethylene dibromide**

# Cancer risk from contaminants in drinking water including arsenic

**Per 100,000**



**Cancer risks from arsenic at the old drinking water standard were >100 times higher than the next highest risk contaminant**

# Contamination of drinking-water by arsenic in Bangladesh: a public health emergency

Allan H. Smith et al

The fundamental intervention is the identification and provision of arsenic-free drinking water. Arsenic is rapidly excreted in urine, and for early or mild cases, **no specific treatment is required**. Community education and participation are essential to ensure that interventions are successful; these should be coupled with **follow-up monitoring to confirm that exposure has ended**.

Bulletin of the World Health Organization,  
2000, 78: 1093-1103



## Cancer risks from arsenic in drinking water

### Lung cancer and smoking

- 10 ug/L      1 in 500 die
- 50 ug/L      1 in 100 die      married to a smoker
- 500 ug/L     1 in 10 die      active smoker
- 5000 ug/L    all die

**And arsenic in water looks good, does not smell and has no taste.      So the risks are incredible**

**High concentrations of arsenic in drinking water result in the highest known increases in mortality attributable to any environmental exposure**

**All wells in the world should be tested for arsenic**

**Fortunately, arsenic is excreted rapidly and no treatment is required after stopping exposure**

**The end**