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

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  Dr. Ashok Giri

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- 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?
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

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  


**Peak exposure**

started  stopped

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate Ratios</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
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<tbody>
<tr>
<td>1950</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1960</td>
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<td>1990</td>
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<td></td>
<td></td>
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<tr>
<td>2000</td>
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</tbody>
</table>
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

- Born: 1950-1970
- Peak arsenic: 1989-1998
Lung cancer mortality in older men
(SMR = standardized mortality ratio = observed/expected deaths)
Lung cancer mortality in older men

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

Age at death

45 – 49

1989 1998

rest Chile exposed

p < 0.001
Lung cancer mortality in men according to exposure in childhood
(SMR = standardized mortality ratio = observed/expected deaths)

Age at death
35 – 39

SMR

peak arsenic

born
1953-57

rest Chile
exposed

p < 0.001
Lung cancer mortality in men according to exposure in childhood

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

SMR

rest Chile  exposed

p < 0.001

Age at death

30 – 34

born after 1957

peak arsenic


p < 0.001
• 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).

Smith AH et al.   Environmental Health Perspectives 2006
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 µg/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

7600 surveyed

Assessed in this study

- 108 selected with skin lesions and high arsenic exposure
  - 27 had chronic cough more than 2 years
  - 18 had evidence of bronchiectasis

Referred for HRCT

- 150 selected with no skin lesions and low arsenic exposure
  - 11 had chronic cough More than 2 years
  - 3 had evidence of bronchiectasis

10-fold increased prevalence of bronchiectasis OR=10.1, p<0.01
End Stage Lung Disease

Obstruction, Infection, Hemoptysis, Bronchiectasis
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
Chronic obstructive pulmonary disease (COPD) mortality in young men according to exposure in childhood.
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)

\[ p < 0.001 \text{ except other COPD } p = 0.004 \]
Map of Chile

Region II

Region V

CHILE

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

<table>
<thead>
<tr>
<th>Years</th>
<th>Total Deaths</th>
<th>Excess Deaths Due to Acute Myocardial Infarction</th>
<th>Excess Deaths Due to Lung Cancer</th>
<th>Excess Deaths Due to Bladder Cancer</th>
<th>Total Excess Deaths</th>
<th>Excess Deaths as a Percentage of Total Deaths (%)</th>
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</thead>
<tbody>
<tr>
<td><strong>Male:</strong></td>
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<tr>
<td>1950-1957</td>
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<td>17</td>
<td>10</td>
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<td>1958-1964</td>
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<td>222</td>
<td>9</td>
<td>6</td>
<td>237</td>
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<td>1965-1970</td>
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<td>230</td>
<td>62</td>
<td>11</td>
<td>303</td>
<td>6.03</td>
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<td>1971-1979*</td>
<td>7,966</td>
<td>267</td>
<td>229</td>
<td>20</td>
<td>516</td>
<td>6.48</td>
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<tr>
<td>1980-1985</td>
<td>6,285</td>
<td>195</td>
<td>303</td>
<td>64</td>
<td>562</td>
<td>8.94</td>
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<td>1986-1990</td>
<td>5,152</td>
<td>154</td>
<td>305</td>
<td>60</td>
<td>519</td>
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<td>1991-1995</td>
<td>5,639</td>
<td>115</td>
<td>412</td>
<td>86</td>
<td>613</td>
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<td>1996-2000</td>
<td>5,944</td>
<td>40</td>
<td>358</td>
<td>73</td>
<td>471</td>
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<td><strong>Total</strong></td>
<td>47,265</td>
<td>1,252</td>
<td>1,695</td>
<td>330</td>
<td>3,277</td>
<td>6.93</td>
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<thead>
<tr>
<th>Years</th>
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<th>Excess Deaths Due to Acute Myocardial Infarction</th>
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<th>Total Excess Deaths</th>
<th>Excess Deaths as a Percentage of Total Deaths (%)</th>
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<td>5</td>
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<td>1965-1970</td>
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<td>1980-1985</td>
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<td>1996-2000</td>
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<td>0</td>
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<td>69</td>
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<td><strong>Total</strong></td>
<td>32,165</td>
<td>300</td>
<td>392</td>
<td>255</td>
<td>947</td>
<td>2.94</td>
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</table>
Acute myocardial infarction, lung cancer and bladder cancer mortality after exposure to arsenic
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.

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.
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.

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