

**Valuing Arsenic Remediation:**  
 A Review of “Valuing the Cancer Mortality Risk Reduction from Lowering the Arsenic Maximum Contaminant Level in NH Municipal Water Supplies”

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 SB 85 Commission on Environmentally-Triggered Chronic Illness,  
 Thomas M Sherman, MD, Chair  
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All views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the NH Dept. of Environmental Services or the University of New Hampshire.

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**Objectives**

**What value do NH citizens place on reduced arsenic contamination in municipal water?**

- Describe our survey methods and results

**Suggest that our arsenic methods can be applied readily to other contamination value questions**

Mention an important difference between ubiquitous environmental pollutants and ongoing pollutant production.

- With an analogy to the FDA

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**No Attention to:**

Review the literature documenting the chronic illnesses associated with arsenic (or other heavy metals such as lead or mercury) or PFAs

Estimate the medical costs associated with treating these illnesses

Quantify either the costs or the benefits of remediation alternatives

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**Outline**

**Arsenic**

Yes, There's Arsenic in New England

Yes, Arsenic Affects Children's Health and Well-being

Our Research on Value of Arsenic Remediation

- Methods
- Results

Application to PFAs Issues

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**Arsenic in New England**

Source: Ayotte et al. 2017. Estimating the High-Arsenic Domestic-Well Population in the Conterminous United States. *Environmental Science & Technology*

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**Yes, Arsenic affects Children's health and well-being**

- Lower IQ
- Impaired brain development
- Growth problems
- Breathing problems
- An unhealthy immune system
- As an adult
  - Lung, Bladder and Skin Cancer
  - I.Q. and Neurodevelopmental Issues (newer)
  - Cardiovascular Disease.

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**University of New Hampshire**

### Valuing the Cancer Mortality Risk Reduction from Lowering the Arsenic Maximum Contaminant Level in New Hampshire Municipal Water Supplies

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### Sample Design

Online Sample of New Hampshire households using a panel company to screen respondents.

Respondents were

- Over 18
- Consumed at least 25% of their drinking water from the household tap.
  - 499 households using public water system.
  - 300 households using private well.

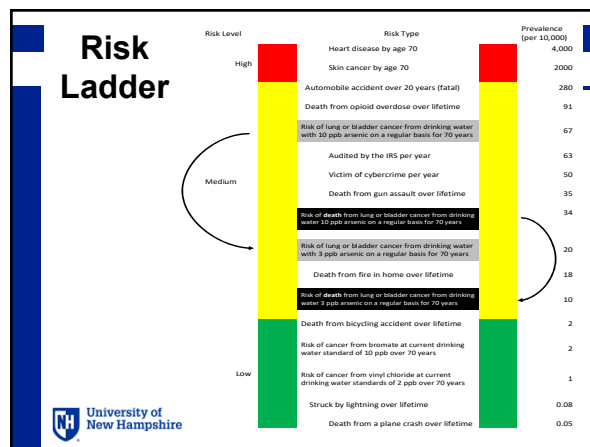
Sample descriptive statistics match well to demographic data from Census.

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### Sample Characteristics

	Full Sample	NH Mean*
Female	66.7%	50.5%
Age	45.0	42.4
Annual HH Income	\$63,291	\$70,936
Education (% BA+)	47.9%	45.3%
Child in Household	30.5%	30.5%
<b>Water System Usage</b>		
Public (Municipal)	62.5%	64.0%
Private Well	37.5%	36.0%
<b>Household Size</b>		
1	14.5%	25.5%
2	37.0%	38.1%
3+	48.5%	36.3%
<b>Health Concern about H<sub>2</sub>O</b>		
None	45.8%	
Minor	32.4%	
Moder./Serious	21.9%	
Home Filter	49.7%	

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### Cancer Risks Associated with Arsenic

Exhibit 5-9 (b)  
Annual Lung Cancer Cases Avoided from Reducing Arsenic in CWSs and NTNCs

Arsenic Level (µg/L)	Reduced Mortality Cases*	Reduced Morbidity Cases*	Total Cancer Cases Avoided*
3	25.2 - 54.1	3.4 - 7.4	28.6 - 61.5
5	22.5 - 39.2	3.1 - 5.3	25.6 - 44.5
10	16.4 - 21.8	2.2 - 3.0	18.7 - 24.8
20	7.4 - 8.7**	1.0 - 1.2**	8.5 - 9.9**

Exhibit 5-9 (c)  
Annual Total Cancer Cases Avoided from Reducing Arsenic in CWSs and NTNCs

Arsenic Level (µg/L)	Reduced Mortality Cases*	Reduced Morbidity Cases*	Total Cancer Cases Avoided*
3	32.6 - 74.1	24.6 - 64.2	57.2 - 138.3
5	29.1 - 53.7	22.0 - 46.5	51.1 - 100.2
10	21.3 - 29.8	16.1 - 25.9	37.4 - 55.7
20	10.2 - 11.3**	8.5 - 8.8	19.0 - 19.8**

\* The lower-end estimate of bladder cancer cases avoided and the lung cancer estimate assume that the...  
 Source: US EPA 2001, Arsenic in Drinking Water Rule. 815-R-00-026

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### Cancer Risks Associated with Arsenic

Table 6. Estimated Bladder and Lung Cancer Deaths Due to Arsenic Exposure for Lung and Bladder Cancer over a 70-Year Period from New Hampshire Public Water Systems Based on Recent Arsenic Testing Results (2014-2017) and Assuming Specified Maximum Contaminant Levels

MCL (ppb)	Total Cancer Cases from Table 4	Total Deaths		Cancer deaths avoided by lowering MCL	
		Lung	Bladder	Lung	Bladder
10	33-101	19-37	1-9	-	-
6	28-89	16-32	1-8	3-5	0-1
5	27-82	16-30	1-8	3-7	0-1
4	25-75	14-27	1-7	5-10	0-2
3	22-66	13-24	1-6	6-13	0-3


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### Contingent Valuation Questions Asked

Assume there is a water treatment system that could be used to reduce the level of arsenic in your water to 3ppb and thus increase the quality of your drinking water. Would you be willing to pay \$ \_\_\_\_ per month for use of this water filtration system?

5 initial bid amounts with set of follow-up bids


- \$5 (\$2.50/\$10)
- \$10 (\$5/\$20)
- \$20 (\$10/\$40)
- \$40 (\$20/\$80)
- \$80 (\$40/\$160)



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### WTP by Subsample

	Health Concern	Home Filter	Household Size=1	Household Size=2	Household Size=3+
<b>WTP</b>	<b>\$44.13</b>	<b>\$35.31</b>	<b>\$30.82</b>	<b>\$27.33</b>	<b>\$41.32</b>
N	434	397	111	295	388



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### Willingness to Pay (WTP) Estimation

Bivariate probit model (Cameron and Quiggin, 1994)


Respondents express two WTP values

Initial bid may influence the follow-up bid.

$$WTP_{i1} = x_{i1}\beta_1 + \epsilon_{i1}$$

$$WTP_{i2} = x_{i2}\beta_2 + \epsilon_{i2}$$


$\epsilon_{i1}$  and  $\epsilon_{i2}$  are correlated and follow a bivariate normal distribution.



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### Multivariate Results

	Full Sample	Public Water	Well Water Users
Female (Yes = 1)	-5.432 (4.104)	-4.781 (5.505)	-5.809 (5.984)
Age	-0.355* (0.141)	-0.270 (0.184)	-0.352 (0.215)
Bachelors+ (Yes = 1)	0.643 (4.133)	-3.454 (5.404)	6.653 (6.265)
ln (HH Income)	8.898** (2.888)	4.948 (3.719)	15.263*** (4.622)
Child in HH (Yes = 1)	6.572* (2.652)	6.895* (3.456)	5.450 (4.037)
Household Size	-1.564 (2.075)	-2.993 (2.715)	1.204 (3.119)
Health Concern (minor)	15.431*** (4.418)	15.575** (5.686)	13.791* (6.849)
Health Concern (major)	19.050*** (5.076)	15.461* (6.648)	25.634** (7.861)
Home Filter (Yes = 1)	15.698*** (3.945)	20.291*** (5.167)	6.456 (6.036)
High Arsenic Exposure	5.580 (5.755)	9.680 (8.215)	0.295 (7.772)
Public Water User	5.256 (3.995)		
N	799	499	300
WTP (Monthly)	\$33.59	\$35.35	\$29.40



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### Value of a Statistical Life Formula

$$VSL = \left( \frac{WTP}{0.0024} \right) \div 2.46$$

WTP = Annual willingness to pay

.0024 = 70 year mortality risk reduction


2.46 = Average number of members per household



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### VSL Estimates

	Full Sample	Public Water	Well Water Users
N	799	499	300
WTP (Monthly)	\$33.59	\$35.35	\$29.40
WTP (Yearly)	\$403.08	\$424.20	\$352.80
VSL	\$4,779,065.04	\$5,029,471.54	\$4,182,926.83



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## Arsenic (and Lead) v PFAs

### Arsenic (and Lead)

Environmental levels basically stable  
Health affects known

### PFAs

Environmental levels growing from manufacturing  
New health affects being discovered  
Lower sperm counts  
Immune system that reduces vaccine efficacy

### Result?

Whack-a-mole approach  
5 Identified as health hazards  
Thousands new products substituted



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## For example

Consider Merrimack's decision to approve St. Gobain's 2001 plant expansion.

+ Jobs, resident incomes, tax revenues  
- Drinking water treatment, cancers, male infertility, lower immunity responses that may reduce vaccine efficacy.

If current knowledge of the long term costs were available, would the expansion have been welcomed or resisted?

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## Selected FDA Highlights

### 1906: The original Food and Drug Act

Enacted to combat the use of the use of poisonous preservatives and dyes in foods, and cure-all claims for worthless and dangerous patent.

### 1938: The Federal Food, Drug, and Cosmetic Act

- Required new drugs to be shown safe before marketing-starting a new system of drug regulation.
- Providing that safe tolerances be set for unavoidable poisonous substances.
- Authorizing factory inspections.
- Adding the remedy of court injunctions to the previous penalties of seizures and prosecutions.

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## Selected FDA Highlights

### 1962

**Thalidomide**, a new sleeping pill, is found to have caused birth defects in thousands of babies born in western Europe

**Kefauver-Harris Drug Amendments** passed to ensure drug efficacy and greater drug safety. For the first time, drug manufacturers are required to prove to FDA the effectiveness of their products before marketing them.

### 1966

FDA contracts with the National Academy of Sciences/National Research Council to evaluate the **effectiveness of 4,000 drugs** approved on the basis of safety alone between 1938 and 1962.

**Child Protection Act** enlarges the scope of the Federal Hazardous Substances Labeling Act to ban hazardous toys and other articles so hazardous that adequate label warnings could not be written.

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## Selected FDA Highlights

### 1970

**Environmental Protection Agency** established; takes over FDA program for setting pesticide tolerances.

### 1971

**National Center for Toxicological Research** is established in the biological facilities of the Pine Bluff Arsenal in Arkansas. Its mission is to examine biological effects of chemicals in the environment, extrapolating data from experimental animals to human health.

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## Rethink the Metaphor?

Isn't drinking water closer to a food or drug than to lake water?

It is to this economist interested in cost-efficient governments

Keeping a pollutant out of drinking water

Makes more sense than filtering polluted water

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### Take-Homes

On average, NH households are willing to pay \$35 per month for municipal water filtration that reduces their risk of bladder and lung cancer from arsenic.

This methodology is readily applicable to an evaluation of other pollutants such as PFAs in municipal water.

But why are firms more able to pollute our drinking water than firms are able to poison our food or sell us drugs without proving their safety?



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# Questions?



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