Arsenic, Food and Water

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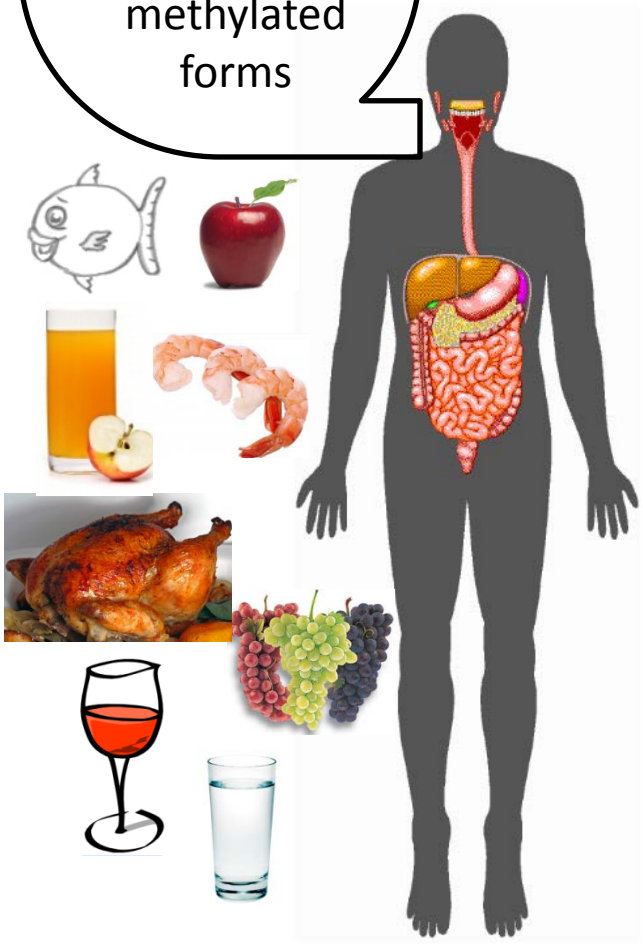
Research Questions & Policy Implications

- The Safe Drinking Water Standard
  - In 2001 the As NPDWR changed from 50 to 10 µg/L
  - Should the As NPDWR be lower?
  - What contribution to body burden is made by food?
  - Regulate water further?
  - Regulate/Advisories on food?

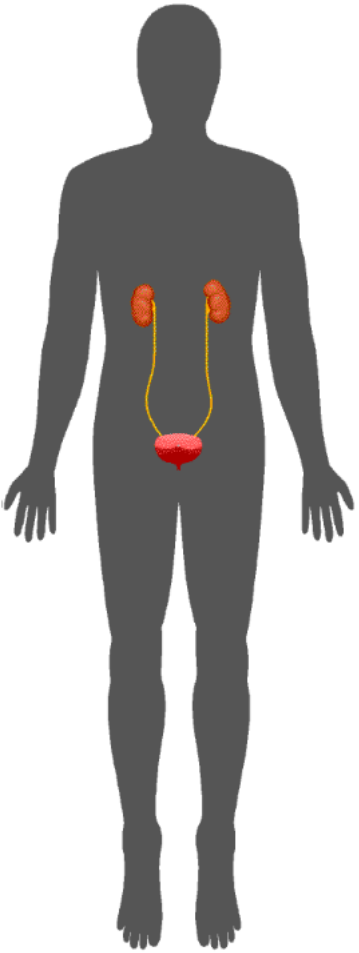
- Healthy bodies methylate and excrete As rendering it harmless. What is the relationship between ingested As and excreted species of As in urine?
  - How much arsenic is consumed via food?
  - What arsenic species are ingested?
  - What impact does water content of food have?

As^{III} & As^{V}

Arsenobetaines, methylated forms



- Ingested material moves to the stomach and on to the small intestine
- Nutrients and other ingested agents are absorbed by blood and moved through the liver
- Methylation (and other processes)
- Blood is then filtered by the kidneys producing urine containing waste



http://www.innerbody.com/image/digeov.html

Methods

- Study Components Extracted from Data Sets
  - NHEXAS-AZ, ABS: Duplicate Diet Collection [Solid Food, Beverage, Water(s)], Food Diary + 24-hr Food Recall, Total Urinary As
  - BAsES: 24-hr Food Recall, As Food Frequency, Speciated Urinary As
  - NHANES 2003-04: 24-hr Dietary Recall Interview, Speciated Urinary As
- Media Measurements Extracted from Data Sets
  - Food As: Modeled As per food item (NDSR, TDS, Schoof)
  - Water As: EPA Water Contract Labs, SWEHSC (UA Lab)
  - Biomarker Measures: Total As (CDC), Speciated As (UA Lab)
- Biostatistics: logistic and linear regression and mixed models
  - Estimates, Assumptions and Uncertainties

Adjusted models of the relationship between measured and modeled dietary As and urinary total As for NHEXAS-AZ & ABS

	Generalized Linear Mixed Models (GLMM) for Binary Traits (urinary As above vs. below LOD)			Linear Mixed Models (restricted analysis, bootstrap method)		
	N	OR (95% C.I.)	P-value	N	Coefficient ± s.e.	P-value
Dup Diet total As	227	2.19 (1.00-4.81)	0.051	132	0.338±0.086	0.001
TDS total mean As	239	1.28† (0.86-1.91)	0.228	137	0.141±0.058	0.014
TDS total max As	239	1.51† (0.79-2.89)	0.217	137	0.261±0.100	0.009
Schoof total As	239	1.38† (0.62-3.07)	0.427	137	0.262±0.138	0.058
Schoof inorganic As	239	0.50† (0.20-1.29)	0.153	137	-0.003±0.146	0.984

†In the logit models, arsenic dose from water used in food preparation was the only significant predictor of urine As above vs. below the LOD ($p<0.05$). As in water used for food preparation was not included as a covariate in the duplicate diet total As regression models.

Adjusted models for BAsES: Total and inorganic dietary arsenic as predictors of urinary total As and species.

	Urine Total As		Urine Sum of species As		Urine % MMA		Urine % DMA	
	P	Adj R^2	*P*	Adj R^2	*P*	Adj R^2	*P*	Adj R^2
Total Dietary As (µg/day)	0.001	0.387	0.001	0.505	0.034	0.224	0.046	0.132
Inorganic Dietary As (µg/day)	0.170	0.320	0.001	0.489	0.932	0.205	0.403	0.116

Covariates in models: sex, age, BMI, Hispanic/non-Hispanic ethnicity, drinking water As concentration, cooking water As exposure, current smoking status, diabetes. Dietary As measures were log-transformed.

Relation of dietary As to urinary total As and As species in NHANES 2003-04, adjusted models

	Urine Total As		Urine sum of species As		Urine % MMA		Urine % DMA	
	P	Adj R^2	P	Adj R^2	P	Adj R^2	P	Adj R^2
Schoof Total As	0.001	0.158	0.001	0.134	0.001	0.054	0.001	0.118
Schoof Inorganic As	0.001	0.035	0.001	0.070	0.003	0.012	0.001	0.054
TDS Total Mean As	0.001	0.131	0.001	0.120	0.001	0.059	0.001	0.114
TDS Total Maximum As	0.001	0.113	0.001	0.096	0.001	0.041	0.001	0.088

Relation of dietary As to urinary % MMA is negative; relation to other urinary biomarkers is positive.

Covariates include age, sex, race/ethnicity, BMI, urine creatinine, current smoking, seafood consumption.

Summary

- Premise: The urinary biomarker reflects multimedia, multipathway exposure. The food:biomarker association reflects the contribution of dietary As exposure as mediated through the body.
- Both measured and modeled total As content of food is associated with total As in urinary biomarkers.
- Water content of food is a significant predictor of urinary arsenic.
- Total As dietary intake accounts for about half the variance in urinary biomarkers.
- Implication: It is not sufficient to regulate drinking/tap water alone, food is a significant contributor of arsenic exposure.