Rice and Rice Products as Potential Dietary Sources of Arsenic in Pregnant Women and Kids

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Project 2 (Pilot): Food Borne Exposure to Arsenic During the First Year of Life
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Project 3 (Pilot): An Integrated Geospatial and Epidemiological Study of Associations Between Birth Defects and Arsenic Exposure in New England
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Project 4 (Pilot): Determining how Arsenic Modulates Hedgehog Signaling During Development
David Robbins

New Project 5: Epigenetic Markers of Exposure and Development
Carmen Marsit

Research Project 1: Arsenic and Maternal and Infant Immune Function
Margaret Karagas, Susan Korrick, Matt Davis, Shohreh Farzan

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Arsenic Drinking Water Standards

World Health Organization
• 1958 – 200 µg/L
• 1963 – 50 µg/L
• 1993 – 10 µg/L

US EPA
• 2001 – 10 µg/L

Some states
• 5 µg/L

Private Wells Not Regulated
40% of New Hampshire households served by private water systems

Restricted study to pregnant women with private well at home

Included a region with high concentrations based on our earlier work

15% of pregnant women – tap water exceeds the MCL of 10 µg/L As
Dietary Sources of Arsenic

- Diet is the main source of arsenic exposure for most.
- There are no statutory limits for arsenic content of food sold in the US and EU.
- In China the limit is 0.15 ug/g.

“Dietary exposure to arsenic should be reduced”
USA long grain rice had the highest mean arsenic level in the grain at 0.26 µg As g⁻¹
Preliminary Studies

- **Pregnancy**: Water & rice in relation to urinary arsenic
- **Infant/Toddler**: As content in formulas
- **Child**: Rice and rice product consumption in relation to urinary arsenic
New Hampshire Birth Cohort Study

Pregnancy ➔ Delivery ➔ Months 4 ➔ Months 8 ➔ Year 1

12-16 Weeks
Eligibility screen
- Gest. age, birth weight

24-28 Weeks
Enrollment
- Questionnaire
- Maternal blood, urine, hair, toenail

Maternal diet
(FFQ, diary)
Prenatal records:
Maternal Infection
- Maternal/infant infection
- Cord blood (immune profile, epigenetics)
- Placenta (gene expression)
- Meconium
- (microbiome)

Infant infection
Infant Diet
Infant Urine/Stool, Breast Milk

Infant infection
Infant Diet
Infant Urine/Stool Breast Milk

Infant health/
infection
Infant/
Maternal diet (FFQ)*
Pediatric record
Infant Blood/Urine/Stool
Physical exam and
developmental evaluation

75-80% participation ~100% urinary As, water/diet
Pregnancy Exposure

- Baseline questionnaire
- Chart review

Samples:
- Home water,
- Spot Urine
- 3-day water, seafood and rice intake

As3 ↔ As5 ↔ MMA ↔ DMA ↔ AsB

ICP-MS
Urinary arsenic higher in rice eaters (n=229)

Median Urinary Arsenic $\mu g/L^*$

- **iAs**
- **MMA**
- **DMA**
- **Total As**

*excludes arsenobetaine

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

Gilbert-Diamond, PNAS, 2011
Water Arsenic & Rice Intake Contribute to Urinary Arsenic

1/2 cup of rice/day = 1 liter of 10 ug/L As water

Gilbert-Diamond, PNAS, 2011
Dietary contributors of As exposure in infants?

How is early life As exposure best measured?
Formulas with organic brown rice syrup contained As when reconstituted with As-free water.

Jackson et al., *EHP*, 2012
Limitations/Future Studies

1. Analysis of individual’s As exposure from rice:
   - No testing of actual rice samples
   - Nor specific brand/country of origin information
   - Didn’t fully account for rice fillers/sweeteners

2. Analysis of infant/toddler formula
   - No actual infant exposure levels i.e., biomarkers such as urine

3. We need to understand the health impacts of food sources of As exposure.
Conclusions

• Estimated arsenic intake via **well water** contributes to urinary arsenic concentrations in pregnant women.

• **Rice**, alone, and without accounting for the arsenic content of rice, is associated with urinary arsenic concentrations in pregnant women and kids.

• Need to consider multiple exposure routes when designing arsenic reduction strategies in the U.S.

**Need for private well testing is clear.**
Need to be careful about making dietary recommendations to pregnant women and children.
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