Arsenic exposure through well water and household behavior in a rural Maine community: Implications for mitigation

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ABSTRACT:

In the US, private well water is unregulated by federal drinking water standards and is solely the responsibility of the owner to ensure quality. The Columbia University Superfund Research Program found that 31% of domestic wells in its 17-town project area in Maine exceed the US EPA Maximum Contaminant Level (MCL) for arsenic (As), resulting in an estimated 13,300 population at risk of drinking As-contaminated water. Analysis of new household survey data on water testing and treatment practices reveals an estimated 66% of those at risk likely remain exposed at present. The different categories of exposed will require unique strategies for mitigation, as suggested by new research on behavioral factors favoring As testing and treatment.

BACKGROUND:

- ~15% of the U.S. population, >43 million people, relies on private wells for their drinking water.
- Elevated As concentrations (>10 µg/L) in well water have been linked to increased risks for cancer, cardiovascular disease, and neuropathy.
- No authority ensures private water is in compliance with federal regulations; it is solely the well owner's responsibility to monitor and maintain quality.
- Significant proportions of households in at-risk areas such as Maine's greater-Augusta area remain exposed to elevated As through drinking their well water.
- 17 towns of Kennebec County comprise the project area of Columbia University's Superfund Research Program (SRP), where well water was sampled 2006-11 and household testing and treatment surveys were conducted in Jan 2013.

STUDY AREA: Kennebec Co., Maine

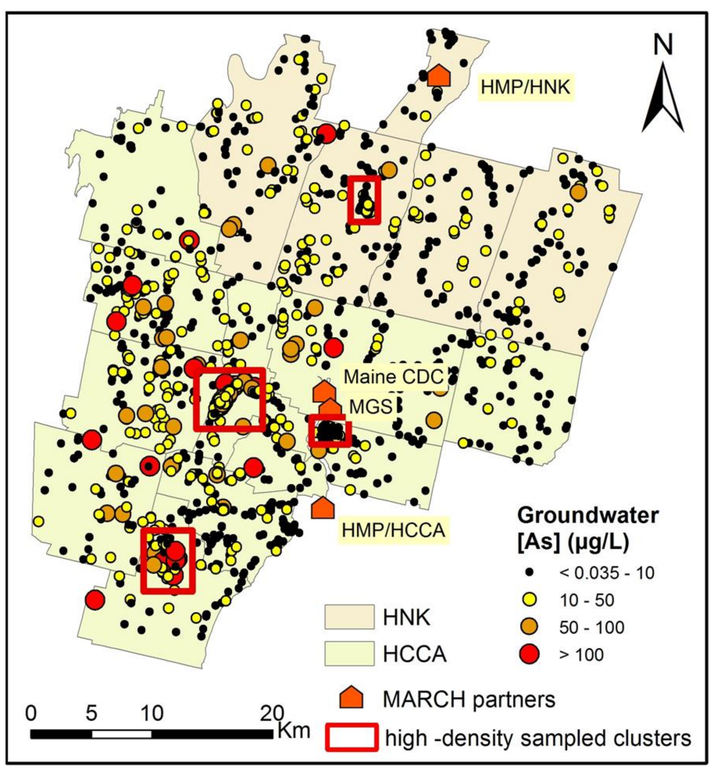


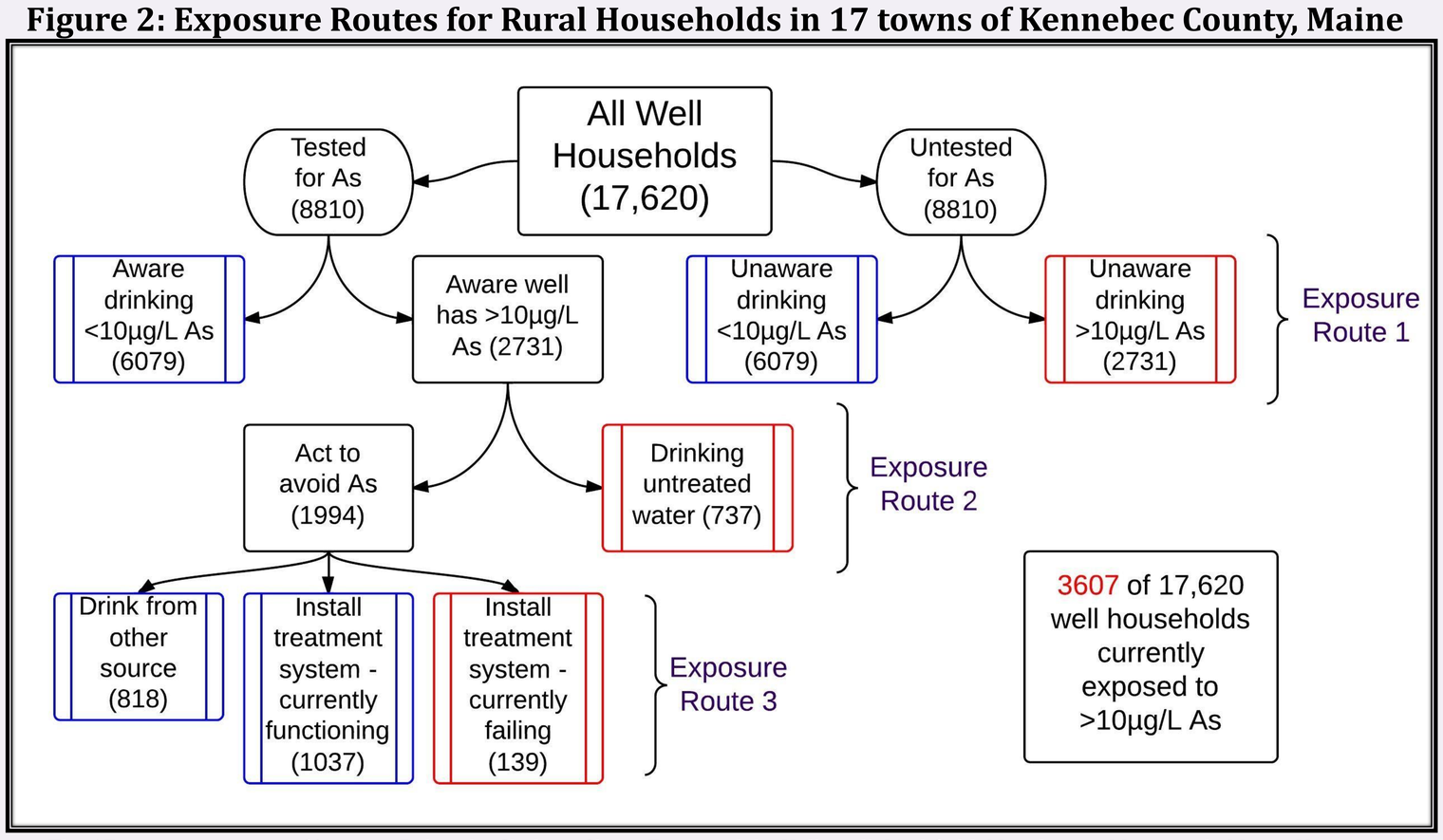
Figure 1. Between 2006-2011, the SRP of Columbia and the Maine Geological Survey (MGS) found that 31% of 1,428 domestic well water samples tested in the 17 towns exceeded the EPA MCL for As (Yang et al. 2012).

KEY FINDINGS (Flanagan et al., 2014):

- Only 44% of area households report having As included on their most recent well test.
- Among households who tested >10 µg/L, 43% report having since installed treatment systems for As, 30% report taking other mitigation actions such as drinking bottled water, but 27% did not act on test results.
- Treatment failure is a risk: Table 1. 2013 test kit results from 68 households (HHs) treating for arsenic.

Untreated Water As Level	# of HHs Treating	# of HHs with treated water As >10 µg/L	Failure Rate
>10-50 µg/L	36	4	11.1%
>50-100 µg/L	29	5	17.2%
>100 µg/L	3	1	33.3%
All >10 µg/L	68	10	14.7%

Figure 2: Exposure Routes for Rural Households in 17 towns of Kennebec County, Maine



The 17-town project area (Augusta, Belgrade, Chelsea, China, Farmingdale, Hallowell, Litchfield, Manchester, Monmouth, Mount Vernon, Readfield, Sidney, Vassalboro, Waterville, West Gardiner, Windsor, and Winthrop) have a combined population of 85,668 of whom about 43,100 drink private well water. Well sampling estimates that 5462 households (31%), or 13,300 people, are at risk of As exposure through drinking water due to wells above MCL. Based on survey findings of testing and treatment practices in this population, an estimated 66% of these households remain currently exposed to As through their drinking water.

BEHAVIORAL INFLUENCES OF PERSISTENT ARSENIC EXPOSURE:

EXPOSURE ROUTE 1: UNTESTED POPULATION

- **Better educated**, **higher income** homeowners who more recently purchased their homes are most likely to have **included As** when last testing their wells.
- Households agree water and As-related health risks can be severe, but feel **low personal vulnerability** and perceive **low testing norms** overall.
- Significant predictors of including As when last testing include: having knowledge that years of exposure increases As-related health risks (**risk knowledge**), knowing who to contact to test well water (**action knowledge**), believing regularly testing does not take too much time (**instrumental attitude**), and having neighbors who regularly test their water (**descriptive norm**).

EXPOSURE ROUTE 2: TESTED BUT NOT TREATING

- Well water As level appears to be a motivation for mitigation: **31% of households** with well water level between **10-50 µg/L** did not act, compared to **11% of households** with well water **>50 µg/L**.
- The belief that the untreated water is not safe to drink (**risk**) and that reducing drinking water As would increase home value (**instrumental attitude**) were identified as significant predictors of mitigating As.
- Mitigation choice was influenced by socio-economic factors, and use of a treatment system specifically was significantly predicted by confidence that one can maintain a treatment system, even if there are additional costs (**self-efficacy**).

EXPOSURE ROUTE 3: USING FAILED TREATMENT

- **15% of treatment units** in the assessment **failed to produce water <10 µg/L**, suggesting there are **continued risks for exposure** even after the decision is made to treat, whether due to inappropriate technology or the influence of groundwater chemistry and homeowner behavior.
- After homeowners have taken action to treat it is important they **vigilantly monitor the quality** of the treated water, but surveys revealed that mitigating As exposure is associated with less worry about the As level (affective attitude), which may lead to lax monitoring or maintenance.

CONCLUSION:

As long as private well drinking water quality remains the responsibility of homeowners, there will always be As exposure in the population due to failure to progress through the necessary stages for mitigation: testing, treatment/avoidance, and monitoring. This research into the psychological and socioeconomic influences behind these actions suggests that different approaches to mitigation intervention may be necessary depending on these different stages of behavior.

For more information please see: Flanagan, S.V., Marvinney, R.G., Johnston, R.A., Yang, Q., Zheng, Y. Dissemination of well water arsenic results to homeowners in Central Maine: Influences on mitigation behavior and continued risks for exposure. *Science of The Total Environment*. In Press, Available online 13 April 2014. http://dx.doi.org/10.1016/j.scitotenv.2014.03.079 and Flanagan, S.V., Marvinney, R.G., Zheng, Y. Influences of domestic well water testing behavior in a Central Maine area with frequent groundwater arsenic occurrence. *Science of the Total Environment.* Forthcoming.