

Community Response to Impaired Drinking Water

Using Sales of Bottled Water and Anti-Diarrheal Medicine

Maura Allaire, Taylor Mackay, Upmanu Lall

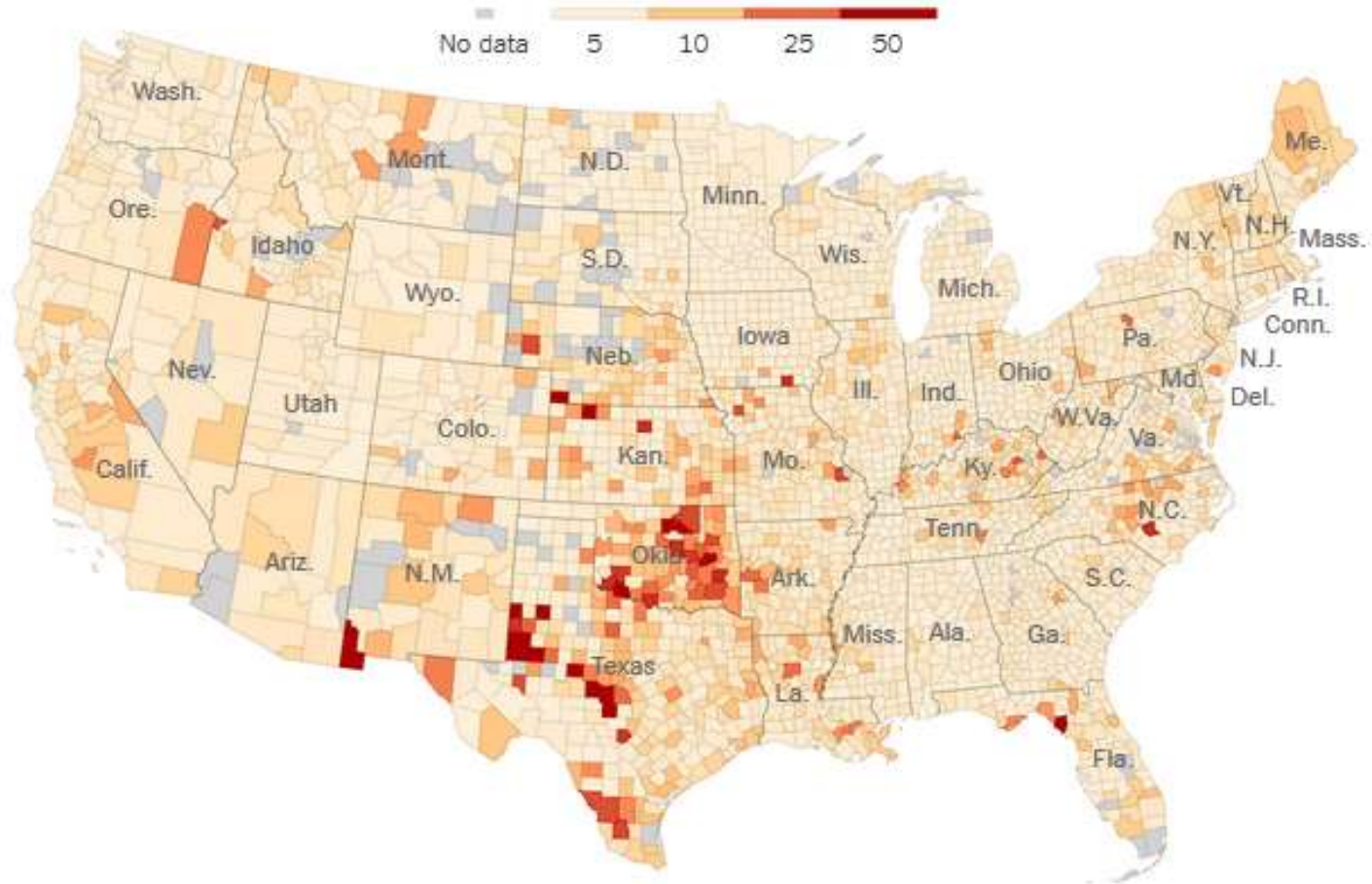


**Urban Planning & Public Policy
University of California, Irvine**

National trends in drinking water quality violations

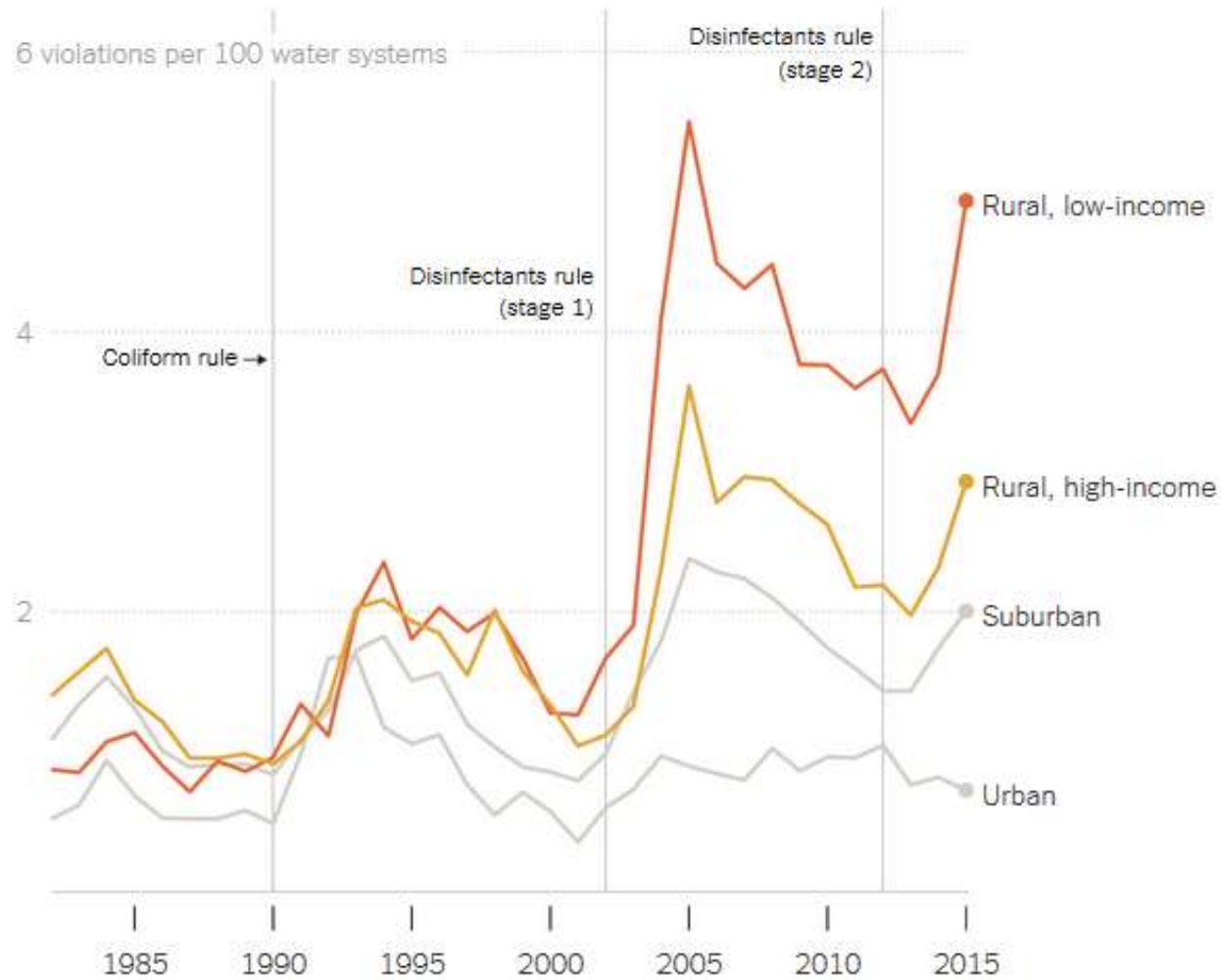
Maura Allaire, Haowei Wu, and Upmanu Lall

**Total violations per community
water system, 2004-2015**



Rural Areas Have More Violations

Low-income, rural communities have especially struggled to comply with new water quality regulations.



Source: Allaire, Wu, and Lall, PNAS

By The New York Times

Research Questions

- 1. Do household take averting actions in response to violations?**
- 2. How do averting actions differ across communities?**



Do communities respond to violations?

Bottled Water
Sales (Weekly)



Consumer
behavior

National Dataset: 10 years, 2,151 counties

- 25,464 stores
- 18,814 water systems, serving 280+ million people

Methods

Fixed Effects Model:

$$S_{ct} = \beta_0 + \beta_1 k_{ict} \left(\frac{p_{ic}}{p_c} \right) + \beta_2 X_{ct} + \alpha_c + \gamma_t + \varepsilon_{ct}$$

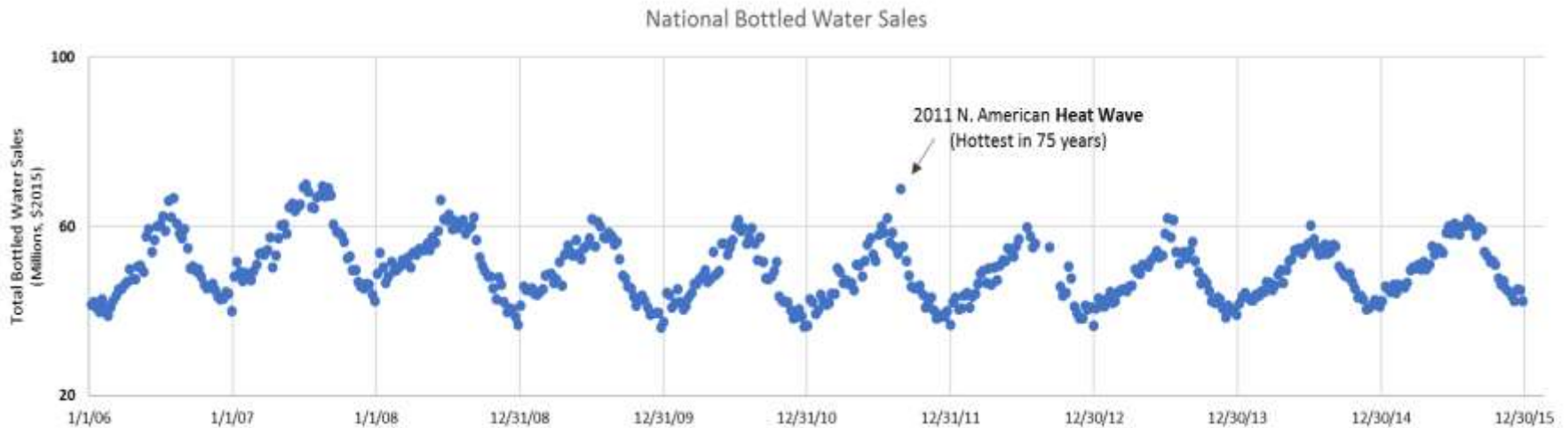
Pop. exposure

- S_{ct} : log(Sales of bottled water, weekly), in county c in week t
- v_{it} : portion of time utility i in county c was in violation in week t
- X_{ct} : time varying county characteristics for county c
- Fixed effects: County (α_c), Time (γ_t)

Data

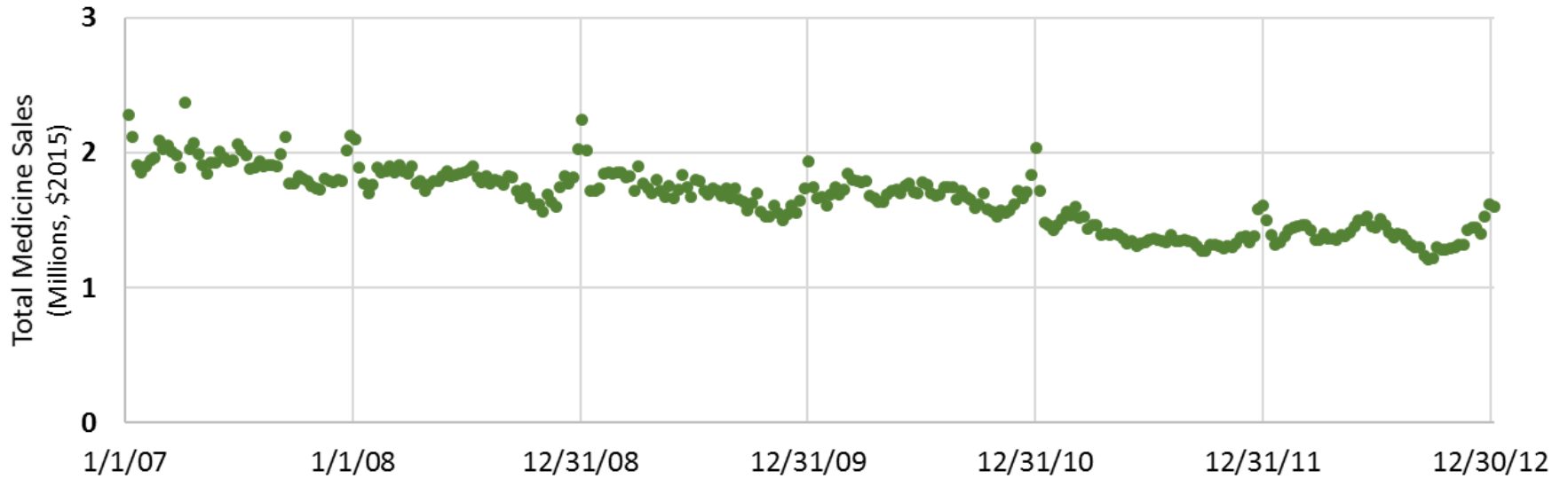
- Retail sales of bottled water (\$): supermarket scanner data, weekly, 2006-2015
- Health-based violations (EPA Safe Drinking Water Information System)
- Climate: temperature; precipitation (NOAA)
- Community characteristics (U.S. Census): income; housing density; % nonwhite (time varying)

Weekly Bottled Water Sales



- Model controls for seasonality & climate (temp., precip.)

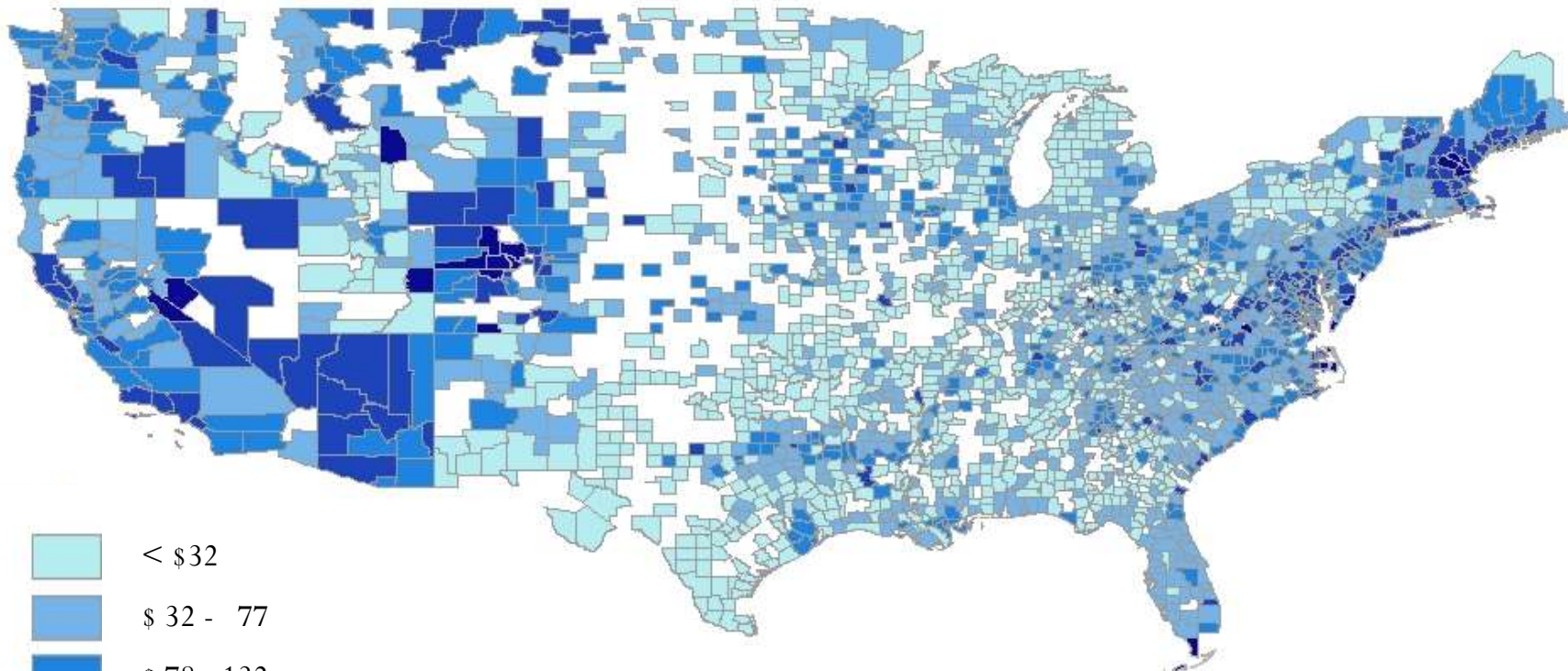
National Antidiarrheal Medicine Sales



- Peaks: December - January

Bottled Water Sales, 2006-2015

(\$2015 per capita)



Study includes (in continental U.S.):

- Nearly **70%** of counties
- Over **95%** of the population

Summary Statistics

	Mean	Std. Dev.	Min.	Max.
Water sales (\$2015), weekly	22,996	89,260	1	4,231,504
Tier 1 violations, proportion variable	0.00	0.03	0	1
Tier 1 (dummy indicator, =1 if violation)	0.01	0.12	0	1
Temp. (Weekly Mean, C)	13.55	10.28	-24.78	38.60
Precip. (# rainy days, Week)	2.05	1.59	0.00	7.00
Median Household Income (\$2015)	51,308	14,439	16,583	145,501
Housing Density (houses per sq mi)	143	983	0.36	38,312
% Nonwhite	0.17	0.16	0.00	0.88
Median year housing stock built	1975	10	1939	2007

n=1,120,666

	Mean	Std. Dev.	Min.	Max.
Medicine sales (\$2015), weekly	864	2,488	0	76,459

Regression Results

Tier 1 Violations

<i>Tier 1 Violations</i>	(1)	(2)	(3)
Any Tier 1	0.141*** (0.051)		
Tier 1 : Bacteria, Pathogens, & Viruses		0.143*** (0.029)	
Tier 1: Nitrate			0.141 (0.102)
<i>Observations</i>	1,120,666	1,120,666	1,120,666
<i>R</i> ²	0.984	0.984	0.984

- 14% increase in sales due to Tier 1 violation

Regression Results

	Water Sales			Medicine Sales		
	Coeff.		Robust Std Err.	Coeff.		Robust Std Err.
Tier 1 Violations	0.14	***	0.01	0.04	**	0.02
Temp. (Mean)	0.01	***	0.00	0.00	***	0.00
Precip. (# rainy days)	-0.02	***	0.00	-0.01	***	0.00
ln(Median Household Income)	0.72	***	0.01	0.39	***	0.01
ln(Housing Density)	-1.14	***	0.01	-0.21	***	0.02
% Nonwhite	-0.96	***	0.01	-0.50	***	0.02
ln(Median year housing stock built)	21.0	***	0.54	-3.81	***	0.80
	County FE	yes		yes		
	Week FE	yes		yes		
	R2	0.98		0.95		
	Obs	1,120,666		962,942		

- Anti-diarrheal medicine sales: 4% increase
Lower response (compared to bottled water)

Do responses vary across demographic groups?

- Less response in **rural, low income** communities

	Rural, Low Income	Rural, High Income
Any Tier 1	0.109 (0.089)	0.287*** (0.079)
Observations	182,871	93,776

Tier 1 : Bacteria, Pathogens, & Viruses	0.167** (0.076)	0.165*** (0.061)
Observations	182,871	93,776

Tier 1: Nitrate	0.084 (0.113)	0.311*** (0.091)
Observations	182,871	93,776

- Concern: Highest prevalence of violations in these communities

Findings

1. Averting behavior → Bottled water

National average: 14% increase in bottled water sales due to Tier 1.

2. Low Income, Rural Communities → Less response

3. Improvements in Public Notification:

- Update communication modes → e-mail, text, social media
(Currently: radio, tv, hand delivered notices)
- Emphasize need for action



Questions?

Maura Allaire

maura.allaire@uci.edu



Urban Planning & Public Policy
School of Social Ecology

