

Goal-Setting and Behavioral Change: Evidence from a Field Experiment on Water Conservation

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- also recent studies in economics (*e.g., Koch and Nafziger 2011, Gómez-Miñambres 2012, Harding/Hsiaw 2014, Corgnet et al. 2015, Samek 2016, Allen et al. 2017, Clark et al. 2020*)

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Goals as **norms**? Potential for low-cost, scalable **interventions**?

- digitization → many new applications and opportunities

Our study: goals for household water conservation

Field experiment on **water conservation** in an everyday activity

- (exogenous) goals and feedback through **smart meters**
- 525 households (>2,000 individuals) in Singapore
- study duration of 4 (to 6) months

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Several **advantages** of our setting:

- natural field context
- can study effect dynamics over many repetitions
- fine-grained data to study behavioral responses

Water conservation in Singapore

Saving water is in our hands

Saving 1 litre of water can make a huge difference. Better still, we can enjoy our daily activities and save water at the same time. Save 5 litres by showering once a week. Save 11 litres by using a tap when you brush your teeth. Save 14 litres by washing vegetables with a tub of water instead of a running tap. Every little bit helps. Saving water is in our hands.




Let's make every drop count

Save 9 litres of water when you do any of the following:



Reduce shower time by 1 minute



Use a tumbler when brushing your teeth



Wash dishes/vegetables in a container and not under a running tap



Wash clothes on a full load

www.pub.gov.sg/conserv
www.facebook.com/PUBsg



Water conservation in Singapore

Saving water is in our hand

Simply 11 litres of water can make a huge difference. Better off 11 litres can 11 enjoy our daily activities and save water at the same time. Save 11 litres by showering on a mat. Save 11 litres by using a cup when you brush your teeth. Save 11 litres by washing vegetables in a tub of water instead of a running tap. Every 11 litres counts. Saving water is in our hand.



Every drop counts.
Use only what you need.

OUR WATER, OUR FUTURE



PUB SINGAPORE'S NATIONAL WATER AGENCY

Let's make drop count

Save 11 litres of water when you do the following:

- Use a tumbler when brushing your teeth
- Wash clothes on a full load



PUB
Water for All. Conserve. Wast. Enjoy.

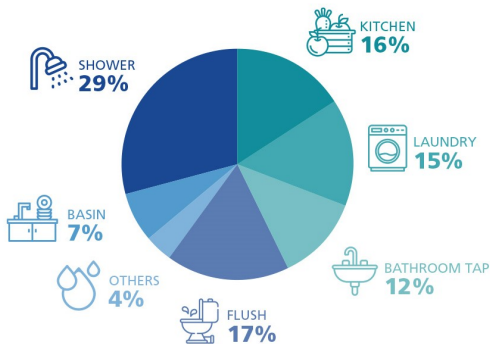
Target behavior: Water conservation in the shower



Target behavior: Water conservation in the shower

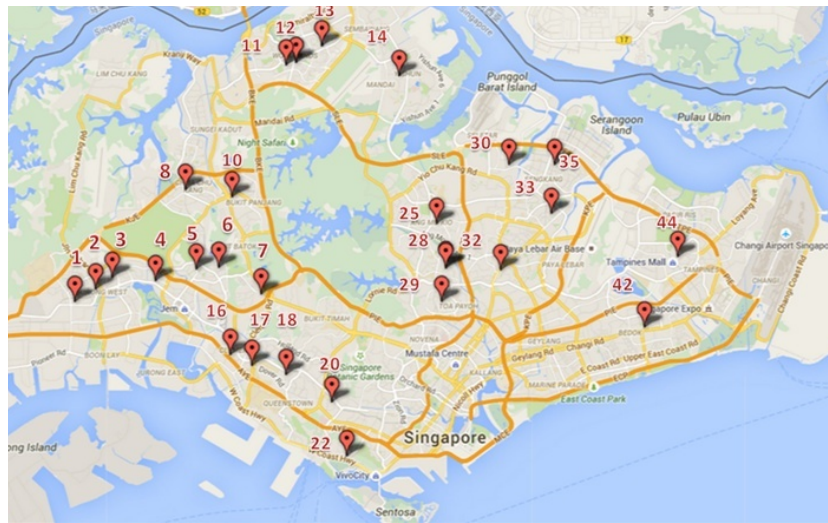


Water Usage In a Household



PUB Household Water Consumption Study in 2018/2019

The field experiment



The field experiment

Households receive **smart meters** that measure water usage in the shower:



Random assignment into experimental conditions

The smart shower meters can show information through a display.

- **Control group:** display only shows water temperature
- **Real-time feedback:** water temperature for first 20 showers, then real-time feedback on water usage (*see Tiefenbeck et al. 2018*)
- **Real-time feedback + Goal:** water temperature for first 20 showers, then real-time feedback **plus goal and injunctive norm**

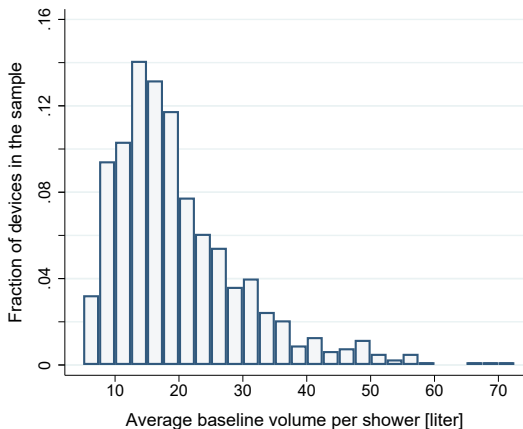


Evaluation

- VERY GOOD: Efficient water usage 😊
- OK: Water usage is reaching your goal 😊
- TOO MUCH: Water usage did not meet your goal 😞

Goals range from hard to easy

Figure: Histogram of baseline usage



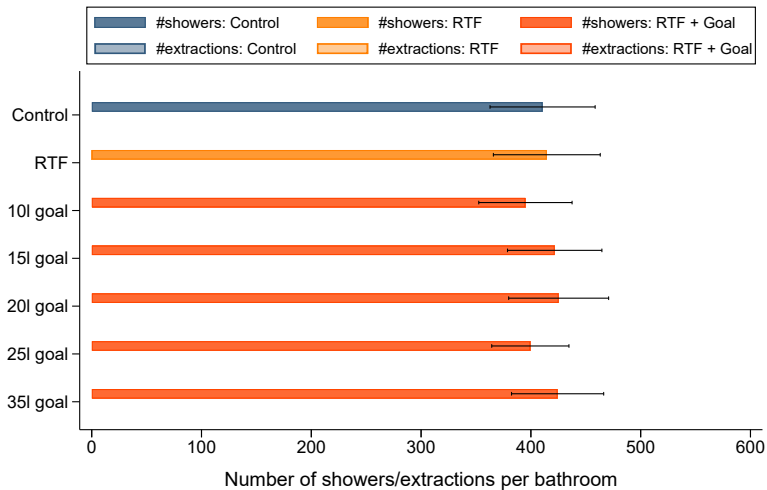
Five goal conditions:

- 10 liter
- 15 liter
- 20 liter
- 25 liter
- 35 liter

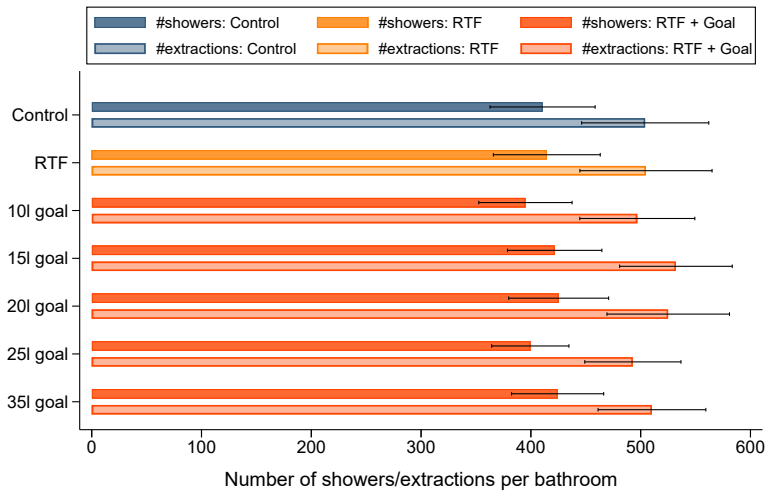
► shower level

Empirical Results

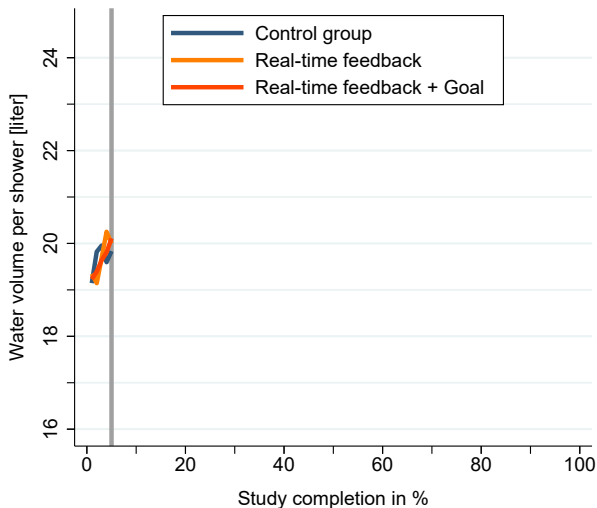
No evidence for extensive margin effects



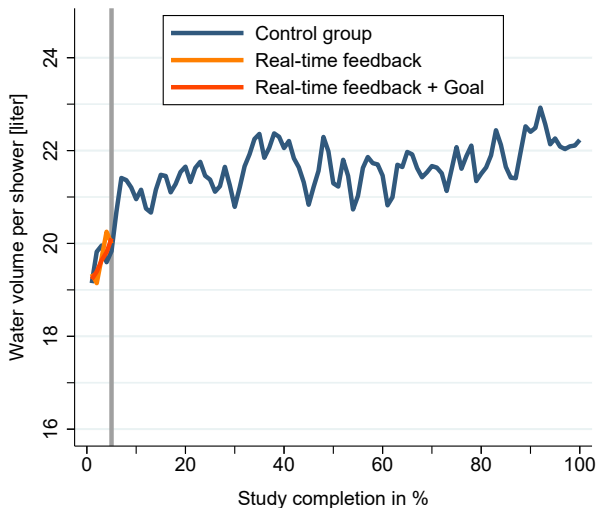
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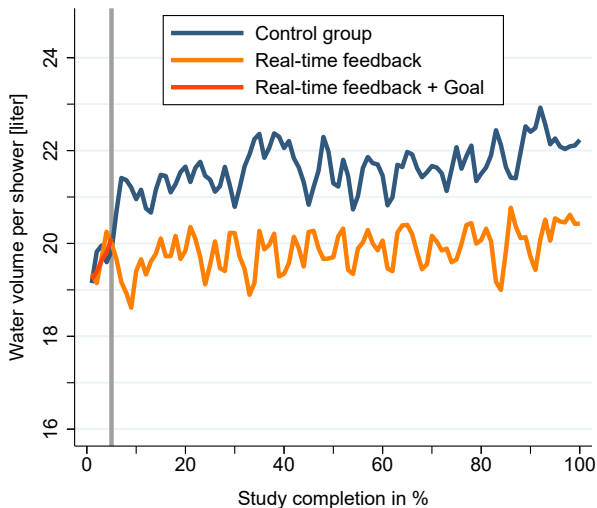
Feedback and goals reduce water usage



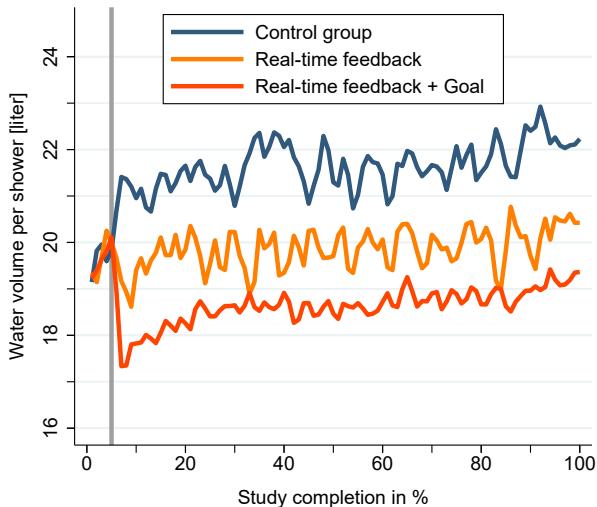
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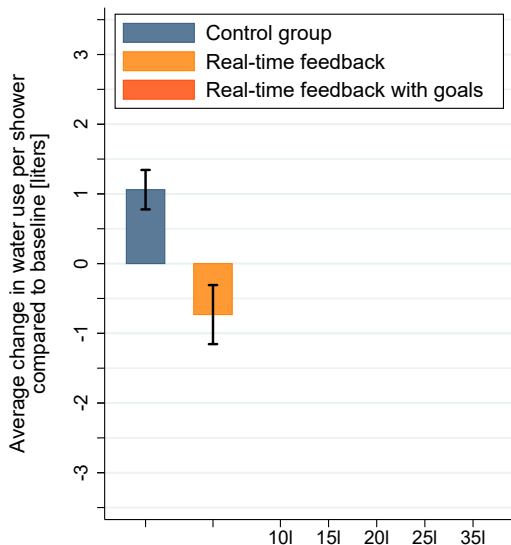
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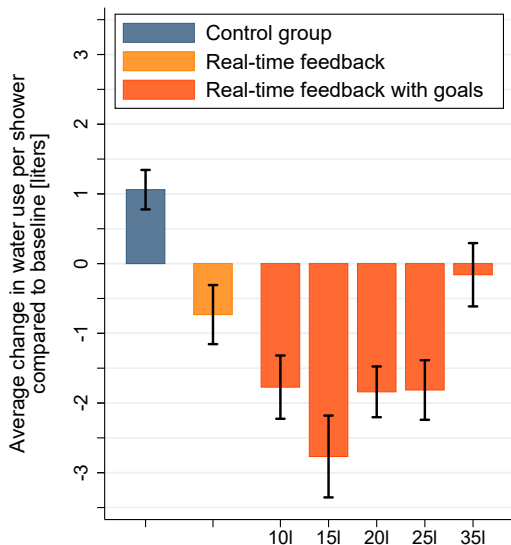
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Water conservation effects by goal difficulty



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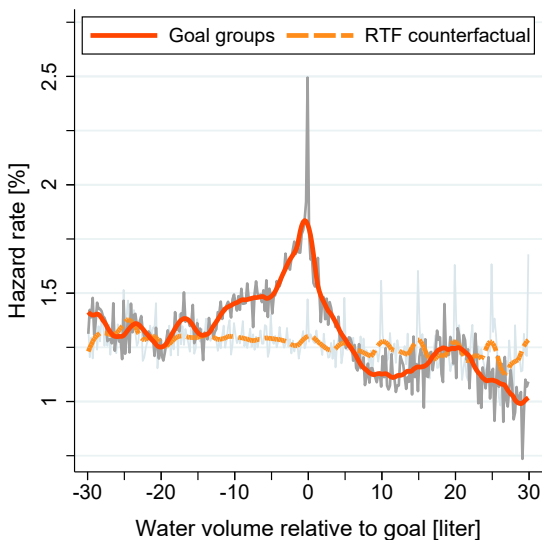


Regression estimates for ATEs

	Full sample	<i>effect stability over time</i>		
		Early-phase	Mid-phase	Late-phase
RTF group	-1.873*** (0.522)	-1.784*** (0.495)	-1.933*** (0.586)	-1.816*** (0.615)
10l goal group	-2.972*** (0.592)	-2.951*** (0.550)	-3.126*** (0.641)	-2.814*** (0.741)
15l goal group	-3.922*** (0.661)	-4.084*** (0.648)	-3.767*** (0.714)	-3.871*** (0.755)
20l goal group	-3.061*** (0.494)	-3.185*** (0.506)	-2.975*** (0.532)	-3.032*** (0.612)
25l goal group	-2.991*** (0.565)	-3.100*** (0.537)	-3.102*** (0.611)	-2.775*** (0.674)
35l goal group	-1.108* (0.592)	-1.115** (0.546)	-1.088 (0.666)	-1.124 (0.728)
<i>Bathroom FEs</i>	yes	yes	yes	yes
<i>"Time" controls</i>	yes	yes	yes	yes
Observations	318318	117220	117457	114461
R^2	0.335	0.325	0.325	0.376

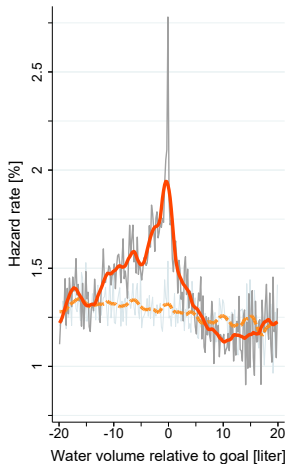
*SEs clustered at household level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$*

Stopping probabilities around the goal

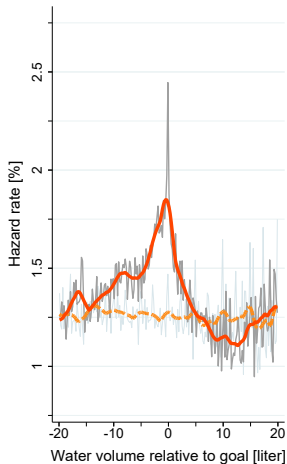


Behavioral adjustments over 4 months

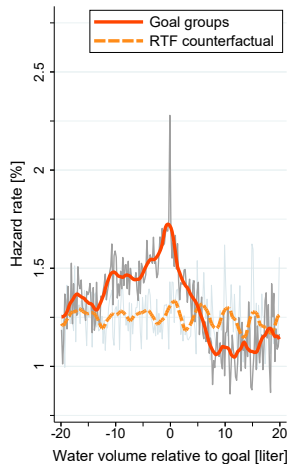
(a) Early-phase



(b) Mid-phase



(c) Late-phase



Goal attainment rates drop over time

	<i>Placebo</i>		<i>Actual attainment rates</i>	
	Control (1)	RTF (2)	Goal conditions (pooled)	
			(3)	(4)
Intervention	-0.009 (0.006)	0.017* (0.010)	0.080*** (0.008)	0.021*** (0.004)
Study progress	-0.010 (0.008)	-0.015 (0.010)	-0.038*** (0.006)	-0.011*** (0.004)
<i>Water volume FEs</i>	–	–	–	yes
<i>Bathroom FEs</i>	yes	yes	yes	yes
Baseline mean	0.626	0.617	0.619	0.619
<i>N</i>	203275	181875	212680	212471
Clusters	70	67	360	360
<i>R</i> ²	0.175	0.189	0.348	0.715

Notes. Linear probabilities model. Standard errors in parentheses are clustered at the household level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Conclusion

Goal setting is effective in encouraging water conservation

- can more than double the effect of feedback alone
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Strongest behavioral responses **at the margin** of goal attainment

- spike in effort at the goal, steep drop after failure (asymmetry)
- ▶ psychological cost of “norm violation”?

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Water conservation effects remarkably **stable over time**

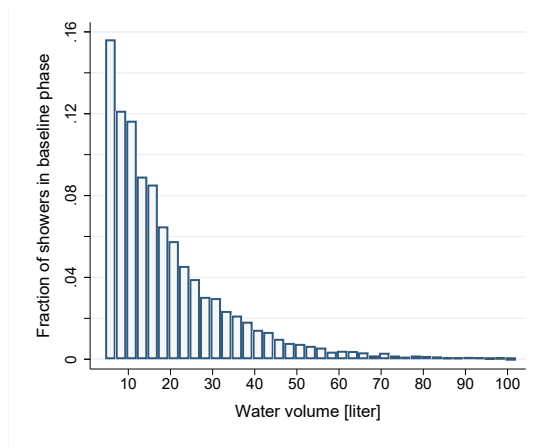
- despite reduction in direct response to goal
- ▶ Félix Ravaisson’s (1838) double law of habit

That was it.

Thanks for your attention!

Goal conditions range from hard to easy

Figure: Histogram of shower volumes in baseline



Five goal conditions:

- 10 liter
- 15 liter
- 20 liter
- 25 liter
- 35 liter

▶ back

Randomization checks: BL shower behavior

	Volume [liter]	Duration [min]	Flow rate [l/min]	Temperature [Celsius]	Energy [kWh]
10l goal	0.36 (1.29)	0.41 (0.25)	-0.32 (0.29)	0.25 (0.29)	0.01 (0.02)
15l goal	0.63 (1.42)	0.20 (0.25)	0.04 (0.32)	-0.54* (0.28)	-0.01 (0.02)
20l goal	0.35 (1.19)	0.26 (0.23)	0.09 (0.31)	-0.01 (0.31)	0.01 (0.02)
25l goal	0.10 (1.31)	0.16 (0.22)	-0.12 (0.28)	-0.08 (0.30)	0.01 (0.02)
35l goal	1.49 (1.33)	0.34 (0.25)	0.14 (0.30)	-0.31 (0.30)	0.01 (0.02)
Real-time feedback	0.66 (1.37)	0.49* (0.26)	-0.39 (0.28)	-0.33 (0.34)	0.01 (0.02)
Constant	19.18*** (0.92)	3.80*** (0.15)	5.30*** (0.21)	33.88*** (0.20)	0.24*** (0.01)
Observations	763	763	763	763	761
R^2	0.002	0.006	0.007	0.011	0.002
F test: p-value	0.950	0.524	0.4277	0.115	0.971

Interactions with baseline water use

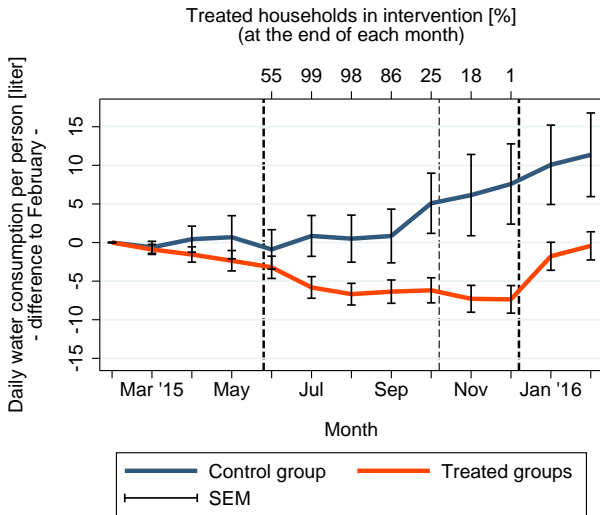
	(1) linear interaction		(2) above median	
	main effect	\times <i>baseline</i>	main effect	\times \mathbb{I}_{median^+}
10l goal \times intervention \times ...	-2.884*** (0.552)	-0.179*** (0.060)	-1.854*** (0.503)	-3.852*** (0.961)
15l goal \times intervention \times ...	-3.827*** (0.515)	-0.405*** (0.077)	-1.562*** (0.406)	-6.192*** (1.131)
20l goal \times intervention \times ...	-2.937*** (0.413)	-0.296*** (0.066)	-1.297*** (0.408)	-4.276*** (0.781)
25l goal \times intervention \times ...	-2.946*** (0.475)	-0.286*** (0.068)	-1.293*** (0.428)	-4.783*** (0.977)
35l goal \times intervention \times ...	-1.172** (0.489)	-0.171** (0.071)	-0.352 (0.450)	-2.115** (0.912)
RTF \times intervention \times ...	-1.699*** (0.441)	-0.265*** (0.053)	-0.093 (0.508)	-3.350*** (0.843)
Intervention \times ...	1.108*** (0.278)	0.048 (0.035)	0.967*** (0.278)	1.242** (0.540)
Observations	314608		314608	
between R^2	0.287		0.109	

Margins of adjustment

	Volume [liter]	Duration [sec]	Flow rate [liter/min]	Temperature [Celsius]
10l goal × intervention	-2.876*** (0.563)	-34.249*** (7.081)	-0.056 (0.071)	0.057 (0.248)
15l goal × intervention	-3.815*** (0.634)	-36.540*** (7.389)	-0.215** (0.097)	0.341 (0.253)
20l goal × intervention	-2.901*** (0.461)	-28.237*** (6.065)	-0.119 (0.080)	0.198 (0.255)
25l goal × intervention	-2.871*** (0.530)	-26.963*** (6.783)	-0.096 (0.069)	-0.011 (0.316)
35l goal × intervention	-1.290** (0.542)	-12.369* (6.399)	-0.010 (0.072)	0.002 (0.319)
RTF × intervention	-1.763*** (0.483)	-20.144*** (5.630)	0.010 (0.069)	0.050 (0.287)
Intervention	1.091*** (0.287)	5.158 (3.514)	0.133** (0.055)	-0.027 (0.231)
Bathroom FEs	Yes	Yes	Yes	Yes
Observations	314608	286732	286732	286732
R ²	0.331	0.297	0.859	0.561

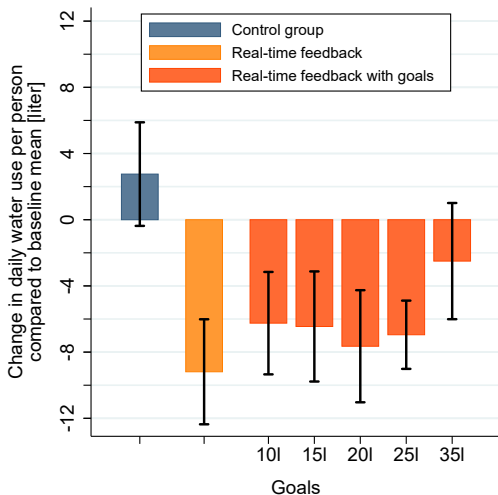
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Effects on household consumption level

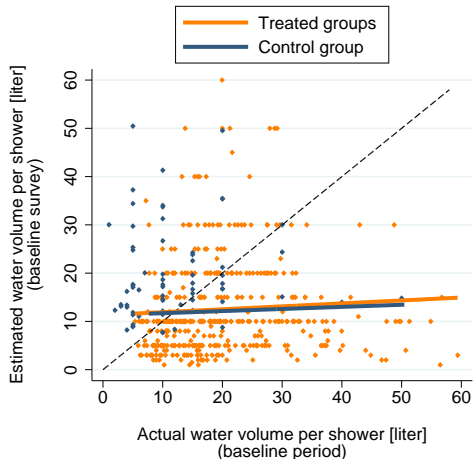


Effects on household consumption level

Treatment effects on daily household water use per capita



1. Estimated vs. actual volume before the intervention

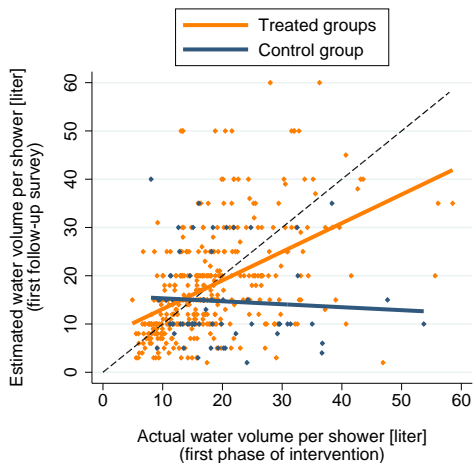


No relationship between actual and estimated water use

- Estimated average is quite close to true value (wisdom-of-the-crowd effect)
- But individuals know virtually nothing about their own water use
- ▶ Quite typical, seen in many other studies.

No differences between control group and experimental conditions (all collapsed into one group).

2. Estimated vs. actual volume during the intervention

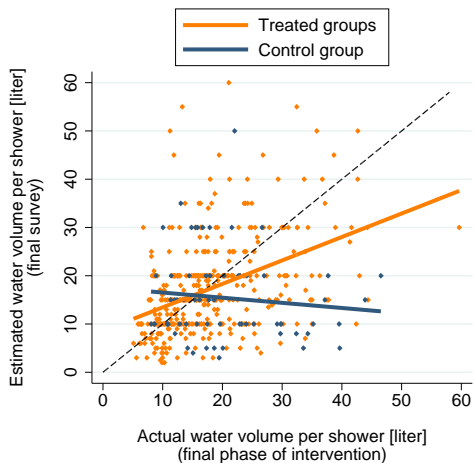


Strong improvement in awareness of resource use in the treatment conditions.

- Relationship between actual and estimated water use becomes much steeper. than it was before.

Control group shows no improvement in awareness of water use (not surprising).

3. Estimated vs. actual volume after the intervention



Awareness persists throughout the study.

- Treated groups continue to show the same, much tighter, relationship between actual and estimated water use.

Control group shows no improvement.