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Saving Water with a Nudge (or Two): Evidence from Costa Rica on the Effectiveness and Limits of Low-Cost Behavioral Interventions on Water Use

Juan Jose Miranda, Saugato Datta, and Laura Zoratto

Abstract

The study uses a randomized controlled trial to test the impact of simple, inexpensive, and nonpersonalized behavioral interventions (or "nudges") on water consumption in the context of a developing country. A descriptive social norm intervention using neighborhood comparisons reduces average water consumption in the first two postintervention months by 4.9 percent relative to the control group, while a planning postcard intervention reduces consumption by 4.8 percent. A descriptive social norm intervention using a town-level comparison also reduces water consumption by 3.2 percent, but this effect is not statistically significant. Finally, the study's one-time interventions continue to generate statistically significant reductions in water use for up to four months after they are implemented.

JEL classification: C93, D03, H41, L95, O12, Q25

Keywords: water conservation, water utilities, field experiments, social norms, behavioral science

1. Introduction

Behavioral economics reveals overlooked but relatively easily alterable influences on decisions and actions (such as the discrepancy between actual and perceived social norms, lack of salience of certain options, unfavorable defaults, choice ordering, and so on), which in turn underlie the design of behaviorally informed interventions, or "nudges," to improve policy outcomes in diverse domains (Thaler and Mullainathan 2010; Thaler and Sunstein 2008; Kahneman 2011). A growing body of evidence about the

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impact and cost-effectiveness of nudges has led to their widespread deployment to address policy challenges in many domains, with a number of countries setting up "nudge" or "behavioral" units to use these insights more effectively in achieving policy goals, albeit predominantly in the developed world (OECD 2017).

The 2015 World Development Report laid out an agenda for the diffusing and adaptation of nudges to development, arguing that applying a deeper understanding of human behavior to program and policy design could "eventually alter the field of development economics and enhance the effectiveness of development policies and interventions" (World Bank 2015, 21). However, furthering the application of nudges to policy in developing countries requires more than replicating nudges tested in developed countries. Rather, it requires rigorous evidence on nudges that are designed with "close attention to the administrative burden or logistical requirements" they impose, since developing-world settings in general have greater resource, capacity, institutional, and implementation constraints than developed countries (Datta and Mullainathan 2014, 33).

Informed by this research agenda, this paper describes the results of a randomized controlled trial evaluating the effectiveness of three one-time nudges on water consumption in Belén, a town in Costa Rica, a middle-income country in Latin America. As in many other low- and middle-income countries, growing concerns about water scarcity coupled with limited impact from traditional price or information interventions has led to considerable interest among Costa Rican policy makers in exploring and evaluating innovative ways, including behavioral nudges, of reducing water consumption. Using the findings from a set of focus groups with town residents, the authors developed three nudges. The first, the "Neighborhood Comparison" treatment, took the form of a colored sticker pasted onto the monthly water bill, whose design leveraged social comparison, smiley/frowny faces, and water-saving tips. The second, the "City Comparison," used similar stickers, with the key difference being the use of city-wide, rather than neighborhood-wide, average water consumption as the reference point for the social comparison element. Finally, the "Planning Postcard" intervention consisted of a postcard leveraging salience, goal-setting, and implementation intentions. All residential households in Belen with active water connections were randomized into three treatment groups and a control group, with the interventions being delivered along with the July 2014 bill to households in the relevant treatment groups. The outcome of interest was changes in water consumption in the months immediately after the intervention. Water consumption in the months of August and September 2014 makes it possible to track the short-term impact of the intervention, but the study was also able to collect data for the months up to February 2015 in order to measure longer-term effects as well as rates of decay. The experimental implementation concluded in July 2014, with postexperimental data collation continuing till the end of February 2015.

The study builds on, but differs from, existing research using nudges for resource conservation in the developed world (Allcott and Mullainathan 2010; Ferraro and Price 2013) in important ways that make it possible to advance the agenda on applying nudges to development. These differences with key studies such as Ferraro and Price (2013) include novel intervention content; the absence of personalized feedback; the design of interventions whose form is informed by strict logistical, technological, and administrative constraints inherent in working with a government in a developing country; the central role of formative qualitative research in guiding intervention design; and the minimization of the need to collect data to evaluate impact. In what follows, the article discusses these key differences with past research and why they matter.

First, while two of the three interventions—a "Neighborhood Comparison" and a "City Comparison" arm—leveraged social comparisons, which have been used in past studies, they supplement these with water-saving tips (to aid the transition from intention-formation to action), and "smiley"/ "frowny" faces to make feedback more salient but also to use positive affirmation for existing good performers, mitigating any boomerang effects. Moreover, the smiley/frowny faces might be particularly effective in contexts where literacy is an issue. These interventions thus differ from prior

social-comparison-based nudges for water consumption, where social comparisons were supplemented with different elements from those used here: appeals to prosocial preferences (Ferraro and Price 2013) or the environmental implications of the impacts (Jaime and Carlsson 2016). Further, the third treatment, the "planning postcard," is entirely novel and untested in the context of water conservation, although it builds on existing research on the effectiveness of each of the behavioral principles (salience, implementation intentions, and so on) employed (Milkman et al. 2011; Stango and Zinman 2011). The intervention content is novel, both for the field of nudges as a whole as well as for its application to the issue of water or wider resource use, whether in the developed or developing world. This is not incidental: Datta and Mullainathan (2014, 33) argue that the deployment of nudges in development will require testing a "suite of linked design innovations" rather than an intervention that "seeks to isolate the impact of a single psychology or pathway." Each intervention tested was a portmanteau, designed to maximize impact rather than tease out the effect of individual behavioral insights or pathways.

Secondly, the interventions provide consumers with a way to compare themselves to a median household in a "catchment area" (neighborhood or city), rather than the kind of personalized feedback employed in similar developed-world nudge experiments around resource use (such as Allcott and Mullainathan 2010; Ferraro and Price 2013) as well as prior work in developing countries (Jaime and Carlsson 2016). This, again, is not an arbitrary choice, but rather reflects the constraints imposed by the limited information technology resources in the developing-world local government within which the interventions were implemented.

Thirdly, the form of the interventions—stickers affixed to an existing bill, or a postcard stapled to the existing bill—was also guided by a key logistical constraint: the city's inability to redesign the bill as a whole. Rather than create a new kind of bill (as in Allcott and Mullainathan 2010), the study explicitly tested an intervention that tightly hews to the physical and logistical constraints imposed by existing billing methods and technologies. Similarly, the use of brightly colored stickers whose colors corresponded to different combinations of treatment arm and feedback type was motivated by the need for the intervention to be implementable with high fidelity by nonspecialized municipal staff in Belén. In all these respects, the authors made design choices that pay "close attention to the administrative burden or logistical requirements" of the setting (Datta and Mullainathan 2014, 33), setting this experiment apart from prior research in order to increase its utility for the application of behavioral nudges at scale in low- and middle-income countries.

Fourthly, while the interventions build on the literature on behavioral nudges, the study explicitly bases the choice of which behavioral principles and corresponding nudges to employ on the output of a series of structured focus groups with residents of Belén, marking a departure from existing research, which typically bases these choices mainly on the literature. Thus, for example, this study uses a social comparison nudge because the qualitative research uncovers that most people lack a benchmark against which to evaluate their own water consumption.

Fifthly, this study relies entirely on households' water consumption data, which were already being collected by the partner municipality. This makes it possible to evaluate the impact of the intervention rigorously without incurring the significant additional costs involved in carrying out household surveys typically associated with randomized trials. This, of course, limits the ability to unpack findings along dimensions such as household size or income, which are not in the administrative data used. Nonetheless, such "nimble," low-cost experimentation using existing data is critical to advancing the affordable generation of rigorous evidence around behavioral insights in developing countries, and so may well be worth the trade-off—a line of thinking that seems to be gaining traction, as demonstrated by a recent World Bank call for proposals to carry out nimble, or "rapid, low-cost" evaluations (Holla 2018).

Beyond advancing the agenda around the application of nudges in development, this study also contributes to a key question for the literature on behavioral nudges in general, namely the issue of the durability and persistence of the effects of behavioral interventions. While this issue has begun to be

addressed in the literature, the evidence on the duration of effects from nudges is still relatively limited (see Brandon et al. [2017] and Allcott and Rogers [2014] for two recent examples in the context of energy nudges). By tracking the rate at which the effects from the one-time interventions decay, this study adds to the evidence on this issue.

Finally, as alluded to earlier, managing the demand for water is an issue that has gained increasing prominence in the development literature. The United Nations estimates that by 2025 over two-thirds of the world's population will reside in regions considered water stressed (UNDP 2006). The major part of this water scarcity is projected to be concentrated in the developing world, with concerns about water scarcity and supply being particularly salient to policy makers in urban jurisdictions, large and small, which are growing at an unprecedented pace. While the focus of the development community has traditionally been on advancing access to improved water sources and sanitation, cities—where 96 percent of the population had access to an improved source of drinking water in 2015 (UNICEF and WHO 2015)—often face a distinct set of policy challenges in this domain. Even as issues around the quantity and quality of water supply persist, the fact is that demand often outstrips the ability of local bodies and governments to provide reliable access to drinking water (Foster 2005). This means that devising effective, feasible, and cost-effective strategies for managing water demand in urban areas emerges as an important issue for policy making and research. This study contributes to the evidence base for effective strategies that governments can employ in this domain.

The key results are as follows. Relative to the control group, households in two of the three treatment groups significantly reduced their water consumption in the first two months after the intervention was implemented in July 2014. Regression estimates suggest that households that received the Neighborhood Comparison treatment reduced average monthly water consumption over the period August 2014 to September 2014 by 1.29 m^3, or 4.9 percent of control group consumption for the same period (26.25 m^3). The Planning Postcard intervention led to a reduction of 1.26 m^3, or about 4.8 percent of average monthly control-group consumption. The City Comparison reduced monthly consumption by 0.83 m^3, or 3.2 percent of control group consumption—an effect that is 64 percent the size of the effect from the Neighborhood Comparison, but one that, given the sample size, is statistically indistinguishable both from zero and from the effect of the neighborhood comparison. Thus, while the relative sizes of the effects from the Neighborhood and City comparison arms suggest that the former may be more effective, the evidence lacks the statistical power to treat this as more than an intriguing possibility that deserves further exploration. Finally, water consumption data for a further five months (that is, until February 2015) show that the interventions led to statistically significant reductions in water consumption for up to four months from their implementation.

Overall, the study was able to draw conclusions not just about whether nimble behavioral interventions succeeded in reducing water consumption in a developing country context, but also about the durability of the effects observed.

2. The Setting: Context in Belén, Costa Rica

The setting of this paper is Belén, a small municipality in Costa Rica. Belén's setting is similar to that inhabited by a large fraction of the world's population: despite the focus on growing megacities, "for the foreseeable future, the majority of urban residents still reside in much smaller urban settlements" as Cohen (2004, 31) points out. According to the 2011 Census, Belén has 21,633 inhabitants living in 6,011 individual dwellings with 3.59 occupants on average. The proportion of households with access to water service is 99.3 percent. Average water consumption in Belén is 27 cubic meters/month, 1.25 times the national average of approximately 22 cubic meters/month (Municipalidad de Belén 2010).

As in many urban jurisdictions, water for domestic use is supplied by the local government. As with many cities and towns globally, Belén could face water shortages by 2030 if consumption were to remain

constant and no additional production or investments were made. Reducing water consumption is thus a key policy priority for the municipal administration of Belén. Costa Rica, as a whole, is relatively water-rich; however, as in many countries, there is considerable risk of a water deficit in the near future, with shortages and rationing of water already prevalent in several parts of the country (Aguilar 2014). In addition to overall demand growth, spatially unbalanced development (or the overdevelopment) of areas with limited water supplies threatens water security.

The context and focus of this study—investigating the potential for using behavioral interventions to affect demand for publicly-provided residential water in a mid-sized town, with rising pressures on water supply and impending water scarcity, growing demand from households, and regulatory and logistical limits on the use of price instruments—is fairly typical of the context in which many policy makers in developing countries operate.

3. Intervention Design and Rationale

Three interventions were designed to try and nudge Belén residents' water consumption. Each intervention addressed some of the behavioral bottlenecks identified through a series of focus groups conducted with residents, which allowed us to understand some of the key aspects around water consumption behavior in Belén. These focus groups were conducted in February 2014 with residents from a variety of socioeconomic backgrounds.[1]

All three interventions were informed by key findings from the focus groups. First, residents *did not know how much water they themselves used*: almost none could say how much water they had consumed in the most recent month, perhaps because the inclusion of charges for both water and sanitation services on the same bill meant that the amount of water consumed was not salient. This is perhaps not uncommon: Attari (2014) finds that U.S. households typically underestimate their water use by a factor of about 2. This suggested that making residents' own water use *salient* to them could be a useful part of any intervention. This led us to make residents' water consumption salient in each of the interventions.

Secondly, residents could not evaluate whether a given level of water consumption was too high or reasonable, because they *lacked a benchmark against which to compare their own consumption*. This suggested that a suitable *benchmark* that placed a household's own water consumption in a relevant context, as in the literature on peer norms, might be useful, and led to the key "social comparison" component of both the social comparison interventions.

Thirdly, few participants could identify concrete steps they could take to reduce water consumption. While participants could name activities (such as watering a lawn, bathing, and brushing teeth) that resulted in water usage, the difficulty of estimating the intensity with which each activity used water meant that it was hard for them to prioritize ways to cut water consumption. This suggested the importance of enabling residents to make a clear plan—with a goal as well as specific steps—to reduce water use. This influenced the *inclusion of water-saving tips* on the versions of the social comparison interventions sent to households who had consumed more than the relevant average, as well as the inclusion of tips on the planning postcard.

Based on the results of the focus group, the study designed three treatments. In the "Neighborhood Comparison," a brightly-colored sticker on the water bill provided people with direct feedback on their own water consumption in comparison to that of the average household in their neighborhood. Households with consumption higher than the median received a yellow sticker with a "frowny face" and a

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1   In total, there were four focus groups with 6–7 participants per session. Three sessions were carried out with the heads of the households (either wife or husband) or members who are in charge of paying the water bill. The fourth session was carried out with maids working in Belén's residences. We streamed the sessions online but did not directly participate.

Figure 1. Sticker Designs: Neighborhood Comparison Intervention

English translation:
"Water also runs out, let's take care of it!"
"Your home consumed less water than the average home in your neighborhood. Good job!"

English translation:
"Look out! Your home consumed more water than the average home in your neighborhood"
"Some tips to reduce your consumption:
-   Take shorter showers.
-   Use less water for the lawn, lawn does not need water!
-   Wash cars less frequently"
"Water also runs out, let's take care of it!"

Source: Authors.

message alerting them to the fact that their water consumption exceeded the neighborhood average,[2] thus visually illustrating the negative feedback about past behavior, while the latter received a blue sticker with a "smiley face" and a message congratulating them for having consumed less water than the average household (see fig. 1 for sticker designs). The inclusion of the smiley face was intended to mitigate any mean-reversion effects on already well-performing households by giving them additional positive affirmation to encourage them to continue conserving water.

The second treatment, the "City Comparison," was identical except that the reference point was the average consumption in Belén and the colors of the stickers (the "smiley" and "frowny" stickers were green

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2   The stickers and planning postcard make reference to "average" (*promedio* in Spanish) and not median to facilitate comprehension.

Figure 2. Sticker Designs: City Comparison Intervention

English translation:
"Water also runs out, let's take care of it!"
"Your home consumed less water than the average home in your city. Good job!"

English translation:
"Look out! Your home consumed more water than the average home in your city"
"Some tips to reduce your consumption:
- *Take shorter showers.*
- *Use less water for the lawn, lawn does not need water!*
- *Wash cars less frequently"*
"Water also runs out, let's take care of it!"

Source: Authors.

and red), which were otherwise identical in design to those in the neighborhood comparison. The sticker colors varied between the two treatments, as well as between the "above median" and "below median" variants of each, in order to aid ease of implementation by the municipal worker tasked with sticking the intervention stickers onto the bills.[3] (See fig. 2 for the designs of the stickers used in this treatment arm.) By using two different reference points, the study tried to assess whether people's responsiveness to a comparison to different reference groups varied with the perceived social distance from that group (city versus neighborhood). The hypothesis was that people would be more responsive to the closer comparison group, that is, the neighborhood.

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3   While this is not ideal from an experimental design point of view, it was a compromise necessary to enable implementation fidelity in a low-resource setting. Care was taken during user testing to ensure that the colors chosen were culturally appropriate and did not introduce additional unintended emotional or cultural valence to the interventions.

The final intervention (denoted by the shorthand "Planning Postcard") built on the finding that few people in the focus group could identify concrete steps they could take to reduce water consumption. Households received a worksheet printed on a postcard along with their July 2014 bill. In addition to prompting recipients to enter their water consumption (making it salient) and compare it with the town average consumption in the same month (providing a benchmark, albeit without providing any explicit feedback as in the other interventions), which was printed on it, the postcard asked people to write down a personal goal for (further) water use reduction (thus encouraging recipients to set a water consumption goal) and to check one or more of six listed tips about ways to use less water. This intervention is perhaps best thought of as a combination of salience, goal-setting, and an implementation intention, which attempted to aid consumers in the journey from intention formation to action (see fig. 3).

It is worth noting that these simple interventions did not require elaborate software to implement, unlike personalized bills containing messages about relative consumption printed on them, which similar interventions in the United States have used (see, for instance, Ferraro and Price 2013). The interventions required only that the municipality in Belén be able to print out color stickers and that the office in charge of stuffing bills into envelopes had access to a spreadsheet that told staff which sticker or postcard to use with each bill. This rendered the intervention feasible in a setting with several technological and resource constraints. It should be noted that the third intervention is even easier to implement. In contrast to the other two interventions, which required the implementing agency to assign or hire a person who could, at a minimum, work out whether a given household's water consumption was above or below the mean for the relevant reference group, the "Planning Postcard" intervention put the entire onus of determining relative consumption on the recipient household. The goal in using this particular format for this intervention was to reduce the human capital requirements for implementing a behavioral intervention to the bare minimum.

4. Experimental Design

The sample was drawn from a list of active residential water consumers in Belén in April 2014.[4] The unit of observation and randomization in the experiment is a physical location, that is, a house or dwelling unit with a water meter. The interventions were implemented during the July 2014 billing cycle in Belén, when households received water bills that were based on their water consumption in the 31-day period prior to this bill being generated. While billing is monthly, households receive their bills at different dates of the month depending on which of one of 25 "postal routes" the residence belongs to. This is due to a unique feature of Costa Rica: lack of official addresses. Outside San José, most addresses simply contain reference points rather than unique addresses. As such, the municipality relies on one or two civil servants to distribute the water bills, and to minimize travel time, they do so following 25 postal routes. The study therefore stratified the households according to the postal route and neighborhood it belongs to. The residences were then randomized into the three treatment groups described above and a control group (fig. 4).

The rationale for the randomization process was the following: The study randomized within "postal routes" because they determine the date on which households receive their monthly water bill, and inter alia, the dates of consumption that this bill covers. The consumption period always refers to the month prior to the generation of the water bill (table 1). Thus, one household might receive a July water bill that is based on water consumption between June 2 and July 1, whereas another's July water bill might be based on consumption between June 8 and July 7. In all cases, however, bills are generated based on the water consumed during the month since the last bill for that route was generated. The study also randomized

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4 The study excluded commercial establishments and residential condominium associations, which receive a joint bill rather than a household-level bill.

Figure 3. Planning Postcard Intervention Design

También en Belén el agua se agota....
¡Evitemos el desperdicio!

Instrucciones: Llena este formulario para planificar cómo tu hogar ahorrará agua.

Consumo promedio mensual de agua en Belén ___**29**___ m³

Este mes, mi hogar consumió: _____ m³

Vamos a seguir reduciendo el consumo a: _____ m³

Vamos a lograr esta meta a través de:
Marque todas las opciones que correspondan.

- Utilice menos agua para regar el jardín. El zacate no necesita agua!
- Cierre el tubo al cepillarse los dientes y al rasurarse.
- No lave el carro a menudo.
- Dúchese en menos tiempo.
- Busque fugas de agua y repárelas.
- Utilice una escoba y no el agua para limpiar la acera.

Visite la página web http://www.belen.go.cr/consulta/Consulta_Agua.htm para más detalle sobre el costo del consumo de agua.

Si tiene alguna duda, puede contactarse con la Dirección de Servicios Públicos al teléfono 2587-0200 / 2587-0201 o al correo electrónico servicios@belen.go.cr

English translation:
"Water in Belén also runs out, let's avoid the waste!"

"Instructions: fill out this form to plan how you will save water:
Average monthly water consumption in Belén: 29 m3.
This month, my home consumed: __ m3.
We will continue reducing our consumption to: __ m3."

"We will achieve this goal through. Check all the options that apply:
Use less water for the lawn, lawn does not need water!
Close the pipe while brushing teeth and shaving.
Wash car less frequently.
Take shorter showers.
Look for water leaks and repair them.
Use a broom and not the water to clean the sidewalk."

within each of the six neighborhoods, to minimize any potential unobserved bias at the neighborhood level because each neighborhood has specific socioeconomic characteristics (for instance, some neighborhoods are considered wealthier, compared to others, and have bigger dwellings and consume more water).

A power analysis was conducted, which made it possible to have up to three treatments and a control group. Sample size was calculated based on a 0.9 power level, and the Type I error rate was set at 0.05. The power analysis implied a sample size of nearly 1,400 water meters (a.k.a. residences or households) per treatment. The first treatment arm ($n = 1,399$) received the "Neighborhood Comparison" treatment. The second treatment arm ($n = 1,399$) received the "City Comparison" treatment. The third treatment arm ($n = 1,399$) received the "Planning Postcard" intervention. The control group ($n = 1,429$) received no additional information during the experiment, and continued to receive a utility bill without a sticker or

Figure 3. (continued)

También en Belén el agua se agota....
¡Evitemos el desperdicio!

Instrucciones: Llena este formulario para planificar cómo tu hogar ahorrará agua.

Consumo promedio mensual de agua en Belén ___**29**___ m³

Este mes, mi hogar consumió: _____ m³

Nos comprometemos a reducir el consumo a: _____ m³

Vamos a lograr esta meta a través de:
Marque todas las opciones que correspondan.

Utilice menos agua para regar el jardín. El zacate no necesita agua!

Cierre el tubo al cepillarse los dientes y al rasurarse.

No lave el carro a menudo.

Dúchese en menos tiempo.

Busque fugas de agua y repárelas.

Utilice una escoba y no el agua para limpiar la acera.

Visite la página web http://www.belen.go.cr/consulta/Consulta_Agua.htm para más detalle sobre el costo del consumo de agua.

Si tiene alguna duda, puede contactarse con la Dirección de Servicios Públicos al teléfono 2587-0200 / 2587-0201 o al correo electrónico servicios@belen.go.cr

English translation:
"Water in Belén also runs out, let's avoid the waste!"

"Instructions: fill out this form to plan how you will save water:
  Average monthly water consumption in Belén: 29 m3.
  This month, my home consumed: __ m3.
  We are committed to reducing consumption to: __ m3."

"We will achieve this goal through. Check all the options that apply:
  Use less water for the lawn, lawn does not need water!
  Close the pipe while brushing teeth and shaving.
  Wash car less frequently.
  Take shorter showers.
  Look for water leaks and repair them.
  Use a broom and not the water to clean the sidewalk."

Source: Authors.

postcard. The final number of households in the experiment was slightly smaller because a change in billing meters in Belén in June 2014 made it necessary to drop some households from the experiment.[5] Although households were not informed about the experiment, the stickers and planning card included the contact of someone at the municipality who could clarify questions related to the information being shared.

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5   In June 2014, the Municipality of Belén started to change water meters, independently of the experiment. Due to the inability to merge postexperiment houses by their unique identifier (meter number), the study lost approximately 8 percent of the original randomized sample. The numbers of observations dropped are homogeneous across treatment arms and did not impact the results.

Figure 4. Timeline Data Collection and Intervention

Source: Authors.
Note: See table 1 for specific intervention delivery dates.

Table 1. Intervention Delivery Dates, by Postal Route Number (July 2014)

Delivery Date	Postal route number			
1-Jul-14				
2-Jul-14	25			
3-Jul-14	21	22	23	
4-Jul-14	14	20		
5-Jul-14		Weekend		
6-Jul-14				
7-Jul-14				
8-Jul-14				
9-Jul-14	1	24		
10-Jul-14	2			
11-Jul-14	3	4	5	13
12-Jul-14		Weekend		
13-Jul-14				
14-Jul-14	6	7		
15-Jul-14	8	9		
16-Jul-14				
17-Jul-14	10	11		
18-Jul-14	12	16		
19-Jul-14		Weekend		
20-Jul-14				
21-Jul-14				
22-Jul-14	15	17	18	19
23-Jul-14				
24-Jul-14				
25-Jul-14				
26-Jul-14		Weekend		
27-Jul-14				
28-Jul-14				
29-Jul-14				
30-Jul-14				
31-Jul-14				

Source: Municipality of Belen's Public Service Unit.

Randomization Check

Table 2 compares baseline water consumption in the four intervention arms (three treatments and one control group) to check for the validity of the randomization. It compares four outcomes: monthly average consumption from December 2012 to November 2013 (12 months), monthly average consumption from January 2013 to November 2013 (11 months), monthly average consumption from May 2013 to June 2013 (2 months), and year-on-year changes from May/June 2013 to May/June 2014.[6] No statistically significant difference was found for any categorization. Average monthly water consumption for the control group is 25.6–28.1 m^3, and there was no significant difference in the baseline water consumption between households in any of the treatment groups and the control group, or in the year-on-year increase in water consumption between the two months prior to the intervention and the corresponding two months of the previous year.[7] The randomization was validated.[8]

5. Analysis and Results

As discussed, monthly water consumption data are available for all sample households. The postintervention consumption variables were named "August 2014 Billed Consumption" and "September 2014 Billed Consumption." As noted above, the way that bills are generated and distributed means that each

Table 2. Summary Statistics and Randomization Check (Treatments vs. Control)

Water consumption (m^3)	Control (C)	Neighborhood comparison		City comparison		Planning postcard	
		Treatment (T$_{NC}$)	Difference (C-T$_{NC}$)	Treatment (T$_{CC}$)	Difference (C-T$_{CC}$)	Treatment (T$_{PP}$)	Difference (C-T$_{PP}$)
Monthly average Dec 2012 to Nov 2013	27.38	27.47	−0.09	27.21	0.17	27.85	−0.47
Standard errors	(0.58)	(0.69)	(0.90)	(0.50)	(0.77)	(0.65)	(0.87)
Observations	1312	1287	2599	1287	2599	1274	2586
Monthly average Jan 2013 to Nov 2013	25.59	25.58	0.02	25.39	0.20	26.01	−0.42
Standard errors	(0.54)	(0.64)	(0.84)	(0.47)	(0.72)	(0.61)	(0.81)
Observations	1312	1287	2599	1287	2599	1274	2586
Monthly average May 2013 to June 2013	28.07	28.02	0.05	27.80	0.27	29.09	−1.02
Standard errors	(0.60)	(0.76)	(0.97)	(0.58)	(0.84)	(0.71)	(0.93)
Observations	1339	1321	2660	1309	2648	1304	2643
Yearly change May/June 2013 to May/June 2014	1.25	1.42	−0.16	1.33	−0.07	1.24	0.01
Standard errors	(0.06)	(0.11)	(0.13)	(0.09)	(0.10)	(0.10)	(0.11)
Observations	1324	1299	2623	1293	2617	1282	2606

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are unconditional parameter estimates (standard errors in parentheses) for a series of *t*-tests of water consumption outcomes (in cubic meters). The first column shows the pretreatment outcome variables for the control group, while the following columns show the average water consumption for each treatment and the difference with the average consumption for the control group. None of the results are statistically significant, suggesting that randomization was effective. * denotes significance at 10 percent, ** significance at 5 percent and *** significance at 1 percent.

6   The number of observations varies slightly for each definition because not all water meters were active in all months (for instance, the water service could be shut down due to unpaid bills or because the water meter was not working properly or, simply, the civil servant did not read the water meter).

7   Note that the municipality did not have data for December 2013. The study therefore used January–November 2013 and December 2012–November 2013 as the "baseline period" for the purposes of the randomization check.

8   Unfortunately, the Municipality of Belén does not systematically collect other household-level variables (such as resident characteristics) that would make it possible to check the randomization.

bill covers the 31-day period prior to its generation.[9] Thus, the outcome data is water consumption for each household *during the two-month period since it received the intervention bill*. For the bulk of the analysis, the study will report results on the average postintervention water consumption, that is, the mean of August and September 2014 billed consumption.

Unconditional Experimental Estimates

Result 1: Comparison of Means Shows That Treatment Groups Reduce Water Consumption More than the Control Group

Table 3 shows the unconditional difference between control and treatment observations for August 2014 Billed Consumption, September 2014 Billed Consumption, and the average in both August 2014 and September 2014 billed consumption. As observed, water consumption in treatment households declined more than in control households, although these unconditional estimates are significant only in the case of one treatment in one of the months. More important, water usage decreased noticeably in September 2014 (compared to August 2014) for the Neighborhood Comparison and Planning Postcard treatment, while only marginally for the City Comparison treatment group.

Table 4 shows the differences between average postintervention water consumption (that is, the average of August 2014 Billed Consumption and September 2014 Billed Consumption) and the average water consumption in the rainy season of 2013 (that is, the average of water consumption between May and November 2013), by treatment status; in other words, it estimates a difference-in-difference, asking whether the size and direction of changes in water consumption between the postintervention period and the "pre-intervention period" was different for treatment groups versus the control group. The study uses water consumption in the rainy season of 2013 as the measure of "preintervention" water consumption to ensure that seasonal factors, which have large effects on water use, are minimized. This ought to ensure that differences in pre- and postintervention water consumption are not driven mainly by seasonality.

Table 3. Post-Treatment Unconditional Means (Treatments vs. Control)

Water consumption (m^3)	Control (C)	Neighborhood comparison		City comparison		Planning postcard	
		Treatment (T$_{NC}$)	Difference (C-T$_{NC}$)	Treatment (T$_{CC}$)	Difference (C-T$_{CC}$)	Treatment (T$_{PP}$)	Difference (C-T$_{PP}$)
August 2014	26.62	25.65	−0.98	25.53	−1.10	25.95	−0.67
Standard errors	(0.66)	(0.59)	(0.89)	(0.57)	(0.87)	(0.80)	(1.03)
Observations	1314	1303	2617	1290	2604	1283	2597
September 2014	26.19	24.68	−1.51*	24.94	−1.25	24.73	−1.46
Standard errors	(0.70)	(0.57)	(0.90)	(0.54)	(0.89)	(0.59)	(0.92)
Observations	1332	1317	2649	1302	2634	1299	2631
Average August to September 2014	26.41	25.21	−1.20	25.25	−1.16	25.32	−1.09
Standard errors	(0.64)	(0.55)	(0.85)	(0.53)	(0.84)	(0.67)	(0.93)
Observations	1310	1299	2609	1283	2593	1278	2588

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are unconditional parameter estimates (standard errors in parentheses) for a series of *t*-tests of water consumption for August 2014, September 2014, and the average between August and September 2014 (in cubic meters). The first column shows the post-treatment outcome variables for the control group, while the following columns show the average water consumption for each treatment and the difference with the average consumption for the control group. *denotes significance at 10 percent, **significance at 5 percent and ***significance at 1 percent.

9   This means that consumption in an August bill, for example, covers a month-long period that lies mostly in July and partly in August, but all of which lies after the consumption period covered by the July bill.

Table 4. Differences-in-Difference in Water Consumption. Difference between Average Monthly Water Consumption between Post-Treatment (August to September 2014) and Pre-Treatment Rainy Season (May to November 2013) in m³

	Δ Control	Δ Treatment	ΔT − ΔC
		Neighborhood comparison	
Outcome	−0.24	−1.50	−1.26*
Standard errors	(0.40)	(0.53)	(0.66)
Observations	1285	1267	2552
		City comparison	
Outcome	−0.24	−0.93	−0.68
Standard errors	(0.40)	(0.44)	(0.60)
Observations	1285	1261	2546
		Planning postcard	
Outcome	−0.24	−1.52	−1.27**
Standard errors	(0.40)	(0.43)	(0.59)
Observations	1285	1248	2533

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are unconditional parameter estimates (standard errors in parentheses) for a series of t-tests of water consumption on the difference between average monthly water consumption between post-treatment (August to September 2014) and pretreatment rainy season (May to November 2013) in cubi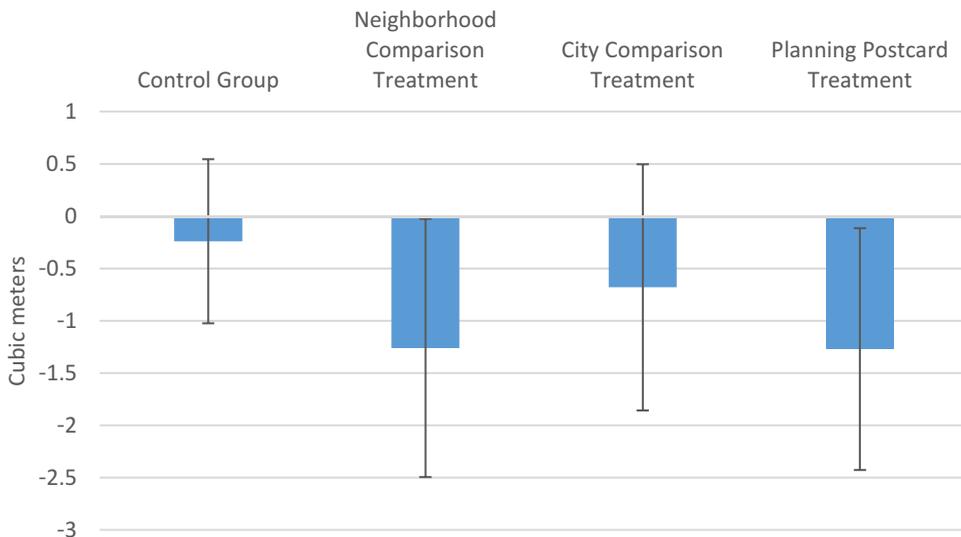c meters. The first column shows the post-treatment outcome variables for the control group, while the panels show the average water consumption for each treatment. *denotes significance at 10 percent, **significance at 5 percent and ***significance at 1 percent.

Figure 5 presents this information graphically. Average water consumption in treated households declined by more than control-group households for each of the three treatments, although the difference-in-differences estimates are significant only for the Neighborhood Comparison and Planning Postcard interventions.

Figure 5. Change in Average Monthly Water Consumption between Rainy Season 2013 (Pretreatment) and August and September 2014 (Post-treatment)

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: The figure provides a graphical representation of estimates shown in table 3 representing the unconditional point estimates. All the set of bars show the average water consumption difference between average monthly water consumption between post-treatment (August–September 2014) and pretreatment rainy season (May–November 2013) in cubic meters.

Conditional Experimental Estimates

In what follows, the article presents regression results where water consumption for August and September 2014 (in cubic meters) was regressed on three dummy variables representing the three treatments in the experiment (see equation 1). To increase the precision of the estimates, the study also includes, as explanatory variables, previous household consumption to capture water consumption patterns (X_i) and route billing fixed effects (γ_j), similar to Ferraro and Price (2013). The main outcome is the average water consumption in August to September 2014. In additional specifications, the study uses data for a further five months—up to February 2015—to evaluate medium-term impacts. To control for heteroskedasticity, the study estimates clustered robust standard errors for the model:

$$Y_{\text{Aug–Sep } 2014_{ij}} = \alpha_i + \beta_1 * Treat_1 + \beta_2 * Treat_2 + \beta_3 * Treat_3 + \gamma_j + \theta_i * X_i + \varepsilon_{ij} \tag{1}$$

where the unit of observation is household "i" within route billing "j"; $Treat_1$ refers to the neighbor comparison treatment, $Treat_2$ refers to the city comparison treatment, and $Treat_3$ refers to the planning postcard treatment.

The preferred estimations use the rainy season months in preference to using all previous months of consumption in 2014 because several of them would have fallen in the dry season (December to April), when water use patterns are likely to have been quite different from those in the postintervention months. The coefficients β_1, β_2, and β_3, are the parameters of interest and represent the marginal value of each intervention. In order to check that the results are robust to these econometric choices, we also ran a fixed effects panel model (table 5) and used alternative measures of baseline water consumption in equation (1) (table 6).

Table 5. Robustness Check: Effect of Treatments on Post-Treatment Water Consumption using Fixed-Effects Panel Models

	Water consumption (m^3)
Neighborhood comparison treat * Post-treatment	−0.789[*]
	(0.410)
City comparison treat * Post-treatment	−0.573
	(0.411)
Planning postcard treat * Post-treatment	−0.833[**]
	(0.411)
Post-treatment	−1.098[***]
	(0.289)
Constant	27.15[***]
	(0.0513)
Observations	83,954
R-squared	0.002
Number of HHs	5,273

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are parameter estimates (standard errors in parentheses) for a fixed effect panel model of water consumption (in cubic meters). Cell entries can be read as follows: households that were randomly assigned into the neighborhood treatment consumed approximately 0.79 m^3 fewer on average than those in the control group. Similarly, households that were randomly assigned into the planning postcard treatment consumed approximately 0.83 m^3 fewer on average than those in the control group. Standard errors are clustered at the household level. [*] Denotes significance at 10 percent, [**] significance at 5 percent and [***] significance at 1 percent.

Result 2: The Neighborhood Comparison Group Reduced Water Use by 4.6 Percent of Control Group Consumption. The City Comparison Treatment Has a Smaller (but not Statistically Significant) Effect on Water Consumption of 2.9 Percent of Control Group Consumption

Table 7 presents the central regression results for equation (1). The study regressed postperiod water consumption on treatment status and control for baseline water consumption. Reading across the first row, it is shown that relative to the control group, the Neighborhood Comparison Treatment reduces water

Table 6. Robustness Check: Effect of Treatments on Average Post-Treatment Water Consumption Using Alternative Measures of Baseline Water Consumption

	Average of August and September 2014 water consumption (m^3)					
	(1)	(2)	(3)	(4)	(5)	(6)
Neighborhood comparison treatment	-1.27^*	-0.98^{**}	-1.47^{**}	-1.27^*	-0.99^{**}	-1.47^{**}
Standard errors	(0.67)	(0.50)	(0.58)	(0.67)	(0.49)	(0.58)
City comparison treatment	-0.81	-0.77	-0.92	-0.82	-0.77	-0.92
Standard errors	(0.65)	(0.50)	(0.56)	(0.65)	(0.49)	(0.56)
Planning postcard treatment	-1.11^*	-0.90^{**}	-1.46^{***}	-1.13^*	-0.93^{**}	-1.49^{***}
Standard errors	(0.64)	(0.46)	(0.57)	(0.64)	(0.46)	(0.57)
Constant	11.40^{***}	2.96^{***}	6.09^{***}	8.77^{***}	1.42	4.97^{***}
Standard errors	(2.13)	(1.12)	(1.71)	(1.97)	(1.25)	(1.59)
August and September 2013 consumption	Yes			Yes		
Rainy season 2013 consumption (May13 to Nov13)		Yes			Yes	
May to June 2014 consumption		Yes			Yes	
Average annual consumption (Dec12 to Nov13)			Yes			Yes
Billing date fixed effects				Yes	Yes	Yes
Mean outcome value (m^3)	28.30					
Observations	5126	5061	5061	5126	5061	5061
R-squared	0.41	0.68	0.56	0.41	0.69	0.56

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are parameter estimates (standard errors in parentheses) for a series of linear regression models of water consumption (in cubic meters). The models differ in whether billing dates fixed effects are included and specific explanatory variables on previous water use. Cell entries can be read as follows: as indicated in column (1), households that were randomly assigned into the neighborhood treatment consumed approximately 1.27 m^3 fewer on average than those in the control group. Standard errors are clustered at the household level. *denotes significance at 10 percent, ** significance at 5 percent and *** significance at 1 percent.

consumption by 1.29 m^3 per household, or 4.9 percent of water consumption for the control group over the same period. Results are statistically significant in both specifications at least at 5 percent ($p < 0.05$ level). In contrast, there is no evidence that the City Comparison reduced water consumption significantly in any specification, although the point estimates point to a statistically insignificant effect that is consistently negative and represents three-fifths the size of the effect of the Neighborhood Comparison. While the estimated effect sizes for the City Comparison are consistently smaller than that for the Neighborhood Comparison, the statistical power is not strong enough to differentiate between the two effect sizes and cannot therefore provide more than suggestive evidence in favor of the hypothesized relationship between the proximity of the reference group and the corresponding effect on behavior.

Result 3: The "Planning Postcard" Group Reduced Water Use by 4.8 Percent of Control Group Water Consumption
Reading across the third row of table 7, it can be seen that relative to the control group, the Planning Postcard treatment reduces water consumption by 1.26 m^3 per household, or 4.8 percent of water consumption for the control group over the same period. Results are statistically significant at the 5 percent ($p < 0.05$ level) for the preferred specification (column (2)), which includes previous water consumption as explanatory variables as well as billing dates fixed effects.

It would have been useful to gather the following information: (a) whether the postcard, (b) whether the households, and (c) which steps. This information would have helped both in understanding which bits of this portmanteau "Planning Postcard" intervention generated the 4.5 percent reduction in water use as well as why the overall effect was similar to that of the neighborhood social norm intervention. Unfortunately, it was not possible to track these behaviors, and so it was not possible to shed further light on these issues.

Table 7. Effect of Treatments on Average Post-Treatment Water Consumption

	Average of August and September 2014 water consumption (m^3)	
	(1)	(2)
Neighborhood comparison treatment	−1.28**	−1.29**
Standard errors	(0.60)	(0.60)
City comparison treatment	−0.81	−0.83
Standard errors	(0.58)	(0.58)
Planning postcard treatment	−1.23**	−1.26**
Standard errors	(0.59)	(0.59)
Constant	7.12***	5.41***
Standard errors	(1.89)	(1.75)
Rainy season 2013 consumption (May13 to Nov13)	Yes	Yes
Billing date fixed effects		Yes
Mean outcome value (m^3)	28.3	
Observations	5061	5061
R-squared	0.52	0.53

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are parameter estimates (standard errors in parentheses) for a series of linear regression models of water consumption (in cubic meters). The models differ in whether billing dates fixed effects are included. Cell entries can be read as follows: as indicated in column (1), households that were randomly assigned into the neighborhood treatment consumed approximately 1.28 m^3 fewer on average than those in the control group. Standard errors are clustered at the household level. * denotes significance at 10 percent, ** significance at 5 percent and *** significance at 1 percent.

As discussed above, robustness checks were run to ensure that the results were not driven by the choice of specification and/or measure of baseline water consumption. The choice of different baseline water consumption measures does not affect the sign or statistical significance of the estimated treatment effects (see table 6). Similarly, a fixed-effect panel data model confirms the effectiveness of the neighborhood comparison and the planning postcard (see table 5), albeit with the average estimates lower than the linear estimates shown in table 7, but within the confidence interval. Angrist and Piscke (2009) suggest that panel data estimators tend to be smaller than estimates from cross-sectional data due to bias from measurement error that is aggravated when individual effects are removed.

Result 4: Neighborhood Comparison and the Planning Postcard Significantly Reduce Water Consumption for up to Four Months After the Intervention Period

Table 8 replicates the results of table 4 using consumption data for one additional month at a time. As table 7 shows for the preferred specification (that is, controlling for the previous year's rainy season as well as for billing date fixed effect), the interventions continue to reduce average water consumption for up to four months since implementation with statistical significance at the $p < 0.05$ level using a parametric test (see columns (1), (2), and (3) in table 8). However, as shown in columns (4), (5), and (6), the average water consumption in the treatment groups, while still smaller in magnitude than that of the control group, is no longer statistically distinguishable from the latter by the fifth month since the one-time behavioral interventions were implemented in July 2014.[10] That is, the size of the average treatment effect diminishes monotonically with time, becoming statistically indistinguishable from zero by the fifth month since implementation. Figure 6 gives a graphical representation of this information for the Neighborhood Comparison and Planning Postcard treatments (including results for the 2-months period from table 7).

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10 Following Ferraro and Miranda (2014), to adjust for multiple hypothesis testing, the results were evaluated using a conservative Bonferroni adjustment (that is, taking the predetermined Type I error rate 0.05 and dividing it by the number of tests; the null of no difference is rejected if $p < 0.008$). Results up to four months do not change the conclusions.

Table 8. Short and Medium-Term Effects of Treatments on Average Post-Treatment Water Consumption

	Average water consumption (m^3)					
	2 months (Aug 14 to Sep 14) (1)	3 months (Aug 14 to Oct 14) (2)	4 months (Aug 14 to Nov 14) (3)	5 months (Aug 14 to Dec 14) (4)	6 months (Aug 14 to Jan 15) (5)	7 months (Aug 14 to Feb 15) (6)
Neighborhood comparison treatment	−1.29**	−1.132**	−1.169**	−0.790	−0.769	−0.845
Standard errors	(0.60)	(0.566)	(0.540)	(0.718)	(0.661)	(0.619)
City comparison treatment	−0.83	−0.603	−0.615	−0.481	−0.508	−0.423
Standard errors	(0.58)	(0.537)	(0.505)	(0.543)	(0.518)	(0.503)
Planning postcard treatment	−1.26**	−1.092**	−1.047**	−0.898	−0.327	−0.350
Standard errors	(0.59)	(0.534)	(0.516)	(0.548)	(0.685)	(0.654)
Constant	5.41***	6.397***	6.379***	6.061***	5.559***	5.607***
Standard errors	(1.75)	(1.592)	(1.558)	(1.612)	(1.612)	(1.610)
Rainy season 2013 consumption (May13 to Nov13)	Yes	Yes	Yes	Yes	Yes	Yes
Billing date fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Mean outcome value (m^3)	28.30	27.02	26.90	27.12	27.84	28.10
Observations	5061	4919	4917	4913	4912	4894
R-squared	0.530	0.528	0.550	0.451	0.435	0.468

Source: Authors' own calculations from Municipality of Belen's water consumption database.

Note: Cell entries are parameter estimates (standard errors in parentheses) for a series of linear regression models of water consumption (in cubic meters). The models differ in the number of months considered for the outcome average. All models include billing dates fixed effects and 2013 rainy season as explanatory variables. Results for column (1) are obtained from table 7, column (2). Results for columns (2)–(6) are obtained from similar regressions available upon request. Cell entries can be read as follows: as indicated in column (1), households that were randomly assigned into the neighborhood treatment consumed approximately 1.29 m^3 fewer on average than those in the control groups two months after the experiment was implemented. Standard errors are clustered at the household level. * denotes significance at 10 percent, ** significance at 5 percent and *** significance at 1 percent.
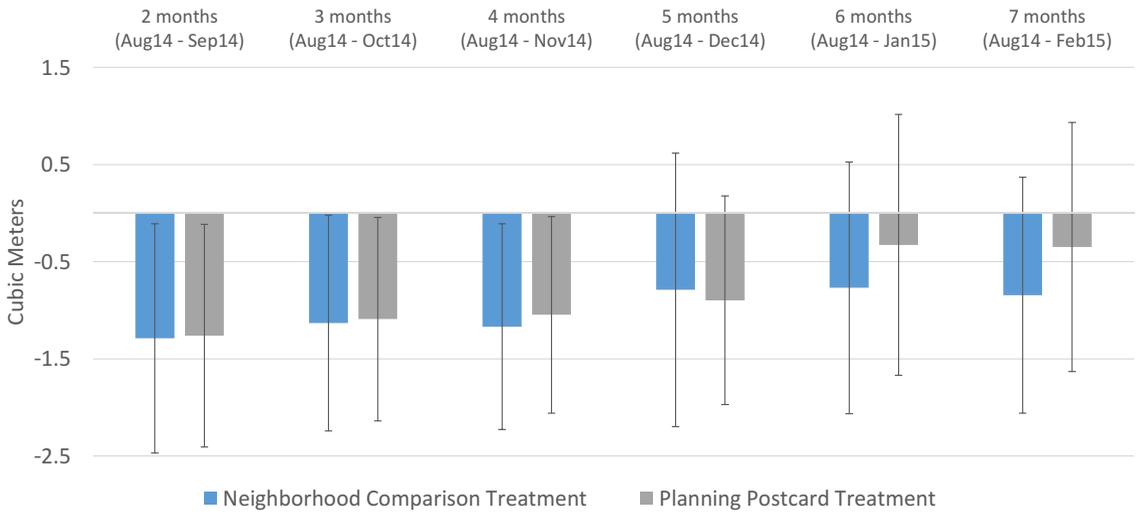
Result 5: The Interventions Are Cost-Effective

Since the price of water in Belén is not set to equal its marginal cost of production, and there are no direct measures of the costs of supplying water available, it is not possible to carry out a true cost-effectiveness calculation. Nonetheless, a rough calculation based on the monthly average water consumption and the current water rates[11] suggest that the monthly water savings (from the household perspective) in monetary terms could be estimated to be from ¢2.8 million colones (US$5,240) to ¢5.6 million colones (US$10,470), about 13 to 26 times the US$400 spent on the intervention (mainly the cost of producing the stickers and postcards). Including the manpower to manage the interventions (assuming conservatively a week of a professional's time), the ratios decrease to five to nine times the potential total cost. As suggested by Result 5, the intervention has potential benefits up to four months, while the costs are one-time, so that the cost-benefit ratio estimates are fairly conservative.

In terms of water conserved, the results indicate that, on average, Belén would reduce water use by approximately 6,720 m^3 each month as a result of either of the most effective interventions—the neighborhood comparison or planning postcard. In perspective, this is equivalent to 87,300 fewer baths, 94,080 fewer washing machine loads, 188,000 fewer showers, 221,760 fewer dishwasher loads, or 745,920 fewer toilet flushes.

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11 Water rates in Belén follow an increasing block tariff scheme; that is the rate per unit of water increases as the volume of consumption increases. From 0 to 20 cubic meters, the tariff is 1,400 colones (nearly US$2.6). From 21 to 40 cubic meters, each cubic meter costs on average 250 colones (nearly US$0.5). After 40 cubic meters, prices start increasing substantially; however, most of households consume less than 40 cubic meters.

Figure 6. Effect of Treatments over Time from Two Post-Treatment Months (August 2014 to September 2014) up to Seven Post-Treatment Months (August 2014 to February 2015)

Source: Authors' own calculations from Municipality of Belen's water consumption database.
Note: The figure provides a graphical representation of the estimates shown in table 6 representing the conditional point estimates (in cubic meters) for the preferred specification, that is, controlling for the previous year's rainy season as well as for billing date fixed effect.

6. Key Contributions and Policy Relevance

Considerable promise attaches to the application of behavioral approaches to policy issues in developing countries, but we need to adapt both the kinds of interventions they design, and the ways in which they test them, to derive scalable insights about how best to cost-effectively apply behavioral economics to improve outcomes of interest. By designing and testing a set of low-cost, easily implemented and technologically undemanding nudges to reduce water consumption in a small town in Costa Rica, this study contributes to building a body of evidence about how behavioral nudges can be used in low-resource, low-capacity settings where design and implementation are subject to resource, logistical, and administrative constraints.

Secondly, working with governments, who often are responsible for water services and who interface directly with citizens, is critical to ensuring that interventions can be scaled. Yet, while behavioral economics has the potential to cost-effectively improve outcomes at all levels of government, this study is perhaps the first to apply behavioral economics to water use in a municipality in a developing country.

Thirdly, the study shows that simple one-time interventions based on behavioral economics are effective at curbing water use. Given constraints on the ability to increase supply and the corresponding need to dampen demand, the findings of this study are encouraging insofar as they suggest that behavioral economics interventions can supplement the price- and persuasion-based tools currently in use to tackle this issue, and can do so cost-effectively.

Finally, the study finds that the effects from a one-time intervention can last up to four months, beyond which they attenuate. While this is an improvement over prior studies that only looked at even shorter-term effects, it does suggest that a key direction for future research is to investigate the duration of effects and to derive implications for optimal frequency of interventions. Ideally, these experiments would have a price arm, in order to facilitate the comparison of the long-term effects of behavioral interventions with those of changes in prices. Such experimentation would aid policy makers in determining the optimal mix of complementary policy instruments.

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