



ARTICLE



<https://doi.org/10.1057/s41599-025-04608-2>

OPEN

Information is not enough to boost water savings in hotel rooms

Sofía López-Rodríguez ^{1✉}, Bartolomé Deyá-Tortella ¹ & Tomás Lejarraga ^{1,2}

Water is a key scarce resource. Therefore, most hotels place written messages in their rooms to promote guests' water-saving behaviors. Existing research has focused on how *nudges* prompt towel reuse, reducing water consumption indirectly. We examine the impact of a *boost*—that fosters people's competences—on direct water consumption in the shower, tap, and toilet. We conducted two field studies in Mallorca, Spain, in 2022 and 2023, at 14 hotel rooms equipped with digital water meters. In treatment rooms, guests were exposed to a leaflet informing them about water scarcity in Mallorca and of ways to save water in the hotel room. In the control condition, rooms had no leaflets. The results show that the *boost* had no impact on guests' water savings—but on towel reuse. Our findings, with important implications for hotel management and policy making, show some limits of *boosts* for direct water conservation and reveal a possible form of greenwashing.

¹Universitat de les Illes Balears, Palma, Spain. ²Max Planck Institute for Human Development, Berlin, Germany. ✉email: sofia.lopez@uib.es

Introduction

Insufficient fresh water is one of the most critical environmental challenges that many parts of the world face today and in the coming decades (UN, 2023). There are many causes for the current *water stress*¹, such as the exponential increase in population, the changes in water consumption habits, the effects of climate change, and the growth of water-intensive economic activities (Vandecasteele et al. 2014). One of the most water-intensive economic activities is tourism (Angulo et al. 2014; Cole, 2012; Essex et al. 2004; Holden, 2016; Rico-Amoros et al. 2009; UNWTO, 2012). The daily water consumption by a tourist in developed countries can double or even triple the consumption of residents in those regions, and estimates indicate significant growth in the coming years (UNWTO, 2012; UNEP, 2024).

Compared to other accommodation options, such as bed-and-breakfasts or camp sites, hotels have the highest water consumption per guest (Mendoza et al. 2023). Moreover, given that hotels serve most of the demand for accommodation in most destinations (AETIB, 2023; Turespaña, 2024), they play a central role in the conservation and sustainability of water resources (Han et al. 2020; International Tourism Partnership, 2014; Kasim et al. 2014; Styles et al. 2015).

In-room water consumption accounts for 126 l/gn, (37.27% of total direct water consumption)—and within rooms, showers consume the most (70 l/gn) followed by toilets (45 l/gn), taps (8 l/gn), and bathtubs (3 l/gn)—Gössling (2015). For this reason, hotel managers have traditionally attempted to influence tourist behaviors to reduce water consumption at hotel rooms.

Besides, in recent years, private and public organizations have used insights from the behavioral sciences to influence the behavior of customers and citizens, often with the goal of guiding them toward more sustainable behaviors. One approach that has received much attention is “nudging” (Thaler and Sunstein, 2008), which builds on the assumption that people are biased and prone to error (also known as the heuristics-and-biases program, Tversky and Kahneman, 1974). The essence of nudging is that managers or policy makers can strategically design the choice environment to promote a particular behavior. The classic example is to place an item in a cafeteria or supermarket at eye level to increase the chance of being noticed and thus bought. According to the proponents of this approach, nudges never limit freedom of choice, but this has been criticized (Grüne-Yanoff and Hertwig, 2016). Instead of influencing behavior inadvertently by subtly changing the choice environment, other researchers propose “boosts” as an alternative behavioral intervention. Boosts are targeted at fostering people’s competences by increasing their knowledge and skills and providing them with decision support tools to make better decisions by themselves (Hertwig and Grüne-Yanoff, 2017).

Fostering capable and engaged citizens is a reliable strategy for tackling current environmental challenges (Herzog and Hertwig, 2025). Boosts can even outperform nudges in conservation behaviors such as saving energy (Paunov and Grüne-Yanoff, 2023). Research on household water conservation also suggests that combining informational components (e.g., knowing there is a water shortage) with behavioral components (e.g., knowing that shorter showers can save water) may result in water savings (Ehret et al. 2021). Moreover, providing information is a criterion of the EU Ecolabel to encourage customers to adopt environmental practices in tourist accommodations (European Commission: Directorate-General for Environment, 2021). However, more research is needed to better understand when enabling approaches, such as “boosts”, are effective (Hallsworth, 2023).

Research into hotel guests’ conservation behaviors is relatively recent (Moscardo, 2019), with most behavioral interventions adopting nudge-based approaches and focused on fostering towel

or linen reuse (Nisa et al. 2017; Souza-Neto et al. 2022). For instance, Goldstein Cialdini and Griskevicius (2008) show the role of social normative influence on this type of conservation behavior. Baca-Motes et al. (2013) advance that hotel guests’ endorsing a—detailed and action oriented—symbolic commitment and receiving a lapel pin to symbolize their commitment, substantially influences hotel guests’ participation in towel-reuse programs. Terrier and Marfaing (2015) indicate that although both normative appeals and commitment have a positive effect on guests’ towel reuse when used separately, combining these two strategies does not result in more towel reuse. Gössling et al. (2019) also indicate that comprehensive normative messages—including elements of descriptive norms based on factual-procedural-effectiveness knowledge, common identities, reciprocity-by-proxy, as well as moral rewards—increase towel (and bed linen) reuse, as compared to existing in-room messages.

Beyond towel (and linen) reuse programs that can help reduce water (and energy) during the cleaning process, the literature on behavioral interventions to encourage hotel guests to decrease their water consumption more directly is sparse. Some exceptions are, for instance, Joo et al. (2018) research on the impact of social norms, commitment, and social goals (donations to an environmental charity) on water reduction at the hotel room, and Pereira-Doel et al. (2019) advancing a potential water reduction by providing hotel guests’ real-time information on shower length—particularly when combined with a message reflecting a selfless value orientation and requiring high effort from the guest (Pereira-Doel et al. 2024).

There is scant research on behavioral interventions focusing on fostering hotel guests’ competences to exercise their own agency (i.e. *boosts*). Within the specific area of targeting hotel guests to reduce their water consumption (directly or indirectly, through reusing towels/linen program) the existing nudge-based interventions might include information. In this case, the information provided is short and requires minimal effort to be read. If this environmental information were to be based on a boost approach—improving hotel guests’ decision-making competences (Hertwig, 2017)—it would require a larger investment in time, effort, and motivation on the part of the hotel guests (Hertwig and Grüne-Yanoff, 2017). Thus, boost-based behavioral interventions to promote hotel guests’ water consumption reduction in the room deserve further academic attention. Moreover, boosts seem to be more likely to foster generalizable and lasting behaviors (Hertwig, 2017)—which is particularly relevant in the case of water resource management worldwide. We expect boosting to be an effective approach to saving water in hotel rooms.

In sum, water stress is becoming more prevalent across the globe, particularly in water-scarce regions such as the Mediterranean basin. A close look at tourism shows that most of the consumption happens when tourists stay at hotels and that consumption peaks within their rooms, particularly in their bathroom and when they shower. Because this consumption depends largely on the private behavior of the guests, hotels have attempted to influence guests’ behaviors using direct and indirect approaches to influence water consumption. While some research indicates that messages to reuse towels have a small but detectable effect, little is known about whether direct methods are effective. Moreover, research on interventions to encourage in-room water conservation behaviors through *boosts*—fostering people’s competences to exercise their own agency—is even a scantly. Our goal, therefore, is to examine the impact of a boost to reduce direct in-room water consumption by hotel guests.

More specifically, our intervention consists of the introduction of an information leaflet in the hotel bathroom that, instead of persuading, informs guests about the scarcity of water resources

in Mallorca Spain—one of the most important tourist destinations in Europe and a region experiencing heavy water stress (Garcia et al. 2023)—and about ways to reduce water consumption in the bathroom (i.e., shower, use the tap, or toilet). The central idea is to make evident the sheer contrast in water resources between Mallorca and northern Europe, which is home to most tourists who visit the island. The information leaflet also included ways to save water in showers, flushing, and using the sink.

Viglia et al. (2024) recently emphasized that understanding changes in tourists' behavior requires observing their actual actions rather than relying on their reported intentions, as actual behavior often differs from intended behavior. To this end, we measured real water consumption in hotel rooms using digital meters. This method allows for precise calculation of in-room water usage, excluding other water consumption in the hotel that is beyond the tourists' direct control.

We conducted two field experiments, one in the summer of 2022 and the other in the summer of 2023. The second study was a replication of the first but showed the informative message at the check-in, in addition to the hotel bathroom. The studies show that the rooms with an information leaflet had no impact on water consumption relative to rooms without any leaflet. Moreover, a check-out survey showed that the intervention had neither an effect on non-targeted outcomes, that is guests' perceptions of the hotel, such as their liking of the hotel, their willingness to return, and their perceptions of the hotel's commitment to protect the environment.

Methods

Study design. Partnering with a coastal hotel in Mallorca, Spain, we conducted two field studies to examine whether boosting guests' competences on water scarcity and water conservation influenced their subsequent water consumption.² The hotel is rated four stars and is located in Capdepera, in the easternmost coast of Mallorca, and receives only adult tourists largely from northern Europe, predominantly from Germany. The modal stay is 5 days long, with two people occupying the room.

We installed digital water meters in 14 identical hotel rooms to measure hourly hot and cold water consumption. Six rooms we were assigned to the control condition, and 8 to the treatment condition³. Guests in both types of rooms were unaware that their water consumption was being measured and were also not made aware of their participation in the study. The studies were approved by the research committee of the Universitat de les Illes Balears. Study 1 was conducted during the 2022 summer season (from June 29 to October 23), and study 2 was a replication of study 1, with a minor modification, and was conducted during the 2023 summer season (from June 12 to October 22).

Materials and procedure. The material for both studies consisted of a printed message card with the shape of a water drop, as shown in Appendix A.⁴ It included information on (i) water resources in Mallorca—as compared to Northern Europe; and (ii) how to reduce water consumption in the hotel room when showering, using the tap sink or the WC (see Appendix A). We implemented our manipulations in the bathroom to ensure that exposure to the printed message card coincides with their opportunity for the guests to reduce water. To increase the likelihood that guests noticed it there were two copies of the information leaflet. One was hanging from the extendable magnifying mirror, the other one was hanging from the shower head. The message could be read in four languages, which respond to the majority nationalities of guests: English/German on one side of the card, and Spanish/French on the other side. The rooms in the

control condition had no message. We ensured that there was no other water-related message available in the room. Finally, all hotel staff involved in the experiment were trained, and the hotel was visited regularly by the research team to verify the desired protocol was followed and that the digital water meters were correctly registering water consumption.

Measurement of water consumption. Our main measure of water consumption is the total liters of water consumed in the room during the length of the stay divided by the number of days of the stay and people in the room (l/gd). We take the stay as the unit of analysis because the intervention is set to influence behavior throughout the stay. To exclude the water used for cleaning the room after check-out, and because the specific check-in and check-out times are unknown, we start counting water consumption at 0:00:00 of the following day after check-in, and we stop counting at 00:00:00 of the day of check-out.⁵ Data on guests' board type, country of origin, age, and gender were recorded by the hotel management.

During check-out, guests were invited to complete a survey that included the following questions:

Was there any message in the bathroom of your room? (yes or no)

If yes, what was the content of this message? (open text response)

How would you evaluate this message? (1, "very uninformative" to 7, "very informative", and 1, "very unpleasant" to 7, "very pleasant")

1. Did you make any effort to reduce water consumption during your stay? (1, "no effort at all" to 7, "maximum effort")
2. Please rate your overall liking for this hotel: (1, "very negative" to 7, "very positive")
3. Please rate your willingness to stay at this hotel again: (1, "not at all" to 7, "very much")
4. In your opinion, is the hotel committed to environmental protection: (1, "not at all" to 7, "very much")
5. How do you see yourself: are you generally a person who is fully prepared to take pro-environmental actions, or do you try to avoid pro-environmental actions? (1, "not at all willing to take pro-environmental actions" to 7, "very willing to take pro-environmental actions")

Differences between study 1 and study 2. Because study 1 suggested that guests paid little attention to the informative message, in study 2 we introduced a minor variation to increase the chances that guests attended to the message. Therefore, in addition to hanging the informative messages from the bathroom's extendable magnifying mirror and shower head, the hotel staff handed the informative message to the guests at check-in. Relatedly, the check-out survey in study 2 included two additional questions to those in study 1: (i) Were you given any information about the environment at check-in (yes or no); and (ii) If yes, what was the content of this message? (open text response).

Another difference between studies is that check-out surveys in study 1 suggested that people paid little attention to the content of the information leaflet, and incorrectly recalled that it concerned the reuse of towels for saving water. To examine the possibility that our information leaflet could have had a positive spillover reducing the use of towels, instead of direct water consumption, in study 2 we also recorded the number of towels used during the stay.

Data. Figure 1 shows the main features of the data collected ($N = 180$ stays—average length of the stay 5.59 days—in study 1

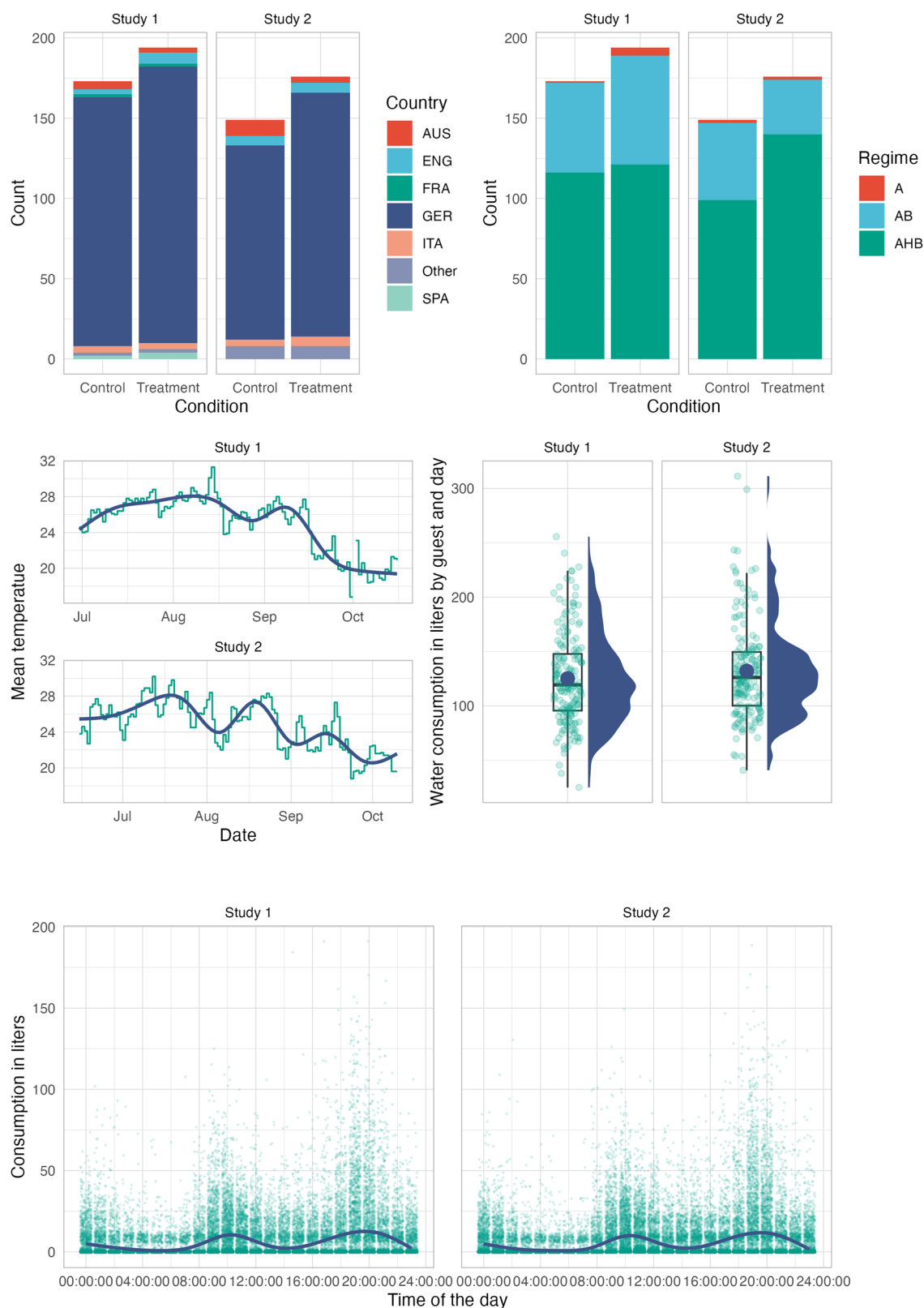


Fig. 1 Main characteristics of the samples in Studies 1 and 2 and main consumption patterns. The top left panel shows the country of origin of guests. The top right panel shows the regime of stay. The mid-left panel shows the mean daily temperatures. The mid-right panel shows the aggregate consumption by study. The bottom panel shows the aggregate hourly consumption.

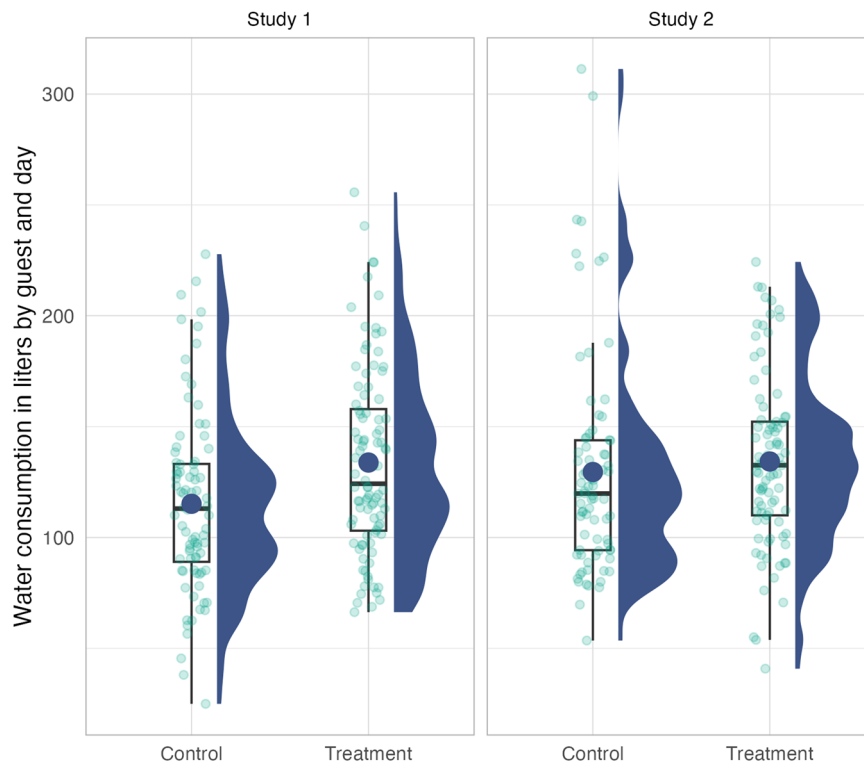


Fig. 2 Water consumption. Water consumption per guest and day in liters for each stay across control and treatment conditions in studies 1 (left) and 2 (right).

and $N = 168$ —average length of the stay 6.61 days—in study 2). In both studies, a clear majority of guests came from Germany (88% in study 1, and 83% in study 2).⁶ There was a minority of guests from England (4% in study 1, and also 4% in study 2), Italy (2% in study 1, and 3% in study 2) and France (1% in study 1). Importantly, there were only a few guests from Spain (2% in study 1), which could have had a qualitatively different response to the intervention.

Most guests visited on a half-board regime (63% in study 1 and 73% in study 2), and accommodation and breakfast (34% in study 1 and 26% in study 2). Only a small minority used only accommodation (3% in study 1 and 2% in study 2). Importantly, the distribution of guests in terms of origin and regime across treatment and control conditions in both studies 1 and 2 is roughly constant. This reflects the random assignment of guests to rooms—thus determining a random allocation of people into the two experimental conditions.

Figure 1 also shows the mean daily temperatures across the two periods of the field studies (left). In both summers, temperatures were high in the early weeks of the study and decreased towards the end. The mid-right panel shows the overall water consumption. This panel shows that the median consumption was 119 (SD = 42.5) in study 1 and 126 l/gd (SD = 44.3) in study 2, comparable to the consumption of 126 l/gd observed by Gössling (2015). Finally, the bottom panel shows the water consumption across the day, with peaks at around 10 a.m. and 7 p.m., suggesting that guests shower upon waking up and before dinner.

Results

The strength of randomized controlled experiments, such as the ones conducted here, lies in that participants are randomly assigned to conditions that differ only in one aspect, namely, the treatment of interest. If observed behavior differs between the two groups, such difference can be causally attributed to the treatment. In other words, if the treatment group consumes less water

than the control group, then we can conclude that such an effect was caused by the treatment. Thus, the key test of the intervention is a comparison between the mean consumption in both groups. This test was pre-registered before conducting the studies. Figure 2 shows the distribution of water consumption for each stay in studies 1 and 2. Each point represents the water consumption of a stay, computed as the total consumption during a stay divided by the number of nights and people in the room. In study 1, conducted in the summer of 2022, the intervention backfired. Guests who had an information leaflet in their rooms consumed more, rather than less, ($M = 134$ l/gd, $SD = 42.1$) than participants in the control rooms where there was no such leaflet ($M = 115$ l/gd, $SD = 40.9$), $t(176.1) = 3.00$, $p = 0.003$. In study 2, however, there were no differences between conditions ($M = 134$ l/gd, $SD = 38.8$ and $M = 130$ l/gd, $SD = 49.8$, respectively), $t(147.01) = 0.681$, $p = 0.49$.

The results speak unambiguously. The leaflets did not help reduce water consumption. If anything, the intervention may have led to a small increase in water consumption. To examine the results in greater detail, we modeled water consumption using linear mixed models (also known as multilevel models). This analysis is exploratory, as it was not pre-registered. Consistent with the analysis in Fig. 2, the dependent variable is the mean daily consumption in liters per guest and day during the stay. More specifically, we divided the total water consumption (of hot and cold water) in a room during a stay by the number of days and guests in the room. Therefore, each observation in this analysis is the mean consumption in a stay, by a guest in a day. The analysis includes studies 1 and 2 but uses the study as an independent variable to examine whether there were any differences across studies. The independent variable of interest is, of course, the condition to which guests were randomly assigned (control or treatment), but we also had a variety of other predictors that can help us isolate the effect of the treatment. We estimated the model sequentially, adding independent variables

Table 1 Linear mixed model of water consumption fit by REML.					
Random effects					
	Name	Variance	Std. dev.		
Room	(Intercept)	120.1	10.96		
Residual		1681.9	41.01		
Number of obs.	348				
Groups (room)	14				
Fixed effects					
	Estimate	Std. error	df	t value	Pr(> t)
(Intercept)	169.25	13.143	195.137	12.877	<0.001
Condition: Treatment	13.049	7.384	11.048	1.767	0.105
People in room	−23.942	6.038	338.069	−3.965	<0.001

REML criterion at convergence: 3568.
Significance codes: '***' 0.001.

one by one, and examining the additional explanatory contribution of each variable using the Bayesian information criterion (BIC). The models were estimated using maximum-likelihood estimation (ML). Once we identified the best-fitting model, we re-estimated the parameters using the restricted maximum likelihood method (REML).

The best-fitting model had, in addition to the condition, the number of people in the room as independent variables. These variables were included as fixed effects (i.e., we estimated a single intercept and slope coefficient for the whole sample). Other control variables such as the temperature during the stay, the guests' country of residence, their gender, the length of the stay, the regime hired, and the study had no significant additional explanatory power. Importantly, because measurements of water consumption are nested within rooms, we modeled this hierarchical relationship using random effects for each room. Namely, we allowed intercepts to vary across rooms. In sum, the model we estimated is:

$$consumption_{ij} = b_{0j} + b_1 condition_{ij} + controls_{ij} + e_{ij}$$
$$b_{0j} = b_0 + u_{0j}$$

were i represents the stay and j represents the room. Then, b_{0j} is the intercept that is allowed to vary by room j , and is the overall effect of b_0 , the intercept across rooms, plus some variability u_{0j} . Table 1 shows the coefficient estimates for the best-fitting model. Results reflect no impact of the intervention on water consumption, but the number of people in the room was associated to lower per-person consumption (Table 1). The full model, including all control variables, is reported in Table 1a (Appendix B).

Did those who recalled having seen a leaflet consume less? To address this question, we used variable coding for whether the guests recalled having seen a leaflet in their bathroom. In study 1, only 50% (22) of the respondents who had a message in their bathroom (i.e., the treatment condition, 44 respondents) recalled having seen it. In study 2, the proportion of respondents who correctly recalled having seen the message was 74% (43 of 58). This higher recall in study 2 is most likely due to the fact that the message was also handed during check-in. This variable entered the best-fitting model as a main effect and interacted with the condition. Although the number of observations is drastically reduced from 357 to 190—because only a subset of guests completed the survey—the pattern of results does not change (see Table 2a, Appendix C). People who remembered having seen the

leaflet were not more inclined to save water than those who did not remember having seen a leaflet.

Has the intervention influenced the reuse of towels? Guests do not seem to have paid much attention to the leaflets hanging in their mirrors and showers. It is possible, however, that they noticed a leaflet but did not read it. Some indication of this possibility is evident in the guests' answers to the survey examined below. Indeed, some guests reported remembering a message about water saving but incorrectly recalled that it concerned the reuse of towels. Although our message did not make any reference to towel reuse, such messages are common in hotel rooms, and guests may have incorrectly anticipated that ours was another of those messages. Therefore, it is possible that our intervention could have inadvertently influenced towel reuse. To examine this possibility, in study 2 we recorded the number of towels used in each stay. We thus estimated the best-fitting model using the number of towels used by guests and day as the dependent variable. The results in Table 2 indicate that, indeed, our intervention had an unexpected effect on the reuse of towels. Guests who stayed in rooms with a leaflet in their bathrooms were more likely to use fewer towels (by person and day) than guests who had no leaflet in their bathrooms. Specifically, guests in the treatment condition used about a third fewer towels than those used by guests in the control condition. A lower use of towels was also associated with having more people in the room, lower temperatures longer stays, and having a higher proportion of men in the room.

Did those who saw the leaflet exert more effort to save water? We asked all guests whether they exerted any effort to reduce water consumption. If we examine the guests' responses in the treatment condition (Fig. 3), which is the group who stayed in rooms where a leaflet was indeed present, we see that those who did recall having seen a message in the bathroom did not exert more saving effort than those who did not recall having seen any message.

Figure 4 shows the results of the survey across control and treatment conditions for both studies. The survey shows that there was no difference between how informative the message was perceived across conditions in both studies and the message was found roughly equally pleasant. Similarly, there were no differences in the overall liking of the hotel or their willingness to stay at the hotel again, across conditions, and there was also no difference in how pro-environment the hotel was perceived. These results are consistent with the observation that guests paid little attention to the leaflet. Finally, people rated themselves no

Table 2 Linear mixed model of towel use fit by REML.						
Random effects						
	Name	Variance	Std. dev.			
Room	(Intercept)	0.01	0.11			
Residual		0.36	0.60			
Number of obs.	168					
Groups (room)	14					
Fixed effects						
	Estimate	Std. error	df	t value	Pr(> t)	
(Intercept)	2.6377	0.6964	156.7955	3.79	<0.001	***
Condition: Treatment	−0.3212	0.1128	11.3181	−2.85	0.015	*
People in room	−0.7769	0.1663	156.8169	−4.67	<0.001	***
Temperature	0.0659	0.0228	154.5154	2.9	0.004	**
Length of stay	−0.0701	0.0126	156.4965	−5.57	<0.001	***
Proportion of men	−0.3301	0.1592	157.883	−2.07	0.040	*
Country: ENG	0.4114	0.3284	155.2962	1.25	0.212	
Country: GER	−0.1039	0.2361	151.8122	−0.44	0.660	
Country: ITA	0.0814	0.3576	153.2803	0.23	0.820	
Country: Other	0.3821	0.3139	155.5799	1.22	0.226	
REML criterion at convergence: 328.2.						
Significance codes: '***' 0.001, '**' 0.01, '*' 0.05.						

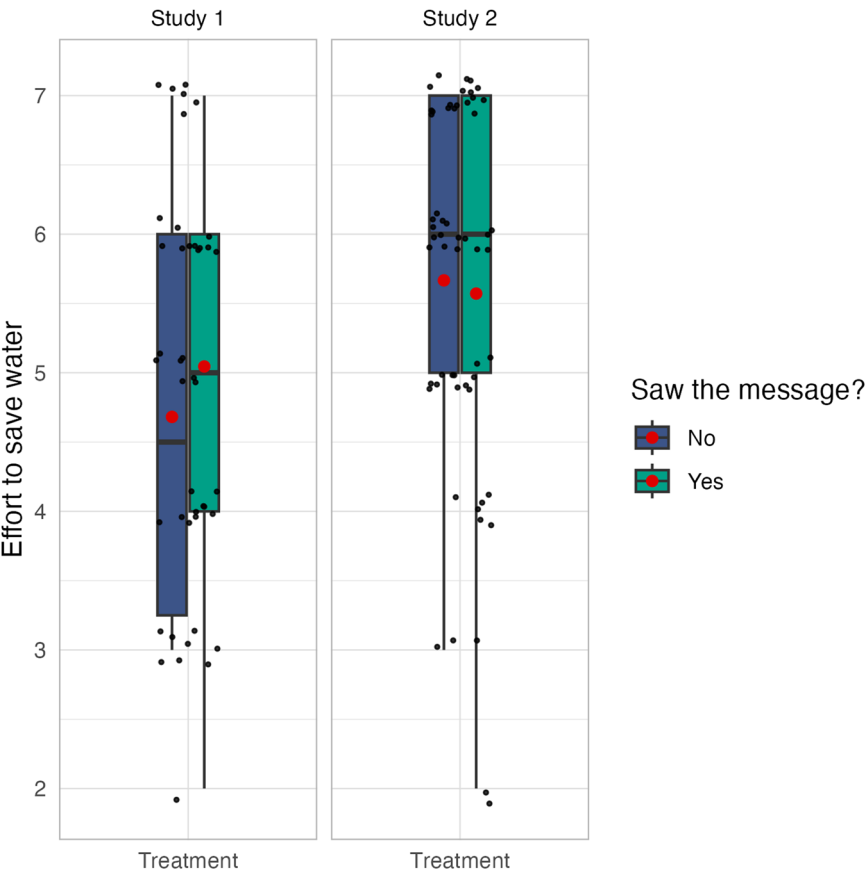


Fig. 3 Effort to save water. Response to the survey question “Did you make any effort to reduce water consumption during your stay?” in a scale from 1 (“no effort at all”) to 7 (“maximum effort”), according to whether the guest saw the message.

differently across conditions in terms of the extent to which they see themselves as pro-environment.

Discussion

Europe has been affected by severe and prolonged droughts for over two years (Toreti et al. 2024). The Mediterranean and

southern regions of Spain, such as Catalonia, Andalucía, and the Balearic Islands are prime examples of the severity of these droughts that will likely become more frequent due to climate change. Water is becoming precious in Europe. This problem is exacerbated as tourism grows yearly. In this project, we tested whether informing hotel guests about the scarcity of water in Mallorca—and how to save it—could reduce water consumption

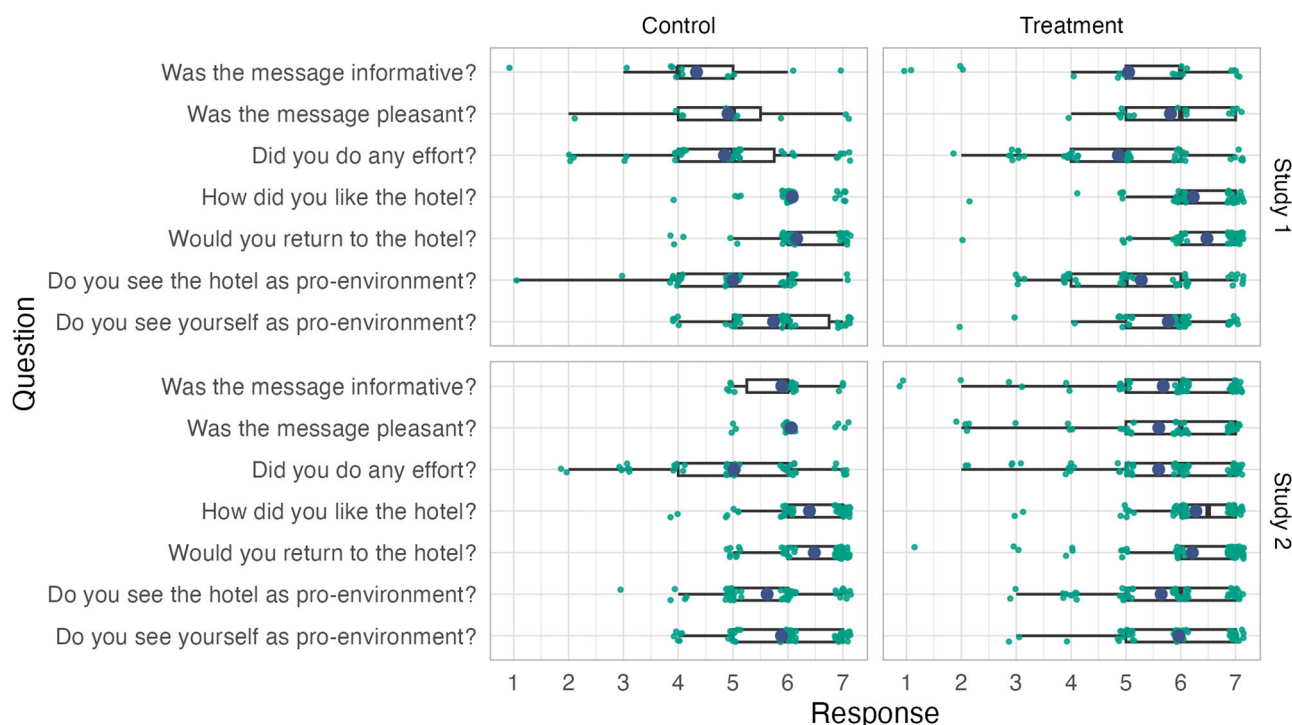


Fig. 4 Responses to the post-stay survey. Responses to seven survey questions by control and treatment condition for study 1 (top) and 2 (bottom).

in hotel rooms. Over the summers of 2022 and 2023, we collected water consumption data from a set of rooms, some with an informative message and some without. What we observed was that the informative message had zero impact on water saving. Moreover, only a minority of guests recalled having seen a message in the hotel bathroom, and among those who recalled having seen a message, they had inaccurate memories of what the message said.

There are several potential reasons why our intervention did not reduce water consumption. One possibility is that tourists do not care about environmental protection and, in particular, water scarcity in the destinations that they visit. To address this possibility, we asked guests to rate themselves according to how they see themselves in terms of their concern for the environment. The results show that guests rate themselves high in terms of being pro-environment—almost a 6 on a 1-to-7 scale. It is possible that, if all guests are highly concerned about saving water, as these ratings seem to suggest, and water usage is generally low, then the margin for saving additional water through an informative message would be minimal. We think this possibility is unlikely, given that the median water consumption by guest and day was 119 l/gd in study 1 and 126 l/gd in study 2, closely approximating the water usage in hotel rooms estimated by Gössling (2015), of 126 l/gd.

It is also possible that our intervention did not have an effect because saving water involves some degree of effort that guests were unwilling to make. For example, taking shorter showers needs an explicit attempt to change the habit of otherwise long showers. If such effort is perceived as interfering with the guests' comfort, then our intervention is likely to be innocuous. The guests' hedonic state is a major obstacle that has to be overcome to promote pro-environmental behavior in hotels (Miao and Wei, 2016).

Finally, another possible explanation for not observing the expected effect is that hotel guests are well accustomed to seeing messages in hotel rooms suggesting to save water by reusing towels. We tested the possibility that our message had inadvertently influenced towel reuse, instead of direct water

consumption in the bathroom, and it did. Guests in treatment rooms used fewer towels than guests in control rooms. Because this reduction in towel use seems unrelated to the content of the written messages of the intervention, we expect that the effect is short-lived and only likely to be present when a reminder is present.

Behavioral interventions are becoming increasingly frequent in the attempt to protect the environment. One approach is to nudge people to behave in a particular pro-environmental way. Instead, we used an intervention that does not attempt to nudge hotel guests but to boost their knowledge about water scarcity in Mallorca and how to reduce water consumption in the hotel room. While nudges often influence unconsciously, boosts of the sort we used here require that people are a priori willing to protect the environment. If this willingness to engage with the problem is not present, boosts are unlikely to be effective (Hertwig, 2017).

The effectiveness of behavioral interventions as a tool to help solve society's immediate challenges has been recently questioned (Chater and Loewenstein, 2023). Although behavioral interventions sometimes work, they often do not, or their effects are minimal (Mertens et al. 2022). There is still a poor understanding of the conditions in which behavioral interventions can help steer behavior toward environmental protection. In this study, we showed that informing hotel guests about water scarcity in Mallorca, and how to reduce its consumption does not promote water savings in the hotel room—but has an indirect effect. However, the significant growth of the tourism sector, along with the increase in water stress in many tourist destinations, is an emergency call for researchers to examine more effective interventions. Thus, future research should explore alternative behavioral interventions for in-room water savings.

The results of our studies have important implications for hotel managers and policy makers. Due to the widespread use of conservation message cards in hotel rooms, it is important to know whether they work as intended; and whether they should be stopped when found ineffective. We show that the informative

messages traditionally used by the hotel industry in hotel rooms are not an effective tool for reducing water consumption directly. Consequently, the costs associated with creating and maintaining these messages could be better utilized by implementing proven water-saving measures, such as installing dual-flush systems in toilets, low-flow fittings in taps, and volume displacers in toilet cisterns. For example, Gatt and Schranz (2015) showed that these devices can reduce water consumption drastically to around 48% in a three-star hotel. Other effective measures involve controlling leakages and reducing pressure in the water distribution network (Tirado et al., 2019; for a review of water-saving approaches in hotels, see Gabarda-Mallorquí et al. 2024).

Finally, our study also highlights the importance of measuring the impact of information campaigns to protect the environment. We are certain that all informative campaigns are costly, but their effectiveness is uncertain. New empirical studies that involve an actual measurement of the potential effects of an intervention are a key element to evaluate the effectiveness of the proposed measures. Therefore, these studies are essential for policy makers and hotel managers to design effective strategies to reduce the water footprint generated by tourists during their vacations while also reducing the attempts at greenwashing.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Received: 5 September 2024; Accepted: 19 February 2025;

Published online: 23 March 2025

Notes

- 1 Water stress is defined as the failure to meet the ecological and human demand for freshwater (CEO Water Mandate, 2014).
- 2 Pre-registration and materials are available in OSF: https://osf.io/5z7qj/?view_only=455293f38ffe4e4d87c5cc82e1b2f68e.
- 3 We opted for this distribution of rooms across conditions to reduce the chances of mistakes. More specifically, 6 rooms were in one building and 8 in a different but adjacent one. The 6 vs. 8 distribution that we chose meant that the cleaning personnel operated in only one type of room. Had we chosen a 7 vs. 7 distribution across conditions, the cleaning personnel would have operated in both control and treatment rooms, introducing the possibility of making mistakes (e.g., incorrectly hanging an informative message in a control room). To minimize this possibility, we opted for a 6 vs. 8 distribution.
- 4 This information leaflet was inspired by a water-saving campaign conducted by the government of the Balearic Islands: https://www.youtube.com/watch?v=_t1o5ypFs60.
- 5 This means that guests who stayed only one night are excluded from the analysis. There were 8 such cases in study 1 and 1 case in study 2.
- 6 The country of origin was only registered for the person in the room who made the reservation. We assume that all the people in the room came from the same country.

References

- AETIB—Agencia de Estrategia Turística de las Illes Balears (2023) El turismo en las Islas Baleares. In: Anuario 2022. Conselleria de Model Econòmic, Turisme y Trabajo, Govern de les Illes Balears, (eds. de Estrategia A, de las Illes Balears T) Agencia de Estrategia Turística de las Illes Balears, Conselleria de Model Econòmic, Turisme y Trabajo, Govern de les Illes Balears
- Angulo A, Atwi M, Barberan R, Mur J (2014) Economic analysis of the water demand in the hotels and restaurants sector: shadow prices and elasticities. *Water Resour Res* 50(8):6577–6591
- Baca-Motes K, Brown A, Gneezy A, Keenan EA, Nelson LD (2013) Commitment and behavior change: evidence from the field. *J Consum Res* 39(5):1070–1084
- CEO Water Mandate (2014) Water mandate driving harmonization of water-related terminology. Pacific Institute, Oakland, CA, USA
- Chater N, Loewenstein G (2023) The i-frame and the s-frame: how focusing on individual-level solutions has led behavioral public policy astray. *Behav Brain Sci* 46:e147
- Cole S (2012) A political ecology of water equity and tourism. *Ann Tour Res* 39(2):1221–1241
- Ehret PJ, Hodges HE, Kuehl C, Brick C, Mueller S, Anderson SE (2021) Systematic review of household water conservation interventions using the information–motivation–behavioral skills model. *Environ Behav* 53(5):485–519
- Essex S, Kent M, Newnham R (2004) Tourism development in Mallorca: is water supply a constraint? *J Sustain Tour* 12(1):4–28
- European Commission: Directorate-General for Environment (2021) The EU ecolabel for tourist accommodation: the EU ecolabel is the official European Union label for environmental excellence. Publications Office of the European Union
- Gabarda-Mallorquí A, Deyá B, Tirado D (2024) Exploring research on water-saving measures applied to the hotel sector. A critical systematic review. *Int J Hosp Manag* 120:103747
- Gatt K, Schranz C (2015) Retrofitting a 3 star hotel as a basis for piloting water minimisation interventions in the hospitality sector. *Int J Hosp Manag* 50:115–121
- García C, Deyá-Tortella B, Lorenzo-Lacruz J, Morán-Tejeda E, Rodríguez-Lozano P, Tirado D (2023) Zero tourism due to COVID-19: an opportunity to assess water consumption associated to tourism. *J Sustain Tour* 31(8):1869–1884
- Goldstein NJ, Cialdini RB, Griskevicius V (2008) A room with a viewpoint: using social norms to motivate environmental conservation in hotels. *J Consum Res* 35(3):472–482
- Gössling S (2015) New performance indicators for water management in tourism. *Tour Manag* 46:233–244
- Gössling S, Araña JE, Aguiar-Quintana JT (2019) Towel reuse in hotels: importance of normative appeal designs. *Tour Manag* 70:273–283
- Grüne-Yanoff T, Hertwig R (2016) Nudge versus boost: how coherent are policy and theory? *Minds Mach* 26(1):149–183
- Hallsworth M (2023) A manifesto for applying behavioural science. *Nat Hum Behav* 7(3):310–322
- Han H, Chua BL, Hyun SS (2020) Eliciting customers' waste reduction and water saving behaviors at a hotel. *Int J Hosp Manag* 87:Article 102386
- Hertwig R (2017) When to consider boosting: some rules for policy-makers. *Behav Public Policy* 1(2):143–161
- Hertwig R, Grüne-Yanoff T (2017) Nudging and boosting: steering or empowering good decisions. *Perspect Psychol Sci* 12(6):973–986
- Herzog SM, Hertwig R (2025) Boosting: empowering citizens with behavioral science. *Annu Rev Psychol* 76:851–881
- Holden A (2016) Environment and tourism. Routledge, New York
- International Tourism Partnership (2014) Environmental management for hotels: the industry guide to sustainable operation. <https://www.greenhotelier.org/our-manuals/environmentalmanagement-for-hotels/chapter-3-water/>. Accessed on 24 Nov 2019
- Joo HH, Lee J, Park S (2018) Every drop counts: a water conservation experiment with hotel guests. *Econ Inq* 56(3):1788–1808
- Kasim A, Gursory D, Okumus F, Wong A (2014) The importance of water management in hotels: a framework for sustainability through innovation. *J Sustain Tour* 22(7):1090–1107
- Mendoza E, Ferrero F, Slokar YM, Amores X, Azzellino A, Buttiglieri G (2023) Water management practices in Euro-Mediterranean hotels and resorts. *Int J Water Resour Dev* 39(3):485–506
- Mertens S, Herberz M, Hahnel UJ, Brosch T (2022) The effectiveness of nudging: a meta-analysis of choice architecture interventions across behavioral domains. *Proc Natl Acad Sci USA* 119(1):e2107346118
- Miao L, Wei W (2016) Consumers' pro-environmental behavior and its determinants in the lodging segment. *J Hosp Tour Res* 40(3):319–338
- Moscardo G (2019) Encouraging hospitality guest engagement in responsible action: building comprehensive theoretical models to support effective action (invited paper for 'luminaries' special issue of International Journal of Hospitality Management). *Int J Hosp Manag* 76:61–69
- Nisa C, Varum C, Botelho A (2017) Promoting sustainable hotel guest behavior: a systematic review and meta-analysis. *Cornell Hosp Q* 58(4):354–363
- Paunov Y, Grüne-Yanoff T (2023) Boosting vs. nudging sustainable energy consumption: a long-term comparative field test in a residential context. *Behav Public Policy* 1–26. <https://doi.org/10.1017/bpp.2023.30>
- Pereira-Doel P, Font X, Wyles K, Pereira-Moliner J (2019) Showering smartly. A field experiment using water-saving technology to foster pro-environmental behaviour among hotel guests. *e-Rev Tour Res* 17(3):407–425
- Pereira-Doel P, Font X, Wyles K, Pereira-Moliner J (2024) Reducing shower duration in tourist accommodations: a covert true experiment of continuous real-time eco-feedback and persuasive messaging. *J Travel Res* <https://doi.org/10.1177/00472875241245045>
- Rico-Amoros AM, Olcina-Cantos J, Sauri D (2009) Tourist land use patterns and water demand: evidence from the Western Mediterranean. *Land Use Policy* 26(2):493–501
- Souza-Neto V, Marques O, Mayer VF, Lohmann G (2022) Lowering the harm of tourist activities: a systematic literature review on nudges. *J Sustain Tour* 31(9):2173–2194

- Styles D, Schoenberger H, Galvez-Martos JL (2015) Water management in the European hospitality sector: Best practice, performance benchmarks and improvement potential. *Tour Manag* 46:187–202
- Terrier L, Marfaing B (2015) Using social norms and commitment to promote pro-environmental behavior among hotel guests. *J Environ Psychol* 44:10–15
- Thaler RH, Sunstein CR (2008) *Nudge: improving decisions about health, wealth, and happiness*. Yale University Press, New Haven, CT
- Tirado D, Nilsson W, Deyà-Tortella B, García C (2019) Implementation of water-saving measures in hotels in Mallorca. *Sustainability* 11(23):6880
- Toreti A, Bavera D, Acosta Navarro J, Acquafresca L, Azas K, Barbosa P, de Jager A, Ficchi A, Fioravanti G, Grimaldi S, Hrst Essenfelder A, Magni D, Maz-zeschi M, McCormick N, Salamon P, Santos Nunes S, Volpi D (2024) Drought in Europe July 2024, JRC138930. Publications Office of the European Union, Luxembourg
- Turespaña (2024) Perfil del Viajero. Ministerio de Industria y Turismo. Gobierno de España. Retrieved from: <https://conocimiento.tourspain.es/es/perfil-viajero>
- Tversky A, Kahneman D (1974) Judgment under uncertainty: heuristics and biases. *Science* 185(4157):1124–1131
- UN (2023) The United Nations world water development report 2023: partnerships and cooperation for water. UNESCO
- UNWTO (2012) Background report tourism in the green economy. United Nations World Tourism Organization, pp. 12–16
- UNEP (2024) Tourism. <https://www.unep.org/explore-topics/resource-efficiency/what-we-do/responsible-industry/tourism/>. Accessed 8 Nov 2024
- Vandecasteele I, Bianchi A, Batista e Silva F, Lavalle C, Batelaan O (2014) Mapping current and future European public water withdrawals and consumption. *Hydrol Earth Syst Sci* 18(2):407–416
- Viglia G, Dolnicar S, Acuti D, Nicolau JL (2024) If you want to learn about real behaviour, measure real behaviour. *J Sustain Tour* 32(11):2245–2257

Acknowledgements

We thank the representatives of Parque Nereida Suites Hotel for all the support and collaboration in the project, especially Miguel Ángel Flaquer (general manager), Pedro Aso, and Javier Requena (hotel managers). We also are grateful for the financial support of the Environment and Tourism Chair of Capdepera Municipality. We also thank the financial support of Grant PID2023-152226NB-I00, funded by MICIU/AEI/10.13039/501100011033/ and by "ERDF/EU"; and Grant PID2020-115018RB-C33 funded by MICIU/AEI/ 10.13039/501100011033. This study was also financially supported by the Ministry of Science, Innovation and Universities, Government of Spain, through the research funding call MICIU/AEI/10.13039/501100011033 - European Union "Next-GenerationEU"/PRTR (project ref. TED2021-132639B-I00).

Author contributions

Sofía López-Rodríguez: Conceived and designed the experiments, performed the experiments, contributed materials/analysis tools and wrote the paper. Bartolomé Deyà-Tortella: Conceived and designed the experiments, performed the experiments, contributed materials/analysis tools and wrote the paper. Tomás Lejarraga: Conceived and designed the experiments, analyzed the data, contributed materials/analysis tools and wrote the paper.

Competing interests

The authors declare no competing interests.

Ethical approval

The questionnaire and methodology for this study were approved by the Research Ethics Committee (CER) of the University of the Balearic Islands (Ethics approval number: 258CER22) on March 15, 2022.

Informed consent

Informed consent was waived by the Ethics Committee of the Universitat de les Illes Balears on March 15, 2022 (Ethics approval number: 258CER22). The Ethics Committee approved our submission stating: "In order not to influence the behavior of the control group, guests in either group will not be informed that their room's water consumption will be measured during their stay". In this study, human participants' individual information is anonymized and the submission does not include images that may identify the person.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-025-04608-2>.

Correspondence and requests for materials should be addressed to Sofia. López-Rodríguez.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2025