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Nudges in the restroom: How hand-washing can be impacted by environmental cues

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Abstract
Using a field experiment, we demonstrate how hand-washing, an important public health behavior, can be impacted by environmental cues. We examine hand-washing behavior in public restrooms on the campus of a medium-sized university. We measure the impact of how two "nudges", in the form of visual cues, impact hand-washing. One inexpensive visual cue (arrow-shaped stickers on the floor of the restroom pointing from the toilets to the sink) increases hand-washing by up to 15%.

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Introduction

Although the health hazards of "dirty hands" are widely known today, regular hand-washing is far from universal, with one study indicating that a mere 5 percent of Americans wash their hands in line with the Centers for Disease Control's standards (Borchgrevink, Cha, and Kim, 2013). Low hand-washing rates contribute to the spread of infectious diseases (Liu et al., 2016), raising health care costs and reducing employee productivity from missed or sick work. In the developing world, improper hand hygiene is the root of more than half of preventable child deaths associated with diarrhea (Curtis and Cairncross, 2003) and respiratory infections, which kill more than 3.5 million children annually (CDC, 2012). Even healthcare workers regularly fail to wash their hands as often as recommended (Sharir, Teitler, Lavi, and Raz, 2001; Whitby, McLaws, and Ross, 2006), and these poor hand-washing habits are estimated to be the most frequent culprit for the 80,000 Americans per year who die from hospital-induced infections (Boyce, 1999).

Lack of resources and knowledge has been implicated as the source of low hand-washing rates in the developing world, yet neither of these factors explain why hand-washing rates are so low in a developed country like the United States, and why they are significantly lower than recommended among well-educated health professionals. Instead of imposing rules to force behavior in a particular direction, creating subtle mechanisms that gently push people to freely choose a socially desirable outcome can be more effective and less cost prohibitive.

Hence, in designing an intervention to increase hand washing, we adopt the approach of Thaler and Sunstein (2009). They argue for designing the individual's choice architecture to induce behavioral change (i.e., use a "nudge"). The simpler the nudge, the more easily deployable and generalizable it can be. Understanding low-cost, easily replicable nudges that impact human behavior in predictable ways is an area ripe for exploration in the domain of hand-washing behavior, and it is one that finds clear backing from the field of behavioral economics. We build on the burgeoning literature on "nudges", and use two environmental cues in an attempt to influence hand-washing behavior. The data from our field experiment shows that one cheap, easy to implement tactic (a strong visual cue) is effective.

Literature review

It is well established that hand-washing is a beneficial practice. For example, the US Centers for Disease Control (CDC) has issued numerous documents encouraging hand-washing and making recommendations as to how to wash one's hands (CDC, 2012). What is less clear is how often people wash their hands and what factors can encourage them to wash more often. Given the importance of the topic, the academic literature on hand-washing is fairly large. Before delving into the topic, we first address the issue of measurement.

Measurement of hand-washing

How can we measure hand-washing rates? Ellingson et al. (2014) outline four main types of hand-wash monitoring approaches: those involving technology systems, self-reporting, direct observation, and product volume measurement. Technology systems can provide detailed data on hand-washing behavior, but major concerns arise regarding subject privacy.

For instance, public facilities might be banned from using this type of equipment when it involves video monitoring. Self-reporting is a quick, easy way to capture subject preferences and behavior reporting. However, self-reported hand-washing rates may be exaggerated (Contzen, De Pasquale, and Mosler, 2015; Judah et al., 2009). Direct observation, on the other hand, provides the most comprehensive data of the approaches. Unfortunately, Cardinale Lagomarsino et al. (2017) and others have shown that direct observation can generate a Hawthorne-like effect, where the simple act of observation alters hand-washing behavior.

The final approach, product volume measurement, avoids the Hawthorne effect. Because observers will measure the volume of soap used, there is no need to be in the restroom to directly observe hand-washing compliance. Additionally, this approach allows for continuous data monitoring because aggregate soap measurements captures all entrants' behavior within a specified period. It also ensures complete privacy because any specific individual's behavior is impossible to attain from product totals. This product volume-method has some drawbacks, however. First, detailed information about restroom behavior is unavailable, such as time users spend washing their hands, whether they use the sink without soap, variations in individuals' soap usage, and the number of users who enter the restroom but do not use the facilities (i.e. cleaning staff, etc.).

Basic findings

Though the above methods vary in their applicability and potential drawbacks, direct observation and product volume measurement, the two most commonly used approaches for research designs, have revealed some consistent findings. First, hand-washing rates are much lower than 100%. Most studies have observed that hand-washing rates tend to be between 40-60% (Cardinale Lagomarsino et al., 2017; Guinan, McGuckin-Guinan, and Sevareid, 1997; Johnson, Sholcosky, Gabello, Ni, and Ogonosky, 2003; Munger and Harris, 1989). Second, male hand-washing rates are lower than female rates. The exact difference between male and female hand-washing rates varies according to each study, but all relevant data indicate statistically significant differences between the two (Berry, Fournier, and Porter, 2012; Borchgrevink et al., 2013; Edwards et al., 2002; Guinan et al., 1997; Johnson et al., 2003; Judah et al., 2009).

Psychological explanations of hand washing

Aunger et al. (2010) dissect some of the cognitive underpinnings that explain hand-washing decisions. They posit that three psychological processes -reactive, motivated, and cognitive- help explain hand-washing behavior.

Reactive processes are those that are "triggered automatically by particular kinds of stimuli" (Aunger et al., 2010, p. 384) and can become habitual. This means that someone could, out of habit, wash their hands every time they go to the bathroom or before they eat each meal, without explicitly thinking about why they are performing that action. Some nudges have attempted to target this psychological motivation of habituation in efforts to increase hand-washing compliance. This is a "backward-looking" approach to psychological actions, whereas a "forward-looking" approach is that of motivated actions.

Motivated behavior is the result of "a perceived discrepancy between an aspect of a person's current state and an ideal state" (Aunger et al., 2010, p. 384). In other words, if one wants to reduce disgust they feel because they just defecated, or if there is a social status reason, they might wash their hands.

Finally, cognitive processes are those that are "consciously determined plans to achieve a long-term goal" (Aunger et al., 2010, p. 384), such as the need to protect a baby from infections or the washing of hands for religious reasons. This cognitive process is often targeted by educational professionals, healthcare teams, and NGOs. Large, costly, and information-rich campaigns that seek to educate children or parents about the benefits of hand-washing are examples of efforts to influence this cognitive behavior. Unfortunately, these efforts have failed to show long-term, measurable effects (Bischoff, Reynolds, Sessler, Edmond, and Wenzel, 2000; Dubbert, Dolce, Richter, Miller, and Chapman, 1990). For this reason, many of the studies relevant to hand-washing rates to-date concern the above-mentioned reactive or motivated psychological processes.

Interventions to increase hand washing

Categorizing nudges as based on reactive versus motivated psychology is difficult because a nudge could affect reactive motivations in one person, motivated psychology in another person, and both processes in yet another person. However, both these processes can be interlinked and provide the foundation for most of the previous nudges aimed at improving hand-washing behavior.

Visible signage

A number of studies on hand-washing behavior in public restrooms deal with the altering of visible signage. Johnson et al. (2003) found that while women are more likely to wash their hands when they observe a sign in a restroom (above the sink) that tells them to do so, men's behavior does not change. Botta, Dunker, Fenson-Hood, Maltarich, and McDonald (2013) examined how students' hand-washing behavior changed when the students saw threat messaging in the restroom. They found that messages like, "That's pee you know, wash your hands" and "Poo on you, wash your hands" increased hand-washing for both males and females. Judah et al. (2009) demonstrated that signage that made use of social norms increased hand-washing behavior for both men and women.

Drying options

One design feature of restrooms seems to play an important role in how often people wash their hands: drying options. When surveyed, people indicate that they prefer paper towels over air-drying machines after washing their hands (Huang, Ma, and Stack, 2012). Borchgrevink et al. (2013) found that people tend to wash their hands at higher rates in restrooms that have paper towels (or at restrooms that have both paper towels and hand dryers) than they do at restrooms that have hand dryers but no paper towels. In another study, Ford, Boyer, Menachemi, and Huerta (2014) found that when the paper towel machine was set so the paper towel was already dispensed, both paper towel usage and soap usage increased, indicating that overall hand-washing had also increased.

Priming

Behavioral science studies have demonstrated that individuals can be "primed", or subconsciously influenced, in a way that makes certain behavior more likely. King et al. (2016) drew on the concept of priming to try to impact hand hygiene in a hospital's intensive care unit. King et al. implemented two separate treatments: 1) a citrus smell near the sink and 2) a sign of eyes placed above the sink. Both the citrus smell and the eyes treatments increased hand-washing.

Signals that target the non-deliberative, reactive psychology of restroom entrants are the exact nudge treatments we seek to find in this study. Cheap, easy to avoid, psychologically-based nudges that foster full freedom of choice provide a sound platform for treatments that might significantly increase hand-washing rates cost-effectively. We turn to the previous literature on hand-washing practices and on the behavioral economics insights to develop two nudges with potential for producing increased, sustainable hand hygiene compliance.

Methods

As mentioned earlier, a variety of approaches to measure hand-washing have been used in the literature. For this research project, indirect observation via a modification of the product volume method was chosen. This measurement strategy allowed for a continuous stream of data and a large sample size throughout the study, while minimizing privacy issues and the Hawthorne effect.

The College of Charleston Beatty Center was selected as the data collection site. Restrooms on the first, second and third floors were selected for observation. All of the restrooms are located on the southeast corner of the building, regardless of floor. The restrooms on the second and third floors have paper towel dispensers, while the restrooms on the first floor have jet air dryers.

The first aim of the research was to establish baseline hand-washing rates for all of the restrooms. After measuring baseline rates in the natural environment, the next goal was to deploy interventions and measure their effectiveness on influencing hand-washing rates. By comparing the baseline rates to the treatment rates, the effectiveness of treatments could be studied. A proxy for hand washing rates was obtained by using the following method for any given restroom:

1. First, the researchers installed an infrared sensor system at the entrance to the restroom. These sensors counted the number of people who entered and exited the restroom.
2. The researchers were granted access to be solely responsible for refilling the soap dispensers in the restrooms. The restrooms have automatic soap dispensers installed above the sinks. The researchers measured the weight of the soap container each time they recorded the people counter data. For each measurement event, the total soap usage amongst all the soap dispensers in a restroom was subtracted from the total soap usage in the previous measurement event. This generated a net change in the total weight of soap used in a given time period, accurate to the milligram level. The researchers also recorded the time and date of each measurement event.
3. The average amount of soap used per person during the time period was then calculated as the ratio of the net soap usage to the net person count.

One important note to mention on the proxy used is that this percent calculated indicates the minimum, or lower-bound, percent of people who washed their hands after using the restrooms. This number does not take into account individuals who enter the restroom but do not use the restroom, and are therefore not expected to use the soap dispensers. For instance, janitorial staff regularly enter the restroom to clean the facilities. Other people may enter the restroom to fix their hair, use the mirrors, wash their face, or another reason that does not relate to using the stalls or urinals. These entrants depress our calculated figures for hand washing percentages. On the other hand, people who, on the rare occasion, might put their hand under the soap dispenser more than one time in order to get additional soap are also not included in these calculated percentages, and they would have the opposite effect of inflating our estimates. Nonetheless, these rarities are expected to be infrequent when compared to the more typical restroom entrant. Moreover, our research focuses on the differences between baseline rates and treatment rates, and on the rate differences between different treatments. We do not expect that janitorial staff cleaning or atypical restroom entrants occur relatively more in one restroom than another, or that they occur with one treatment compared to another, so these differences do not affect our relative comparison so much as they might depress our percentage estimates. This method does not account for individuals who do use the sinks with water to wash their hands but fail to use soap. It also does not account for how long individuals washed their hands, but rather whether or not they were likely to have used the soap dispensers at all.

Treatments

The first treatment involved the placing of smiley face signs on the mirrors above the bathroom sinks. Based on the idea that these smiley faces would produce a pleasing feeling when entrants used the sinks, we hypothesized that this could lead to increased hand-washing rates. Smiley face usage has been shown to dramatically reduce electricity usage in one study (Thaler and Sunstein, 2009). A picture of the smiley faces affixed to the mirrors is shown in figure 1.

Figure 1. Smiley faces treatment

For the second treatment, the researchers placed lines of large, red, arrow-shaped stickers directed towards the sinks. Arrows were placed in lines from the urinals and stalls to the sinks with the intent to produce the notion that people should follow the arrows and use the sinks after having used the urinals and stalls. Figure 2 shows the arrows setup.

Figure 2. Arrows treatment

Results

Data collections began on January 21, 2017 and ended on April 19, 2017. Over that time period, a total of 19,098 persons used the restrooms, 10,448 males and 8,650 females[1]. Each data point consisted of the following information: the amount of soap consumed and the number of individuals who used the restroom. By dividing the amount of soap by the number of individuals, we obtain an "average amount of soap used" as a data point. Because the data that we are using consists of averages over varying quantities of people, we cannot give each data point equal weight in our analysis. Instead, throughout our analysis, we weight each data point by the number of users. Table 1 shows the descriptive statistics for average soap usage by treatment and gender.

Treatment	Avg	Std Dev	Min	Max	#obs
Overall	0.445	0.143	0.056	1.07	88
Baseline	0.435	0.144	0.056	0.834	28
Male	0.332	0.098	0.056	0.491	14
Female	0.554	0.082	0.488	0.834	14
Smiles	0.444	0.123	0.344	0.789	26
Male	0.36	0.017	0.344	0.408	10
Female	0.552	0.114	0.39	0.789	16
Arrows	0.495	0.163	0.283	1.07	34
Male	0.381	0.07	0.283	0.536	16
Female	0.64	0.128	0.467	1.07	18

Table 1. Descriptive statistics on average soap usage by treatment and gender

Figure 3 shows daily average soap usage by treatment and gender for the duration of the experiment.

Taken together, table 1 and figure 3 suggest that 1) women use more soap than men (consistent with the literature on sex differences in hand-washing) and 2) the Smiles and Arrows treatments both increase soap usage, with the Arrows treatment having a larger impact.

To more formally examine the impact of our treatments, we estimate equation 1:

$$x_{it} = \alpha_0 + \gamma T + \varepsilon_{it} \quad (1)$$

where x_{it} is the average amount of soap used in restroom i during period t, T is a vector of treatment dummy variables, and ε_{it} is an i.i.d. heteroscedastic error term. x_{it}, being an average, has a variance that depends upon the number of observations, and so x_{it} has a variance of σ^2/n_{it}, where n_t is the 'count', the number of people using restroom i during

[1] Restrooms were checked on 20 different days. However, not every restroom was checked every single time (because of people in the restroom, janitors cleaning the restroom, etc.). 20 days x 6 restrooms in the building means we had at most 120 potential observations, but because of these disruptions we were only able to gather 88 observations.

Model	1	2	3	4	5
Constant	0.435***	0.332***	0.335***	0.332***	0.347***
	(0.019)	(0.015)	(0.021)	(0.016)	(0.026)
Arrows	0.06	0.065**	0.064**	0.049	0.046
	(0.044)	(0.028)	(0.028)	(0.037)	(0.038)
Smiles	0.009	0.015	0.014	0.028	0.028
	(0.04)	(0.025)	(0.025)	(0.034)	(0.034)
Female		0.221***	0.222***	0.221***	0.197***
		(0.019)	(0.019)	(0.024)	(0.039)
Dryer			-0.004		-0.021
			(0.021)		(0.029)
FemalexArrows				0.037	0.042
				(0.056)	(0.056)
FemalexSmiles				-0.03	-0.028
				(0.051)	(0.051)
FemalexDryer					0.035
					(0.042)
R^2	0.022	0.624	0.624	0.629	0.632
Adjusted R^2	-0.001	0.611	0.606	0.606	0.6
F^{obs}	0.93	46.50***	34.48***	27.75***	19.62***

* indicates significance at the 10% level, ** indicates significance at 5% level and *** indicates significance at 1% level. Standard errors are in parentheses.

Table 2. Regression results

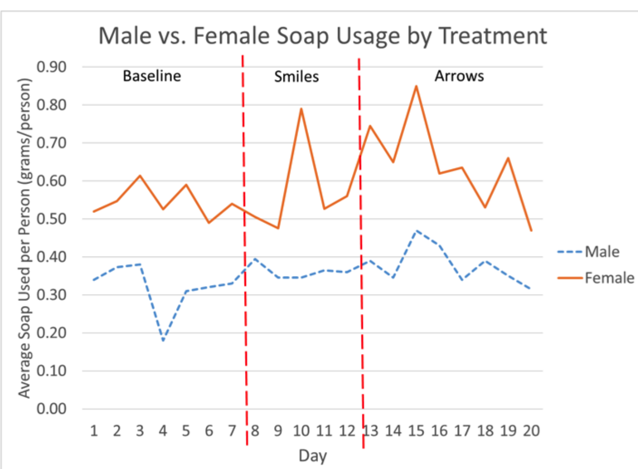

Figure 3. Soap usage by treatment and gender

period t. To address this heteroscedasticity, we use weighted least squares to estimate equation 1. Estimates for various specifications of α_0 and are presented in table 2.

The regression results mostly corroborate the conclusions inferred from the treatment averages in table 1. Women use more soap than men. Although the impact of the Smiles treatment is positive, it is not statistically significant. The Arrows treatment is statistically significant in the most powerful models (those with fewer explanatory variables, and higher adjusted R2), and is always positive. The existence of a dryer appears to have no impact on soap usage. There are no statistically significant interaction effects, suggesting that men and women react similarly to the treatments. Joint hypothesis tests suggest that moving from model 1 to model 2 is appropriate[2] (p-value = 0.0001), but that adding more parameters in models 3, 4, and 5 do not significantly improve explanatory power (p-values 0.16, 0.18 and 0.32).

Discussion

To help better understand the ratio of soap used per entrant, we can translate that data into an approximation of the percent of people who washed their hands[3]. Making this adjustment, we find that in the control condition, 40% of males and 66% of

[2] The opposite is true as well, that is, taking the model with just Ladies as an exogenous variable and adding Smiles and Arrows to that model statistically significantly increases explanatory power (p-value = 0.069).

[3] We weighed how much soap was used in individual dispensations on 50 occasions to determine the average weight of soap the soap machine dispensed each time it was activated. The dispenser used a minimum of 0.7 grams and a maximum of 1.0 grams per activation, with an average of 0.837 grams per use. By taking the ratio of soap used per person, and then dividing that number by 0.837, this provided an approximation for the percent of people who washed their hands in a given time interval.

females wash their hands. Under the Smiles treatment, these numbers rise to 43% for males while the female percentage does not change. With the Arrows treatment, hand-washing rates increase to 46% for males and 76% for females, translating into a 7% increase for males and a 15% increase for females. The baseline numbers are higher than some estimates (Borchgrevink et al. (2013) estimated 5%), but in line with many others (Cardinale Lagomarsino et al., 2017; Johnson et al., 2003; Munger and Harris, 1989; Nalbone, Lee, Suroviak, and Lannon, 2005). With the Arrows treatment, females reach hand-washing rates similar to those found among medical professionals (Sharir et al., 2001).

The exact economic impact of this intervention is difficult to calculate, but it appears to pass any reasonable cost-benefit analysis, as the costs are minimal. A package of stickers sufficient to cover one bathroom sells for $19.50 on Amazon, while buying these items in bulk would likely produce large cost savings. Additionally, for new construction this cost could effectively be zero if restroom designers, who are required to select floor decor when they build bathrooms, incorporate a bathroom floor design that has arrows directed from the stalls and urinals towards the sinks. It is even possible that a less overt stylistic choice, such as the convergence of lines that meet at the restroom sinks, could produce increased hand washing rates. Although difficult to measure, the benefits of increased hand-washing are clearly substantial. Aiello, Coulborn, Perez, and Larson (2008) found that more hand-washing compliance reduces colds and other respiratory illnesses by 21%[4]. Increased hand washing compliance is associated with reduced absenteeism (Hammond, Ali, Fendler, Dolan, and Donovan, 2000), and reduced absenteeism is associated with increased productivity (Mitchell and Bates, 2011). Given the low rates of hand-washing across a multitude of settings, and the potential benefits to be gained by increasing compliance, we hope that researchers build on our work to design simple, cost-effective ways to increase hand-washing.

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