Exploring Potential Methods for Reducing Paper Napkin Waste
In A High School Cafeteria

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ABSTRACT

With increased urbanization, the amount of waste we produce has become a growing concern, especially municipal solid waste (MSW), which individuals and households interact with the most daily. Albeit seemingly trivial, paper napkins constitute a sizable portion of MSW and are major contaminants in multiple waste streams. I explored factors influencing napkin usage and possibilities to reduce paper napkins via two main strategies—demand-side management in the form of education and default nudge—implemented in isolation and in combination. Specifically, my default nudge strategy made napkins more difficult to access while the education treatment informed diners of the environmental footprint of paper napkins. My data consisted of the napkin count per person during lunch on Mondays, Wednesdays, and Fridays for each treatment week (baseline, default nudge, education, and combined treatments) and I performed statistical tests (t-test, ANOVA, and Tukey HSD) to aid the analysis of my results. I found a statistically significant difference in the mean napkin reductions per meal per person between default nudge and education where the former produced greater reductions than the latter. Education did not yield statistically significant results compared to the baseline level, and the combined implementation of both treatments made no significant contribution than the effects attributable to default nudge alone. Analysis of surveys with diners revealed a disconnect between thoughts and actions regarding environmental knowledge and behavior, highlighting napkin use rationales that echoed the effectiveness of default nudge. Therefore, default nudge is optimal for managing paper napkins and, more generally, single-use disposable goods.

KEYWORDS

municipal solid waste, demand-side management, education, default nudge, paper napkins

INTRODUCTION

Solid waste is a byproduct of development that has significant environmental and public health impacts. Specifically, municipal solid waste (MSW) acquires much attention from the public for being waste that individuals and households interact with the most daily. MSW has become a growing concern as the world becomes more urbanized, particularly because the amount of MSW has been increasing at a rate faster than that of urbanization (Hoornweg and Perinaz 2012). MSW has extensive impacts on the environment because solid waste accounts for a substantial source of methane, a greenhouse gas (GHG) that has a powerful atmospheric warming effect within a short amount of time, and the generation rates of urban solid waste correlate with GHG emissions (Hoornweg and Perinaz 2012). Although MSW seems non-toxic when compared to heavy metals and industrial chemicals, solid wastes are capable of polluting air, land, and water at both local and global levels, which poses a threat to all aspects vital to our living environment (Yadav 2015). Moreover, solid wastes discarded throughout the environment and uncollected in neighborhoods and streets contribute to flooding and public health impacts, including, but not limited to, respiratory ailments, diarrhea, and dengue fever, mainly in developing countries (Hoornweg and Perinaz 2012). Given this situation, it is valuable to identify specific categories within MSW where households and individuals can modify certain behaviors to reduce the waste they generate.

Although seemingly trivial, napkins comprise a sizable portion of paper waste, which, in turn, makes up a large share of MSW, making napkins an area of interest to be studied and managed. Paper waste makes up a considerable portion of household MSW, especially in medium-income and high-income countries where its relative composition of household waste ranges from a low of 15% to a high of 40% (INTOSAI Working Group on Environmental Auditing 2002). Organics—mainly food and horticultural waste in residential settings—and paper constitute the majority of total MSW and are easier to manage (Hoornweg and Perinaz 2012), so there is an advantage in reducing our paper waste as means of reducing overall MSW. Within paper waste, napkins and tissue paper constitute a pronounced proportion of about 40% based on a study done in Turkey (Ozbek and Sanin 2004). Moreover, napkins are a prime contaminant in paper bins, compostable containers, and garbage bins (Zelenika et al. 2018), meaning that paper napkins should have gone to other recycling or composting streams, but is consistently inaccurately sorted

into unsuitable bins, which raises the costs and efficiency of waste sorting and recycling. Therefore, targeting the number of napkins used and disposed of may aid in reducing the amount of solid waste and the contamination of waste streams.

To influence behaviors regarding napkin usage, demand-side management (DSM) and default nudge are two promising strategies. DSM is traditionally, and most commonly, used in utility planning, where electric management and smart grids design activities targeted at consumers to influence their electricity uses to achieve a desirable utility load shape (Gellings 1985). DSM strategies focus on consumer management and target decision-making from the demand side. Consumers make informed decisions about their usage and resource consumption, a process that requires their conscious effort (Esther and Kumar 2016). For these reasons, DSM is a potential solution to reducing napkin paper waste (Saini 2004). Education is a specific form of DSM that many studies identified as a leading strategy for reducing food waste because researchers believe that changes in behavior stem from altered beliefs and considerations regarding resource conservations or use (Rethink Food Waste through Economics and Data 2016). Other researchers claim that offering education can reduce demand for single-use paper products (Ellison et al. 2019).

Alternatively, in settings when a provider controls what they supply to consumers, changing the type of napkins, such as differing in size and paper-content, provided to diners, or making the napkins inconvenient to access and only provided per request, may also be a potential solution. This is the concept of a default nudge—pre-set options that are automatically "chosen" for people and take effect if the decision-maker does not specify any alternatives "without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein 2008). For default nudge, the reasoning is that when people face decisions, they tend to choose the option that demands less of their effort, so when we set our desirable outcome as the default option, people automatically adhere to this option unless they go out of their way to change it (Dinner et al. 2011). With an understanding of the impact of MSW and napkins, along with the knowledge about two promising strategies to reduce paper napkin usage, we need to determine which interventions are more effective at changing people's behaviors and understand how their thoughts and considerations change during the decision-making process when different treatments were in place.

In my study, I explore how demand-side management by education on the influence of demand and default nudge of pre-set options that are automatically "chosen" for people, reduce

residential paper waste. I answer a series of specific questions toward that objective: (a) What factors influence decisions regarding napkin use behavior? (b) Was demand-side management through education or default nudge more effective at reducing paper napkin waste? And (c) does combining both strategies yield larger reductions in paper napkin waste than either method alone? I expect that conditions related to the meal or eating environment and personal use habits influence decisions on how many napkins to take/use in the absence of any interventions. On another note, I expect that changing the default option of the paper napkins provided in cafeterias using the method of default nudge will lead to more pronounced reductions in paper waste than raising awareness through education. Finally, I hypothesize that there may not be a significant benefit to implementing both strategies together compared to using just default nudge. To answer my research questions, I collect data on i) baseline and treatment (default nudge, education, or both) napkin counts in a given meal of the day for several days of the week, ii) the number of diners that ate at the cafeteria during the meal, and iii) survey responses from diners that ate at the cafeteria regarding how many napkins they took that meal and what led them to make that decision during each treatment phase.

BACKGROUND

Social influence and pro-environment behavior

There is an extensive body of research that explores various social influence approaches in promoting sustainability. Abrahamse and Steg (2013) used secondary analysis of data to explore whether social influence is as effective as the approaches are commonly assumed. The researchers conducted a random-effects meta-analysis of 29 sample studies to compare the effectiveness of different social influence approaches that all tried to encourage more resource conservation and environment-friendly practices. Six social influence approaches were covered: group feedback, social norm information and feedback, public commitment, modeling, block leaders and social networks, and socially comparative feedback. They discovered social influence approaches with face-to-face interactions made social influence more powerful, while the approaches that focused on information and feedback were less effective. Moreover, social influence approaches can be effective regardless of the type of behavior (observable or less observable), thus it has the potential

to encourage a wide range of pro-environment behaviors (Abrahamse and Steg 2013), which includes reducing paper napkin usage in dining settings. These results influenced the design of my study approaches with respect to the implementation of my two treatments. To control for the impact of face-to-face interactions, I incorporated a direct human interaction aspect to my default nudge and education interventions. Although the education treatment primarily relies on providing information, which Abrahamse and Steg (2013) found to produce less pronounced results, it is commonly employed and mentioned in discourse, thus I decided to explore the effectiveness of this method in my study due to its prevalence.

Education and waste behavior

Education is a form of demand-side management (DSM) that can change people's beliefs and product demand. DSM has been well-established in the realm of energy and electricity; its techniques have a lot of potentials to achieve economic and environmental benefits and are the cheapest, fastest, and cleanest ways to solve energy problems (Saini 2004). One group of demand-side management, known as static DSM (SDSM), involves the use of policies, activities, education, and/or advertisements to influence the normal consumption patterns of end-users (Meyabadi and Deihimi 2017), in situations where these consumers face choices regarding their usage (Strbac 2008). Among the various strategies in SDSM used to alter consumer choices, education is often implemented in contexts promoting resource conservation and pro-environment actions. For instance, a study of household food waste in Greece called for more research to make consumers more aware of food waste issues to change people's behavior (Ponis et al. 2017), implicitly making a case for education.

Ponis et al. (2017) conducted research to test how effective a food waste reduction campaign at a university dining hall was. University dining halls are often an all-you-can-eat dining setting where people typically do not have an incentive to take less food. Through collecting, weighing, and sorting plates in different treatment groups—one setting had an education campaign and the other was a control group—for a semester and performing analysis on the quality and quantity of food wasted, the researchers concluded that changes in waste behavior were nonsignificant, but the beliefs of individuals did change (Ponis et al. 2019). Although education did not achieve prominent results, using it as a conservation approach is more feasible

for a broader audience, as is the case with my study population—high school students in cafeterias who do not have a lot of time or attention to participate in other interventions. Compared with the other five social influence approaches, which require more complex social networks and ties, extensive time and involvement, and manpower (Abrahamse and Steg 2013), education is more feasible given the time and resource constraints of my study.

A case for default nudge: theory and successful applications

Nudges in general have led to marked reductions in household MSW. A nudge refers to a change when people are making choices without changing available options or prices. Akbulut-Yuksel and Boulatoff (2021) examined the impact of a green nudge (a nudge that encourages green/pro-environment behaviors) on the level of households 'recycling and MSW. They focused on a Clear Bag Policy implemented in a medium-sized city in Canada the summer of 2015 that mandated all households to dispose their trash in clear, transparent bags instead of the previous black garbage bags (except one black trash bag for privacy). The policy maintains the same number of allowed plastic bags at the curb as before (six every other week). The only thing that changed was that with the transparent garbage bags, waste collectors, neighbors, and passerby can easily see what and how much households waste and whether they recycle. This green nudge draws on people's social norms and preferences, such as their desire to have a positive self-image, which may be influenced by other individuals 'perceptions of their waste and recycling levels. The results show that, in this Canadian city, recycling increased by 15% and total MSW decreased by 27% between August 2015 and July 2017 (Akbulut-Yuksel and Boulatoff 2021).

In other fields, nudges have also displayed significant successes in altering consumer behavior. Allcott (2011) found that when the energy company, OPower, conducted randomized control trials involving 600,000 treatment and control households in the United States—some households were given comparison ratings (smiley faces) while others were not—those who had access to comparison information had an overall 2% reduction in electricity usage, a consumption change that would have required an approximately 20% increase in price to achieve (2011). In this example, households still had the choice to consume however much electricity they wished at the same price as before, but their decision now involved information on how their household was doing in terms of saving energy compared to others, which is a modification

to the choice situation. In this case, the nudge takes the form of providing information to some consumers and not others.

Default nudge can be a very effective and low-investment method for reducing paper waste. Wagner and Toews (2013) performed a survey of 133 businesses and explored the effect of an ordinance that modified the default choice of single-use disposable plastic straws, at which their use was prohibited unless asked upon request. After the ordinance was enforced, businesses sampled had an average of a 32% decrease in straw consumption while making no impact on business to most businesses. Hence, the study concluded that this particular ordinance, which relied on default nudge, was successful at reducing plastic straw consumption without harming businesses (Wagner and Toews 2018).

Also focused on plastic straws, Mundt et al. (2020) conducted a field experiment to test how effectively a default nudge intervention could reduce the consumption of drinking straws in Kassel, Germany. In their experiment, they randomly assigned participants to one of two conditions: a) an experiment setting where cups of self-mixed lemonade were presented without straws but there were available in a coverless box beside the cups that participants could voluntarily obtain straws from, or b) a control setting where the straws were already inside half of the cups such that participants had to decide for or against consuming straws. Performing a binomial logistic regression, the analysis resulted in a highly significant difference between the two conditions (a) and (b), indicating that there is a higher probability for participants to consume straws in the control setting (Mundt et al. 2020). The paper highlights that even minor and subtle default nudge interventions like the one studied in this field experiment can have substantial effects in waste reduction.

Another paper by Fowlie et al. (2021) randomized residents of Sacramento into two different electricity-pricing programs. One group was given the option to opt-in to time-varying pricing while the other was defaulted into that option but could choose to opt-out. The results showed that the option that people were defaulted into the had major impacts on the rates they faced, subsequently changing their electricity consumption significantly because over 70% of consumers were passive and did not opt-out, even though they would not have voluntarily opted-in had they been placed into the other group (Fowlie et al. 2021). These studies show that when we set our desirable outcome as the default option, most people automatically adhere to that option, making it relatively effortless to achieve the desired result.

Research Framework

My research design was a field experiment where I applied default nudge and education treatments to the cafeteria at a high school for a week, respectively, then combined both methods for another week to observe the change in napkin use. The specific form of default nudge that I employed was to make napkins more difficult to access. This involved putting up a clear sign at the entrance to and throughout the dining commons which informed the diners that if they would like a napkin(s), they must acquire it at a "napkin station". The "napkin station" consisted of a table with three napkin dispensers and me sitting behind them to verbally remind people to only take what they need.

On the contrary, the demand-side management strategy was via education (Saini 2004), which involved putting up a similar big poster-sign at the entrance to the cafeteria and smaller table-top signs at each table that was designed to educate diners on the natural resources (e.g., water, timber) used to make each napkin and on the impact that their used and disposed napkins may have on polluting the waste streams and contributing to municipal solid waste. In addition, to control for the impact of personal interactions (Abrahamse and Steg 2013), I also sat at a table at the entrance to the dining commons, where the big poster sign was, to have face-to-face interactions with diners. Essentially, this treatment consisted of providing information to diners about the environmental impacts of paper napkins to make them more conscious of, and reduce, their napkin usage (Wagner and Toews 2018). Example flyers can be found in the appendix of this paper.

Note that if the only treatment being applied at a dining hall was demand-side management, napkins were still freely available in their usual manner at each table, the only difference made to the dining hall was that there were flyers and posters put up for education purposes; likewise, if solely default nudge was applied, there were no education resources set up. When both treatments were combined, all measures taken in each of the individual treatments were applied such that education posters were visible on walls and tabletops, I sat outside the dining commons next to the large education poster having direct interactions with diners, and a volunteer ran the "napkin station" inside the cafeteria in the same manner as I did in the default nudge treatment.

METHODS

Study Site Description

To study the napkin usage behavior of a large group of diners, my study sampled the dining commons at an independent K-12 school located in New Jersey. Their cafeteria functions in a buffet-style and meal expenses are covered in the tuition, hence students have no meal cards and are free to enter and leave during their respective dining periods. Students dine at the cafeteria in different groups, with the youngest students in early childcare and primary school eating first, followed by middle school, high school seniors, and the remaining high school students. Faculty do not face such restrictions and can choose to dine at any time during the entire window during which lunch is served. Since it is a day school, the study site only offers lunch. Almost all students and faculty eat lunch at the school cafeteria, making the study site more stable in terms of customer flow.

Food at the high school is catered by SAGE Dining Services. There are six main categories of food every lunch: soups, salads, deli, entrées, sides and vegetables, and desserts. The soup section typically offers two options, example soups include three-bean chili, chicken noodle soup, and split pea soup. The salads section is a self-serve salad bar with different types of greens and lettuce, tomatoes, corn, cucumber, and onions, as well as some pre-maid salads like macaroni salad, tuna salad, egg salad, chickpea salad that vary on a day-to-day basis. The deli section is also known as the self-serve sandwich section that contains a variety of breads, cheeses, hummus, and deli meat that students can use to make their own sandwich. The entrées section contains various types of meat dishes, plant-based dishes, and grains that differ each day. Some examples of entrées include house-roasted beef, Mexican roast chicken, fried zucchini and mozzarella patties, red beans and rice, bang bang tofu, and popcorn shrimp. The sides and vegetables section serves two to three vegetable dishes (e.g., roasted vegetables, steamed broccoli, steamed corn) that are different every time, plain pasta, marinara sauce, and puttanesca sauce. Finally, the desserts section contains fresh-cut fruit, yogurt, assorted fresh fruit (e.g., entire oranges, apples, plums, and bananas that vary by season), and other baked desserts such as cookies, brownies, and cupcakes.

The menus and the types of food offered at the dining commons exhibit overall consistency in terms of meal messiness, as most entrées, soups, salads, and sides and vegetables could be eaten

relatively easily with eating utensils. The deli and desserts, despite being more prone to messiness while eating, are available to diners every day, hence it can be considered a constant across the study period rather than a confounding variable that changes between meals.

Data Collection Methods

To collect the data necessary to answer my research questions, I first estimated the baseline napkin use at the cafeteria by measuring the amount (number) of napkins used per diner per meal for three days of a week, which allowed me to get an average that accounts for random variations in customer number (some students may be sick, not hungry, or choose to eat something else they brought from home on any given day). As aforementioned, since the study site only caters lunch, I recorded the napkin usage for lunch served at the cafeteria on each measuring day (Mondays, Wednesdays, and Fridays).

To determine exactly how many napkins were used each meal, I coordinated with SAGE staff to receive permission to enter the cafeteria an hour before they started catering. During this hour, I prepared all the napkin dispensers such that each dispenser contained 250 paper napkins. In such, I knew exactly how many napkins each dispenser started with and simply went back through them after the dining period ended to count how many were remaining. Computing the difference before and after the dining period yielded the precise number of napkins used. This was easier for the default-nudge-related treatments since all the napkins were gathered at one place such that I only needed to count how many napkins were left compared to the amount I started with.

Due to the buffet-style, free-entry design of the cafeteria, I could not easily acquire data on the specific number of diners. To compensate, I recruited two volunteers that stood at either entrance of the cafeteria who kept count of the number of people that entered using a tally counter. At the end of the dining period, I summed the two numbers on the tally counters to determine the number of diners that day. Combined with the count of paper napkins used, I could calculate the average napkin usage per person per meal to ensure that variation in the number of diners is accounted for.

Table 1. Overview of the data collection plan

	Week 0	Week 1	Week 2	Week 3
Monday	Baseline Napkin Use	Default Nudge Treatment	Education Treatment	Both Treatments Combined
Wednesday				
Friday				

Similar studies found that education interventions influenced the beliefs of some students regarding food waste (Ellison et al. 2019), which implies that education may have a lasting impact after the treatment itself has ended. To minimize the impact of spillover effects from the education treatment, after collecting the baseline napkin count for a week, I first implemented the default nudge intervention, followed by the education treatment, and finally combined both treatments (Table 1).

Additionally, during each measuring day for both the baseline and treatment weeks, I recruited a volunteer who spent 1.5 hours outside the dining commons greeting the diners as they left consuming their meals. The volunteer conducted a quick oral survey with diners about a) how many napkins they used that day, and b) what factors they were considering when they decided how many napkins to take. The volunteer was told to survey at least 30 diners on each measuring day.

Data Analysis Methods

To analyze the factors influencing decisions regarding napkin use behavior, I calculated the range, mean, median, and mode of the napkin count that people reported they used during each week of the treatment (i.e., baseline, education, default nudge, and both treatments combined). Using the mean self-reported napkin count, I computed a mean percent reduction in napkin usage per treatment week compared to the baseline value. I also ranked the factors that people reported influenced their napkin usage by their frequency to find the top 5 factors overall, and for each of the treatment weeks. Since the survey was open-ended, participants answered and described a variety of factors that influenced their napkin usage that day. The survey also allowed multiple

factors to be listed rather than making the participant choose their top 1 reason. Therefore, I sorted through all survey responses and grouped them into categories based on core themes among similar responses, then calculated the frequency by which each factor appeared among all survey responses.

To compare the effectiveness of default nudge versus education in reducing paper napkin usage, I first divided the napkin count per meal by the number of customers that ate at the dining commons for that meal to attain the napkin count per person per meal and I averaged across the three baseline napkin counts to find the average baseline napkin usage level. Next, I computed the difference between each of the treatment napkin counts and the average baseline napkin usage. The resulting 6 values (3 for each treatment) were used to perform a one-tailed two-sample t-test to compare the mean napkin counts per person per meal of the two treatments, specifically, asking whether the default nudge treatment led to greater reductions than the education treatment. My null hypothesis was that the mean napkin count per person per meal for the default nudge treatment is less than the mean napkin count per person per meal for the education treatment.

Finally, to explore whether combining both methods yields more reductions in paper napkin usage than either method alone, I used each measuring day as a replicate to perform a one-way Analysis of Variance (ANOVA) comparing the means across four groups: a) baseline, b) education, c) default nudge, and d) both treatments combined. In addition to the ANOVA, I also computed Tukey Honest Significant Differences (Tukey HSD) to make pairwise comparisons between the mean of each treatment group and that of every other group at a 95% confidence level, which clarified which groups from the ANOVA were different than each other in a statistically significant way.

RESULTS

Napkin Use Behavior

With respect to my first sub-question, I found that meal messiness, especially the need to clean the mouth area after and/or while eating, consistently appeared among the top 3 factors throughout all treatment weeks. During the baseline week before any interventions were taken, the top 5 reasons that explained most of the diners 'decisions regarding their napkin usage were the

messiness of meals, both with respect to the need for one to clean their mouth as well as their hands, personal use habits, social acts of service, and spills or accidents (Table 2).

Table 2: Top 5 factors that influenced subjects' napkin usage (prior to any interventions)

Rank	Reason	Example	Count
1	Messiness of the meal (need to clean mouth)	Eating spaghetti tends to make the mouth area messy	73
2	Personal use habits	Someone always obtains 2 napkins at the start of the meal	55
3	Messiness of the meal (need to clean hands)	Eating sandwiches and burgers tend to make the hands messy	42
4	Social acts	Some people like to hand out napkins to their peers or those sitting around them as an act of service	28
5	Spills	If someone's plate fell on to the floor, they will use napkins to clean up the mess	9

When examining the top 5 self-reported factors shaping napkin usage behavior for each of the treatment weeks, I discovered that the need to clean one's mouth consistently ranked first across all three interventions (Table 3). When default nudge was applied, the need to clean one's hands ranked 2, followed by social and physical factors related to the feelings and process of acquiring napkins from the "napkin station". During the education treatment, consideration about environmental impacts as advertised in the posters throughout the cafeteria ranked 2, meal messiness with respect to dirtying one's hands came third, followed by a desire to reduce one's waste, and personal use habits.

Comparing the list of factors between education and default nudge, I noticed that with the latter, people were socially pressured to only take what they needed without understanding or thinking about the rationale behind doing so; their primary concerns were driven by their need to maintain cleanliness while eating. On the contrary, although the messiness of the meal with respect to the mouth region was still the most important factor, concern about environmental impacts came second and people also developed a desire to produce less waste (ranked 4th), indicating that rather than introducing stimuli that influenced actions as with default nudge, the education treatment

produced a change in thoughts. Finally, the combination of both the education and default nudge treatments revealed that the stimuli that induced changes in actions may have had a greater impact on the change in napkin use behavior than the stimuli that produced different thoughts based on rank 2 and 3 in column 4 of Table 3.

Table 3. Top 5 factors influencing napkin usage by treatment week

Rank	Default Nudge	Education	Combined Treatments
1	Messiness of the meal (need to clean mouth)	Messiness of the meal (need to clean mouth)	Messiness of the meal (need to clean mouth)
2	Messiness of the meal (need to clean hands)	Consideration about environmental impact of paper napkins	Social pressure to ask for only the number of napkins actually needed
3	Social pressure to ask for only the number of napkins actually needed	Messiness of the meal (need to clean hands)	Consideration about environmental impact of paper napkins
4	Ease (or the lack of) in acquiring napkins	Desire to produce less waste	Messiness of the meal (need to clean hands)
5	Feeling awkward about asking for napkins	Personal use habits	Ease (or the lack of) in acquiring napkins

In addition to exploring the factors that influenced napkin usage, I also computed numeric summaries from the number of napkins people self-reported they used during each treatment week. The measured baseline napkin usage ranged from 0 to 10 paper napkins, with a mean of 2.15; the napkin usage when the default nudge treatment was applied ranged from 0 to 5, with a mean of 1.53; the napkin usage during the education intervention ranged from 0 to 7, with a mean of 1.87; when both treatments were combined in implementation, the napkin count ranged from 0 to 5, with a mean of 1.25 (Table 4). Based on the numeric summaries, default nudge led to a 28.84% average reduction, education reduced napkin usage by 13.02%, and the combination of both treatments applied simultaneously produced a 41.86% decline compared to the baseline napkin usage level (Table 4). These self-reported results revealed that combining both treatments led to the most dramatic reduction in paper napkins used; default nudge was second most effective, and education was the least effective in relation to the two other treatments.

Table 4. Numeric summaries of self-reported napkin usage by treatment week

	Baseline	**Default Nudge**	**Education**	**Combined Treatments**
Mean	2.15	1.53	1.87	1.25
Median	2.00	1.00	2.00	1.00
Mode	2.00	1.00	2.00	1.00
Range	0.00-10.00	0.00-5.00	0.00-7.00	0.00-5.00
% Reduction	0	28.84	13.02	41.86

Comparing the Effectiveness of Default Nudge and Education

The mean baseline napkin count across the three measuring days when no intervention was implemented was 2.814. During the second week, when the default nudge treatment was in place, the mean napkin usage was 1.904; during the education intervention, the mean napkin count per meal per person was 2.646; finally, when I carried out a combination of the two treatments, the mean napkin count was 1.825 (Table 5). Compared to the baseline napkin count, default nudge led to a 32.35% decline in napkin usage, education reduced the number of paper napkins used by 5.98%, and the combined implementation of both treatments caused napkin usage to drop by 35.13% (Table 5).

Table 5. Mean napkin count per person per meal on each treatment day by treatment group. The row titled "Mean" refers to the mean napkin count per person per meal averaged across all three days per treatment group.

	Baseline	Default Nudge	Education	Combined Treatments
Monday	3.022	1.833	2.681	1.736
Wednesday	2.769	1.973	2.547	1.892
Friday	2.651	1.905	2.709	1.848
Mean*	2.814	1.904	2.646	1.825
% Reduction	0	32.350	5.982	35.134

The one-tailed two-sample t-test revealed that there was a significant difference in the mean napkin reductions between the default nudge (M = 0.910, SD = 0.070) and the education (M = 0.168, SD = 0.087) treatments (t = -11.542, df = 3.832, p = 0.0002). I used the Hedges 'g calculation for effect size to correct for the bias associated with small sample sizes and found an effect size of 7.52 (95% CI: [-∞, -0.603]). As the 95% confidence interval does not contain 0, we have evidence to reject the null hypothesis that the true difference in mean napkin reductions from education default nudge is equal to 0. These results suggest that default nudge led to greater reductions in the mean napkin usage per meal per person compared with education.

**Effectiveness of Combined Treatments**

The one-way ANOVA revealed that there was a statistically significant difference in the mean napkin count per meal per person between at least two of the four treatment groups ($F(3, 8)$ = 55.92, p = 1.04e-5). Given this p-value, we have sufficient evidence to reject the null hypothesis of no difference between groups at the 0.05, 0.01 and 0.001 alpha levels. Tukey's HSD Test for multiple comparisons found that the mean value of napkins used per meal per person was significantly different between combined treatments and baseline (p = 0.000031, 95% CI = [-1.295, -0.683]), default nudge and baseline (p = 0.000057, 95% CI = [-1.216, -0.604]), education and combined treatments (p = 0.00012, 95% CI = [0.514, 1.126]), and education and default nudge (p = 0.00025, 95% CI = [0.436, 1.048]). There was no statistically significant difference between

education and baseline, and default nudge and combined treatments (Table 6). With respect to whether there is added value in combining both education and default nudge to reduce the amount of paper napkins used, an important finding from these statistical tests is that no statistically significant difference was found between the mean napkin usage when the education intervention was applied and the baseline level; while both default nudge and combined treatments yielded mean napkin counts that were statistically significant from the baseline level of napkin usage, the mean napkin counts per meal per person between default nudge and combined treatments was not statistically significant (Figure 1).

Table 6. Results of Tukey HSD

Pairwise Comparison	Difference	Lower Bound of Confidence Interval	Upper Bound of Confidence Interval	p-value
Combined Treatments - Baseline	-0.989	-1.295	-0.683	< 0.001
Default Nudge - Baseline	-0.910	-1.216	-0.604	< 0.001
Education - Baseline	-0.168	-0.474	0.138	0.356
Default Nudge - Combined Treatments	0.0783	-0.228	0.384	0.844
Education - Combined Treatments	0.820	0.514	1.126	< 0.001
Education - Default Nudge	0.742	0.436	1.048	< 0.001
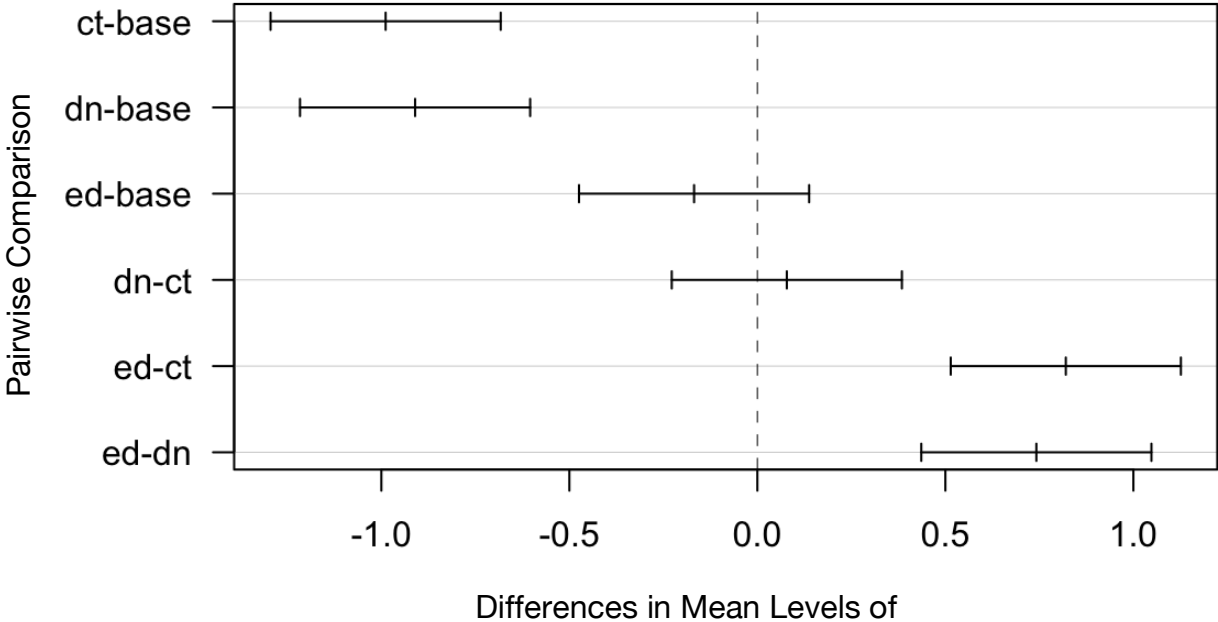
Figure 1. 95% Confidence Intervals of the Differences in Mean Napkin Count Per Person Per Meal. "ct" represents combined treatments, "dn" represents the default nudge treatment, "base" represents the baseline level, and "ed" represents the education treatment.

DISCUSSION

This study aimed to explore the potential for demand-side management via education and default nudge to reduce paper napkin waste, and how the potential changes depending on whether these treatments were implemented in isolation or in combination with one another. This study also examined the factors that influenced diners 'decisions regarding their napkin usage at the baseline level, prior to any interventions, and during each of the treatments. My findings suggest that the difference in the mean napkin reductions per meal per person between default nudge and education was statistically significant, with default nudge being more effective at reducing the number of napkins used. Education did not lead to a statistically significant reduction compared to the baseline level and combining both interventions did not make a statistically significant contribution to further reducing napkin waste beyond the results attributable to default nudge alone. Consequently, I believe default nudge is the optimal strategy at effectively reducing the number of napkins used per meal per person, in comparison with education and the combination of education and default nudge together. On another note, when exposed to the implementation of

combined treatments, diners reported greater concerns about the inconveniences associated with accessing napkins due to the default nudge treatment than thoughts about the environmental issues associated with using more napkins. Therefore, I think that introducing practical obstacles and challenges to napkin use exerts greater pressure on diners to change their behavior as opposed to leaving more of the decision-making power and conscious effort to participants. There is also a disconnect between consumer thoughts and actions as a higher proportion of diners reported consideration about the environmental footprint of paper napkins, yet there was no significant change in their napkin use behavior.

Factors Influencing Napkin Usage

One key finding from my analysis of the factors influencing people's decisions regarding their napkin use behavior was that meal messiness (the need to clean hands and mouth) consistently ranked among the top 5 factors influencing napkin usage. This reiterates the critical function of paper napkins for maintaining cleanliness and highlights how most people are not purposefully adopting wasteful behavior, but that they needed the paper napkins for sanitary purposes. By this logic, the key to reducing napkin usage may reside in the design of menus served at dining halls; if menu items rarely made people's hands and mouths dirty, there may be a much lower demand for paper napkins. In short, meal messiness is an important factor that might be difficult to target, but that can make a major impact on the napkin usage. If schools designed their menus to be less likely to create smudges when consumed, even without any other interventions, napkin usage may be reduced at the core. However, this might reduce the diversity of foods served.

On another note, I found that different interventions led to different top 5 factors diners considered when deciding how many napkins to take. When default nudge was in place, the factors that diners most frequently mentioned when reflecting on their decision to obtain a certain number of napkins had to do with social pressure and discomfort with asking for paper napkins per request. On the contrary, when education was implemented, people's beliefs and awareness of the environmental footprint of napkins became apparent. In other words, default nudge targeted practical behaviors whereas education influenced beliefs. My findings confirm that education can change people's beliefs, but it might not be enough to alter behaviors immediately or in a short-term.

Adding on to what I have established above, I found that the mean number of napkins people reported they used were lower than the amount I observed they actually used, which suggests that people have inaccurate perceptions of their napkin usage, perhaps because they do not pay attention to their consumption or may think that their behavior is less wasteful than reality. The discrepancy between self-reported napkin count and observed napkin count indicates that although education can raise awareness of issues, people may be reluctant to adopt changes in their actions, making education less effective than default nudge, which surpasses the process of altering beliefs, and directly introduces stimuli that increases the level of difficulty to consume paper napkins.

Comparing Default Nudge and Education

I found that default nudge led to a 32.35% reduction in napkin use, education 5.98%, and combined methods 35.13%. The magnitude of the reduction attributable to default nudge is roughly 6 times that of education. Moreover, the one-tailed two-sample t-test revealed that mean reduction across default nudge and education were highly statistically significant. These findings suggest that default nudge is more effective at reducing napkin usage than education. If an institution were to choose to adopt a practice within the two, they should choose default nudge.

Wagner and Toews (2018) performed a similar study of default nudge in reducing the use of single-use disposable plastic straws and found an average 32% decrease in straw consumption at coffee shops. The magnitude of reduction I observed with paper napkins resembles the observed change in plastic straws. In both cases, the magnitude of change was considerably large and statistically significant, highlighting great potential for default nudge to stimulate sustainable behaviors in the realm of single-use disposable goods. Another study examined the impact of using education to reduce food waste in university dining facilities and found an average 3.92% decrease in total food waste per student (Ellison et al. 2019). These researchers also found a change in waste that was statistically insignificant, which is supported by my findings for the education treatment as well. Therefore, education campaigns in the forms of posters and flyers may not be the most effective at improving wasteful behavior.

Value to Combining Both Methods

Although my one-way ANOVA revealed the means across all treatment groups had a statistically significant difference, the post hoc Tukey HSD Test showed no statistically significant difference in mean napkin count per meal per person between default nudge and combined treatments. The Tukey HSD Test also revealed no statistically significant difference in the means for the education and baseline groups, which would explain why there was no significant difference between default nudge and combined treatments, as the only treatment that had a statistically significant impact was default nudge, and not education. Abrahamse and Steg's (2013) study on social influence as a means of encouraging resource consumption yielded results in support of the limited impact on education methods. They noted that approaches that focused on information and feedback were less effective (Abrahamse and Steg 2013). Therefore, it is understandable that if both treatments were applied to a cafeteria together, the results would be very similar to if there was only implementation of the default nudge without the education intervention. In response to my question of whether there is value to implementing education and default nudge together, my conclusion is that just employing default nudge is sufficient.

In the given setting of a high school cafeteria, education did not lead to statistically significant reductions in napkin usage. Default nudge and combined treatments lead to statistically significant changes in mean napkin count, but the change from combined treatments may mostly be due to default nudge as the difference between these two treatments were not statistically significant. Education may not have led to significant reductions because while it did change people's opinions and increased awareness, people could still act out of personal habits and for their convenience, given that their actions were not directly controlled. Default nudge presented practical barriers that did not prohibit the option to use napkins but made it more difficult. While people may not have understood why this change was made, their behavior regarding napkin usage was nonetheless influenced. There were no major changes in napkin usage between default nudge and combined treatments because the former may have already greatly reduced napkin count to the bare minimum for most people such that when education was implemented together, diners still needed to use a certain number of napkins to maintain cleanliness even without taking more than they needed. What this signifies is that there is a minimum floor in usage of paper napkins, hence it is hard to keep reducing napkin count beyond a certain point. Finally, similar studies

applying default nudge to managing single-use disposable goods like plastic straws (Wagner and Toews 2018) also found statistically significant reductions just from making the product available only upon request, making default nudge a promising approach.

Limitations and Future Directions

The study site for my research was a high school that generally had good sense of social responsibility and attention to environmental issues, so they may have been more responsive to the call for reduced napkin usage than the average high school. The study site was also a private school, so the sample of diners may not have been as large as public schools and the study design may not be applicable to other schools in general. This limits the ability to expect that similar findings and conclusions may be drawn if the study was performed at another high school. Moreover, the specific education and default nudge interventions may not have been conducted as rigorously as they could have been. Other ways to carry out an education campaign would be to provide speeches or announcements to the entire school that encourages all students to pay attention or utilize the power of social media in providing information to young audiences in a way that fosters knowledge retainment. The intervention of posting up posters and flyers around the dining hall and having someone greet diners with face-to-face interactions may not guarantee that every single diner is exposed to the treatment—people still had a choice of whether they were subject to the treatment or not. The default nudge intervention, on the contrary, was applied in such a way that every diner was guaranteed to be affected, unless they use their own reusable napkins, which I did not observe to be the case, and may have been more extreme, by design, than the education treatment. Finally, I explored only the short-term effect of treatments; napkin consumption patterns may bounce back in the long-term. Moreover, education might display increased effectiveness due to its potential lingering effect when examining a longer time horizon. If there is additional research about paper napkins in the future, I would recommend researching with other forms of education and default nudge at different study sites, a few such as public schools, higher education institutions, with a longer time horizon. Other interventions beyond education and default nudge should also be explored.

Broader Implications

There are currently limited applications of default nudge to environmental and sustainability related fields; default nudge has mainly been used in energy and economic settings. My study shows the potential of default nudge in a wide range of settings beyond how it has traditionally been applied. Additionally, little attention has been directed to how sustainability efforts can be taken to reduce the waste produced at schools; it has mainly been up to the initiative of individual institutions to decide their own policies. The findings from my study suggest that default nudge may be an efficient way to set up some form of policy or rule that seems small but can lead to significant changes in napkin waste produced. The same could be said about other types of waste at education institutions, dining situations, and beyond.

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APPENDIX

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