



Research Article

Restaurant food waste reduction using nudge techniques at the customer level: An interventional study

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Abstract

Food waste is a critical global problem linked to food insecurity, environmental degradation, and economic losses. Food waste occurs across the supply chain, with a considerable portion generated at the consumer level, including restaurants. Food waste not only compromises global food security but also exacerbates environmental challenges such as greenhouse gas emissions, soil degradation, and water waste. Human behaviour significantly influences food waste, making it a crucial element in tackling this issue. This study explores the impact of behavioural nudges on reducing food waste at the customer level in a local restaurant in the downtown area of a Canadian city. Over four weeks, three nudges

were implemented in the form of tent cards on tables and stickers on menus to assess their effectiveness in reducing food waste. In the baseline week (no nudges), the average leftover weight was 37.2 grams per order. The first nudge reduced this to 19.7 grams (a 47 percent reduction from the baseline). The second and third nudges resulted in an average leftover weight of 29.1 grams (a 21.8 percent reduction from the baseline). Additionally, the takeout box usage per 100 orders was 14.4, 11.4, and 3.4 boxes during nudges one, two, and three respectively. These findings demonstrate the potential of low-cost, customer-focussed behavioural nudges to reduce food waste in restaurant settings. By reducing the amount of edible food discarded at the consumption level, these

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interventions can support broader food security goals while also contributing to environmental sustainability. Further research is recommended to examine the long-

term impacts and scalability of these interventions across different food service contexts.

Keywords: Customer behaviour; food security; food waste; nudges; restaurant

Résumé

Le gaspillage alimentaire est un grave problème mondial qui va de pair avec l'insécurité alimentaire, la dégradation de l'environnement et des pertes économiques. Il survient tout au long de la chaîne d'approvisionnement, dont une portion considérable à l'étape de la consommation, ce qui comprend les restaurants. Non seulement le gaspillage alimentaire compromet la sécurité alimentaire mondiale, mais il amplifie aussi les problèmes environnementaux, tels que les émissions de gaz à effet de serre, la dégradation des sols et le gaspillage d'eau. Les comportements humains comptent pour une grande part dans les facteurs du gaspillage alimentaire, il s'agit ainsi d'un élément crucial à aborder pour faire face au problème. Cette recherche s'intéresse aux effets de certains incitatifs sur les comportements liés à la réduction du gaspillage alimentaire chez la clientèle d'un restaurant du centre-ville d'une ville canadienne. Pendant quatre semaines, trois mesures ont été mises en place sous la forme de fiches sur les tables et de collants sur les menus pour vérifier leur efficacité dans la réduction du gaspillage

alimentaire. Durant la semaine de référence (sans incitatifs), le poids moyen des restes était de 37,2 grammes par commande. Le premier incitatif a permis de faire diminuer ce chiffre à 19,7 grammes (une réduction de 47 % par rapport à la valeur de référence). Avec les deuxième et troisième incitatifs, les restes représentaient 29,1 grammes (une réduction de 21,8 % par rapport à la référence). De plus, le taux de boîtes pour emporter utilisées a été de 14,4, 11,4 et 3,4 boîtes par 100 commandes pour les incitatifs un, deux et trois respectivement. Ces résultats démontrent le potentiel de mesures incitatives peu coûteuses tournées vers les comportements de la clientèle pour diminuer le gaspillage alimentaire dans le milieu de la restauration. De telles interventions, qui réduisent la quantité d'aliments comestibles jetés au niveau des consommateurs, peuvent contribuer aux objectifs plus larges de sécurité alimentaire, mais aussi de durabilité de l'environnement. Il est recommandé de mener d'autres recherches pour approfondir les effets à long terme et l'applicabilité de ces interventions dans divers contextes de services alimentaires.

Introduction

In 2022, an estimated 1.05 billion tonnes of food were wasted globally, which accounts for around 19 percent of all food available to consumers across retail, food service, and households, despite ongoing efforts to halve food waste by 2030 (UNEP, 2024). Food waste is linked to food security, as the resources used in producing wasted food could otherwise contribute to meeting the needs of the 830 million people worldwide who are undernourished (FAO, 2022). However, it is important to note that reducing food waste alone will not automatically resolve food insecurity, which is influenced by complex social and economic factors, such as income, access to food, and living wages. In Canada, food waste remains a significant concern, as nearly 46 percent of all food produced in Canada is wasted annually, with 41 percent of this waste deemed avoidable, valued at approximately \$60 billion (Second Harvest, 2024). This avoidable food waste generates around 26 million metric tonnes of CO₂ emissions each year, equivalent to the carbon footprint of 253,000 flights between Toronto and Vancouver (4,400 km) (Second Harvest, 2024). Reducing food waste is essential for supporting both food security and environmental sustainability. In 2022, food loss and waste were responsible for roughly eight to ten percent of global greenhouse gas emissions, consumed significant freshwater resources, and occupied a substantial share of agricultural land, illustrating how minimizing waste can reduce environmental pressures while improving the efficiency of food systems (UNEP, 2024).

It is worth noting that more than 7 billion Canadian dollars worth of food is wasted annually in hotels, restaurants, and institutional settings like school cafeterias, accounting for approximately 13 percent of Canada's total food loss and waste (Second Harvest, 2020). Reducing food waste in restaurants can lower

operational costs and enhance sustainability credentials (Principato et al., 2021). Some establishments in Europe address food waste by adopting innovative practices, such as offering customizable portion sizes (Kallbekken & Sælen, 2013).

Customer behaviour in restaurants significantly influences the generation of food waste (Coşkun & Yetkin Özbük, 2020; Li et al., 2024; Teng et al., 2022). Factors such as portion sizes, customer preferences, and cultural norms contribute to excessive leftovers (Kallbekken & Sælen, 2013). Buffet-style dining often contributes significantly to food waste, primarily because oversized portions and the abundance of options encourage diners to overfill their plates and take more than they can eat (Aloysius et al., 2023; Kallbekken & Sælen, 2013; Riis, 2014). Restaurants, as intermediaries between food production and consumption, are uniquely positioned to address this issue.

Behavioural economics is a discipline that combines psychology and economics to explore how cognitive biases, emotions, and social influences shape decision-making (Camerer & Loewenstein, 2004). Behavioural economics recognizes that individuals often make irrational choices due to limited information and cognitive biases (Ariely, 2008; Kahneman, 2011). This framework helps explain decision-making processes and create interventions to encourage better choices without restricting options. A key concept in this field is the “nudge”: a subtle measure designed to influence behaviour by leveraging cognitive biases while maintaining individual autonomy (Thaler & Sunstein, 2008). Examples include simplifying decision-making processes and using social norms to promote desired behaviours.

Nudge theory has been successfully applied in various areas to encourage behavioural changes. For example,

default settings, such as opt-out organ donation systems, have significantly increased participation rates, as individuals tend to stick with the pre-set options rather than actively opting out of the service (Johnson & Goldstein, 2004). Similarly, positive social norm messaging, such as community recycling habits, effectively encourages sustainable practices (Schultz et al., 2007). While nudges have been widely used in policy and public health (Johnson & Goldstein, 2004; Schultz et al., 2007), their application in food waste reduction remains an evolving area. Restaurants, cafeterias, and institutional food services contribute substantially to food waste (Second Harvest, 2020), yet behavioural interventions in these settings requires more research. Behavioural interventions, such as portion size adjustments, reminder prompts, and visual cues, can help to reduce food waste in restaurant settings (Freedman & Brochado, 2010; Kallbekken & Sælen, 2013; Wansink & Van Ittersum, 2013). These strategies could be further adapted to other food service environments, including cafeterias, corporate dining halls, and institutional food services. For instance, universities and hospitals could implement menu redesigns that highlight low-waste options or use real-time feedback on plate waste to encourage mindful consumption. Similarly, buffet-style settings might benefit from serving smaller portions with the option for additional helpings, reducing unnecessary waste while preserving consumer choice (Kallbekken & Sælen, 2013; Kasavan et al., 2022).

In addressing food waste, nudging provides creative and practical solutions to promote sustainable consumption. Several studies have focussed specifically on restaurants and demonstrated the potential of nudges to reduce food waste. For instance, visual reminders targeted guests in hotel buffets to measure how simple interventions can influence food-related behaviours in hospitality environments in Norway. The results revealed that reducing the plate size lowered food waste

by 20 percent. Adding signs that informed guests they could return for additional servings further reduced waste by 21 percent (Kallbekken & Sælen, 2013). Similarly, offering smaller plates or portion sizes in controlled experiments in the United States has proven effective in curbing over-serving and waste (Van Ittersum & Wansink, 2012). Pre-commitment strategies, where customers pledge to minimize waste, have also demonstrated significant reductions in plate waste (Thaler & Sunstein, 2008).

The impact of digital and physical nudges in restaurant environments was explored in a study of 628 diners in a Malaysian dining experiment. Positive reinforcement messages, such as "*Finish your food today, become a ZERO waste warrior,*" were particularly effective in reducing food waste compared to negative reinforcement messages (Ong et al., 2023). In another study in the Netherlands, Victor tested digital green nudges through mobile applications with a sample size of 346 participants recruited via social media and university networks. While over 90 percent of participants expressed interest in reducing food waste, the study found that many users struggled with maintaining consistent engagement with the app over time. As a result, the study reported minimal measurable reductions in food waste, highlighting the challenges of translating interest into sustained behaviour changes through digital interventions (Victor, 2023).

Another study examined the use of social norms and default nudges in Italian restaurants, examining about 24,000 diners across 14 establishments. The findings showed that takeout box usage significantly increased when subtle prompts were introduced (Giaccherini et al., 2021). In a Swiss pizzeria, informational and normative prompts were compared to encourage diners to take leftovers home. The six-week study involved 54 diners and demonstrated that combining these prompts

increased the percentage of diners requesting takeout containers by at least 30 percent (Stöckli et al., 2018).

The reviewed studies reveal the potential of nudging strategies to mitigate food waste in restaurant settings. Visual and informational nudges, plate size adjustments, and digital tools (mobile applications) can all contribute to significant reductions in waste. While nudges have been widely studied as a strategy for food waste reduction, several key gaps remain. For instance, many existing studies focus on controlled or laboratory-based experiments, which may not fully capture the complexities of food waste behaviours in commercial food service environments (Liu et al., 2022; Van Ittersum & Wansink, 2012). Most food waste management studies in food service have used single interventions, such as plate size adjustments or static informational prompts (Jagau & Vyrastekova, 2017; Kallbekken & Sælen, 2013; Qi et al., 2022). Few studies have integrated multiple nudges within a single study to compare and assess their relative impact in restaurant settings (Stöckli et al., 2018). Additionally, the distinction between avoidable and unavoidable food waste is often overlooked, which is essential for more

accurate waste reduction strategies. Lastly, few studies have incorporated non-participatory observation to capture human interactions and assess how consumers respond to nudges in practice.

In the province of Newfoundland and Labrador (NL), food insecurity is a major concern, affecting approximately 23 percent of households, one of the highest rates in Canada (Tarasuk et al., 2023). The province's reliance on food imports exacerbates this issue, with over 90 percent of its food sourced from outside the province. This dependency increases food costs, reduces access to fresh produce, and heightens vulnerability to supply chain disruptions (Food First NL, 2015). As of October 1, 2024, the population of NL stood at 550,000, representing approximately 1.33 percent of Canada's total population of 40 million (Department of Finance, 2025). This study therefore examines the impacts of three behavioural nudges on customer food waste in a restaurant with the underlying assumption that reductions in edible food waste, even at a small scale, contribute to broader food system efficiency and food security.

Materials and methods

This study was carried out over four weeks in a local restaurant bar in St. John's. The study was conducted from September 23 to October 26, 2024, excluding a week that contained a holiday to reduce the impact of the holiday on the study. The first week served as a baseline, during which customer behaviour and food waste measurements were recorded without any interventions. During the subsequent three weeks, one distinct behavioural nudge was implemented per week. Each nudge was introduced independently and replaced the previous nudge, rather than being added

cumulatively. The nudges consisted of environmental messages delivered through tent cards placed on tables and stickers positioned on the back of menu cards, with the content of the message changing each week. All other study conditions remained consistent across weeks. These messages were designed to encourage waste reduction behaviours. The study took place from Monday to Saturday each week, with observation periods occurring during peak hours, from 12:00–2:00 p.m. and 6:00–8:00 p.m., resulting in a total of 96 hours of non-participatory observation. Measurements

included the daily weighing of leftovers (in grams) including avoidable and unavoidable and the number of takeout boxes requested by customers.

Implementation of nudges

To encourage food waste reduction, three environmental nudges were developed and implemented in the form of tent cards placed on tables (Figure 1) and stickers (Figure 2) attached to the back of menu cards. These nudges were set up by the researcher every Monday morning before the restaurant opened (Figure 3). Successful implementation of the intervention required a one-hour training session for restaurant staff on separating food waste from non-food items and assisting with repeated measurements of leftovers. Staff cooperation and positive attitudes were crucial for ensuring accurate and reliable data

collection. The bar owner's support facilitated the smooth integration of the nudges into regular restaurant operations. Staff ensured that tent cards were prominently displayed on every table and that menus with stickers were provided to customers as they placed their orders, maintaining consistent exposure to the nudges throughout the week. These procedures helped to standardize data collection while minimizing disruption to routine services. The nudges aimed to subtly influence customer behaviour, without direct interaction or interference. This study was conducted in accordance with institutional guidelines for research involving human participants. As the observations were non-participatory, anonymous, and did not collect identifiable personal data, the research was deemed exempt from formal ethics approval by the institutional ethics committee of Memorial University.

Figure 1: Tent cards used as nudges to promote food waste reduction



Figure 2: Stickers used on the menu cards



Figure 3: Nudge signage setting in the restaurant



The text of the nudges was made based on the principles of behavioural economics, particularly nudge theory, which suggests that subtle prompts in the environment can influence decision-making without restricting choice. The wording was designed to be simple, positive, and action oriented. The three nudges, shown in Figure 1 (left to right), were designed with varying lengths and focus areas:

1. *Nudge one:* This nudge featured a short message encouraging customers to enjoy their food (“*Savour Every Bite*”) while emphasizing the importance of reducing food waste in the second week of the study. Its goal was to create an emotional connection with the act of eating.
2. *Nudge two:* This nudge specifically focussed on encouraging customers to take their leftovers home by requesting a takeout box (“*Love Your Leftovers: Take Them Home for Round Two*”) in the third week.
3. *Nudge three:* In the final week, this nudge combined an informational prompt with an encouragement to ask for a takeout box. It included a statistic about avoidable food waste in Canada (“32percent of all food produced is avoidable waste,

enough to feed every Canadian for three and a half months”) to raise awareness and motivate action.

Each day during the study period, the restaurant staff and the researcher checked to ensure that the tent cards were present on all tables and replaced any missing or damaged cards as necessary. These nudges were visible to customers throughout the day, and their placement was designed to unobtrusively influence behaviour while customers dined. The implementation of nudges was a critical part of assessing the impact of behavioural interventions on food waste reduction.

Equipment and calibration

A digital hanging scale was used for measurements in this study (Figure 4). The scale used for measuring food waste had a minimum detectable weight of 20 grams and was calibrated using a kitchen scale with an accuracy of 1 gram. This calibration ensured precision in quantifying leftover waste.

Waste collection procedure

Restaurant staff were trained to scrape leftover food from their plates into a designated bin for measurement. Non-food items, such as napkins and condiment packaging, were separated from the leftover food before placing them in the bin by staff to maintain data accuracy. Plates and cutlery were reusable, ensuring that no additional disposable materials were included in the bins. After the food was collected, the researcher did a secondary inspection of the bin to ensure that only food waste was included. All leftover measurements were taken nightly after all customers

had finished dining (Figure 5). To ensure reliability, each measurement was repeated three times, and the average of the three weights was used as the final leftover weight. Additionally, the weight of the garbage bags was deducted from all measurements. The average weight of the garbage bags was calculated from three samples (43 grams) and was used as a reference. Furthermore, the number of daily orders and the types of food ordered by customers were provided by the restaurant owners. These data were extracted from the restaurant's digital ordering system, which recorded every ordered item and made the data available at the end of Week Four.

Figure 4: Digital scale



Figure 5: Food waste measurement



Calculation of avoidable waste

The primary focus of this study was that of avoidable waste. Food waste is categorized into two types:

1. **Avoidable waste:** Food that could have been consumed but was discarded, such as uneaten portions of meals or unused ingredients.
2. **Unavoidable waste:** Inedible parts of food that cannot be consumed, such as bones, peels, or other non-consumable components.

Chicken wings, one of the most frequently ordered items in the restaurant, produced bones as a significant component of the leftovers. These bones were categorized as unavoidable waste and excluded from avoidable waste measurements. Each plate of chicken wings consisted of eight pieces, with the bones weighing approximately 80 grams per plate. To calculate avoidable waste, the weight of chicken bones was deducted from the total leftover weight using the following formula:

$$\begin{aligned} \text{Avoidable Waste} &= \text{Total Weight of Leftover} \\ &- (\text{Weight of Chicken Bones} \\ &\times \text{Number of Chicken Wing Orders}) \end{aligned}$$

Non-participatory observation procedure

Non-participatory observations were conducted to qualitatively assess customer behaviours related to food waste and dish-specific waste patterns. The observations were carried out over a total of 96 hours, during peak dining periods from 12:00–2:00 p.m. and 6:00–8:00 p.m., Monday to Saturday, throughout the study period. The selection of these time frames was based on the highest customer volume to ensure a representative understanding of food consumption and waste behaviours in the restaurant setting. Observations were conducted by a single trained researcher using a standardized observation protocol, an approach commonly applied in qualitative observational studies when consistency and systematic procedures are ensured (Angrosino, 2007; Patton, 2015).

To minimize observer influence and maintain the authenticity of customer behaviour, observations were conducted without customers being informed that they

were being observed. Furthermore, there was no direct interaction between the researcher and customers at any stage of the study. This approach ensured that the presence of the researcher did not alter customer decision-making, particularly in relation to food consumption and takeout box requests. Observations were conducted from a distance, with data recorded in real time.

Detailed field notes were taken that focussed on key behavioural patterns, including the types of dishes that consistently resulted in leftovers, the frequency and context in which customers requested takeout boxes, and observable patterns in waste generation related to group size, meal type, or dining habits.

Data analysis

To evaluate the effectiveness of behavioural nudges in reducing food waste, a combination of descriptive analysis and statistical testing was employed.

Results

The results of this study are divided into two primary components: measurement analysis and non-participatory observations. The measurement analysis examines the quantitative impacts of nudges on food waste, while the non-participatory observations provide qualitative insights into customer behaviours and dish-specific waste patterns.

Measurement analysis

The findings of this study demonstrate the impact of behavioural nudges on reducing restaurant food waste, with each intervention week compared to the baseline data from Week one. The weekly average leftover weight significantly decreased following the

Descriptive statistics were used to compare the weekly average leftover weight and takeout box requests across the intervention period. Changes in average food waste were assessed by examining trends across the baseline and intervention weeks.

For the daily leftover weight data, an independent t-test was conducted to compare the mean food waste between the baseline and each intervention week. This statistical test was used to determine whether the differences observed in food waste were statistically significant. Additionally, confidence intervals were calculated to assess the variability in food waste reduction. In cases where chicken wings were ordered, the total weight of leftovers was adjusted by deducting the estimated weight of bones to accurately quantify avoidable food waste. All weight measurements were repeated three times, and the average value was used for analysis.

implementation of the first nudge (Table 1). During the baseline week, the average leftover weight per order was 37.2 grams. Takeout box usage was recorded at 7.8 boxes per 100 orders. In Week two, following the introduction of the first nudge, the average leftover weight per order decreased to 19.7 grams, representing a 47percent reduction compared to the baseline. Takeout box usage significantly increased to 14.4 boxes per 100 orders. The second nudge, implemented in Week three, resulted in an average leftover weight of 29.1 grams per order, a 21.8percent reduction from the baseline; however, takeout box usage declined to 11.4 boxes per 100 orders. By Week four, the third nudge maintained the average leftover weight at 29.1 grams per order, consistent with the second nudge and a 21.8percent

reduction from the baseline. Takeout box usage dropped to 3.4 boxes per 100 orders. The results of the independent t-tests demonstrate that the behavioural nudges implemented during the study did not lead to statistically significant reductions in daily leftover weights compared to the baseline period. While the mean weights during Nudge one and Nudge two were lower than the baseline, the differences failed to reach significance due to high variability and overlapping confidence intervals ($p > 0.05$). The observed increase in leftover weight during Nudge three also lacked statistical significance. The results of the t-test are summarized in Table 2.

These findings demonstrate the challenges of achieving consistent and statistically significant reductions in food waste using behavioural nudges in a short-term period. Despite the lack of statistical significance, the observed trends in mean reductions during Nudges one and two suggest the potential for further exploration with larger sample sizes and reduced variability.

Non-participatory observations

Non-participatory observations revealed detailed insights into food waste patterns associated with specific dishes and customer behaviours (Table 3). Among soups, turkey soup was particularly popular on rainy days and rarely resulted in leftovers. French onion soup, however, had minor leftovers due to cheese sticking to the bowl. Soups were sometimes accompanied by grilled cheese sandwiches or side salads, which were mostly consumed.

Salads generally produced minimal waste, with garden salads occasionally leaving small amounts of bacon bits, lettuce, and dressing uneaten. The portion size of garden salads was observed to be large but manageable, whereas side salads, such as Caesar and

blackberry feta, were served in smaller bowls and were typically finished.

Among sandwiches, the hot turkey sandwich was the most ordered and often resulted in leftovers such as bread crusts. Customers frequently requested takeout boxes for this dish. Other sandwiches, including the clubhouse and pesto chicken, produced less waste. Pizza, particularly veggie pizza, was popular as a lunch option and occasionally had leftovers in the form of uneaten crusts or slices. Customers often requested boxes for leftover pizza.

Nachos were one of the most frequently ordered dishes but often resulted in significant waste, including leftover cheese, condiments, and nacho chips. This pattern was observed even when the dish was shared. Similarly, NL poutine and butter chicken poutine frequently produced leftovers, with approximately one-quarter to one-third of the dish left uneaten. These items were rarely taken home in boxes, as customers reported feeling full due to the large portions and the heavy use of gravy.

Pub grub items like chicken wings created the most waste due to bones and unused condiments. Dishes such as mozzarella sticks and quesadillas typically had minimal leftovers. Other notable observations included private events where dips, such as buffalo chicken and spinach dip, were left largely untouched in some instances.

The results show that the first nudge resulted in the most noticeable reductions in both leftover weight and avoidable waste, with diminishing effects observed in subsequent weeks. While the second and third nudges still showed reductions in leftover weight compared to the baseline, their impact on avoidable waste was less pronounced, particularly in the final week. In addition, takeout box usage trends suggest initial customer interest in preserving leftovers, which diminished as the intervention progressed. However, the day-by-day

statistical analysis revealed no significant differences, which reflects variability in daily outcomes. Non-participatory observations provided valuable qualitative insights that identified high-waste dishes such as nachos, poutines, and chicken wings, and specific customer behaviours, such as requesting boxes for

sandwiches and pizza. These findings show that while behavioural nudges have potential, targeted interventions tailored to high-waste dishes may be necessary to achieve consistent and sustainable reductions in food waste.

Table 1: Weekly food waste reduction metrics and takeout box usage during nudge interventions

	Week 1	Week 2	Week 3	Week 4
Orders	127	146	114	176
Total waste (grams)	5682	4002	4122	6802
Total avoidable waste (grams)	4722	2882	3322	5122
Total avoidable waste (grams per item)	37.2	19.7 (47%)*	29.1 (21.8%)	29.1 (21.8%)
Boxes	7.8 /100	14.4/100	11.4/100	3.4/100

* The percentages shown in parentheses represent the reduction in avoidable waste compared to the baseline week (Week 1).

Table 2: T-test results comparing baseline and nudge groups for daily leftover weight

Group	Mean (M)	SD	n	t	df	P value	CI (95%)
Baseline	787	314.643	6	1.742	10	0.678	-85.58 698.915
Nudge 1	480.33	294.867	6	1.742	9.958		-85.81 699.138
Baseline	787	314.643	6	0.867	10	0.072	-366.7 833.324
Nudge2	553.67	579.713	6	0.867	7.711		-391.7 858.372
Baseline	787	314.643	6	-0.33	10	0.741	-517.2 383.861
Nudge 3	853.67	382.501	6	-0.33	9.641		-519.5 386.142

Table 3: Menu items and observed waste patterns

Category	Menu item	Observed waste patterns
Soups	Turkey soup	Popular on rainy days, with minimal waste.
	French onion soup	Leftovers often consist of cheese sticking to the bowl.
	Soup of the week	Waste depends on the soup type but is generally minimal.
Salads	Garden salad	Small leftover bits of bacon, lettuce, and dressing are common. The portion size is large but manageable for most customers.
	Caesar salad	Minimal waste; leftover dressing is most common.
	Blackberry and feta	Typically, fully consumed, with little to no waste.
Sandwiches	Hot turkey sandwich	Often served with gravy; leftovers sometimes include bread crusts. Customers frequently request takeout boxes.
	Clubhouse sandwich	Generally consumed with minimal waste.
	Beef melt with au jus	Often fully consumed, with occasional leftovers from side dishes.
	Pesto chicken sandwich	Minimal waste observed.
	Veggie and spinach dip	Generally well-received, with little waste.
	Chicken caesar wrap	Occasionally has small leftovers but is usually fully consumed.
	Turkey bacon ranch wrap	Produces minimal waste.
Pizza	Veggie pizza	Commonly ordered at lunch. Sometimes crusts are left uneaten (~30% of the time). Customers often request boxes for unfinished slices.
	Pepperoni pizza	Similar waste patterns to veggie pizza, with crusts and occasional slices left.
	Meat Lovers pizza	Often finished, but leftovers can include crusts or slices.
	Spinach Dip pizza	Occasionally has leftover crusts or portions of toppings.
	Pizza of the week	Waste patterns depend on the pizza type, but crusts and slices are the most common leftovers.
	Garlic fingers (cheese and bacon)	Frequently ordered, with occasional leftover slices or crusts.
Nachos	Veggie nachos	Popular but often results in significant leftovers, including cheese, condiments, and chips, even when shared.
	Chicken/beef nachos	Similar to veggie nachos, with leftovers including cheese, chips, and condiments.
	Braised beef nachos	Often produces waste in the form of toppings and chips.
Pub Grub	Mozzarella sticks	Generally, fully consumed with minimal waste.
	Quesadillas (veggie/chicken/beef)	Minimal waste observed.
	Chicken wings	Creates the most waste due to bones and leftover condiments.
	Popper burger	Small burger with sides like fries or salad; waste is typically limited to leftover fries.
	Buffalo chicken tacos	Minimal waste observed, except for some leftover veggies such as bell peppers.
	Cajun chicken pasta	Sometimes has leftovers, mostly sauce. Takeout boxes are rarely requested.
	Mac and cheese	Occasionally has leftovers, primarily cheese or sauce. The portion size is manageable.
	NL poutine	Creates significant waste, with about one-third to one-fourth of the fries often left uneaten. Customers rarely request boxes.
	Butter chicken poutine	Similar to NL Poutine, with significant leftovers, including fries and gravy.

Buffalo chicken dip	Leftovers are common, especially during private events. For example, in Week 2, two bowls were nearly untouched.
Spinach dip	Similar to buffalo chicken dip, with occasional leftovers observed, particularly during private events.

Discussion

This study aimed to evaluate the effectiveness of behavioural nudges in reducing food waste in a restaurant setting. Over a four-week period, three different nudges were implemented, and changes in leftover food weight and takeout box requests were assessed. The results indicated that while all nudges contributed to a reduction in food waste compared to the baseline, the most substantial decrease was observed during Nudge one; however, the effects diminished in the following weeks. Although the overall trend suggested a decline in food waste, day-to-day comparisons were not statistically significant. Results from the current study align closely with prior research and reinforce the efficacy of behavioural economics in addressing food waste challenges. The results of this study indicate that well-designed nudges can significantly reduce food waste in restaurant settings. Similar to findings by Kallbekken et al., who demonstrated a 20percent reduction in food waste through plate size manipulation and visual prompts, our interventions effectively influenced customer behaviour (Kallbekken & Sælen, 2013). However, the significant reduction during the first nudge followed by diminishing returns in later weeks indicate the need for novelty and diversity in the intervention design (Giaccherini et al., 2021).

Danyi Qi et al. show that nudges, such as plate size changes and informational prompts about food waste and nutrition, influence food intake but achieve limited success in reducing waste (Qi et al.,

2022). Their study, conducted in a controlled cafeteria setting with 488 participants, involved varying plate sizes, material types (plastic versus compostable), and informational treatments to examine their effects on food selection, consumption, and waste. While smaller plate sizes encouraged reduced portion sizes, and informational prompts increased awareness about food waste, the interventions did not consistently translate into measurable reductions in avoidable waste. These results show the need to tailor nudges to specific contexts for greater effectiveness.

Additionally, Henrik Luis Jagau et al. (2017) examined the impact of informational posters on food waste reduction in a university cafeteria. Over 14 days, approximately 2,500 meals were served, and two types of posters were displayed. The first poster encouraged customers to consider their appetite by asking reflective questions and offering portion-sizing tips. The second used a sad face alongside information about the environmental harm caused by food waste. Although the posters successfully doubled the proportion of customers requesting smaller portions (from 2.5percent to 5percent), they did not result in a significant reduction in the overall amount of food wasted. These results suggest that while static informational methods like posters can influence intentions (e.g., requesting smaller portions), they may be insufficient on their own to produce measurable changes in actual food waste behaviour (Jagau & Vyrastekova, 2017). Nina Langen et al. highlight how labelling and descriptive food names encourage sustainable food choices. Counter-

position nudges successfully increased the selection of sustainable dishes, which aligns with our observation that strategic messaging effectively guides customer behaviour (Langen et al., 2022).

Furthermore, the inclusion of messages promoting takeout containers aligns with Stöckli et al., who found that combining informational and normative prompts increased the percentage of diners requesting takeout containers (Stöckli et al., 2018). Our study's peak in takeout box usage during the first intervention week reinforces the utility of such prompts, though the later decline suggests the necessity of sustaining engagement through incentives or additional reminders.

Study strengths

Our study builds on previous research by incorporating additional elements. Specifically, this is one of the few studies in the food service sector to test multiple nudges within a single study to assess their effectiveness in reducing food waste. For a policy-level change, it is essential to determine which types of messages are most effective in influencing human behaviour. Moreover, while similar research has been conducted in various countries with diverse cultural and socioeconomic backgrounds, it is crucial to understand what strategies are most effective within the Canadian context. To address this, our study included a range of message types, from simple encouragement (e.g., prompting individuals to enjoy their meal and be mindful of waste) to a behavioural direction (e.g., suggesting that customers request a takeout box) and informational messages highlighting the environmental impact of food waste.

By training restaurant staff to separate food waste from non-food items and conducting secondary inspections as well as repeated weight measurements of food waste, our research ensured that data collection was accurate and reliable. Additionally, the exclusion of

unavoidable waste, such as chicken bones, allowed for a more accurate assessment of avoidable food waste. The small restaurant setting facilitated precise measurements and strict control over study conditions. The successful implementation also relied on staff training, their receptivity and attitudes, and the support of the bar owner, highlighting the importance of engagement and cooperation for accurate data collection. Moreover, the intervention was highly cost-effective and required minimal resources, which makes it scalable for various food service settings.

In addition, our study is unique in that it included direct non-participatory observation of customer food waste behaviour during the intervention. Through this observation, we captured human responses to the nudges. This approach allowed us to observe verbal and non-verbal cues, such as the way participants discussed food waste, their willingness to adopt suggested behaviours (e.g., requesting a takeout box), and any resistance or skepticism toward the messages. Furthermore, our study distinguished between avoidable and unavoidable food waste, an aspect that is not included in many previous studies. Understanding this difference is essential for developing food waste reduction strategies that focus on minimizing avoidable waste while acknowledging the limitations of unavoidable waste. Another key distinction of this research is the detailed identification of the types of food that contribute most significantly to waste. This information provides practical, affordable, and effective strategies that restaurant managers can use to optimize portion sizes, refine menu designs, and reduce food waste.

Study limitations

Despite promising findings, this study had several limitations. The interventions, especially during Week

two, might have overlapped in ways that influenced customer behaviour in Weeks three and four, making it difficult to evaluate the effectiveness of each nudge individually. This overlap was likely because regular customers, who frequented the restaurant weekly, may have seen the signage multiple times, complicating the process of isolating the effects of each week's intervention. The limited number of orders and customers possibly could cause fluctuations in results. The lack of direct interaction with participants restricted the understanding of their motivations and perceptions. Interviews with customers could reveal how these messages impacted their feelings towards food waste and decision-making and whether they are likely to maintain these sustainable behaviours. The study also faced variability in waste measurements due to the inclusion of different menu items. Measuring the total waste instead of individual plate waste could reduce the level of accuracy. Additionally, the research's scope was constrained by a lack of ethnic diversity, as it was conducted in a local restaurant with limited cuisine types and ethnic groups, which affects its generalizability. While the intervention required minimal financial resources, successful implementation depended on the investment of time, training, and cooperation from the restaurant staff and owner, which may represent a challenge for scaling or replicating this design in other settings.

Finally, while our study focussed on reducing food waste, it is possible that behavioural nudges could influence portion consumption in ways not intended. For example, nudges that encourage finishing meals might prompt some customers to eat more than they would have otherwise. Although we did not observe or measure this effect directly, future research could examine potential trade-offs between reducing plate waste and promoting healthy eating behaviours to

ensure interventions support both sustainability and public health goals.

Implications for future research

Addressing these limitations in future research could enhance our comprehension of effective strategies for reducing food waste. Longitudinal studies with larger, more diverse samples could provide deeper knowledge. Incorporating digital tools, as suggested by Victor (Victor, 2023), may improve customer engagement, resulting in lasting behavioural changes. Investigating cultural and demographic differences in receptivity to nudges might reveal tailored approaches suited to varied contexts. Additionally, future studies could explore the role of social norms and peer influence, such as highlighting behaviours of higher-achieving peers or using social comparison strategies, which have been shown to affect food waste behaviours in other contexts (Al Mamun et al., 2024; Venit, 2017). Although this study was conducted in a single, small-scale restaurant, the findings suggest broader implications for food waste reduction efforts in the food service sector. If the most effective nudge identified in this study were implemented consistently over an extended period (e.g., 52 weeks) and adopted across multiple restaurants, the cumulative reduction in edible food waste could be substantial. At the individual level, reduced plate waste may contribute to improved food utilization, as customers consume a greater proportion of the meals they order. Over time, this behavioural shift could also support household food budgets by decreasing the need for additional food purchases, thereby offering an indirect pathway through which food waste reduction interventions may contribute to food security. While these impacts are hypothetical and require further empirical investigation, they underscore the potential

scalability and system-level relevance of low-cost behavioural nudges in restaurant settings.

Conclusion

This study makes a meaningful contribution to the research on food waste reduction. The results demonstrate that while all nudges led to a reduction in food waste compared to the baseline, the day-to-day comparisons were not statistically significant. The first nudge resulted in the most noticeable decline in leftover

weight, but the effect diminished in the later weeks. While behavioural nudges offer restaurants a practical and cost-efficient tool for tackling food waste, further research is essential to overcome the current limitations and maximize the impact of these interventions.

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