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# Evaluation of a community-based food waste campaign using a national control group

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ABSTRACT

Communities are increasingly interested in bolstering sustainability by implementing local campaigns to reduce wasted food and divert it from landfills. Evaluation can be challenging, however, as community-engaged interventions may reach all community members, making it difficult to find an appropriate control group. We leverage a recently validated online survey instrument with samples from both the treated community of Upper Arlington, Ohio, USA, and from the United States at large to provide an additional mode for assessing community-based campaign efficacy. We find that the amount of wasted food reported by Upper Arlington households declined by 23% after a multi-modal local implementation of the 'Save More Than Food' campaign while the national sample reported a 29% increase in wasted food over the same period with the 52% net difference between these trends being statistically significant. A contemporaneous curbside audit of Upper Arlington households revealed a 17% reduction in wasted food and a 30% reduction in inedible food scraps where only the latter pre/post campaign reduction was statistically significant and no parallel national curbside audit data was available. There were few significant differences across neighborhoods that received differential intensities of campaign elements, which emphasizes the importance of identifying and conducting parallel measurement in a control group. The inclusion of the parallel national control group survey provided a cost-effective means to improve the accuracy and robustness of local campaign evaluation. We also discuss the campaign's effects on awareness, attitudes, composting behaviors, and non-organic waste rates.

## 1. Introduction

Community engagement is increasingly emphasized as a factor critical to achieving household food waste (FW) reduction goals with recent funding opportunities (U.S. Environmental Protection Agency, 2021) and consensus reports (NASEM, 2020) emphasizing community-based approaches. While numerous evidence-based community-engaged interventions exist for health and wellness (Nickel and von dem Knesebeck, 2020; Merzel and D'Afflitti, 2003), similar evidence is needed to prioritize sustainable behavior interventions, particularly for reducing household FW (Reynolds et al., 2019; NASEM, 2020). Robust evaluation of interventions ideally leverage a control group rather than a simple before/after comparison of a treatment group. The inclusion of a control group permits contrasting the change before and after intervention implementation against a similar group who did not receive the intervention, which controls for secular or seasonal changes in focal outcomes unrelated to the intervention. For community-based interventions that rely upon untargeted local communication channels to deliver intervention materials (e.g., community newsletters or mass/social media), constructing a control group can often be difficult as it requires measuring outcomes for a group outside the reach of community-based communications, which can be costly. This led Grilli and Curtis (2021) to observe that most community-based evaluations rely upon simple before/after comparisons, which undermines

*Abbreviations:* FW, food waste; SMTF, Save More Than Food.

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identification of efficacious interventions.

Several household FW interventions have been evaluated using a control group, but none of these interventions occurred as a community-wide intervention despite the increasing emphasis on leveraging community engagement to address wasted food (U.S. Environmental Protection Agency., 2021; NASEM, 2020). Romani et al. (2018) evaluate an information intervention that yields a significant (24 %) reduction relative to the control group. Van der Werf et al. (2018) evaluate a multi-component intervention that yields a significant (29 %) reduction in avoidable food waste compared to control. Soma et al. (2020) evaluate three treatments: information; information and community workshops[1]; and information with online quizzes with prizes. No significant post-campaign differences across control and treatment were identified. However, each study communicated individually with households (e.g., letters, door-to-door recruitment) rather than using community-based communications, which allowed formation of within-community control groups that did not receive intervention materials. To the best of our knowledge, there exists no published evaluations of community-based household food waste interventions, likely due to the difficulty in establishing a relevant control group.

In this article, we begin to fill this gap in the literature by explicating an evaluation approach for community-based household FW interventions and using it to evaluate a FW intervention in Upper Arlington, Ohio, USA. The campaign included community-wide communications, while additional communications were targeted to residents in specific neighborhoods. In addition to evaluating neighborhood differences using curbside waste audits, we enhance evaluation by leveraging a recently validated online FW measurement survey (van Herpen et al., 2019a; Shu et al., 2021) with samples drawn from both the community and from the United States at large. This use of a parallel implementation of national-level household FW survey measurement to enhance evaluation of a community-based intervention is, to the best of our knowledge, a unique contribution to this literature.

We also assess how participant self-selection, i.e., voluntary participation in evaluation activities (surveys and curbside waste audits) may shape results. While researchers recognize the general issue of sample representativeness in evaluation (matching on demographic and household characteristics, e.g., Romani et al., 2018; van Herpen et al., 2019b; Wharton et al., 2021; Van der Werf et al., 2018), few address how behavior among voluntary participants may differ from non-volunteers in the same community. Finally, we explore how monitoring of community-wide composting activity can be another source of convergent validity for ground truthing survey and curbside FW trends.

The remainder of the article proceeds by providing details of the campaign (Section 2); outlining the measurement approaches and the evaluation methods deployed (Section 3); presenting the results of the several evaluation approaches (Section 4); and discussing the results and conclusions (Section 5).

## 2. The ‘Save More than Food’ campaign

The Solid Waste Authority of Central Ohio (Solid Waste Authority of Central Ohio SWACO, 2019) found 15 percent of all landfilled material in the region was food waste, which motivated the development of the Save More Than Food (SMTF) campaign in coordination with other Central Ohio organizations. Launched in September 2020, SMTF (savemorethanfood.org) provides residents, schools, and businesses with resources, information, and strategies for FW reduction. SMTF uses various public outreach channels to provide information on FW prevention and diversion. However, little is known about the impact that this messaging has on FW behaviors among residents, particularly when implemented as a community-based campaign. SWACO partnered with the City of Upper Arlington (suburban Columbus, population 36,800) and Ohio State University to study the effectiveness of a Spring 2021 community-based campaign in improving residents’ FW attitudes, knowledge, and behaviors.

## 3. Approach and methods

A difference-in-differences approach is used to evaluate campaign effectiveness, i.e., we contrast the difference in key outcomes over time for treatment households against a control group. For this study we consider two control groups. The first control group consists of Upper Arlington households that received the least intensive exposure to SMTF campaign materials. The research team divided Upper Arlington into three evaluation areas based upon refuse hauling routes with residents having their refuse picked up on Mondays or Tuesdays assigned to treatment group one and residents having their refuse picked up on Thursdays assigned to treatment group two. The control group featured residents in the area that received general campaign materials offered via community-based communication (those with refuse collected on Wednesdays). Treatment group one resided in areas that also received intensive materials focused on how food storage can reduce food waste (Storage) while treatment group two received the storage materials and intensive materials concerning FW composting (Storage + Compost).

Because these control households received many of the same campaign materials as the treatment groups, we also consider a second control group: a sample of households recruited from a panel of online participants who reside throughout the United States. Table 1 depicts when each group received campaign and assessment materials, which are included in the supplemental materials.

All Upper Arlington households received a letter via U.S. mail in February 2021 explaining that some foods end up in landfills or composting facilities and that more information about the types and amounts of this food originating from households would help the City of Upper Arlington reduce solid waste removal spending. Qualifying readers ($\geq$18 years, responsible for $\geq$ 50 % of household food preparation duties) were encouraged to participate and provided a link to an online survey. All participants provided informed consent and the study received prior approval from Ohio State University’s Institutional Review Board. Messages encouraging survey participation were also shared via community newsletter, social media and website. This resulted in 536 complete responses to the Spring online survey and 229 participating in the Spring curbside audit of waste; Upper Arlington contains about 14,000 households.

In late March, after completion of the baseline surveys and audits, Upper Arlington residents (control and both treatment groups) were exposed to SMTF campaign materials via community newsletter, social media, local newspaper ads, and webinar. Treatment groups received additional materials. Both treatment groups received mailers with tips on how to reduce food waste via improved storage and a refrigerator magnet with FW reduction tips. Both treatment groups were also offered free BluApple FW prevention pods (see Appendix for product details). Those from the Storage + Compost treatment group were also offered compostable liners to assist in collecting and transporting kitchen scraps to community FW drop-off sites and a discount for an Earth Machine backyard composter (see Appendix). BluApple pods were requested by 173 (44 %) of households from the treatment groups. Among the Storage + Compost group, 32 (26 %) requested compost bins while 33 (27 %) requested liners. These materials were distributed in the second half of May 2021. In terms of the actual use of these items, 61 out of the 173 households (35 %) indicated that they used the BluApple pods, 13 out of 32 (41 %) households indicated they used the Earth machine for backyard composting, and 16 out of 33 (48 %) households indicated that they used the liners at least once per week. While only the treatment groups were eligible to receive free FW prevention items, all groups could attend general webinars focused on FW prevention tips and composting,

[1] These were attended by residents individually invited from those randomly assigned to this treatment arm rather than from untargeted community-wide communications.

**Table 1**
Timeline for Study Communications and Data Collection.

| Period | Activity | National Control* | UA Control | UA Storage Treatment | UA Storage + Compost Treatment |
|---|---|---|---|---|---|
| Sep. 2020 | SMTF Central Ohio Mass & Social Media Campaign Launch | | x | x | x |
| Feb. 2021 | Survey Promotion Letter and Postcard (U.S. mail) | | x | x | x |
| | City of UA Social Media Survey Promotion Posts (2) | | x | x | x |
| | UA Community Newsletter Survey Promo Story | | x | x | x |
| | City of UA Website Posting Promoting Survey Participation | | x | x | x |
| | Text/email Invitation to Participate in a Survey | x | | | |
| | Surveys Conducted | 2/24–3/4 (N = 361) | 2/6 – 3/11 (N = 145) | 2/6 – 3/11 (N = 267) | 2/6 – 3/11 (N = 124) |
| Mar. 2021 | Curbside and Route Waste Audits | | 3/15 – 3/18 (N = 73) | 3/15 – 3/18 (N = 100) | 3/15 – 3/18 (N = 56) |
| | UA Community Newsletter SMTF Campaign Story** | | x | x | x |
| | City of UA Social Media Posts (2) SMTF Campaign | | x | x | x |
| Apr. 2021 | UA Community Newsletter SMTF Campaign Story | | x | x | x |
| | SMTF Webinar | | x | x | x |
| | City of UA Social Media Posts (2) SMTF Campaign | | x | x | x |
| | UA Community Newspaper SMTF Campaign Paid Ads | | x | x | x |
| May 2021 | Compost Mailer (U.S. mail) | | | | x |
| | Compost Webinar | | x | x | x |
| | Food Storage Mailer (U.S. mail) | | | x | x |
| | Compost Equipment Instructional Webinar | | | | x |
| | Reducing Food Waste at Home Fridge Magnet Mailer | | | x | x |
| | BluApple Pods - Food Storage Enhancement Give Away | | | x | x |
| | Home Composting Equipment Discounts | | | | x |
| | UA Community Newspaper SMTF Campaign Paid Ads | | x | x | x |
| | Food Waste Reduction Tips Webinar | | x | x | x |
| Jun-Aug 2021 | Survey Promotion Letter & Postcard (U.S. mail) and Emails | | x | x | x |
| | City of UA Social Media Survey Promotion Posts | | x | x | x |
| | Text/email Invitation to Participate in a Survey | x | | | |
| | 2nd Surveys Conducted | 7/22–8/15 (N = 430) | 6/3–7/4 (N = 75) | 6/3–7/4 (N = 156) | 6/3–7/4 (N = 157) |
| | 2nd Curbside and Route Waste Audits | | 7/19–7/22 (N = 45) | 7/19–7/22 (N = 99) | 7/19–7/22 (N = 37) |

*Notes*: UA – Upper Arlington, SMTF – Save More Than Food. x - The group in this column was potentially exposed to the activity in this row. *4.1% of national survey respondents reside in Ohio and could have been exposed to regional SMTF media exposure. N refers to number of food waste measurements collected. **Campaign materials shared after curbside and waste audits were complete.

though how many attended the webinar from each area was not recorded.

June featured another cycle of promotion to encourage post-campaign survey and audit participation (letters, post cards, e-mail, and social media), which yielded 388 completed Summer surveys (152 who also completed the Spring survey) and 181 completed Summer curbside audits (155 who completed a Spring curbside audit). Summer surveys were completed 10 to 14 weeks after the campaign's launch while summer audits occurred about 17 weeks after campaign initiation. The summer surveys occurred from 3 to 7 weeks after those in the treatment groups received their free and discounted materials (BluApple Pods and composting materials) while the summer audits occurred about 9 weeks after receipt of these materials. Thus, the evaluation is capturing only the short-run impacts of the campaign.

Recruitment for the National control sample, who completed a parallel online survey, occurred during an overlapping period in February

and March and about a month after Upper Arlington's summer survey (late July, early August). National survey recruits received a message from the vendor inviting them to participate in an online survey "…to understand your use of food at home, and how this may have changed due to how recent events surrounding COVID-19…" Eligible recruits (≥18 years, ≥50 % of household food preparation duties) who provided informed consent and completed the survey received compensation from the vendor. This yielded 361 Spring national respondents and 430 Summer respondents (no Summer national participants are known to have completed the Spring survey).

### 3.1. Measurement approaches

#### 3.1.1. Survey

The first measurement comes from an online survey. The survey is based on an approach first published by van Herpen et al. (2019a) (though versions of it also appear in van Geffen et al., (2017)) that was then adapted and validated for U.S. audiences by Shu et al. (2021). The same core survey questions eliciting the amount and type of household food waste were asked of both Upper Arlington and National participants, though each group received distinct additional questions (see supplemental materials for all surveys). The survey cycle begins with a brief survey to confirm eligibility, obtain consent, and remind participants to monitor foods discarded over the next 7 days in preparation for a follow-up survey. About 7 days later, participants report the amount of food wasted in up to 24 categories (see Table S1, supplemental materials) and its most frequent form (e.g., completely unused/unopened foods, partly used foods, plate waste, or unwanted leftovers). Participants reported discarded food regardless of dispensation, i.e., even if composted or fed to pets, but did not report food parts deemed inedible such as pits, bones and peels.

#### 3.1.2. Waste audits

Two types of audits were conducted: individual household level (Household Waste), and samples of all material collected at the curbside for several collection routes (Route-level Waste). Once collected and transported to a covered location, staff weighed the total waste sample, isolated and weighed the food waste, sorted the food waste into the mutually exclusive categories listed in the lower panel of Table S1, weighed each category of waste, and verified the sum of weight across categories reconciled with the weight measured for the unsorted waste. Weights were collected by placing waste in plastic containers before measuring via digital scale with the weight of the empty box netted from the recorded weight. Weights were encoded immediately into a spreadsheet accompanied by a household or route identification number.

*3.1.2.1. Household waste.* During the survey administered to Upper Arlington residents, we asked participants to consent to having their household's waste collected so that the amount of food discarded could be measured as part of this study. Staff traveled to the addresses of consenting households on the morning of the household's normal waste collection day about 1 to 4 weeks after survey completion. Upon arrival staff collected waste from all consenting households who had placed containers with waste in its normal collection location (e.g., some households did not provide containers as they may have been traveling or forgot to put out the trash or were rejected for other reasons, e.g., some containers were too heavy to be collected). Identification numbers were attached before transport to the covered location for sorting and measurement.

*3.1.2.2. Route-level waste.* Samples of waste generated by households who did not volunteer for individual curbside waste audits were also collected. Samples were obtained from the mixed refuse contributed curbside by non-volunteering households on four different collection routes in each area for a total of 12 samples community wide. Samples were drawn from collection vehicles upon route completion where each route serviced households from a single treatment or control area. Note that the route-level samples exclude waste from households that volunteered for individual waste audits. Hence, route-level audits represent households who did **not** volunteer for the individual waste audits, providing a comparison between volunteer and non-volunteer households.

#### 3.1.3. Community-level dropoff composting participation

The amount of material removed from Upper Arlington's drop-off FW composting sites was also measured since composting drop-off services were first offered in May 2019 at two sites. The containers were emptied every other week with the weight recorded. These first two sites faced capacity issues (e.g., full bins), which discouraged resident participation. Prior to the introduction of the SMTF campaign promotion, capacity was expanded by adding an additional pick-up site and by increasing to weekly pickup. We note that backyard composting amounts are not part of these figures.

#### 3.1.4. Campaign awareness, attitudes and other relevant behaviors

The Upper Arlington surveys also included several questions relevant to campaign evaluation. We asked participants to report awareness of the SMTF campaign ('In the past 30 days, do you recall seeing or hearing about the "Save More Than Food" campaign?') and, for those affirming awareness, to report the source of awareness (e.g., newsletter, social media).

Attitudes about food waste were assessed by respondent agreement with eleven statements (e.g., Throwing away food is bad for the environment) on a four-point scale (e.g., agree strongly, agree somewhat, …) where most statements were adapted from previous studies (Neff et al., 2015; Qi and Roe, 2016). Respondents assessed their knowledge of three topics (composting, food storage, FW prevention) on a five-point scale and the frequency of four FW-reduction precursor behaviors (shopping with a list, creating a meal plan, proper food storage, eating bruised or discounted food) on a four-point scale. Respondents were also asked if they were engaged in any type of composting, if they perceived any barriers to composting, and if there were any steps that would promote their own level of composting.

### 3.2. Analysis

We used a censored regression model (the tobit procedure in Stata Version 14.2), which adjusts for possible statistical biases that arise from a standard linear regression model when many observations feature dependent variables with a value of zero. More than 10 % of waste values had a zero value, necessitating this approach. Survey waste is on a per-person basis as the survey provided household size. These regressions control for household size; respondent age and sex; self-reported occurrence of an event that affected waste during the measurement week (e.g., hosted a party with food); and the household's national region (e.g., Midwest, East, etc). Audit waste is expressed per-household as some audits could not be connected to survey responses with household size because some respondents missed the household size question in the survey, and some respondents used different contact information for the baseline and follow up surveys causing difficulty in connecting all audits with corresponding household sizes. Further, this meant that other control variables were also unavailable, which also leads us to not control for demographic characteristics. Using only household level food waste prevented us from understanding whether the level of audited food waste was affected by the size of the household; one would naturally assume the larger the household size, the more the household wastes. However, assuming household size stays the same from spring and summer, we are still able to assess whether there are any differences between treatment and control groups in terms of audited household level food waste.

Ordinary linear regression was used to estimate effects measured on multi-point scales. Chi-square tests are used to assess demographic differences between the national and Upper Arlington samples. Because few Upper Arlington participants and no national participants provided both Spring and Summer responses, the analysis does not account for repeated observations (panel data methods). Statistical significance was set at 5 % with results featuring *p*-values between 5 % − 10 % deemed marginally significant.

### 3.3. Participant characteristics

Table 2 contains summary statistics for Upper Arlington and National samples.[2] The samples differ on every characteristic. Upper Arlington features more participants: aged 35–64; with households of 3–4 members; with more formal education; employed full time or are a student; in the highest income category; who identify as White and not Hispanic; and who shop for food weekly. Hence, we controlled for several characteristics when comparing responses for Upper Arlington and National samples to ensure effects are not attributable to personal and household characteristics. These included age, household size, sex, region, and if the respondent noted any household event that altered waste patterns during the measurement week (e.g., hosting a party). Household size and age are well-established factors in the amount of household food waste (Schanes et al., 2018). For attitude and knowledge analyses, respondent education and income were also controlled.

**Table 2**
Respondent Characteristics for Upper Arlington and National Samples.

| Characteristic[A] | Upper Arlington[B] | National | |
|---|---|---|---|
| Age | | | |
| <35 | 8.7 | 17.8 | |
| 35 – 64 | 65.2 | 42.3 | $\chi^2(2) = 120.1$ |
| 65+ | 26.1 | 39.9 | $p < 0.001$ |
| Household Size | | | |
| 1 | 19.2 | 27.4 | |
| 2 | 34.2 | 43.3 | |
| 3 | 19.7 | 11.4 | |
| 4 | 20.0 | 7.4 | $\chi^2(4) = 108.8$ |
| 5+ | 9.9 | 10.5 | $p < 0.001$ |
| Education | | | |
| High School or less | 0.6 | 14.4 | |
| Some College | 5.3 | 26.7 | |
| College Degree | 40.2 | 33.6 | $\chi^2(3) = 443.3$ |
| Grad/Professional | 53.8 | 25.3 | $p < 0.001$ |
| Employment | | | |
| Full Time or Student | 52.5 | 37.0 | |
| Part Time | 14.7 | 8.4 | $\chi^2(2) = 108.9$ |
| Other | 33.1 | 54.6 | $p < 0.001$ |
| Income | | | |
| <$50,000 | 5.3 | 31.2 | |
| $50 – 99,999 | 15.8 | 35.4 | |
| $100 k - $149,999 | 19.4 | 17.2 | |
| $150,000+ | 39.0 | 12.5 | $\chi^2(4) = 603.2$ |
| No Answer | 20.5 | 3.6 | $p < 0.001$ |
| Self-identified Race | | | |
| Asian | 4.9 | 6.6 | |
| Black | 0.0 | 6.2 | |
| White | 90.7 | 82.3 | $\chi^2(3) = 77.1$ |
| Other affiliations | 4.4 | 4.8 | $p < 0.001$ |
| Identify as Hispanic | 1.6 | 5.9 | $p < 0.001$ |
| Food Shopping | | | |
| Less than weekly | 12.8 | 22.3 | |
| Weekly | 57.6 | 50.2 | $\chi^2(2) = 35.6$ |
| More than weekly | 29.7 | 27.5 | $p < 0.001$ |

*Notes*: A – characteristics of household or survey respondent. B – percent in each subgroup. Final column reports the chi-square test statistic for significant differences between Upper Arlington and the National samples for the characteristic. Upper Arlington sample size ranges from N = 1151 to 1181 (see text for details). National sample size ranges from N = 1066 to 1168 (see text for details).

## 4. Results

### 4.1. Wasted food measured by survey

Fig. 1 displays grams of food waste per person per week reported from the survey for the Upper Arlington and National samples. The numbers are the regression-adjusted means for the most frequent Upper Arlington household pattern: two people where the survey respondent is aged

35–65 and female and the household featured an event that caused more food waste than typical during measurement week.

Fig. 1 reveals that food waste in Upper Arlington trended downward (–23 %, $p < 0.01$, Table 3) from Spring to Summer while National waste trended upward (+29 %, $p < 0.01$, Table 3), yielding a difference in differences of 52 % (29 % minus a negative 23 %), which is also statistically significant ($p < 0.01$, Table 3).[3] Our National results featuring greater waste in summer than spring mirrors previously documented seasonal patterns of residential food waste (Adelodun et al., 2021), though not all such previous work reveals such seasonal patterns (e.g., Hanc et al., 2011; van der Werf et al., 2018).

One notable difference between Upper Arlington and National samples is a statistically different level of Spring waste with 15 % more waste reported by Upper Arlington (311 vs 270 g/person, $p = 0.001$). To understand this difference, we assess the number of different waste categories in which survey respondents indicated any waste (Fig. S1) and, among participants who report any positive waste in a category, the ratio of National to Upper Arlington waste (Fig. S2). The main takeaway from Figs. S1 and S2 is that Upper Arlington participants were more likely to mark that there was some waste in more categories than National participants. However, once any waste was indicated in a category, Upper Arlington participants indicated similar or lower levels of waste per category. The first point is clear from Figure S1 where the National sample had a smaller proportion that reported positive waste in three or more categories (e.g., ~20 % of the national sample reported 3 + categories in the Spring while ~ 50 % of Upper Arlington reported 3 + categories in the Spring). The second point is clear from Fig. S2, which indicates that, among households reporting any waste in a particular category, there is no significant difference in the amount of waste reported by National and Upper Arlington samples for 18 of 24 categories.

A key difference between National and Upper Arlington samples is survey recruitment. Upper Arlington recruited with physical letters, local media articles, and local social media posts that motivated participation as beneficial to Upper Arlington for planning purposes. National recruitment was part of standing panels where participation was motivated via compensation (Upper Arlington participants were not directly compensated for surveys, but some became eligible for free/

[2] Upper Arlington sample size ranges from N=1151 (age) to 1159 (employment, race, ethnicity, food shopping) to 1181 (income, education, household size). National sample size ranges from N=1066 (age) to 1112 (employment, race, ethnicity, food shopping) to 1168 (income, education, household size). The Upper Arlington sample includes 342 participants who responded to both Spring and Summer surveys, while there were no known repeat responders to the National survey. 59% of the Upper Arlington sample were in the Spring while 43% of the National survey respondents were in the Spring. The National sample included 24.9% from the Midwest, 22.4% from the Northeast, 38.8% from the South and 23.9% from the West.

[3] Dropping the 26 observations in the National survey who resided in Ohio results in no change to the qualitative results or statistical significance. Since only 17% of Ohio residents live in the treatment area and we do not know the city of residence for these Ohio participants in the national survey, we include them in the sample.

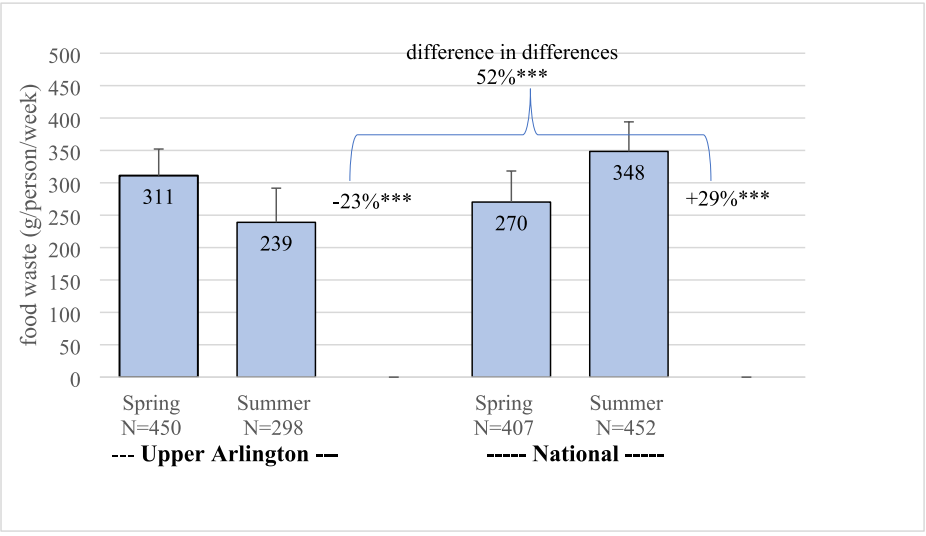


**Fig. 1.** Regression-adjusted means for food waste reported by Upper Arlington and National households with 2 people where the respondent was age 35 – 65 and female and the household featured an event that caused more food waste than was typical for that household. The National household average is representative of Midwest households in the national survey. Error bars depict 95% confidence intervals. The number of observations is less than the number listed in Table 1 because some observations are omitted due to missing control variables needed to conduct the regression. *** depicts changes that are statistically different from zero at the 1% level. Surveys did not assess inedible food scraps. The 'difference-in-differences' is the difference in seasonal changes between Upper Arlington and the National samples. Significance levels determined by the censored regression results reported in Table 3.

**Table 3**
Censored regression model of self-reported (surveyed) solid wasted food (g/person).

| Variable | Coefficient | Robust Standard Errors | *p*-value |
|---|---|---|---|
| Sample Group and Season | | | |
| Upper Arlington (vs National) | 155.95 | 35.18 | <0.001 |
| Summer (vs Spring) | 112.62 | 33.98 | <0.001 |
| Upper Arlington × Summer (diff in diff term) | −185.88 | 41.50 | <0.001 |
| Age Category (35 – 64 omitted) | | | |
| < 35 | 154.62 | 36.14 | <0.001 |
| 65+ | −71.27 | 27.46 | 0.010 |
| Region (Midwest omitted) | | | |
| Northeast | 102.97 | 48.86 | 0.035 |
| South | −26.32 | 39.33 | 0.503 |
| West | 27.37 | 47.17 | 0.562 |
| Household Size (omitted group is 2 members) | | | |
| 1 | 166.40 | 38.44 | <0.001 |
| 3 | −26.20 | 28.09 | 0.351 |
| 4 | −11.58 | 28.02 | 0.679 |
| 5 | −91.56 | 34.66 | 0.008 |
| 6 | −104.20 | 50.45 | 0.039 |
| 7 | −96.81 | 83.37 | 0.246 |
| 8 | −161.89 | 77.44 | 0.037 |
| 10 | −226.01 | 80.69 | 0.005 |
| 11 | 3.38 | 50.60 | 0.947 |
| 13 | −293.82 | 55.57 | <0.001 |
| =1 if HH reported any event that increased waste | 390.15 | 31.07 | <0.001 |
| =1 if respondent was female | −44.02 | 22.19 | 0.048 |
| Constant Term | 177.35 | 33.77 | <0.001 |
| σ | 388.47 | 25.30 | – |
| Log pseudo-likelihood value | −8890.82 | | |

N = 1607.

discounted storage and composting items). The national sample had no motivation that the results would be used for local benefit. Hence, reporting more categories with positive waste may be consistent with greater Upper Arlington motivation and therefore more diligence in providing complete information to aid local efforts. That is, the National survey participants may have had less motivation to think critically about all 24 categories of waste and to report small amounts in additional categories. However, once reporting in a waste category, it takes the same time and effort to report the waste level.

These patterns provide context for interpreting Spring to Summer changes. The percent of National participants reporting 3 + categories nearly doubles. If national participants were saving effort by not reporting in categories with small amounts of waste, it suggests that actual waste levels become much larger and triggered more categories to be reported during summer. For Upper Arlington, the number of categories stayed constant between spring and summer, suggesting the waste reduction came from reductions in the amounts of waste occurring in categories with positive waste.

Fig. 2 breaks out the Upper Arlington survey waste figures into the two treatment areas (grouped as 'Treatment') and control. Both groups reported a reduction, though somewhat unexpectedly, the control group reported the greater reduction. Furthermore, the treatment reduction is not statistically significant and the difference in differences was not statistically significant.

### 4.2. *Wasted food measured by curbside audit*

Fig. 3 depicts the grams of audited waste per household. Further, we do not control for other household differences as missing data on these control variables decreases the available sample and because demographic differences between treatment and control households who do report these characteristics (race, education, household size, etc.,) is not statistically significant. The results show that summer waste for all Upper Arlington households were lower than spring figures by 21 % with a 17 % reduction among once edible food that was wasted and a 30 % reduction among inedible food scraps. Only the inedible food scrap reduction was statistically significant.

Given the potentially important role of composting in affecting the amount of wasted food and food scraps that enter the audited waste stream, Fig. 3 also shows results for the area that received the intensive composting intervention (Storage + Compost) and the other areas (Control and Storage).[4] The overall reduction for the Storage + Compost group was greater (42 %, which was statistically significant) and also featured a statistically significant reduction in once edible food (53 %) as well as a 26 % reduction in inedible food scraps (though this was not a statistically significant change). The other areas (Control and Storage) largely mirror the overall results though the reduction in total and once

[4] We note that this differs from the control group chosen for the within-Upper Arlington survey analysis, which consisted of households who received neither the composting nor the food waste reduction materials. This change was motivated by the fact that survey respondents were directed to report composted materials as discarded items whereas composted items would not appear in curbside waste audits.

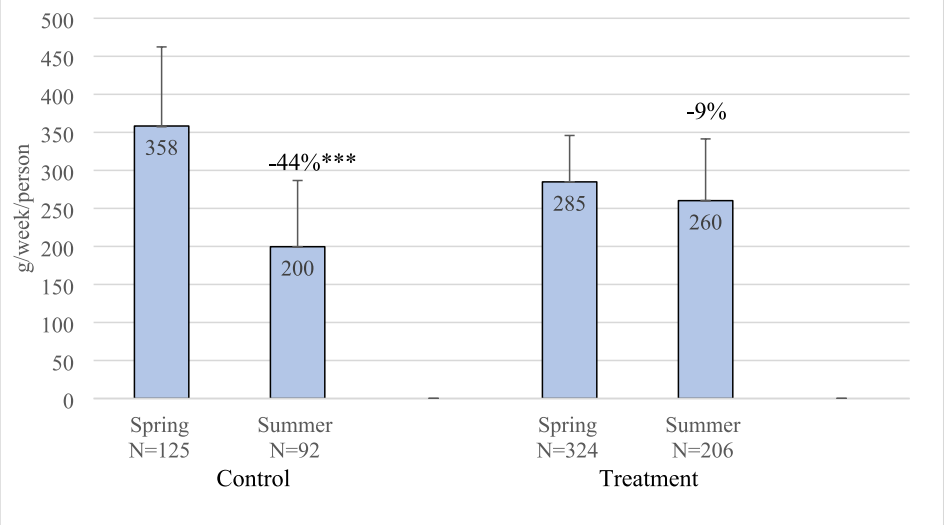


**Fig. 2.** Regression-adjusted means for food waste reported by Upper Arlington households with 2 people where the respondent was age 35 – 65 and female and the household featured an event that caused more food waste than was typical for that household. Error bars depict 95% confidence intervals. *** depicts changes that are statistically different from zero at the 1% level. Surveys did not assess inedible food scraps. The 'difference in differences' was not statistically significant (i.e., different from zero). Significance levels determined by the censored regression results reported in Table S2, supplemental materials.

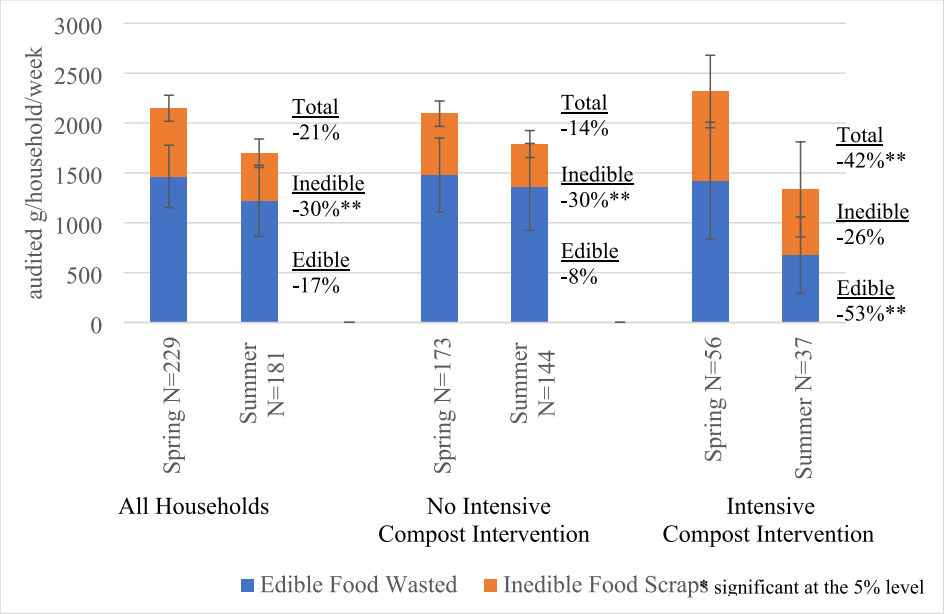


**Fig. 3.** Audit results for once edible food that was wasted and inedible food scraps by season in Upper Arlington. Error bars depict 95 % confidence intervals for each subsection of each bar. The 'Intensive Compost Intervention' group includes only the UA Storage + Compost Treatment group (final column of Table 1), while the 'No Intensive Compost Intervention' includes all others. Unlike waste figures from the survey, audit figures are on a per household basis rather than a per person basis (due to some missing household size figures among audited households), include inedible food scraps (which were not measured by the survey) and do not control for household characteristics. The difference in the amount audited figures decline between the two depicted areas is not statistically significant for the total, inedible nor edible waste figures, as determined by the censored regression results in Table S2. ** denotes statistically significant differences between spring and summer measures at the 5 % levels.

edible waste are slightly smaller. The difference in differences was not statistically significant. Hence, we cannot definitively attribute these larger declines to the intensive composting intervention.

Fig. 4 reports the percent of the captured waste attributable to once edible wasted food and inedible food scraps from both those who volunteered for the curbside audit and from the route-level samples drawn from non-volunteers. Regardless of season or waste type, the route-level waste figures are not statistically different from the figures taken from the audits of the voluntary participants. For example, considering the first two bars in Fig. 4, we find that in the Spring, about 14 % of all waste in the audited samples of both the volunteers and the non-volunteers on their same route consisted of once edible food that was wasted. Hence the comparison of the composition of waste types between the audits of volunteers and route-level samples suggests that the FW patterns observed among the volunteers is consistent with community-wide disposal trends. We note that, consistent with Fig. 3, the fraction of waste attributable to inedible food scraps declined by a statistically significant amount.

The audit also provided information on recyclable non-food items and non-recyclable non-food items. It is possible that residents who started paying more attention to their food waste may then also alter their attention toward non-food related waste. Households disposed of an average of 562 g of recyclable items in spring and 442 g in summer. This decline was not statistically significant ($p = 0.139$) and the difference in differences was insignificant ($p = 0.958$). Residents disposed 5.7 kg of non-food non-recyclable waste in spring and 7.4 kg in summer. This increase was marginally significant ($p = 0.096$) but the difference in differences was insignificant ($p = 0.536$). We summarize that SMTF did not create spillovers to other streams of household waste.

Like previous research (van Herpen et al., 2019b), we find that waste reported via audit (637.5 g/person for those where household size was available with average household size of 2.7) is larger than waste reported via survey (266.5 g/person). However, there is considerable variability across households in the ratio of survey to audit figures with more than 20 % reporting more waste via survey than audit. This may occur because audits were conducted several weeks after the survey.

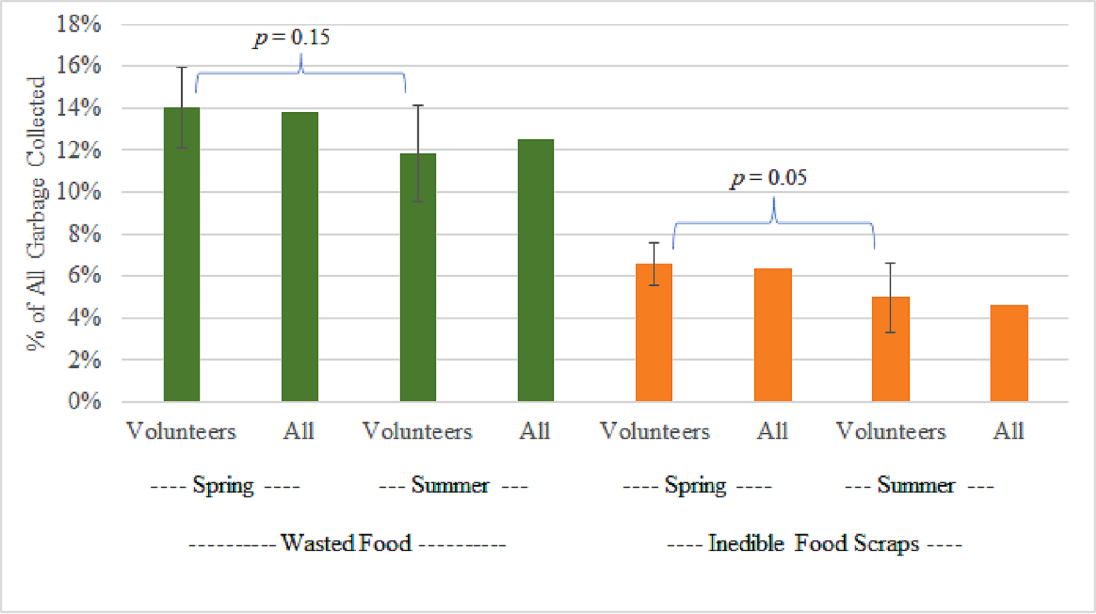


**Fig. 4.** Audited Upper Arlington Waste as Food and Food Scraps: Volunteers and All Residents. The sample size for volunteers equals 229 and 181 for spring and summer, respectively. 'All' refers to route-level samples drawn from households who did not volunteer for the individual waste audits with one route sampled in each of the four research areas across Upper Arlington. Error bars represent 95% confidence intervals. Error bars are not presented for the 'All' groups as these are based on only four route-level audit measures. *P*-values are from a *t*-test of the null hypothesis that spring and summer proportions are identical.

### 4.3. Compost collections at drop-off sites

Another validation of the Spring to Summer reduction of food scrap disposal identified by the audit results can be found in Fig. 5, which depicts bi-weekly measurements of food scraps collected at Upper Arlington drop-off sites. There is a discrete increase in composting activity starting in April of 2021, which corresponds to campaign initiation. This also aligns with Spring and Summer survey responses, which report that composting activity increased from 50.4 % in the Spring to 58.0 % in the Summer ($p = 0.035$) though the difference in differences is insignificant ($p = 0.463$). Of those who reported Summer composting, 21.6 % reported that they were either composting for the first time (13.8 %) or had restarted composting after a considerable hiatus (7.8 %). We note that previous research has documented increases in source-separated household-level food waste collection in response to campaigns (Bernstad, 2014). However, in the case of that intervention, only the group who received equipment that facilitated in-kitchen source separation displayed significant improvement, while only a fraction of the Upper Arlington community requested and received similar supplies (compostable liners).

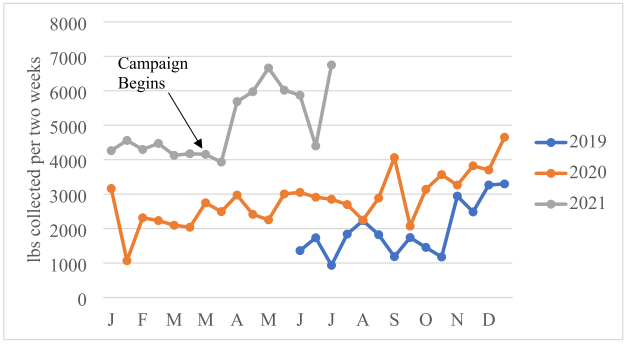


**Fig. 5.** Participation in the Upper Arlington Drop Off Composting Program. Bi-weekly measures of total pounds of material collected by year in Upper Arlington's community wide drop off compost program. Note: Campaign materials included information on how to compost and the existence of the city's drop off composting program.

When summer survey participants from Upper Arlington were pressed to identify factors that could encourage more composting and barriers to undertaking composting, 34 % indicated that they already compost all their waste (Fig. 6) while 30 % could not identify any current barriers to composting (Fig. 7). However, many still perceived significant barriers, such as a lack of equipment and supplies (30 %) and a lack of knowledge (15 %) or time (14 %), and nearly half (46 %) suggested that the provision of a curbside composting program would encourage more composting.

### 4.4. Awareness, attitudes, knowledge and waste antecedent behaviors

#### 4.4.1. Awareness

There was a large increase in the percent of Upper Arlington survey respondents reporting awareness of SMTF between Spring (6.5 %) and Summer (41.8 %), though the increase is statistically similar for the treatment and control areas within Upper Arlington ($p = 0.254$). During Summer, respondents were asked to evaluate the effectiveness of the SMTF campaign in (a) driving awareness of food waste as an important topic and (b) creating action around FW reduction. More than 57 % said the campaign was either effective or very effective in driving awareness of food waste as an important topic while 40 % said it was effective or very effective at creating action around FW reduction. For both questions, perceived effectiveness was greater in the areas that received the more intensive campaign, with a significantly larger percent in the treatment vs control areas for the awareness question (64 % vs 46 %, $p = 0.015$) and a marginally significant difference for the action question (46 % treatment vs 31 % control, $p = 0.097$).

#### 4.4.2. Attitudes

The attitude results for Spring and Summer across all areas within Upper Arlington are reported in Table S4 along with the estimated difference in differences. Only two of 11 difference-in-difference estimates (items 4 and 7) are significant (one marginally significant) with treated participants indicating a larger decrease in agreement with these statements (item 4, "You don't have enough time to worry about the amount of food you waste" and item 7, "You waste more food when you

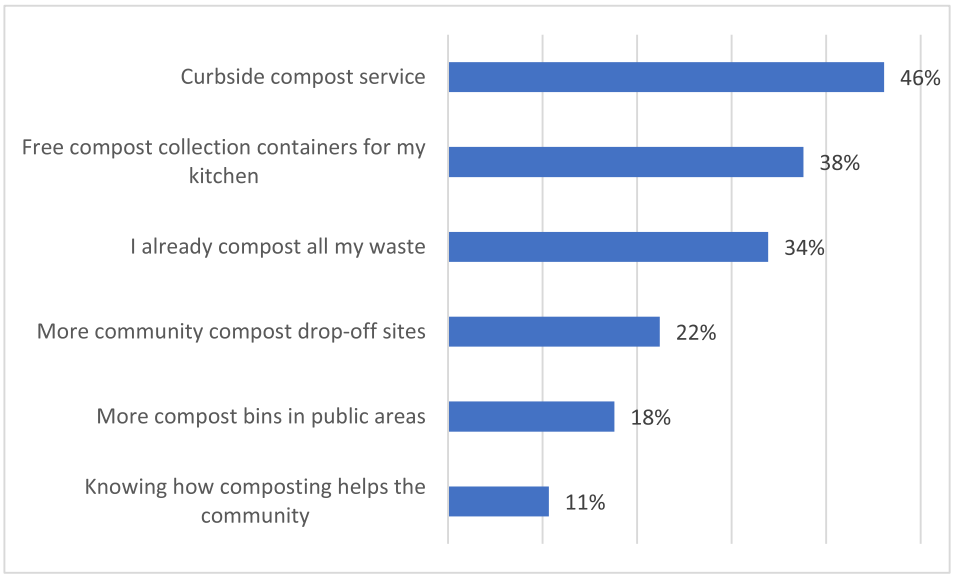


**Fig. 6.** Factors that could encourage Upper Alington residents to compost more. N = 376. Responses from summer survey only. Respondents could provide multiple responses so figures do not sum to 100 %. Percentages correspond to percent of respondents who selected each response.

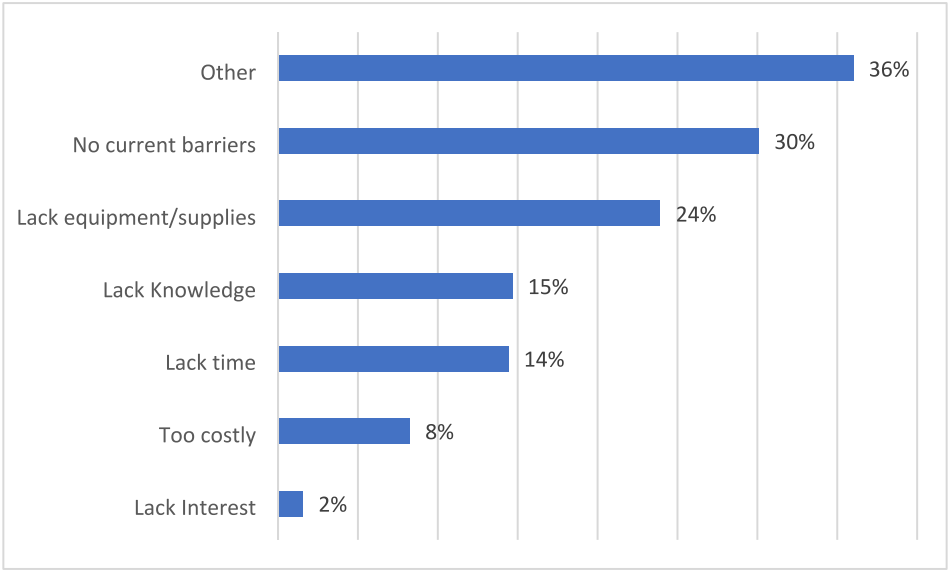


**Fig. 7.** Perceived Barriers to Composting, Upper Arlington Respondents. N = 389. Percent of respondents mentioning each barrier from summer survey only. Respondents could provide multiple responses so figures do not sum to 100 %.

buy things in large packages or when you buy in large quantities during a sale"). This suggests that those in the treated areas came to be more uniformly in strong disagreement with these statements, suggesting the materials were effective in drawing attention to the food waste as an issue warranting participant concern and helping participants mitigate food waste attributable to large/bulk purchases.

#### *4.4.3. Knowledge*

The changes in knowledge among Upper Arlington participants were quite small with no significant difference-in-difference estimates (Table S5). The results suggest that most participants view themselves as at least somewhat knowledgeable on all practices (though least knowledgeable about composting) and that knowledge measures changed very little between Spring and Summer.

#### *4.4.4. Waste antecedent behaviors*

A similar pattern was observed with Upper Arlington participants' knowledge (Table S6), where results are the self-reported frequency of waste-prevention practices. The mean for all practices lies between implementing the practice regularly and every time though the practice of creating a meal plan is least frequently reported. None of the difference-in-difference estimates are statistically significant. The fact that so many participants rated their Spring use of these practices at the highest level (a four on the four-point scale) impedes identifying significant campaign effects as participants have little room to report an increase in frequency (so-called 'ceiling effects').

## 5. Discussion and conclusions

Community-based interventions are increasingly recommended to change sustainability-related behaviors such as those associated with

food waste creation and recycling. However, evaluating such interventions pose multiple challenges, including the difficulty of defining and assessing a control group during the evaluation process, accounting for self-selection in evaluations that rely upon voluntary participation, and of accumulating sufficient data prior to the intervention to ensure robust evaluation. In this article, we tackle the reality of these challenges by collecting and assessing several sources of data to assess the efficacy of the Save More Than Food campaign. As each evaluation approach suffers from shortcomings, we must turn to the entirety of the evidence to assess campaign efficacy. However, due to the inherent challenges and limitations of the study design detailed below, we encourage caution when interpreting the study results.

Several sources of evidence suggest that the campaign reduced the amount of food wasted by Upper Arlington households and the amount of wasted food and food scraps that entered landfill. First, the survey results revealed a statistically significant reduction of self-reported wasted food by Upper Arlington households after campaign implementation while a National sample with parallel self-report questions revealed a statistically significant increase in waste over the same period. Second, the before/after analysis of the curbside audit of the waste among volunteers revealed a significant reduction in inedible food scraps. Third, the audit of the composition of waste among volunteers, which revealed a significant reduction in the proportion of waste attributable to inedible food scraps, was mirrored by the results of audits conducted on waste samples drawn from non-volunteers on the same days. Finally, there was a distinct increase in food waste collected at Upper Arlington's drop-off composting sites immediately after campaign initiation.

The absolute levels of decline in waste are also notable, but vary considerably between the self-reported amounts and curbside audits. The survey, which leverages a National control group, reveals a 52 % net reduction between Upper Arlington and control, while the audited amounts, which have no control group external to the treated community, reveal a 21 % reduction in total food waste (once-edible food plus inedible food scraps). We note that, had the survey not had access to a national control group (i.e., a before/after comparison in Upper Arlington only), the assessment would be a 23 % reduction, which aligns closely to the audited level and is quite comparable to reductions reported in similar types of campaigns in North America (Van der Werf et al., 2021, 31 % in Canada) and Europe (Romani et al., 2018, 24 % reduction in Italy). This highlights the critical role that an appropriate control group can play when assessing campaign effectiveness. In contrast, there is little evidence of significant differences in the amount of waste generated across areas that received different intensities of campaign materials. This is not surprising given that Upper Arlington is small and that treatment and control areas abut. This also reveals the practical difficulties of using a control group from within the same community that is subject to community-based interventions.

There is also evidence that the campaign significantly increased awareness of the SMTF campaign. By the end of the Upper Arlington campaign, about 40 % of survey respondents recalled the SMTF campaign (vs 6 % in Spring). This compares favorably to large national campaigns such as Save The Food, which reported a recall rate for its Public Service Announcement of 35 % (Shortyaward.com, undated). The majority of those recalling the campaign in Summer found it to drive awareness of food waste as an important topic (57 %). Further, the perceived effectiveness of the campaign was significantly influenced by the additional materials made available to those in the treatment areas.

While more people became aware of the existence of the campaign and waste levels appeared to have declined, it did not seem to translate to changes to the cognitive pre-cursors to FW reduction such as attitudes, knowledge or FW reduction precursor activities (e.g., making shopping lists) captured on the survey. The results suggest that within Upper Arlington attitudes, knowledge and pre-cursor practices changed little between Spring and Summer with the simple differences in means never achieving statistical significance and very few meaningful patterns among the few statistically significant difference-in-difference effects. We also verify that restricting analysis to only the smaller group of residents who responded to both the Spring and Summer surveys does not alter these results.

To put the results of this study in context, we note several limitations. First, with respect to the difference-in-difference approach between Upper Arlington and National self-reported food waste, we recognize that we only have observations at a single point in time for both groups prior to the implementation of the campaign. Under ideal circumstances, observations at several time points would be available for both groups preceding the campaign so that we could establish that the two groups were following parallel trends in behavior prior to the implementation of the campaign. Several pre-campaign observations would provide greater confidence that the difference in ambient waste levels observed between Upper Arlington and National survey takers was stable and attributable to differential engagement with the campaign as conjectured in the results section.

Second, the assessment of audited waste features no control group outside of Upper Arlington, which reduces confidence in attributing pre-post differences as a causal response to the campaign. This is a particularly challenging barrier for evaluating community-based campaigns, as it requires obtaining cooperation of another community outside the area affected by the campaign to permit capture of physical samples of waste curbside. Third, some survey instruments focused on behaviors and knowledge faced ceiling effects (i.e., most participants chose the highest response level possible), suggesting a need to re-calibrate such questions. Had the instruments been calibrated with greater nuance, and the results registered larger changes in knowledge and antecedent behaviors surrounding food waste reduction, it would have provided more confidence in the overall efficacy of the campaign.

Finally, we note that household survey and household-level audit data is only available for those who volunteered for these activities, and that volunteers may think and act differently than non-volunteers. Volunteers may be motivated to participate because they are more interested in reducing food waste than residents who did not respond to our surveys and nationwide respondents are likely motivated to participate because compensation was offered not because they are interested in reducing food waste. Such sample selection bias, self-selection bias in particular, complicates the evaluation of the effectiveness of the treatment. For example, if self-selection bias resulted in 'better actors' responding to the survey and curbside audit opportunities, then we might expect the initial levels of waste to be lower than if participants were randomly selected from the community. This might suggest that there was less room for improvement in response to the campaign, which could lead to an underestimate of the campaign's general effectiveness. On the other hand, if we think the self-selection led to disproportionate participation by those who were more malleable in their food handling behaviors, then self-selection bias might manifest as greater campaign effectiveness than would be observed had the evaluation featured randomly selected community members. While our route-level data features audit data from non-volunteers and does feature similar patterns as volunteers, more types of data from non-volunteers would be preferable.

We conclude that there is evidence that the community-based implementation of the Save More Than Food campaign worked to improve awareness of the campaign, reduce self-reported wasted food, reduce the amount of inedible food scraps entering landfills and increase FW composting activity, but that it did not significantly influence the discard of other materials (recyclables and non-food waste) nor have an appreciable effect on residents' FW attitudes, knowledge or antecedent behaviors. The levels of documented net reduction of once-edible food among survey respondents (52 %) is considerably higher than the effects documented for previous campaigns implemented in North America and Europe, while the documented level of reductions in the audited waste streams (21 %), which did not benefit from a comparison to an external control group, were more in line with previous findings. We also

conclude that implementing a parallel online assessment with a National sample can bolster the robustness of assessment when conducting a community-based campaign where it is difficult to create a local control group. While implementing a National control group introduces methodological challenges of its own, this technique warrants further consideration for evaluating community-based campaigns.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wasman.2023.02.011.

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