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Toward zero waste events: Reducing contamination in waste streams with volunteer assistance

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ABSTRACT

Public festivals and events generate a tremendous amount of waste, especially when they involve food and drink. To reduce contamination across waste streams, we evaluated three types of interventions at a public event. In a randomized control trial, we examined the impact of volunteer staff assistance, bin tops, and sample 3D items with bin tops, on the amount of contamination and the weight of the organics, recyclable containers, paper, and garbage bins at a public event. The event was the annual Apple Festival held at the University of British Columbia, which was attended by around 10,000 visitors. We found that contamination was the lowest in the volunteer staff condition among all conditions. Specifically, volunteer staff reduced contamination by 96.1% on average in the organics bin, 96.9% in the recyclable containers bin, 97.0% in the paper bin, and 84.9% in the garbage bin. Our interventions did not influence the weight of the materials in the bins. This finding highlights the impact of volunteers on reducing contamination in waste streams at events, and provides suggestions and implications for waste management for event organizers to minimize contamination in all waste streams to achieve zero waste goals.

1. Introduction

The increasing volume of solid waste in landfills contributes to unprecedented levels of environmental problems, such as water and soil contamination via leaching of heavy metals, and air pollution via emission of greenhouse gases (Humes, 2012; Statistics Canada, 2013; Tammemagi, 1999). Given that the amount of global waste has increased ten-fold over the past century and is expected to double by 2025, it is urgent and imperative to divert waste from landfill in the form of recycling and composting which can help mitigate the negative impacts of waste and recover useful materials from landfills (Hershkowitz, 1998; Hoornweg et al., 2013).

While recycling and composting bins are becoming more prevalent in cities and municipalities, most of the waste created in North America is still sent to landfill. For example in Canada, the overall diversion rate of household waste (e.g., mixed paper, plastics, glass, metal, and organic matter) is estimated to be around 33% (Dewis and Wesenbeeck, 2016; Statistics Canada, 2014), while the rate for the U.S. household is around 35% (Environmental Protection Agency, 2013). This rate is well below the potential 75–90% diversion rate of household waste which could be recovered and recycled (Geyer et al., 2017).

Public festivals and events generate a tremendous amount of waste every year, especially when the events involve food and drink (Gibson and Wong, 2011; Laing and Frost, 2010). One study found that the largest amount of waste generated at a festival was residual waste, followed by food and kitchen waste and packaging waste (Martinho et al., 2018). While waste management is one of the priorities for an increasing number of event organizers, it is currently not well understood how best to reduce waste at events (Laing and Frost, 2010). Waste reduction at events depends on a number of factors, including the host organization, the participating vendors, the materials used, and the participants of the events (Getz, 2009). Previous research has suggested that waste reduction at events depends strongly on the environmental values and beliefs of the managers and the host organizations of the events, who can act both as a champion and a steward of waste reduction (Mair and Laing, 2012). However, the reality often involves a disconnection between the intentions and the operations of the event managers (Henderson, 2007; Laing & Frost, 2010). This disconnection is largely driven by barriers such as the financial costs involved in recycling and composting, a lack of time, and a lack of control over venues or suppliers (Mair and Laing,

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2012). One study suggests that the outsourcing of compostable biopolymer is often driven by organizational sustainability goals, while the ability to compost depends on local waste management legislation and available infrastructure (Meeks et al., 2015).

One successful case study of waste management at events involved the use of volunteer staff who guarded the recycling and composting bins at sporting events at Arizona State University (Hottle et al., 2015). In this study, the authors examined the impact of volunteer staffed bins on contamination rates at three baseball games at the university. The first game served as a baseline, the second game used staffed bins, and the third game had non-staffed bins. The authors found that contamination rates in both recycling and compost bins were reduced from 34% in the first game without the staff bins, to 11% on the second game with the staffed bins, and to 23% at the third game without the staff bins (Hottle et al., 2015). This study presented first evidence that volunteer staff helped reduce waste contamination at public events.

In addition to volunteer staff, there are many behavioral factors that determine waste diversion, including infrastructure, environmental attitudes, social norms, and sorting knowledge (Schultz et al., 1995; Thomas and Sharp, 2013). Recent studies have demonstrated that convenience measured by the distance between the unit door and bins, environmental cues, and bin design are crucial in motivating recycling participation (DiGiacomo et al., 2017; Duffy and Verges, 2008; Wu et al., 2016). Lack of knowledge or feedback about what goes into which bin is a significant behavioral challenge. This problem has most often been addressed by providing sorting information in written form through the use of posters and signage (Duprè and Meineri, 2016; McKenzie-Mohr, 2000). More recently, studies have attempted to reduce waste contamination and motivate waste diversion with additional visual prompts such as 3D displays (Foster, 2016), modeling of the desired behavior (Sussman et al., 2013), and through games with immediate feedback to induce higher sorting accuracy.

1.1. Current study

While previous studies have separately demonstrated the importance of volunteer assistance (Hottle et al., 2015), and signage and prompts (Duffy and Verges, 2008; Sussman et al., 2013), it is currently not known which method is more effective at reducing contamination, since each study examined one factor in a unique context. The goal of the current study was to examine and directly compare the impact of three different interventions on contamination in the same context, in order to identify the best practice for waste management at public events. Our study aimed to provide evidence in support of identifying and implementing best practices of recycling and composting at UBC. Contamination in the waste streams could be a serious issue at UBC because if an organic or recycling bin is contaminated, all the materials in the entire bin will be dumped into the garbage bin (i.e., landfills) by custodial staff. Specifically, we conducted a randomized control trial where we examined the impact of volunteer staff assistance, bin tops displays, and sample 3D items with bin tops on the level of contamination and the weight of the organics, recyclable containers, paper, and garbage bins at a public event. The event was the annual Apple Festival hosted at the Botanical Garden of the University of British Columbia (UBC), which is attended by thousands of visitors every year. Like most festivals, the Apple Festival features a large variety and quantity of apples for sale, and different food and drinks for purchase, and as a result creates a large amount of organic, paper, and plastic waste. Working closely with the Campus Sustainability Office and UBC Building Operations, we tested the newly designed bin-tops that sit on top of the bin carts, real-life 3D items with the bin tops, and volunteer staff who guarded the bin carts, with a control condition where the regular bin carts were used (see Fig. 2).

2. Methods

2.1. Participants

Hosted at the UBC Botanical Garden, the annual Apple Festival is a popular family event that draws around 10,000 visitors over a weekend. The Apple Festival, in its 25th year features apple trees and apples for sale, apple tasting, with food trucks, live entertainment, and activities throughout the garden. With over 35,000 lb of apples for sale featuring 60 local and heritage varieties, and other food and drink products for purchase, the event generates a large amount of waste, such as food, cardboard, coffee cups, and take-out containers. According to UBC sorting guidelines, food scraps, napkins, and compostable take-out containers should go to the organics bin; drinking containers (plastic, paper, or glass) and any cutlery should go to the recyclable containers bin; clean sheet paper should go to the paper bin; and styrofoam, unmarked and soft plastics should go to the garbage bin (i.e., landfills). As such, most of waste at UBC can be diverted from landfills, going into compost and recyclable streams. The event took place from 11 am to 5 pm on a Saturday and from 11 am to 4 pm on a Sunday (October 17–18, 2015). While the festival takes place throughout the whole Botanical Garden (Fig. 1), we focused our interventions at two main locations where food and beverages were sold: entrance to the garden (location A) and main festival lawn (location B).

2.2. Materials

There were four conditions in the experiment (Fig. 2): volunteer staffed, bin tops only, bin tops with 3D displays, and control. In the volunteer staffed condition, trained volunteers stood beside regular waste stations to help people at the festival sort their waste. The volunteers verbally instructed people which item should go to which bin, and people had to sort the waste themselves. A total of 39 volunteers were recruited to serve in this experiment. Each volunteer guarded one waste station during one shift which was between one to three hours long, and each volunteer received a training and orientation session one day before or on the day of the festival. In the bin tops (BT) only condition, plastic bin tops were designed by UBC Sustainability Office, and presented 2D visual signage of the bin category and icons of items that should go to the bin. The bin tops were put on top of the bin cart, such that the bins always remained open so people didn't have to handle the lids. In the bin tops with 3D displays (BT3D) condition, the same bin tops were used on the bin carts, but in addition real-world sample items were placed on the bin tops to further demonstrate which items should go into the bin. In the control condition, the regular bins were used without volunteer staff, bin tops, or 3D items. The lids of the regular bins also contained the same 2D visual signage of the bin category and the icons of items that should go to the bin, which were identical to those on the bin tops in the BT condition.

In each condition, there were four bins representing four waste streams: organics (food scraps), recyclable containers, paper, and garbage. The organics, recyclable containers, and paper bins were Schaefer bins ($22 \times 24 \times 40$ in.), and the garbage bin was a smaller round bin covered with a black garbage bag. We note that the garbage bin did not have a lid, whereas other bins had lids. This was true in every condition in our experiment, so any difference between conditions could not be attributed to this factor.

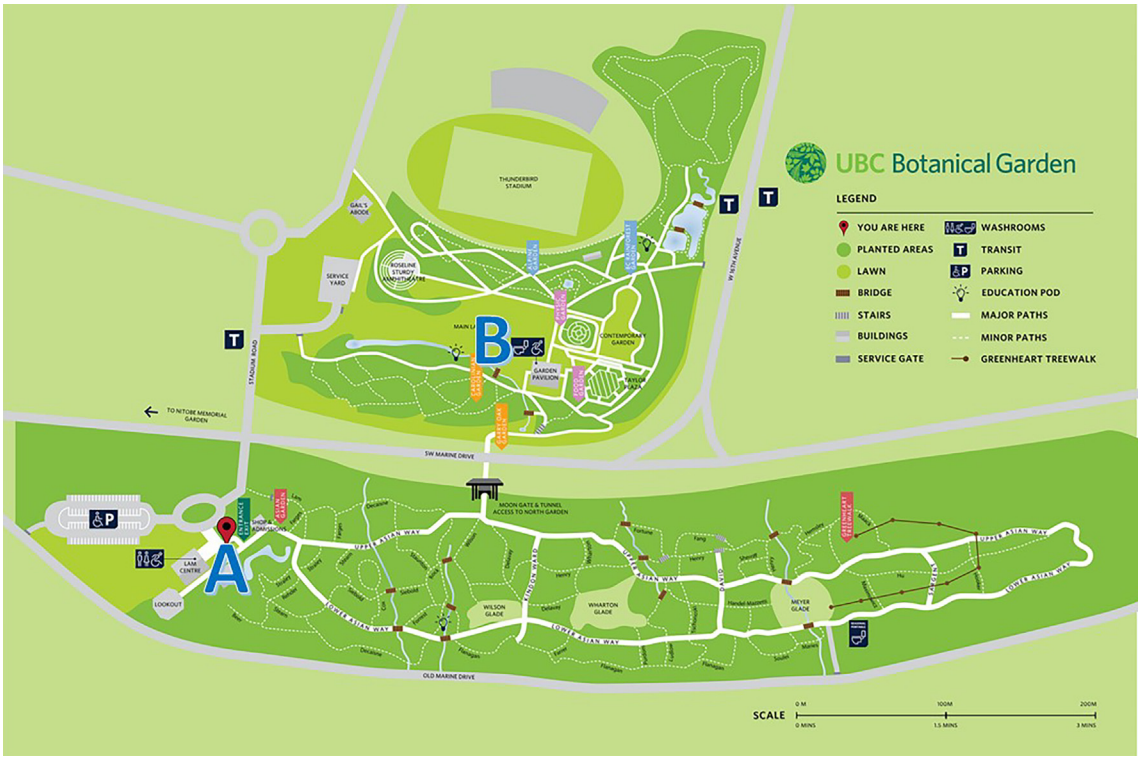

Fig. 1. Map of the Botanical Garden at UBC. Locations A was the entrance to the garden and location B was the main festival lawn, where the experiment was conducted.

Fig. 2. Photos of the four conditions at location B at the Apple Festival. The conditions in location A were set up in the same manner.

2.3. Procedure

We set up the four conditions at location A (garden entrance) and the same four conditions at location B (main festival lawn). The four bins in each condition were placed next to each other, and the bins in each condition were at least 30 feet away from the bins in a different condition. The bins in the experiment were labeled by a masking tape on the side of the bin indicating which condition and location they were in. When the bin was full, a research assistant replaced it with an empty bin, and took the full bin to a holding area at the garden. At the end of each day, the researchers and research assistants gathered at the holding area to weigh and inspect each bin. Each bin was first weighed by a digital DYMO® S250 shipping scale, and we recorded the net weight of the contents inside the bin in kilograms (kg), by subtracting the weight of an empty bin (12 kg) from the total weight. After weighing each bin, the researchers used gloves to dump all the items out of the bin, inspected all items, and counted the number of items that did not belong to the waste stream. When the contaminants were food or organic materials, we counted the number of contaminants as the number of compostable containers or individual food pieces, because most of the food contaminants were food scraps in

compostable boxes or plates, such as a compostable chilli bowl with or without chilli leftovers in the box which would be counted as one contaminant. When there was an individual food item (such as an apple core, or pizza crust), we counted each item as one contaminant. Thus, for every bin we recorded contamination as the number of incorrect items in the bin, and the weight of the total materials inside the bin. Table 1 shows the total number of bins we measured in the experiment in each condition within each waste stream. The number of bins per waste stream per condition was unequal because of the different generation rates in the four waste streams.

3. Results

Since there were four conditions (volunteer staffed, BT3D, BT, and control) and four waste streams (organics, recyclable containers, paper, and garbage), we used a two-way between-subjects analysis of variance (ANOVA) to examine the effects of our interventions on contamination and weight of the bins. This ANOVA allowed us to examine whether there was a significant difference among the four conditions, among the waste streams, and whether there was a significant interaction between conditions and waste streams.

The average number of contaminants per bin is presented in Fig. 3. For contamination, the ANOVA showed that there was a main effect of conditions [$F(3,66) = 14.21$, $p < .001$, $\eta_p^2 = .39$], no main effect of waste streams [$F(3,66) = 0.78$, $p = .50$, $\eta_p^2 = .03$], and no significant interaction between conditions and waste streams [$F(9,66) = 1.38$, $p = .21$, $\eta_p^2 = .15$]. To examine which conditions were different, we conducted post hoc Tukey's HSD tests, which showed a significant difference between volunteer staffed and BT conditions ($p < .001$), volunteer staffed and BT3D conditions ($p < .001$), and volunteer staffed and control conditions ($p < .001$). These results demonstrate that the volunteer staffed condition had the lowest level of contamination among all conditions. Specifically, volunteer staff helped reduce contamination by 96.1% compared to other conditions on average in the organics bin, 96.9% in the recyclable containers bin, 97.0% in the paper bin, and 84.9% in the garbage bin. Most of the contaminants were items that should have gone to other recycling or composting streams. For example, the key contaminants in the paper bin were used napkins and compostable containers (with or without food scraps) which should have gone to the organics bin. The key contaminants in the organics bin were coffee cups which should have gone to the recyclable containers bin. The key contaminants in the recyclable containers bin were compostable containers which should have gone to the organics bin. The key contaminants in the garbage bin were food scraps, compostable containers, and used napkins.

To examine the impact of our interventions on the volume of the materials, we also collected the total net weight (kg) of materials in each bin including contaminants (Fig. 4). The ANOVA showed that there was no main effect of conditions [$F(3,66) = 0.42$, $p = .73$, $\eta_p^2 = .01$], a main effect of waste streams [$F(3,66) = 5.84$, $p = .001$, $\eta_p^2 = .20$], but no significant interaction between conditions and waste streams [$F(9,66) = 0.37$, $p = .94$, $\eta_p^2 = .04$]. This shows that there was no significant difference in the weight of the materials in the bins between different conditions, suggesting that our interventions had no impact on the weight. The total weight of waste generated at the Festival was 108 kg of organics, 37 kg of recyclable containers, 35 kg of paper, and 51 kg of garbage.

We further examined the number of contaminants per kilogram (Fig. 5). The ANOVA showed a main effect of conditions [$F(3,66) = 9.47$, $p < .001$, $\eta_p^2 = .30$], a main effect of waste streams [$F(3,66) = 3.63$, $p = .01$, $\eta_p^2 = .35$], but no significant interaction between conditions and waste streams [$F(9,66) = .94$, $p = .49$, $\eta_p^2 = .12$]. Post-hoc Tukey's HSD tests showed a significant difference between volunteer staffed and BT3D conditions ($p < .008$), and between volunteer staffed and control conditions ($p < .001$), and close to marginal difference between volunteer staffed and BT conditions ($p = .11$). For waste streams, there was a significant difference between paper and organics bins ($p = .01$), and a marginal difference between recyclable containers and paper bins ($p = .09$). These results again demonstrate that the volunteer staffed condition had the lowest level of contamination among all conditions.

4. General discussion

The goal of the current study was to examine the impact of three different interventions on contamination in waste streams at a public event, in order to identify the best practices for waste management at events. Specifically, we conducted a randomized control trial at the Apple Festival at UBC where we examined the impact of volunteer staff assistance, bin tops, and sample 3D items with bin tops on the level of contamination and the weight of the organics, recyclable containers, paper, and garbage bins. The results showed that volunteer staff significantly reduced contamination in all waste streams, compared to the other interventions. The finding suggests that recruiting volunteer staff at waste stations is the most effective method to reduce contamination at public events. Since most waste management systems require front-end sorting which relies on individuals to sort waste at the bins, using volunteers offers a teaching opportunity to give feedback to people on how to sort.

The volunteers had no impact on the weight of the materials in the bins. However, according to the waste management practice on UBC campus, if an organic or recycling bin has more than 10 pieces of contaminants, all the materials in the entire bin will be dumped into garbage by custodial staff. So by reducing contamination in the bin, volunteer staff can prevent the bin from going to the garbage stream, thus indirectly diverting waste from landfill.

We did not find a significant effect of the bin tops or the use of 3D items on contamination. There are five explanations. First, the icons presented on the bin tops may not be sufficiently salient or clear to instruct people how to sort. Second, the icons presented on the bin tops were identical to the icons on the lids of the bins in the control condition, so there was no additional information presented in the bin top condition, and the only difference was that the top was always open in the bin top condition, whereas people had to lift the lid to dispose waste in the control condition. The null effect implies that whether people had to lift the lid or not had no

Table 1
Number of bins measured in each condition in each waste stream.

Conditions	Organics	Recyclable containers	Paper	Garbage
Volunteer staffed	10	5	4	5
Bin tops with 3D items	9	5	4	6
Bin tops only	3	3	3	3
Control	5	5	6	6
Total	27	18	17	20

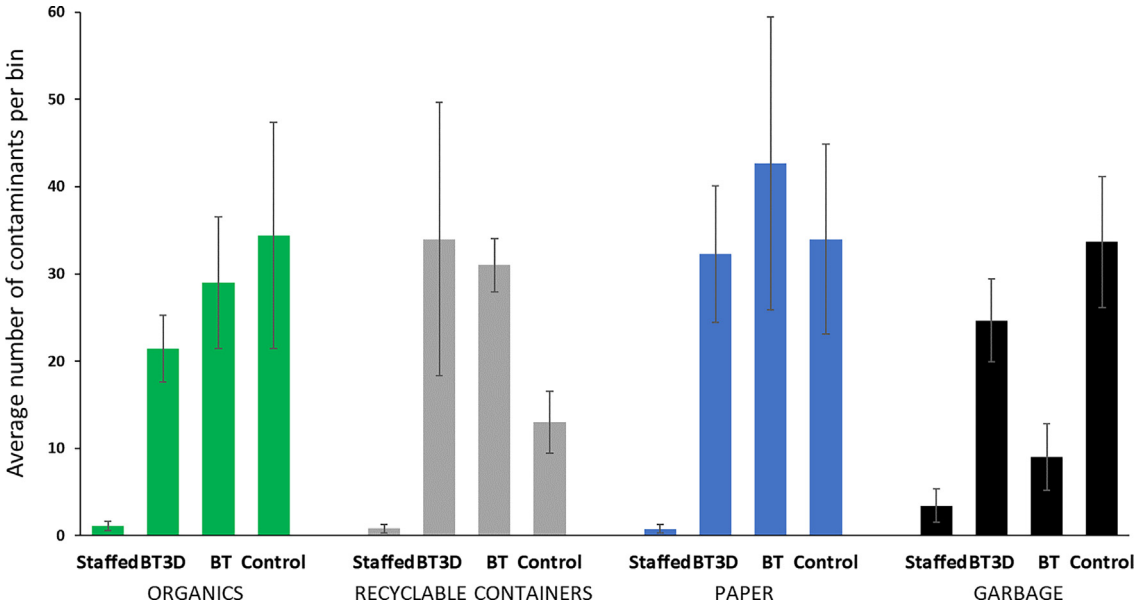

Fig. 3. Average number of contaminants per bin per waste stream (organics, recyclable containers, paper, and garbage) across the four conditions: volunteer staffed, bin tops with 3D displays (BT3D), bin tops only (BT), and control. The average contamination in the volunteer staffed condition was significantly lower than that in the BT3D, BT, and control conditions. Error bars reflect ±1 SEM.

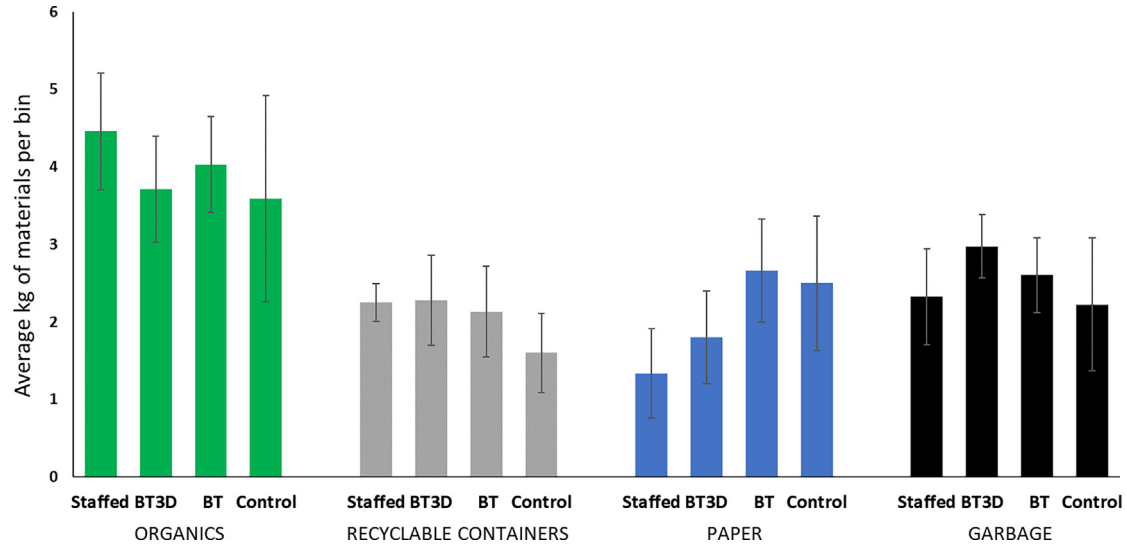

Fig. 4. Average weight (kilogram) of materials per bin per waste stream (organics, recyclable containers, paper, and garbage) across the four conditions: volunteer staffed, bin tops with 3D displays (BT3D), bin tops only (BT), and control. The average weight in the organics bin was significantly higher than that in the recyclable containers, paper, and garbage bins. Error bars reflect ±1 SEM.

impact on sorting accuracy. Third, at the end of each day we found that people misused the bin tops with 3D displays, and put extra waste items on the bin tops, which suggests that they might have mistaken the 3D items on the bin tops as waste from other people. Fourth, the waste items at the Apple Festival were diverse and complex, and the visual signage on the bins was not comprehensive enough to guide sorting. Finally, there were inconsistencies in the sorting rules between UBC and Metro Vancouver, and since the attendees of the festival were people from Metro Vancouver, they may not know what UBC's sorting guideline is, and therefore still followed Metro Vancouver's guidelines. For example, pizza boxes and compostable cutlery should go to the compost bin in Metro Vancouver, but these items should go to the garbage bin at UBC because UBC waste facilities cannot process these items. This calls for a need to standardize the sorting guidelines and infrastructural capabilities across municipalities.

Based on our conversation with the event organizer, there were significant costs in the provision of the organics and recycling bins. Specifically, each organics bin costs $30 to order, a recyclable containers or paper bin is $5, but each garbage bin is free. From Table 1, we calculated that the organics bins cost $810, the recyclable containers bins cost $90, the paper bins cost $85, and the garbage bins cost $0. The greater costs of the organics and recycling bins present a financial barrier for the event organizer. Thus, to increase waste diversion, the cost structure of the bins should be reversed, such that the garbage bins should be the most expensive.

The current study had several limitations. First, while we placed the bins in the most populous locations at the garden, we could not

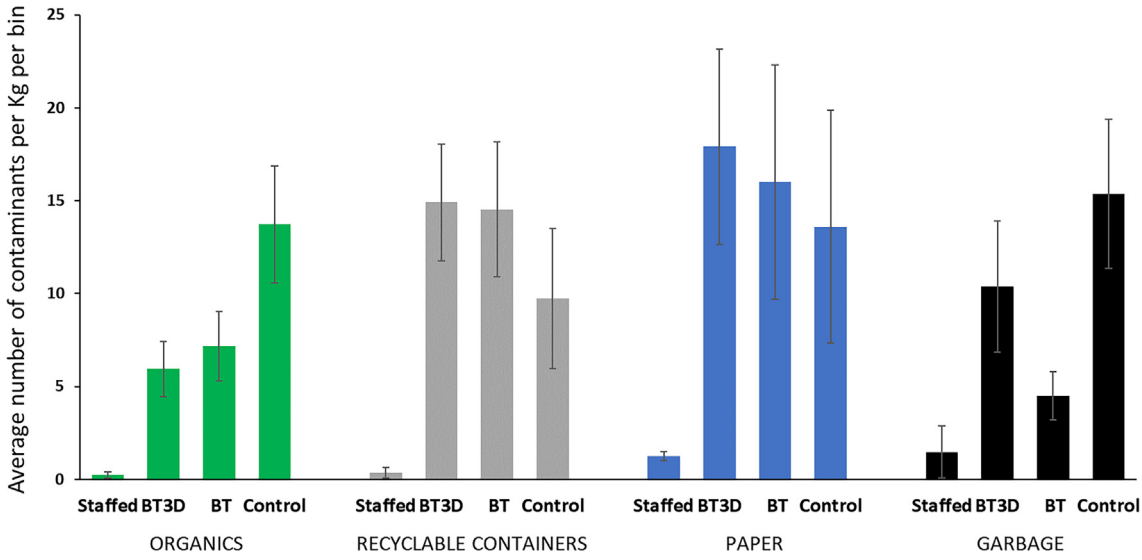

Fig. 5. Average number of contaminants per kilogram per bin per waste stream (organics, recyclable containers, paper, and garbage) across the four conditions: volunteer staffed, bin tops with 3D displays (BT3D), bin tops only (BT), and control. The average contamination in the volunteer staffed condition was lower than that in the BT3D, BT, and control conditions. Error bars reflect ±1 SEM.

control the foot traffic near each bin. There was variability in how often people used the bins throughout the day, and how convenient the bins were to access. This variability may have contributed to the large error bars. Second, we don't know the longevity of the effect because we did not track participants after they left the festival. Third, the null effects of bin tops or bin tops with 3D displays do not necessarily mean that signage does not work. This only highlights the need to develop more effective signage to guide sorting at events. Finally, the current study did not find direct evidence that volunteer staff increased waste diversion from landfill since the weight of the bins did not change. This raises the limits of volunteer guidance on sorting.

4.1. Recommendations for better waste management at events and festivals

- Recruit volunteers at events to help people sort and reduce contamination.
- Work with vendors ahead of time to ensure materials provided are standardized, consistent, and can be recycled or composted in local systems.
- Ensure sufficient numbers of composting and recycling bins at the event.
- Reduce financial barriers of composting and recycling by reducing the costs of bins.
- Promote the benefits of composting and recycling and/or the negative impacts of landfilling through event communication.

With foresight and inclusion of zero waste principles at the start of the event planning, the organizers can control what type of waste is generated on site and ensure that most of it is diverted from landfills. Policymakers, food and beverage manufacturers, and recycling companies should continue to work together to make zero-waste materials and infrastructure more affordable for organizers and intuitive for consumers.

Contribution provided by each of the Authors of this paper: IZ, TM, JZ designed and carried out the experiment; IZ and JZ conducted the statistical analysis; IZ and JZ prepared the manuscript and TM revised the manuscript.

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Declaration of interest

The authors have no competing interests to declare.

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