Community Science

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Home Waste Audit: A Community Science Activity to Increase Waste Literacy and Reduce Household Waste

Hannah De Frond[1], **Rafaela F. Gutierrez**[1], **Susan Debreceni**[1], **and Chelsea M. Rochman**[1]

[1]Department of Ecology and Evolutionary Biology, U of T Trash Team, University of Toronto, Toronto, ON, Canada

Abstract The amount of household waste produced worldwide is increasing every year. In combination with other actions to reduce waste production and improve waste management, community engagement and community-focused programs are needed to motivate the public to change their behavior in such a way that reduces their waste generation and increases the accuracy of waste sorting. It is also helpful for people to become more waste literate to empower them to be part of the solution. The Home Waste Audit (HWA) is a community science activity designed to increase waste literacy and reduce household waste. In the HWA, participants record their waste for a set period of time, research their local waste streams, and complete surveys to share perceptions of household waste habits. Here, we present data from a HWA conducted in 2021 as a case study. Before the audit, 66% of participants underestimated their weekly waste generation. Throughout the HWA, weekly waste count among households decreased by 31%. Participants found purchasing items with less/no packaging and avoiding single-use plastics challenging. Easier changes included learning which items can/cannot be recycled and repurposing waste items. Several changes to waste habits were maintained 1 year after participation. These results demonstrate that the HWA is an effective tool for individuals to be a part of the solution by learning about local waste streams, reducing waste production, and accurately managing their household waste.

Plain Language Summary To tackle growing global waste generation, outreach programs can engage the public to reduce their household waste production and improve their individual waste management. Here, we introduce the Home Waste Audit (HWA), a community science activity designed to increase understanding about how to sort household waste and provide motivation for participants to decrease the amount of waste they generate and throw away each week. We present data from our 2021 HWA as a case study. In 2021, participants underestimated their weekly waste before the audit and collectively decreased both their weekly recycling and landfill waste throughout the activity. Participants found that buying items with less or no packaging and avoiding single-use plastics was very challenging. However, they found it easier to learn about waste sorting guidelines and reuse items that would otherwise be thrown away. The results of this work demonstrate that the HWA is an effective way for the public to learn information about waste, pollution, and their local waste sorting guidelines and initiate both short and long-term behavioral changes to reduce and manage their household waste effectively. Collectively, the HWA can help reduce the amount of waste sent to landfills and mismanaged waste in our communities.

Key Points:

- The Home Waste Audit is a community science activity designed to increase participants waste literacy and reduce household waste
- Participants recorded their waste for 4 weeks while learning about local waste streams and taking action to decrease their weekly waste
- Participants decreased their waste by 31% and made long-term behavioral changes to reduce household waste

Supporting Information:

Supporting Information may be found in the online version of this article.

Correspondence to:

H. De Frond,
hannah.defrond@utoronto.ca

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Author Contributions:

Conceptualization: Hannah De Frond, Rafaela F. Gutierrez, Susan Debreceni, Chelsea M. Rochman
Data curation: Hannah De Frond, Rafaela F. Gutierrez, Chelsea M. Rochman
Methodology: Hannah De Frond, Rafaela F. Gutierrez, Susan Debreceni, Chelsea M. Rochman
Resources: Hannah De Frond, Rafaela F. Gutierrez, Susan Debreceni, Chelsea M. Rochman
Supervision: Chelsea M. Rochman
Visualization: Hannah De Frond, Rafaela F. Gutierrez, Chelsea M. Rochman

1. Introduction

Global municipal solid waste (MSW) generation was estimated at between 60 and 99 million metric tonnes (Mt) in 2015, and this is expected to increase to up to 265 Mt by the year 2050 (Lebreton & Andrady, 2019). Globally, MSW collection rates vary widely due to differences in waste generation and management infrastructure (Kaza et al., 2018). As a result of many low rates of waste collection and management, the end point for most of the world's waste is a combination of the environment, dumps, and engineered landfills (Geyer et al., 2017). Due to our growing consumption of non-recyclable waste, land-use for landfills is continually increasing. Through the expansion of landfills, ecologically important habitats are destroyed, threatening the survival of sensitive and ecologically important species (e.g., Bialas et al., 2021). The degradation of waste in landfills produces one of the greatest sources of greenhouse gas emissions (IPCC, 2013). Further, due to an abundance of poorly managed landfills, a large proportion of waste is not retained within management systems and enters the environment (Fei et al., 2022), including toxic chemicals in landfill leachate that contaminate groundwater that supplies lakes and irrigation for agriculture (Maqbool et al., 2011; Shafie et al., 2018). A sizable proportion of our waste is plastic waste—which has a low recycling rate (OECD, 2022) and is incredibly persistent (Worm et al., 2017). Plastic

Writing – original draft: Hannah De Frond, Rafaela F. Gutierrez, Susan Debreceni, Chelsea M. Rochman
Writing – review & editing: Hannah De Frond, Rafaela F. Gutierrez, Susan Debreceni, Chelsea M. Rochman

pollution has become an increasingly prominent concern due to its environmental persistence and ubiquity, and the physical and chemical hazards this form of pollution poses to the health and survival of ecosystems (MacLeod et al., 2021). It has been estimated that in 2020, between 24 and 35 Mt of plastic waste entered global aquatic ecosystems, due to a combination of increased production of plastic products, consumption of single-use plastic items, and poor waste management (Borrelle et al., 2020).

Many countries have set targets to divert waste from landfills, increase national recycling rates (European Environment Agency, 2021; Government of Canada, 2021), and take actions to reduce plastic pollution (National Geographic, 2019). Although a reduction in the production and consumption of unnecessary materials (especially single-use items) is imperative to mitigate waste and environmental pollution, recycling is an important part of the solution as this process retains materials within the economic system, reducing the need for the manufacturing of new products and helping create a circular economy (Maio & Rem, 2015). Currently, global plastic recycling is estimated to be just 9% (Geyer et al., 2017). Recycling rates must substantially increase to reduce unsustainable waste generation (Chen et al., 2020), therefore efforts to improve both the recyclability of materials and waste management at a national and local level are crucial. Due to the dominance of household waste in MSW, recycling rates can be significantly increased by improving household waste management practices. The participation of residents in local recycling programs is essential for their success (Vicente & Reis, 2008). However, there are several barriers to participation in household recycling programs, including institutional barriers (e.g., lack of collection and waste management streams); situational barriers (e.g., lack of space, unreliable collections); behavioral barriers (household disorganization, lack of time); knowledge barriers (not knowing what to recycle, how to recycle, or what the local guidelines are); and attitude barriers (not believing in the environmental benefit, or lack of reward or recognition for efforts) (Jesson et al., 2014). Tackling one or more of these barriers has been found to produce a substantial positive effect on the rate of household recycling (Haldeman & Turner, 2009), and relevant knowledge of recycling and motivation to do so are the most significant predictors of recycling behavior (Gamba & Oskamp, 1994). Therefore, the implementation of awareness raising campaigns and activities to inform communities and guide behavior change toward more sustainable consumption, waste management and use of plastic products is essential (Gough, 2017; Rochman et al., 2016; Veiga et al., 2016).

Here we, the University of Toronto (U of T) Trash Team, present our Home Waste Audit (HWA)—a community science activity designed with two main objectives: (a) increase awareness and understanding about environmental plastic pollution and solutions such as local waste management (i.e., municipal recycling, landfill, organics waste streams), and (b) provide motivation and mechanisms for participants to decrease their household waste and divert waste from landfill by avoiding single-use items, and instead procuring and using products that can be reused and/or recycled. As a case study, we also present the details and results of a HWA conducted in 2021 to provide insight into the effectiveness of this activity for increasing awareness and understanding of this problem and solutions (aka., "waste literacy") and empowering the community to reduce household waste, increase recycling rates and retain these behavior changes both in the short and long term.

2. Material and Methods

The HWA is a community science activity that can be used for both education and data collection. The activity and resources are designed so that they can be used in different regions of the world and with different participants (e.g., community, workplace, schools). The HWA uses a combination of educational and instructional webinars, online surveys, and at-home waste quantification and characterization to motivate and facilitate learning and behavior change. Here, we present the HWA and its utility through data collected from our 2021 HWA which was run virtually (i.e., webinars, instructions, resources and data were shared online). Success in achieving the objectives of the HWA are measured quantitatively and qualitatively, via data collection on waste production and sorting per household as well as surveys. The data can be synthesized and shared with participants. For the purpose of this manuscript, we used a paired sample Wilcoxon test to determine whether there was a significant difference in waste generation (all waste, landfill waste and recycling waste) among participants between weeks one and four. In addition, we qualitatively explored the survey data for patterns and trends relevant to increases in waste literacy and changes in behaviors. Below, we describe the HWA process in temporal order to share the activity and methods in the case study.

Resources for the HWA are freely available on our website. We also conduct one HWA annually, which is available to anyone who would like to join. It is advertised through our volunteer and public newsletters, social

media channels and promotion by organizations we collaborate with (e.g., Ocean Conservancy, PortsToronto). Participants from any age group, demographic and location can sign up to participate in the HWA by registering online. This means participation is self-selected, and thus the data does not come from a representative portion of the population. During registration, participants are prompted to complete survey one, the "Entrance Survey" before beginning the first week, to provide details of their current waste habits and level of waste literacy (Text S2 in Supporting Information S1). Surveys are all hosted on Google Forms. For the purpose of the 2021 HWA, where the data is being used for publication, informed consent was obtained from participants (the data reported here were all collected under the Human Participant Ethics Protocol #40317 granted by the University of Toronto).

Prior to taking part in the HWA, all participants attend an introductory webinar hosted by the U of T Trash Team and the recording is made available at: youtube.com/@uofttrashteam. Within the webinar, we provide background information on the issue of global waste and plastic pollution (why we use plastics, how they became so popular, and the increase in global plastic production), the extent of the problem (the rise in single-use plastics and global waste generation and management) and environmental impacts of plastic pollution. We also outline potential solutions, including reducing plastic consumption and improving waste management. We then focus on waste management and highlight the importance of reducing household waste and sorting waste items accurately, by learning local waste sorting guidelines. Following this, we introduce the HWA and provide detailed instructions on how to take part, with time for participants to ask questions. To encourage honest and accurate data reporting, participants are informed during the webinar that the HWA is an opportunity for learning and self-improvement (i.e., not a competition), that they will not be judged on their household waste generation, and that individual results will be anonymized prior to data analysis and results reporting. Instructions for taking part in the HWA are also provided to participants on the U of T Trash Team webpage (https://uofttrashteam.ca/home-wasteaudit/ and in Text S1 of Supporting Information S1).

During the 4-week HWA, participants document their weekly household waste on separate datasheets for recycling waste and landfill waste (Data can be found within Supporting Information S2). On each datasheet, participants record their name, location, the number of people in the household (including pets as 0.5 people), start date, and any other relevant notes. For example, participants might document reasons why their waste habits may be affected that week, such as hosting a birthday party at their home. Each week, participants record the total item count, the item description (e.g., cup, wrapper) and the material type (plastic, metal, glass, paper, other) of each waste item.

Week 1: In week one, considered a baseline, participants document their "business as usual" waste habits on the recycling and landfill datasheets. That is, without making any conscious efforts to change their waste habits. At the end of week one, participants also filled out survey two (Text S3 in Supporting Information S1) to increase participants waste literacy by prompting them to check their local waste sorting guidelines, and answer questions based on what can or cannot be recycled in their local municipality.

Weeks 2–4: Participants try to reduce their total count of waste items per week, with a specific focus on reducing landfill waste. Participants were directed to the U of T Trash Team's Waste Reduction Tips (uofttrashteam.ca/wastereduction/) as a starting point but were also encouraged to seek out additional resources. At the end of week four, participants submitted all weekly datasheets via email to the U of T Trash Team. Following this, participants completed survey three, relaying feedback on their experience in the HWA, how they made changes to their waste habits, and the resources that were used to inform their behavior (Text S4 in Supporting Information S1).

The self-reported data submitted by participants was anonymized and summarized to identify the most common items of household waste, the most common material type in each waste stream, and how the average amount of weekly waste among households changed throughout the HWA. A second webinar was offered about 2 weeks after participants submitted all weekly datasheets to share data regarding local waste management and how it varied across locations where participants resided, the waste collection data, and general findings from the first three surveys. We also provided time for participants to reflect and discuss their experiences.

Eight weeks after the HWA, participants were prompted to complete survey four to document how taking part in the HWA affected their long-term waste habits (Text S5 in Supporting Information S1). In the case of the 2021 HWA, a fifth survey was sent to participants of the HWA again approximately 14 months after completing the audit, in April 2022, with the same questions and purpose as survey four.

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3. Results

3.1. Participation

During January 2021, 15 households took part in the HWA, with 13 households submitting waste data for all 4 weeks. Of the two households that did not submit data for all 4 weeks, one reported difficulty in getting their household to cooperate in the activity, and so did not record data for the final week. The second household was on vacation during the final week, during which they did not record waste data. Anonymized waste audit data separated by household, week and material type can be found in De Frond et al. (2024).

In week one of the audit, 26 participants attended the first webinar, and 34 participants took part in survey one. The participants of the survey spanned across three countries, four provinces/states, and eight cities. Canadian participants were from Alberta (St. Albert) and Ontario (Caledon, Etobicoke, Hamilton, Orangeville, Toronto). American participants were from Oregon (Corvalis) and English participants were from London. Participation in the surveys decreased from survey one to survey four with 20 participants completing the second survey, 15 completing the third and seven completing the fourth. Attendance at the second webinar to share results was 13 people. Five participants completed survey five, over 1 year after completion of the HWA. All anonymized survey responses can be found in De Frond et al. (2024).

Below, we share the results of the 2021 HWA, summarizing the similarities and differences in local waste management among participants, HWA data on waste items produced per household across the 4-week activity, survey responses, and reported changes in waste literacy and behavior.

3.2. Local Waste Management

Within survey two, participants reported their local waste management streams. All participants of the survey reported having access to curbside landfill and recycling waste collection. Eighteen of 20 participants had access to organic waste collection. Five of 20 participants had access to other waste streams including yard waste or large item collection.

Among participants, 80% were required by local guidelines to separate their waste by product type (e.g., bag, egg carton, milk carton), 15% separated waste by material type (e.g., by plastic recycling symbol numbers) and 5% were required to sort their waste using a combination of both product and material type.

In survey two, participants were also presented with certain items and asked if they could be recycled within their municipality. The results demonstrate that waste sorting guidelines vary across locations, even within the same country (most participants were based in Canada). Fourteen of 20 participants could recycle plastic grocery bags and Styrofoam in their local municipality, seven of 20 could recycle single-use cutlery, only two could recycle black plastics and no participants were able to recycle plastic straws.

3.3. Changes in Waste Habits

Throughout the HWA the mean count of all waste (recycling and landfill) among households decreased by 31%. In week one, mean count of all waste was 154 (SD = 100) items per household per week. In week four, the mean count of all waste per household was 106 (SD = 80) items per week (Figure 1). Although the change in all waste generation was not statistically significant ($p = 0.09$), this result still demonstrates that collectively participants were making conscious efforts to reduce their household waste. Due to the high variation among households (Figure S1–S3 in Supporting Information S1), it is also evident that participating households began the HWA from a wide range of starting points. In week one, total waste counts per household ranged from 41 to 413 items among the 15 participants. The reason for this wide range is likely partially due to lifestyle and waste habits but also the number of people within each household (ranging from one to six).

Of the households that took part in the HWA, 67% reduced their weekly count of landfill waste throughout the 4 weeks. Mean landfill waste items decreased from 90 (SD = 53) to 74 (SD = 60) items per household per week from week one to week four. The change in landfill waste generation among participating households was not significant ($p = 0.19$). Throughout the audit, 47% of households reduced their weekly recycling waste and the mean number of recycling waste items decreased from an average of 64 (SD = 56) items per household in week one to 48 (SD = 22) in week four. The change in recycling waste generation among participating households was also not significant ($p = 0.84$).

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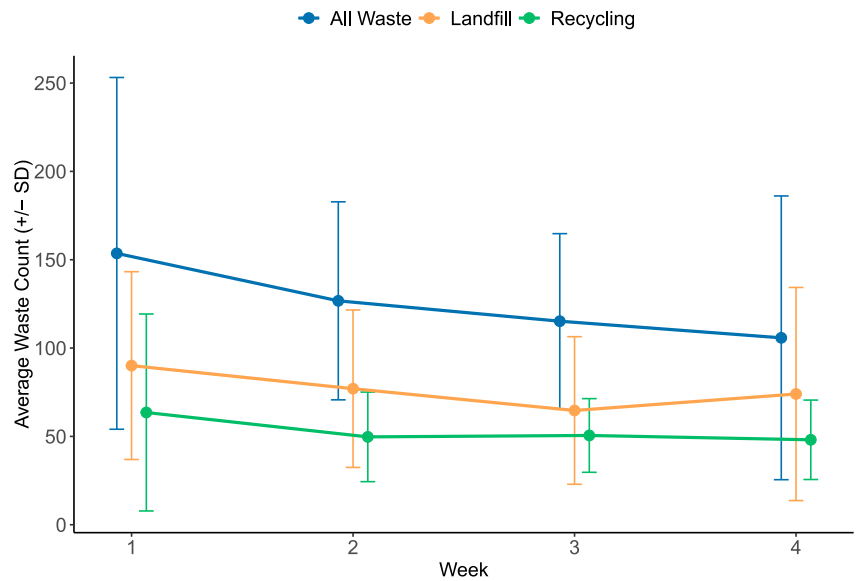

Figure 1. Average number of waste items per household across the 4-week Home Waste Audit; recycling waste (green), landfill waste (orange) and all waste combined (blue). Data points are the mean waste count among households for each week, error bars represent standard deviation ($n = 15$).

Throughout all 4 weeks, the most common material type within landfill waste was plastic (Figure S4 in Supporting Information S1). The most common plastic items within landfill waste in week one was soft plastic packaging, dental floss and produce stickers. In week four, the top items were soft packaging, dental floss, and hard packaging. As the most common item within landfill waste throughout the audit was plastic packaging, this likely reflects the options available for consumers. Within recycling waste, paper was the most common item throughout all 4 weeks (Figure S5 in Supporting Information S1). The most common items within recycling waste were cardboard boxes, paper, and toilet paper rolls in week one. By week four, this had changed to flyers, paper packaging, envelopes, and toilet paper rolls.

3.4. The Home Waste Audit as a Tool to Increase Waste Literacy

Overall, the results of the surveys indicate that the HWA was successful as a tool to increase waste literacy. When comparing perceptions of weekly waste production to real data, many participants learned that they were producing much more household waste than they had estimated. Prior to taking part in the HWA, 34 households took part in survey one to estimate the number of items that their household throws away in one week. Here, only data from the 15 households that submitted waste data for the entire duration of the HWA are discussed (Figure 2, data compared for all households can be found in Figure S6 of Supporting Information S1). When estimated and actual waste counts per week are compared, households tended to underestimate the amount of waste they produced. Of the 15 participating households, 73% estimated that they discarded between 51 and 100 waste items per week. In week one, most participants (53%) recorded over 150 waste items. Overall, 60% (9 households) underestimated their weekly waste in their response to survey one. Of these households, 8 of the 9 underestimated their weekly waste by over 50 items.

In responses from survey three, 95% of the 15 participants reported learning something new during the audit, including learning about their waste streams and local waste sorting guidelines. In terms of specific materials, several participants reported learning about how to correctly dispose of Styrofoam according to their local guidelines. One participant highlighted that Styrofoam could go into the recycling bin and other participants highlighted that Styrofoam could be taken to a recycling depot (Figure 3).

Importantly, participants reported becoming more aware of the amount of waste they produced on a weekly basis throughout the HWA. In efforts to decrease their weekly household waste counts, 12 out of 15 participants looked for information on how to dispose of their waste properly. Participating in the HWA also had ripple effects to increase waste literacy among non-participants. In survey four, 57% of participants reported that they had shared

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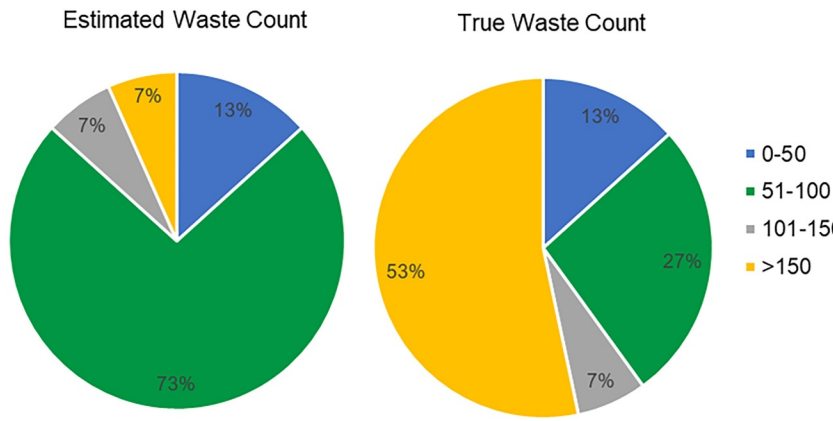

Figure 2. Estimates of weekly household waste in survey one prior to taking part in the Home Waste Audit (HWA), compared to data collected in Week 1 ($n = 15$). Although 34 households completed the survey, data is presented only for those who completed both survey one and documented their waste data throughout the entire HWA.

something they had learned with others. Over 1 year later, in survey five, 80% of participants reported sharing what they had learned in the HWA with friends and family.

3.5. Short-Term Changes to Waste Habits

The HWA seems to be a useful tool to change short-term behavior. To reduce their weekly waste, participants made changes throughout the 4-week activity, and reported that they continued with these habits after their audit was complete. Among participants who responded to survey four ($n = 7$), 71% kept some of the changes and 29% kept all the changes made to their waste habits during the HWA.

Participants reported that they found tips for reducing their waste from the U of T Trash Team (tips on our website and social media), and from websites, with some tips learned from blogs, friends and leaflets (Figure S7 in Supporting Information S1). When making changes throughout the HWA, participants reported the easiest changes were remembering which bin to place items in (57%), reusing and repurposing items (29%) and avoiding single-use plastics (14%) (Figure S8 in Supporting Information S1). When asked why these changes were easiest to make, participants responded that there was a good availability of information on waste sorting online in the areas they lived. With practice, placing items in the right bins became a new habit. Additionally, these changes relied only on their individual behavior and not the behavior of others (Figure S9 in Supporting Information S1). Reported difficult changes to maintain included buying items with less or no packaging, finding items packaged in recyclable materials and reusing and repurposing items (Figure S10 in Supporting Information S1). Changes

Figure 3. Comments from participants about what they learned during the Home Waste Audit ($n = 15$).

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that were difficult to maintain were largely due to a lack of accessible alternatives for consumers to avoid plastic or non-recyclable packaging for items they would usually buy in stores. Sometimes, these alternatives did not exist and sometimes if they did, they would cost more to purchase (Figure S11 in Supporting Information S1). Participants had a mixed response in efforts to avoid single-use plastics, with some also finding this difficult. Seven out of 15 participants upcycled or reused items that would otherwise go to waste, threw items into the recycling bin that they previously would have put in the landfill bin, swapped a single-use plastic item for a reusable alternative, and/or used reusable containers instead of disposable bags. Other changes participants self-reported included watching a video clip on waste reduction and walking further to buy products sold without plastic packaging. Some participants stopped buying certain products to avoid plastic packaging, and even had an in-depth conversation with family members regarding their consumption habits.

3.6. Long-Term Changes to Waste Habits

Five participants completed survey five, 1 year after taking part in the HWA. The participants of survey five did not answer survey four, so unfortunately a direct comparison between short and long-term waste habits was not possible. In survey five, 60% of participants reported keeping some of the changes made during the HWA. The easiest change to maintain was remembering which waste bin to place items in (40%), followed by reusing and repurposing items (20%), avoiding single-use plastics (20%) and buying items in recyclable packaging (20%) (Figure S12 in Supporting Information S1). 80% of participants also reported now using a designated resource to check where waste items should go (e.g., Toronto Waste Wizard), which likely supports the long-term habit of remembering which bin to place items in. 50% of participants reported that buying items with no packaging was the most difficult change to make and maintain (Figure S13 in Supporting Information S1), which indicates that even with motivation to do so, purchasing items with low-waste packaging options is still not an easy option for consumers.

4. Discussion

4.1. Impact

The results of the HWA demonstrate that low-cost interventions, such as educational activities that increase waste literacy, are effective in initiating behavior change. Participants decreased their waste footprint and diverted waste away from landfill by not only reducing the number of non-recyclable waste items produced per week, but also the number of waste items overall. Participants learned how much, and what waste their household was producing, and through data collection participants were able to identify actions for behavior change, such as items that could be swapped for alternatives with either zero or recyclable packaging. Participants also learned about the waste streams in their municipality and their local waste sorting guidelines. This improved the accuracy of waste sorting and reduced contamination of recycling, as participants reported learning about certain items that they had previously been placing in the incorrect waste stream.

In this case study, average waste generation among households decreased for both landfill and recyclable waste. This suggests a decrease in material usage overall. Another observation we could have seen, but did not, was for landfill waste to go down and recycling waste to increase. This may occur as participants learn their local waste sorting guidelines and items move from the landfill bin to the recycling bin. Alternatively, we could have seen an increase in landfill waste and a decrease in recycling waste upon learning local waste sorting guidelines if a participant was putting the wrong items in the recycling bin. The best long-term outcome would be for participants to reduce their waste generation altogether, as we observed here. This follows the waste management hierarchy, where prevention and re-use are of highest priority, followed by recycling (European Commission, 2024). Although participation in this activity is relatively short (4 weeks), long-term changes to waste habits were self-reported by participants, demonstrating the value of activities such as the HWA for habit formation through initiating a new behavior and supporting the repetition of this behavior via weekly data collection (Lally & Gardner, 2013). Participation also led to increased motivation to continue changes made throughout the HWA into the future, and survey responses both 8 weeks after the HWA and 1 year after the HWA reported many participants continuing some of the changes made throughout the activity.

The information shared throughout the HWA reached further than immediate participants in the activity, as 80% of participants shared what they had learned with friends and family. This knowledge sharing amongst members

of the same social group can increase motivation to comply with waste sorting guidelines and take actions to reduce individual waste production (Abrahamse & Steg, 2013; Cialdini & Goldstein, 2004). Behavior changes can also occur within social groups due to social pressures and the desire to comply to social norms (Abbott et al., 2013).

4.2. Activity Design and Adaptations

The design and components of the HWA address barriers to participation in household recycling programs (Jesson et al., 2014). With the opportunity to involve all members of the household in this activity, situational barriers were removed, such as inconsistent waste sorting by different members of the household. The HWA was initially developed and carried out in summer of 2020 during the COVID-19 pandemic, where participants had more free time, and were spending most of the HWA at home. Following this, we (U of T Trash Team) host the HWA in January each year for participants in any location. This month is chosen intentionally to take advantage of the new year, a time when people often reflect on their individual actions and make lifestyle changes and create goals for long term self-improvement. Through the provision of surveys and data collection requiring participants to look up their local waste sorting guidelines, the HWA removes knowledge barriers for effective waste sorting. Finally, attitude barriers are addressed within webinar one, where the issue of global waste management and plastic pollution are presented prior to taking part in the HWA, and in webinar two by presenting the results to participants, providing a broader context to their achievements, and providing recognition for their efforts. Further, by collecting both quantitative and qualitative data on participants waste habits, knowledge and perceptions, the HWA enables us to document complimentary information to evaluate success and also to inform future campaigns or management actions (Makrakis & Kostoulas-Makrakis, 2015).

It should be noted that most participants in this HWA were already engaged with the work of the U of T Trash Team prior to taking part. As such, participants were already interested in the issue of plastic pollution and motivated to reduce their individual waste generation. This prior interest likely influenced the behavior changes made during the 2021 HWA and the increased likelihood of waste reduction, participation in the webinars and surveys, and sharing this information with others. Even so, the majority of participants did report learning something new, which indicated the experience was still of value for increasing waste literacy. Furthermore, the program is still applicable to those who are not already engaged in the topic. In fact, greater changes in behavior may occur for participants who have not previously considered their household waste habits as they will likely be starting from a much greater weekly waste count and may find the information shared throughout the webinars more impactful having not heard it before. As such, we hope that the HWA can be utilized for a variety of audiences. The HWA was developed as an activity that is publicly available, and all materials required to carry out the HWA are available and free to download via the U of T Trash Team website (uofttrashteam.ca). The activity can be adapted to different audiences and scenarios. For example, if the HWA is carried out only with participants from a specific region of the world, the information about waste and plastic pollution provided in the first webinar can be tailored to that region. In locations where formal waste sorting and recycling programs are not available, the HWA can be adapted to focus on the count of waste items more generally and ways to decrease all waste generation throughout the activity. With school groups or workplaces, the content of webinar one can be adapted to appeal to different age groups, and audits can be carried out in-person as participants audit their waste together throughout a certain timeframe. This scenario may also increase the accuracy of data reporting by moving the focus from individual household waste generation and sorting to a waste generation and sorting in a group setting. The HWA can also be done individually, and participants can adapt the protocol to their personal goals, such as monitoring their household waste over a longer time frame.

4.3. Challenges

Although the HWA proved successful in encouraging participants to learn about their local waste streams and providing motivation to decrease their waste footprint and divert waste away from landfill, some challenges were still observed. First, although almost all participants took part in the waste data collection throughout the 4 weeks, participation in the online surveys was low, and declined between survey one ($n = 34$) and survey four ($n = 7$) and five ($n = 5$). It is possible that participation in the surveys decreased as participants did not feel this was directly useful for them, and it was also an additional time commitment to documenting their waste. However, the survey

responses were valuable for us to understand participants perceptions, experiences, and changes in waste literacy throughout the HWA. The qualitative information obtained through the surveys is important to inform current and future management actions to reduce household waste and increase recycling rates, so future iterations of the HWA could utilize incentives such as a lottery with a prize for participation to increase survey participation (Sauermann & Roach, 2013). Since this study, an annual HWA has been led by the U of T Trash Team, with the most recent activity in 2024. In 2024 we adapted the HWA to run for a shorter time of 2 weeks, with two surveys (entrance survey and waste management survey) to investigate if this would increase participation in the HWA (webinars, data collection and reporting and surveys). With this shorter adaptation of the HWA, participation did not notably change compared to a 4-week HWA, however participants did share that the timeframe was more feasible. Following each annual HWA, we have had continued engagement with participants, and some have requested information to host their own HWA, adapting the activity for different audiences. This demonstrates long-term behavior change, willingness to take positive action and motivation to share knowledge gained throughout the HWA.

While educational campaigns are vital for behavior change, obstacle removal is also imperative to address waste management and pollution (Truelove et al., 2022). Institutional barriers to decreasing waste production and increasing recycling participation were identified but not tackled by the HWA. For example, during the HWA some households reported difficulty in finding information on their local waste sorting guidelines. To avoid contaminating the recycling waste bins, participants without clear guidance from their municipality placed items in the landfill if they were not sure they could be recycled. In many cases, participants also reported difficulty in finding package free items, or items in recyclable packaging as alternatives to their usual purchases. Further, although throughout the HWA participants collectively made positive changes to their waste habits, the decrease in waste counts differed among households. Individual scenarios are important to consider for collective change. For example, some households do not have the time or finances to travel farther away to shop at locations with a greater selection of package free goods. Although certain members of a household may be motivated to reduce their weekly waste and follow waste sorting guidelines, other household members may not see the value in this and thus not cooperate (i.e., place waste items in the incorrect bin). This demonstrates how even with motivation and education for change, informational, economical, or behavioral obstacles can impact household waste management and waste production. To remove such obstacles, municipalities must provide clear and accessible waste sorting guidelines to communities, convenient access to recycling bins or facilities, and introduce policies for producers to reduce the use of non-recyclable packaging and provide alternatives that are accessible and affordable for all consumers.

5. Conclusions

The mission of the U of T Trash Team is to increase waste literacy and reduce plastic pollution. We believe that a literate society can be better empowered to be part of the change needed to reduce environmental problems. Although there are many institutional barriers to sustainable waste management, consumers do play an important role in this process, including making conscious decisions on how we procure, use, and waste materials. The HWA is a successful way to engage and educate individuals and households to learn about the waste stream in their municipality, and to provide motivation to decrease their waste footprint by making changes to waste habits in both the short and long-term. By managing our household waste effectively, we can increase recycling rates, and divert waste from landfill and the environment. By learning ways that we can reduce our household waste on an individual level, consumers can initiate change throughout their community. The HWA elicited a variety of actions and habits, that when combined with other pre- and post-consumer management actions can improve waste management on both individual and community scales.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

The anonymized data submitted by participants in the HWA case study, including household waste data and survey responses are available at Borealis via https://doi.org/10.5683/SP3/D7HMUD.

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