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Comparison of Recycling Outcomes in Three Types of Recycling Collection Units

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Abstract

Commercial institutions have many factors to consider when implementing an effective recycling program. This study examined the effectiveness of three different types of recycling bins on recycling accuracy by determining the percent weight of recyclable material placed in the recycling bins, comparing the percent weight of recyclable material by type of container used, and examining whether a change in signage increased recycling accuracy. Data were collected over 6 weeks totaling 30 days from 3 different recycling bin types at a Midwest university medical center. Five bin locations for each bin type were used. Bags from these bins were collected, sorted into recyclable and nonrecyclable material, and weighed. The percent recyclable material was calculated using these weights. Common contaminates found in the bins were napkins and paper towels, plastic food wrapping, plastic bags, and coffee cups. The results showed a significant difference in percent recyclable material between bin types and bin locations. Bin type 2 was found to have one bin location to be statistically different ($p = 0.048$), which may have been due to lack of a trash bin next to the recycling bin in that location. Bin type 3 had significantly lower percent recyclable material ($p < 0.001$), which may have been due to lack of a trash bin next to the recycling bin and increased contamination due to the combination of commingled and paper into one bag. There was no significant change in percent recyclable material in recycling bins post signage change. These results suggest a signage change may not be an effective way, when used alone, to increase recycling compliance and accuracy. This study showed two or three-compartment bins located next to a trash bin may be the best bin type for recycling accuracy.

Keywords: recycling, waste, waste management

1. Introduction

According to the Environmental Protection Agency (2010), the amount of municipal solid waste (MSW) produced by the United States has been continuously rising since 1960. In 2010, the United States produced 250 million tons of waste, equaling 4.4 lb of solid waste per day per person. The majority of the waste generated comes from residential areas, but 35–45% of waste generated comes from commercial institutions. The EPA cited environmental concerns in solid waste management (SWM) because of lack of landfill space to deposit the MSW and the harmful effects landfills have on the environment. The benefits of recycling on the environment are numerous; recycling has been shown to contribute to cleaner air, water, and land (EPA, 2010).

With further knowledge about the harmful effects of landfills, and the growing concern of lack of landfill space, there has been an increased demand for commercial institutions to incorporate waste reduction and recycling programs (Ward and Richards, 1991). A recycling program is successful only if it can initiate individual participation. This has brought attention to the predictors and influencers of recycling behavior. These factors have been separated into two different categories: personal and situational factors.

Prior research has focused on how individual's attitudes, beliefs, and values, or personal factors, affected their recycling behavior (Chen et al., 2010a, 2010b; De Young, 1986; Huang et al., 2011; Nyamwange, 1996; Sia et al., 1985; Vining and Ebreo, 1990; Williams, 1991). Individuals with greater knowledge of recycling and other environmental factors, greater perceived skill, and who are older, have higher income and are from the northeastern and western areas of the United States are more likely to participate in a recycling program. Individuals who perceived greater ease of use of a recycling station had increased recycling participation; this may be a result of a combination of personal and situational factors (Vencatasawmy et al., 2000).

Situational factors are able to be manipulated and therefore are useful for organizations when implementing a recycling program. Institutions can use these factors to help increase recycling participation. Situational factors reported most often were rewards, prompts, block leaders, informational brochures, proximity or location of bins, and physical structure of the bins (Austin et al., 1993; Brothers et al., 1994; Cole, 2007; Duffy and Vargas, 2009; Geller et al., 1975; Hopper and Nielson, 1991; Ludwig et al., 1998; Schultz et al., 1995). Research has shown distance of recycling stations to have an impact on recycling participation in urban and rural areas, with an increase in participation with a decrease in distance (Vencatasawmy et al., 2000). The effect of these external cues is important for institutions when developing a recycling program.

Rush University Medical Center (Rush) expanded its recycling program in 2007, and a "Green Team" was established to champion and implement sustainable practices. Rush provides containers for recycling for plastics, aluminum, glass, and paper. Items that can be recycled at Rush include #1, 2, 3, 4, 5, and 7 plastics, aluminum and tin cans, foil, glass, colored and white paper, newspaper, and magazines. Currently, Rush utilizes three different types of recycling receptacles, which vary in look, size, shape, and signage. Rush diverted 950,000 tons from the landfill in 2010. Anecdotal comments from Environmental Services (EVS) staff suggested varying recycling compliance and accuracy across the campus, but no empirical data existed to guide the purchase of future bins.

Previous research has shown that external cues have an impact on recycling compliance (Austin et al., 1993; Brothers et al., 1994; Cole, 2007; Duffy and Vargas, 2009; Geller et al., 1975; Hopper and Nielson, 1991; Ludwig et al., 1998; Schultz et al., 1995), but minimal research has studied the effect of different types of bins, or the impact of prompt manipulation on recycling compliance.

The purpose of this study was to examine the effectiveness of three different types of recycling bins on recycling accuracy by determining the percent weight of recyclable material placed in recycling bins, comparing the percent of recyclable material based on the type of container used, and to examine whether a change in signage increased the percent weight of recyclable material placed in recycling bins.

2. Materials and methods

2.1. Description of facility

This study took place at Rush, in Chicago, Illinois, a combined university and academic medical center setting. Rush had more than 8000 employees and 1800 students during the study (2010–2011). The campus, located in a two-square-block area, included office, professional practice, hospital, and academic buildings. Individuals who might place items in a recycling bin on the campus property included medical staff, skilled professionals, unskilled support staff, faculty, and students affiliated with the academic medical center, and members of the general public who were on the campus for physician office visits and/or visiting hospitalized patients. All buildings were available for public access.

Rush's Green Team is a committee of Rush employees from various areas of the medical center who volunteer to be on the committee. The Green Team's goals are to create a culture supportive of reducing, reusing, and recycling.

2.2. Description of recycling containers

Two recycling waste streams were collected at Rush, commingled items (glass, plastic, aluminum, and tin) and mixed paper (colored paper, white paper, newspaper, and magazines). Recycling bins were placed in hallways and lobbies in buildings around campus. All bins were available for use by medical center employees, faculty, students, and the general public. Three types of bins were used on the Rush campus: bin type 1 was a large, grey, three-compartment recycling kiosk made by Midpoint International. These bins were segmented into three receptacles, one for commingled, one for mixed paper, and one for garbage. Bin type 1 was found in public areas in the academic, research, physician office, and hospital buildings. Bin type 2 was a set of individual, colored bins made by Rubbermaid. A green bin with a specialized lid with a circular hole for disposal of bottles and cans was used for commingled items and a blue bin with a specialized lid with a narrow slit for disposal of paper items. The presence of a trash bin next to bin type 2 varied by location. Bin type 2 was found in public areas in the academic buildings. Bin type 3 was a round, gray bin specifically for recyclable materials with slots for commingled and paper that fed into one liner made by Glaro (see Fig. 1). Bin type 3 was found by elevators in the hospital and physician office buildings. Trash bins were not located next to bin type 3. Five bins from each bin type were chosen for sampling from various buildings across campus for geographical diversity.

Figure 1. Three bin types used at Rush University Medical Center, bin type 1, bin type 2, and bin type 3, respectively.

2.3. Data collection

Data were collected in two phases, baseline and post–new signage implementation. Bags were pulled from each type of recycling bin on five consecutive weekdays, Monday through Friday, between the hours of 5 and 8 AM. When bags were pulled, the liners were replaced. Pulled bags were labeled with bin type and location and transported to the sorting area. EVS, the waste management team at Rush, was notified not to pull the bags on the days data were being collected.

A table with data sorting bins, a bucket, and a scale were used. Each empty sorting bin was weighed each day to give a base weight prior to the sorting process. Contents of each pulled bag were sorted into two groups—recyclable and nonrecyclable items—and placed into the respective sorting bin. Items with liquids present were emptied into a liquid waste collection bucket, as the liquid may have misrepresented the weight of the items. If nonrecyclable items were found inside a recyclable item, the nonrecyclable item was removed to the best of the ability of the researcher (e.g., napkins in a plastic bottle). The items in the sorting bins were weighed after each bag was emptied and weights were recorded on the data collection form. The weight of the items was determined by subtracting the weight of the sorting bin from the total weight. If the item's weight was less than 28 g (1 oz) and unable to be detected by the scale 14 g (0.5 oz) was recorded; weights were converted to grams using 1 oz = 28 g. Commingled items were counted and the number of items and number of nonclean, or items with liquid or other substance present in them, were recorded. The type and number of nonrecyclable items in each bag were recorded. After the items were weighed, counted, and recorded, they were disposed of in the proper recycling or trash containers. The liquids were emptied in the dish room. This method was repeated for each bag on the day it was pulled. The sorting bins and bucket were washed each day after data collection concluded, and the table and scale were wiped clear of any liquid residue.

2.4. Signage intervention

The Green Team, a sustainability group at Rush, developed new signage for the recycling bin types 1 and 2. New signage was not developed for bin type 3 because of limited space on bin lids and restrictions for placement on walls in patient units. The signs were developed to help the patrons at Rush better understand what should be placed in each bin. The new signage had pictures of items specific to Rush that could be placed in each bin as well as new titles for descriptions of the bin (see Fig. 2). All signs were changed within 48 h in March 2011. Signs for bin type 2 were placed on the lid (rather than the front used previously) for more accessible viewing; signs for bin type 1 replaced the previous signage. Approximately 8 weeks after the new signage was implemented, data were collected again for 2 weeks on 5 consecutive days, Monday through Friday, in the same manner as the first phase for only bin types 1 and 2. EVS was renotified not to pull the specific bins during the time data were being collected. The commingled bags were collected and weighed in the first week, and with recycled paper were collected and weighed in the second week.

Figure 2. New signage for bin type 1 (top) and bin type 2 (below) for phase 2 of data collection.

2.5. Statistical analysis

The Statistical Package for the Social Sciences (SPSS) Version 17.0, Chicago, Illinois, was used for all statistical analyses. Descriptive statistics were calculated for each of the variables. Total weight of paper bin contents and total weight of commingled bin contents were calculated for bin types 1 and 2 (see Table 1 for all statistical equations). Total recyclable weight for each bin type was determined by combining weight of recyclable paper and weight of recyclable commingled. A total nonrecyclable weight for bin types 1 and 2 was calculated. A total weight of bin was calculated for all bin types to allow for comparison of all bin types, as bin type 3 contained one bag for commingled recyclables and paper recyclables. Percent recyclable for each bin type was determined. Percent clean for all commingled bins was determined.

Analysis of variance (ANOVA) with a Least Significant Difference post hoc test was used to compare differences in percent recyclable and percent clean based on location within the type of bin. If no differences were found the data were grouped together by bin type for further analysis. ANOVA was used to determine if the percent recyclable and percent clean differed among bin types.

To determine the effect of the signage change on percent recyclable by bin type an ANOVA with an LSD-post hoc was used. To determine the overall effect of the signage change on percent recyclable by phase, an ANOVA with a LSD-post hoc was used. A *p*-value of less than 0.05 was considered significant.

Table 1. Formulas used to compute statistical variables for individual bins

Variable	Formula
Total weight of paper bin contents	Weight of recyclable paper + weight of nonrecyclables in paper bin
Total weight of commingled bin contents	Weight of recyclable commingled + weight of nonrecyclables in commingled bin
Total weight of recyclable contents	Weight of recyclable paper + weight of recyclable commingled
Total nonrecyclable weight	Weight of nonrecyclables in commingled bin + weight of nonrecyclables in paper bin
Total weight of bin contents	Weight of recyclable paper + weight of recyclable commingled + total nonrecyclable weight
Percent recyclable	$\left(\frac{\text{Total weight of recyclable contents}}{\text{Total weight of bin contents}}\right) \times 100$
Percent clean recyclable commingled items	$\left(\frac{\text{Number clean commingled items}}{\text{Total number commingled items}}\right) \times 100$

3. Results and discussion

The data were collected in two phases over 6 weeks totaling 30 days of data collection from 15 bin locations. The weight of recyclable material and nonrecyclable material varied by day, bin location, and bin type. Having a trash bin located next to the recycling bin was important for improved recycling accuracy. Changes in signage did not appear to improve recycling accuracy.

3.1. Contaminants

The most common contaminants found in the recycling bins were napkins and paper towels, plastic food wrapping, plastic bags, coffee cups, coffee sleeves, rubber gloves, and plastic medical waste, in descending order. The presence of contaminants varied with bin type. These findings are consistent with the findings of Heathcote et al. (2010) and Allan et al. (2011) with their most common contaminants being coffee cups, sleeves and tissues, juice cups, food packaging, and wet paper. The inconsistencies are likely due to the differences in the facilities as Heathcote et al. (2010) and Allan et al. (2011) sampled from a university library exclusively, and this study covered academic, office, and medical buildings.

3.2. Variation by bin location

Bin type 2 was found to have one bin location to be statistically different ($p = 0.048$), as shown in Table 2. In this bin location the differentiating factor was the absence of a trash bin located next to the recycling bins; however, a few feet around the corner was a trash bin. This difference may suggest the need for recycling bins to be located next to a trash bin to decrease contamination in the recycling bin. This finding was somewhat consistent with the findings of Austin et al. (1993), which resulted in decreased contamination of the trash bin when moved next to the recycling bin. Because of the significant difference of bin location, 7 AAC, was excluded from further analysis for the comparison of bin types. Bin types 1 and 3 were found to have no significant difference with different bin locations ($p = 0.103$, $p = 0.289$, respectively).

Table 2. Comparison of percent recyclable material by bin location for bin type 2 on the Rush University Medical Center Campus over 5 days

		M ± SD		
Bin location	*n*	Weight recyclable material (g (oz))	Total weight of bin (g (oz))	Percent recyclable material[a]
10 AAC	5	413.9 ± 629.4 (14.6 ± 22.2)	433.7 ± 635.0 (15.3 ± 22.4)	91.5 ± 10.9[y]
9 AAC	5	805.1 ± 731.4 (28.4 ± 25.8)	893.0 ± 824.9 (31.5 ± 29.1)	89.4 ± 9.1[y]
7 AAC	5	524.4 ± 686.0 (18.5 ± 24.2)	623.6 ± 700.2 (22.0 ± 24.7)	65.0 ± 29.0[x]
5 AAC	5	2645.0 ± 4235.4 (93.3 ± 149.4)	2792.4 ± 4371.5 (98.5 ± 154.2)	90.4 ± 15.0[y]
5 Library	5	816.4 ± 1105.6 (28.8 ± 39.0)	830.6 ± 1119.8 (29.3 ± 39.5)	98.8 ± 2.0[y]

a. Values with different superscripts were significantly different from each other, $p = 0.048$, ANOVA

3.3. Variation by bin type

As shown in Table 3, bin type 3 was found to be statistically different from the bin types 1 and 2 ($p < 0.001$). Bin type 3 had significantly lower recycling accuracy (i.e., lower percent recyclable material) than the other bin types. Bin type 3 was not located next to a trash bin, as were the other two bin types. This may have contributed to the increase in contamination in the bin. The increased contamination may also be attributed to the combined commingled and paper recyclables being placed in one bag, resulting in increased paper contamination from nonclean commingled material. These findings were similar to those by Heathcote et al. (2010), who found a four-compartment system resulted in a decrease in contamination from an individual refuse container.

Table 3. Comparison of percent recyclable material in three bin types on the Rush University Medical Center Campus over 5 days

Bin type	*n*	M ± SD Weight recyclable material (g (oz))	Total weight of bin (g (oz))	Percent recyclable material[a]
1	23	1142.4 ± 1784.5 (40.3 ± 63.3)	1216.2 ± 1822.8 (42.9 ± 64.3)	87.7 ± 12.8[y]
2	24	1170.8 ± 2239.6 (41.3 ± 79.0)	1238.8 ± 2324.6 (43.7 ± 82.0)	86.6 ± 18.9[y]
3	24	93.5 ± 124.7 (3.3 ± 4.4)	184.3 ± 223.9 (6.5 ± 7.9)	48.7 ± 25.3[x]

a. Values with different superscripts were significantly different from each other $p < 0.001$, ANOVA

3.4. Percent clean material

The percent clean and nonclean material varied by bin type, as shown in Table 4. Bin type 3 was shown to have significantly lower percent clean recyclable material than bin types 1 and 2 (see Table 4). This increase in nonclean commingled items may have contributed to the increase in nonrecyclable material present in bin type 3. An increase in nonclean material has been shown to decrease the ability for material to be recycled. According to Waste Management (2012) "Think Green," one nonclean product can contaminate a bale of plastics, resulting in the inability to recycle thousands of pounds of plastic.

Table 4. Comparison of percent clean commingled recyclable material in three bin types on the Rush University Medical Center Campus over 5 days

		M ± SD					
		Pre-signage change			Post-signage change		
Bin type	*n*	Recyclable items (number)	Nonclean recyclable items (number)	Clean recyclable material (%)[a]	Recyclable items (number)	Nonclean recyclable items (number)	Clean recyclable material (%)[b]
1	21	12.0 ± 15.4	2.2 ± 7.9	89.9 ± 16.5[y]	7.1 ± 8.7	0.6 ± 0.9	89.1 ± 11.2
2	19	10.9 ± 20.3	0.4 ± 0.9	94.9 ± 11.8[y]	5.0 ± 10.5	0.4 ± 0.8	92.1 ± 10.4
3	20	8.4 ± 15.2	0.6 ± 0.6	26.3 ± 5.8[z]	N/A	N/A	N/A

a. Values with different superscript were significantly different from each other $p = 0.003$, ANOVA
b. Phase 1 to phase 2 was not significantly different from each other $p < 0.05$, ANOVA

3.5. Post-signage intervention

In the second phase of this study, new signs developed by the Rush Green Team were implemented for bin types 1 and 2 (see Fig. 2). Eight weeks following the signage change data were collected in the same manner as the first. Weight of recyclable and nonrecyclable material varied from day to day. As shown in Table 5, there was no significant difference in recycling accuracy (percent recyclable material) between pre and post signage change for paper or commingled ($p = 0.738$, $p = 0.684$, respectively). Percent clean recyclable material was also not significantly different from pre– and post–signage change for bin types 1 and 2 (see Table 4). Although the new signs put on the bins included photos of commonly disposed products, this change in signage did not have an impact on recycling accuracy. This differs somewhat from research by Austin et al. (1993), who reported placement of signage focusing on what is recyclable significantly decreased contamination in the bins.

A possible reason for this difference was that Austin et al. added signs where none had been previously, where in the current study the content of the signs was what changed. These results suggest a signage change may not be enough to impact a change in recycling accuracy, and more extensive education may be necessary to make an impact.

Table 5. Comparison of weight and percent recyclable material in two bin types on the Rush University Medical Center Campus pre– and post–signage change

		M ± SD		
Phase	*n*	Weight recyclable material (g (oz))	Weight of nonrecyclable material (g (oz))	Percent recyclable material[a]
Paper bins				
Pre	33	683.2 ± 1193.5 (24.1 ± 42.1)	31.1 ± 53.8 (1.1 ± 1.9)	79.8 ± 31.6
Post	29	1479.8 ± 3121.2 (52.2 ± 110.1)	39.6 ± 79.3 (1.4 ± 2.8)	82.4 ± 29.6
Commingled bins				
Pre	30	257.9 ± 484.7 (9.1 ± 17.1)	28.3 ± 42.5 (1.0 ± 1.5)	83.7 ± 18.3
Post	31	365.7 ± 771.1 (12.9 ± 27.2)	39.6 ± 79.3 (1.4 ± 2.8)	85.8 ± 22.1

a. Pre– and post–signage change were found to be not significantly different, $p < 0.05$, ANOVA

3.6. Limitations

Limitations of this study should be considered when making conclusions from the data. A limitation is the use of one facility's bin types, which limits its generalizability to other settings. During data collection, occasionally bags were found to be empty. The researchers were not able to determine if the absence of material present was because of nonuse or EVS removing the bags before collection. These days' data were counted as missing variables and may have had an impact on the accuracy of the data.

4. Conclusion

Results of this study suggest that the physical structure of a recycling bin may impact recycling accuracy with use of multiple bins with separate paper, commingled, and trash bins providing the most accurate recycling. This study suggests the importance of including a trash bin next to recycling bins to decrease contamination in the recycling bins. A change in signage appears to be an insufficient way to increase recycling compliance and a more extensive education program may be needed. More studies are needed to determine effective ways to increase recycling compliance in large commercial institutions. Research using different forms of education to determine the most efficient and effective way to increase compliance is needed. These outcomes can provide insight for large institutions to decrease recycling contamination.

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