Nudging households to segregate at source

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Abstract

Often, asking households to segregate at source faces a major hurdle of unsegregated collection. In absence of such a service, households slide back to disposing off waste in an unsegregated manner. To overcome this hurdle, and to ensure households don't stop segregating because of unsegregated collection, we provided households with a collection service for plastics. Given this set up, we conducted a field experiment with a sample size of 1242 households over 2 months. We document households' responses to provision of one-time information on waste segregation and dustbins and a collection service. We find that households tend to continue with their changed on receiving the one-time information only. We also find that reminders sent to them further strengthens their resolve to segregate waste.

1. Introduction

Often, we engage in certain practices because we are used to doing things in a particular way , ie. Habits are hard to break. However, our habits lead to actions that have social, and environmental consequences. Given the dire need to reduce greenhouse gas emissions in our bid to combat climate change, it becomes imperative to look at solutions that are not only financially viable but also sustainable. Segregation is one such step to reduce greenhouse gas emissions. It is also essential step to transitioning to Circular Economy (Reike et al, 2018). Segregating at source ensures better waste processing, reduced costs of recycling. However, households in India and many developing nations are not habituated to segregating their waste prior to disposal. A reason for this could be that these countries were largely agrarian economies and waste was almost 100% organic. For any recyclable waste, countries often have an informal waste collection system in place and do segregate waste that is collected by these collectors. Also, earlier, any organic waste would be fed to cattle. It is with the advent of plastics, and greater urbanization that unsegregated disposal of waste has become an issue. While the composition of waste changed, waste disposal habits did not which then led to mountains of garbage, drains getting choked with plastic etc. However, changing waste disposal habit might not require immense financial investment. Information campaigns and increasing households' awareness might be able to bring about the desired change.

In this paper, we study the effectiveness of a one-time information campaign on waste disposal behavior. We follow households for two weeks to understand the effect after the nudges have been stopped. Secondly, we evaluate the incremental effect of continued treatment. This is especially relevant in India's context as it will provide insights into the effectiveness of sending reminders in maintaining pro-social behavior. This context is especially important to study as providing monetary incentives might not always be feasible or desired. While separating waste is not a time consuming one, it is not an enjoyable one either. Thus, people might require targeted policy intervention to change habits.

We conduct a field experiment in Palwal, India. We approached 1328 randomly selected households for their participation in our study, with 1,242 households agree to join our study. Most of these households are serviced by waste collection provided urban local authority. However, a few of them also employ their own garbage collectors as the service provided by urban local authority tends to erratic and does not provide door to door service. Households generally have only one dustbin. A few households also indulge in some form of segregation by using organic waste as feed for cattle or compost for their garden. We randomize households to treatment and control groups. The first treatment consists of informing randomly selected households on how to segregate and also providing them with a dustbin. A collection service for recyclable waste was also provided to both control and treatment households. The second round of treatment was given to subset of houses receiving the first treatment. This consisted of households receiving a weekly reminder on the importance of segregation. Households were monitored for a two rounds, each round lasting 4 days, after every treatment.

Treatment also included providing a subset of households with weekly reminders, on the importance of segregation. Households received two such reminders.

One framework that explains the mechanism behind is the cue driven consumption theory outlined by Laibson (2001). The intervention acts as a cue which temporarily lowers the marginal utility of disposing in an unsegregated manner. After the cue is withdrawn, people lose their motivation and revert back to their habits. However, in our experiment we do not find that households revert back to their old behavior. In our study, we find that reminders increase the probability of households to segregate.

Our paper makes the following contribution. First, it contributes to literature on habit formation. We find persistence in behavioral response to our interventions. Secondly, we provide a collection service for recyclables. Provision of this service is essential to understanding why households do not segregate especially in a developing country context where waste collection services are unreliable. Also, we collect information on the sale of these recyclables. This will provide insights on the financial feasibility of segregation at source.

The paper proceeds as follows. Section 1 provides background on related literature. Section 2 provides background on the experiment. Section 3 provides the results and discusses the behavioral mechanisms, including the policy implications. Section 4 provides the policy implications and concludes.

1.1 Related Literature

Our study is related to several literatures. Despite Indian authorities' advertisements to encourage households to segregate at source, compliance has been low. Ouellette and Wood (1998) state that past behavior guides future responses though two processes. Either, well practised behaviors in constant context recur or conscious decision making is required to initiate behavior in unstable or difficult context. Given this, perhaps lack of personalised information is the reason behind low uptake of segregation 7 years after the launch of Clean India Mission. Following literature on provision of personalized information (Chetty & Saez, 2013), we provided households with information on segregation, at their doorstep. The intervention acts as a cue that increases their marginal utility from disposing in a segregated manner. Also, in an earlier study (Wadehra & Mishra, 2018), households had highlighted lack of segregated collection as a reason for not segregating. We solve this chicken and egg situation by providing households a waste collection service for plastics. Further, in the said earlier study, a drop in the percentage of households segregating was noticed with time. Similarly, Gallagher, (2014) finds that take up of flood insurance spikes immediately after a flood but declines over time. Following Karlan et al. (2016), who find that reminders help clients meet their savings goal, we provide a reminder service to a subset of households.

There are studies that looked at short run and long run effects of interventions on energy conservation (Allcott & Rogers, 2014), hand washing (Hussam et al., 2017), meeting savings targets (Karlan et al., 2016). Compared with these studies our results find persistent effects over a long period of time.

Finally, our study is also related to other studies on waste segregation conducted in Nepal and Bangladesh (Nepal et al., 2022). However, contrary to their findings we do find that provision of information is essential to waste segregation. This could also be due to the fact that while we did provide households with a waste collection service, we did not explicitly advertise it. In essence, households who segregated saw that their waste was not mixed on collection.

1.2 Description of the Study Site and Data Collection

Palwal is a city in the state of Haryana, India, covers an area of 1359 sq. Km with a population 1 million (Census, 2011). The city is divided into 31 wards from where we derived our sampled households. . The total waste generated by the city was stated as 400 tons per day comprising of 30% dry recyclable, wet (organic) 55% and inert 15%[1]. The municipal council provides street sweeping and garbage collection from secondary points for all 31 wards. For door to door collection, residents have employed garbage collectors[2] or dump it themselves either at designated secondary collection points or any other

[1] Assuming 400 gms of per capita waste generated. This information is rough estimate of the EO.
[2] Garbage collector provide collection services for door to door services at a fee

open plot. In 5 wards of the council, 8300 households also have the option of door-to-door collection by auto tipper is provided. While all households in the 5 wards have the additional option of door to door collection by auto tipper[3] (provided by a contractor) not all households avail the service[4] either because they already have a garbage collector who provides a doorstep collection or because of time mismatch[5]. As per official communication from municipal council, 60% of the residents in 5 wards avail this facility. The MC or the contractor presently don't charge any amount for this facility[6]

Households were informed of the study and their consent to participation for the study was taken. 1242 households consented to be a part of the study. Data on weight of garbage and whether it is segregated or not was collected prior to waste being picked up.

2. Experiment Design

2.1 Waste Collection Service

Studies find that households in developing countries often cite mixing of waste by the garbage collector as a reason to not segregate or discontinue segregation (Nepal et al., 2022; Wadehra & Mishra, 2018). To overcome this challenge, we introduced a collection service for inorganic waste. It was a separate collection service from their usual waste collection service provided by the municipality, because the collection service provided by the municipality are often considered unreliable by the households and they did not have a history to collection sorted waste. Therefore, households may perceive them as not credible even if they want to collect separately. In order to strengthen the perception about the reliability of the service, we organized local ragpickers who normally picked sellable waste from dumpsites as our waste collectors. Ragpickers are known to pick recyclable waste at dumpsites and landfills for a living. A segregated collection service targeting the recyclables by the ragpickers could help create a sense of creditability that these collected recyclables are going to the recycled, which would then feed back to the households. The ragpickers only collected segregated inorganic waste from the households and left the unsegregated waste or segregated non-recyclables to the usual waste collectors. The service was provided to all households in our study.

[3] The auto tipper provides door to door collection for lanes it can enter and for independent houses. For multi-storied houses, the residents are expected to come down. For some lanes that are narrow for the tipper, residents are expected to come to drop the waste.

[4] 8 auto tippers as informed by the contractor's supervisors, the EO oscillated between 5 and 8, though he had also called up the contractor for this information

[5] The auto tipper plies from 7:30-12:00 and then 2:30-4/5

[6] While the residents who avail the tipper's services informed that the tippers collect no fee, a few residents in one ward mentioned that tipper started charging 100 INR per month and so they stopped using the tipper for waste disposal.

Because our intervention involves information provision, introducing the collection service in an explicit way might contain information (such as what to collect, how segregate) that could contaminate the control group. To reduce potential contamination, we inform households implicitly about the segregated collection service through the households' own observation in the following way. The collectors went along with the enumerators when they went to weigh and monitor the garbage. If the waste was segregated, the recyclable bin was handed over to the waste collector. So, households who segregated saw that that their waste was not being mixed by the collector. In case, it was not segregated, the enumerator handed the garbage back to the household, to be collected by their usual waste collector. This ensured, that, while households in control group are not contaminated by the mere provision of this service, treatment households also knew that their efforts in segregating waste are not being nullified by the waste collector.

Further, involving informal waste management sectors such as ragpickers is also specified in Solid Waste Management Rules 2016, we also aim to explore the cost-effectiveness of such ragpicker service and its potential as part of the municipal waste management system.

2.2 Interventions

Our intervention on the household side has two treatment groups and one control group. Households are randomly allocated into one of these three groups.

In the control group, households would not receive anything other than the collection service from the ragpickers.

Households in the first treatment group, received a one-shot campaign with regard to better waste segregation at home. The campaign had two components: informational provision through a brochure and a dustbin for segregation. The information brochure offered the households information on the benefits of waste segregation at source and how to do it properly following Solid Waste Management Rules, 2016. It was to increase the know-how and increase households' intrinsic motivation to do so. The bins were provided to the households for free and households were told that they could use that bin to store recyclable waste such as plastics. We provided the bins to reduce the behavioral costs of waste segregation. Households could decide to use it or not and there would be no consequences regardless their decisions. The campaign was delivered only once.

The second treatment is an add-on to the first one. It had the same one-shot campaign as described above, with additional reminders after the initial campaign. The reminders were delivered in form of a leaflet with information about the benefits of waste segregation. They were meant to increase waste segregation by recapturing people's attention to segregation, as inattention is often found to contribute to the decay of behavioral changes. The reminders were delivered on a weekly basis to the households

by the enumerators. After two rounds of the reminders, households were given an opportunity to decide to what extent they want to keep or stop the next two rounds of reminders through a multiple price list approach similar to Allcott and Kessler (2019).

2.3 Experiment structure

Table AA show the overall structure of experimental design and the timeline. The experiment was divided into 5 phases- baseline, intervention 1, intervention 2, removal of nudges, endline survey.

Table AA: Experimental Design and Timeline

December 27, 2021-January 12, 2022: Baseline Survey
January 14, 2022-January 17, 2022: Intervention 1 to 422 households
January 25, 2022-January 26, 2022: Intervention 2-Reminder 1 to 431 households
January 31, 2022-February 1, 2022: Intervention 2-Reminder 2 to 431 households
February 7, 2022-February 11, 2022: Choice game played with 431 households to opt out of reminder service
February 14, 2022-February 15, 2022: Intervention 2-Reminder 3 to households who opted in
February 21, 2022-February 22, 2022: Intervention 2-Reminder 4 to households who opted in
March 4, 2022- March 11, 2022: Endline Survey

Baseline survey captured the socio-demographic variables, households' perception towards environment and waste management. In addition, information was also collected on whether households segregated or not. The next phase was delivering information on segregation and a dustbin to randomly selected households. The third phase of intervention involved giving two reminders to a subset of households who received the first intervention. In the fourth phase, households who received reminders were given an option to discontinue the reminder service.

2.3 Outcome variables: Monitoring of Households

Households were monitored to collect data on weight of garbage and whether a households segregate or not twice in 8 days. Monitoring of waste had to be finished before it was picked up by the usual collector, so enumerators only had 2-3 hours in the morning for this task. Further, enumerators also accompanied the rag picker service to ensure that the service was reliable. Given the time limitations, combined monitoring and rag picker service and were unable to randomize the monitoring of households. While household monitoring did follow a pattern, days on which households were monitored were not fixed, thus, we do not expect our results to be affected.

3. Results and Discussions

3.1. Summary Statistics and balance check

We first give a brief description of our sample and check if the randomized treatment allocation actually generated a balance sample across treatment and control groups. **Table A** describes the demographic and economic characteristics of the households for our whole sample, as well as for the subsamples of the treatment and control groups. The information is obtained from our baseline household survey.

Most of respondents of the survey are middle-age females, who are more likely to be the ones that are responsible for daily waste management. The respondents as a whole are relatively well educated, with over a quarter that received higher education, which reflect the general population features of Palwal. The average household size is 5.3 members. Over 93% households have at least one refrigerator and 10% with a microwave. The self-reported household monthly income concentrates in the range between Rs. 0 – 60,000.

The demographic and economic characteristics of the treatment and control groups are largely balanced. In most of the cases, the sample means of the variables are close. Education levels of survey respondents exhibit somewhat large differences in some categories. However, pairwise Mann-Whitney tests show no statistically significant differences between any two groups. One key variable that shows signs of unbalance is the proportion of households not having a refrigerator. Having a refrigerator or not is an important factor for household waste generation. While the proportions are similar with T1 and T2, it is much higher in the control group. Proportion tests show that the difference between Control and T2 is marginally significant at 10% level. Despite signs of differences between certain groups for particular variables, a joint evaluation approach shows no individual and household characteristic could predict the allocation to the treatment or control groups (Details in Table AA in Appendix). Hence, the overall the randomization process has produced a well-balanced sample across groups with regard to demographic and economic characteristics.

Table A. Summary Statistics by treatment conditions

	Total	Control	T1	T2
No. of obs.	1242	422	389	431
Respondent's characteristics				
Age	44.2	44.1	42.7	45.6
Female	72.8%	76.1%	70.2%	71.9%
Education levels				
Illiterate	15.5%	16.6%	13.9%	15.8%
Up to class 5	9.8%	9.5%	11.3%	8.8%
Up to class 8	11.3%	10.7%	11.8%	11.4%
Up to class 10	15.0%	15.9%	11.8%	16.9%

Up to class 12	15.4%	14.5%	16.7%	15.1%
Diploma and certificate	6.9%	5.9%	7.5%	7.4%
Graduate	17.3%	17.5%	19.3%	15.3%
Post graduate and above	8.9%	9.5%	7.71%	9.3%
Household characteristics				
Household size	5.3	5.3	5.3	5.3
Area of housing*	115	110	120	116
No refrigerator	6.2%	8.1%	5.4%	5.1%
Have microwave	10.2%	9.5%	10.3%	10.9%
House ownership	87.8%	84.5%	89.7%	89.1%
Household income**:				
Below Rs. 30000	50.0%	51.0%	48.8%	50.1%
Rs. 30000-59999	37.5%	37.1%	38.9%	36.6%
Rs. 60000-99999	9.0%	9.2%	8.5%	9.3%
Above Rs. 1 lakh	3.5%	2.7%	3.8%	4.0%

Note: Calculated by the authors from the data.

* There are missing values for the area of housing. Only 1171 households with valid information in total, with 394 in Control, 366 in T1 and 411 in T2.

** There are households refused to provide income information. There are 1088 households that provided income information with 369 in Control, 342 in T1 and 377 in T2.

With a balanced sample with regard to demographic and socio-economic characteristics, we look at the waste related behavior before the intervention, particularly the waste segregation behavior. Table B shows the waste segregation and waste generation observed in the baseline monitoring. At the baseline monitoring, the households in our sample on average generated 1.71 kg waste. Accounting for the time since previous waste collection, an average household in our sample generated 1.11 kg waste per day before the interventions, which puts per capita per day generation at 0.22 kg. Per capita waste generation in the country varies from 0.2 to 0.6 kg per capita per day, which shows that per capita waste generated in Palwal is very low. There is no significant difference in the total amount of waste generated by individual households between groups.[7]

Overall, about 12.6% of the households (156/1242) segregated their waste at the baseline. Households segregated their waste mostly because they could use the organic waste as animal feed or for compost. The differences between control and treatment groups in households' waste segregation behaviour is small in absolute terms and not statistically significant.[8] We further look at the amount of segregated waste generated by the waste-segregating households. The total amount of waste of these households is more than the sample mean, and also greater than those of the households that did not segregate. Among the segregated waste, about 22% (0.51/(0.51+1.76)) of the total waste is recyclables, which is largely consistent with the national waste compositions. Again, between groups, there are no significant

[7] In pairwise t-tests for weight of waste collected at baseline monitoring, Control vs. T1, p=0.891; Control vs. T2, p=0.407; T1 vs. T2, p=0.539; for waste per day, Control vs. T1, p=0.423; Control vs. T2, p=0.616; T1 vs. T2, p=0.779.

[8] In pairwise tests of proportions, Control vs. T1, p=0.825; Control vs. T2, p=0.689; T1 vs. T2, p=0.865.

differences. The fact that households across groups behaved very similarly in waste generation and segregation at baseline offer additional confidence in the quality of our randomization process and thus the casual inference of the treatment effects.

Table B. Baseline waste management behaviour by groups

	Total	Control	T1	T2
Weight of household waste at collection (kg)	1.71	1.74	1.73	1.66
	(1.55)	(1.48)	(1.71)	(1.47)
Waste per day (kg)	1.11	1.13	1.09	1.10
	(0.74)	(0.71)	(0.73)	(0.78)
Segregated	156	51	49	56
Not Segregated	1086	371	340	375
% of segregation	12.6%	12.1%	12.6%	13.0%
For households that segregated waste				
Weight of recyclables at collection (kg)	0.51	0.46	0.55	0.52
	(0.42)	(0.39)	(0.40)	(0.47)
Weight of non-recyclables at collection (kg)	1.76	1.70	1.99	1.63
	(1.66)	(1.36)	(2.09)	(1.49)

Note: Calculated by the authors from the baseline waste monitoring data. Standard deviation in parentheses.
For households that segregated their waste, the total weight of waste is the sum of the weight of recyclables and the non-recyclables; for households that did not segregate, the total weight of waste is the weight of the mixed waste.
Pairwise t-test between the three groups for segregated non-recyclable waste: $p>0.30$; for segregated recyclable waste, $p>0.25$.

3.2. Treatment effect on household waste segregation

We then examine the treatment effects of our waste segregation interventions. **Figure A** plots the evolution of the share of households that segregated their waste over entire study period by the treatment conditions. The horizontal axis represents the waste monitoring rounds. Round 0 represent the baseline round. The intervention happened after the baseline monitoring, indicated with the red dotted line. Round 1-12 are the post-intervention monitoring rounds. For the reminder treatment (T2), the first two reminders were delivered every two rounds of waste monitoring (indicated with the green dotted line). At Round 7, we elicited households' willingness to pay for continuing receiving the reminders. For the households who kept the reminders, we deliver another two reminders (between Round 7 and 8 and between Round 9 and 10, shown by the blue dotted line). For the households going on without the reminders, they will not receive these reminders.

Figure A shows that, starting on an equal foot at the baseline, waste segregation behaviour of households in different group diverge greatly over the course of the post-intervention period. The waste segregation rate in the control groups stays relatively stable over entire 13 rounds of waste monitoring. It experienced slow increase over time, from 12.1% at the baseline to 18.8% at the end of the experiment. Given that the control group also received the recyclable collection service from the rag-picker, the fact

that there is no significant change right after the intervention helps to mitigate the concerns of experimenter demand effect as a result of the provision of collection services. The increase over time may reflect the effect of the collection service, which may induce the behavioural changes from some households or spillover effects. Even though proportional the increase is large (over 50% from the baseline level), the absolute size of the increase is small and the segregation rate is still low.

On the contrary, the households that received the information and the dustbin in both treatment groups show sharp immediate increase in their waste segregation behaviour. The segregation rate of households in T1 jumps from 12.6% at the baseline to 40.1% in first round of monitoring after the intervention and 42.4% in the second round. For T2, the corresponding segregation rate jump from 13.0% to 44.7% and 42.1%. These over three-fold increases from the baseline level represent a very large immediate impact of the initial intervention.

What's more interesting is that for T1 with the one-shot intervention, the initial impact did not fade away as we expected and as what has been found in similar settings (Wadehra and Mishra, 2018). On the contrary, there is a gradual and significant increase in segregation rates over time. In the last round of the waste monitoring, 71.4% of the households segregated, which is the highest point in the entire study period. With a guaranteed collection service for the recyclables, we see a sustained or even reinforced changes in households' waste segregation behavior.

Before receiving the reminders after the second post-intervention monitoring, the reminder treatment T2 received the same intervention materials as T1, and as expected, the effect is also very similar. The divergence comes after T2 received the first reminder, where the segregation rate jumps to an even higher level at Round 3. The segregation rate in T2 increased steadily after that until Round 7 with no significant increase after the second reminder, Interestingly, even though only part of the households in T2 continued receiving the reminder, there's another jump in segregation rate at Round 8 to over 90%, and then remain slowly increasing afterwards. At the last round of waste monitoring, the segregation rate in T2 reaches a stunning 93.8%, when almost all households segregate.

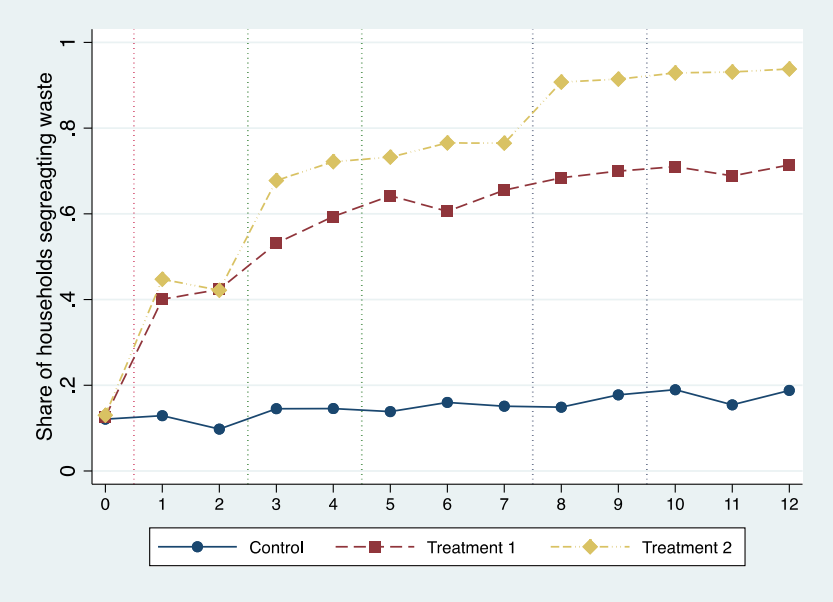

Figure A. Household waste segregation rate over the study period by treatment conditions

The comparison from Figure A reveals significant positive effects of our one-shot intervention on percentage of households segregating, and the positive effects is further reinforced by the reminders. Now we use difference-in-difference regressions to formally estimate the size of the effects for different stages of the game. Table C shows the results based on linear probability models.

In the left panel, we estimated the average treatment effects for the entire study period. Specifically we estimate the follow regression model:

$$Y_{it} = \alpha + \beta_1 T1_i * Post_t + \beta_2 T2_i * Post_t + \boldsymbol{\theta T_i} + Post_t + \varepsilon_{it}. \qquad (1)$$

Y is the binary waste segregation indicator of household i at monitoring round t; $\boldsymbol{T}$ are the treatment status vectors including T1 and T2; *Post* indicates post intervention period; Coefficients of the two interaction terms, β_1 and β_2 are the parameters of interest, representing the average treatment effect of the interventions.

Overall, receiving the one-shot campaign (T1) increases household's probability of waste segregation by 45.5 percentage points, which represent a sharp increase by over 360% from baseline level. Strengthening the one-shot campaign with reminders (T2) proves to be even more effective, raising the probability of segregation by another 15 percentage points to 60 percentage points[9], representing an almost five-fold increase. These results mean that our intervention has been very successful in promoting household waste segregation despite being purely voluntary-based and involving no monetary incentives.

Because the experiment has several phases with different elements, particularly for the treatment with reminders (T2), we also look at the treatment effects of different phases separately. We classify all the

[9] The difference in coefficients is statistically significant at 1% level.

post-intervention waste monitoring into three phases. Phase 1 includes Round 1 and 2, where both treatment groups received the same one-shot provision of information and waste bin. Round 3-7 are phase 2, where households in T2 received reminders. Phase 3 is Round 8-12, where households in T2 had the option to choose to keep the reminders or not. Accordingly, we replace the post-intervention indicator in equation (1) with the three phase indicators and estimate the following model:

$$Y_{it} = \alpha + \sum_{K=1}^{3} \beta_{1K} T1_i * PhaseK_t + \sum_{K=1}^{3} \beta_{2K} T2_i * PhaseK_t + \boldsymbol{\theta T_i} + \sum_{K=1}^{3} PhaseK_t + \varepsilon_{it}. \quad (2)$$

The results are reported in the right panel of Table C. In Phase 1, as expected, the treatment effects of both T1 and T2 are similar. Right after receiving the intervention, the probability of household waste segregation increased by around 30 percentages. The effect of the one-shot intervention in T1 does not fade away as time goes by. In the contrary, its effect goes up to 45 percentage points in Phase 2 and to 52 percentages points in Phase 3. These increases in effect sizes are also statistically significant.[10] This implies that our one-shot intervention along with a collection service may have triggered sustained changes in waste segregation habits.

For households in T2 that received the reminders in phase 2, the reminders reinforced the already strong effect, improves the probability of segregation by 57.5 percentage points, 12 percentage points higher that the effect of T1 in the same phase.[11] Strikingly in phase 3, after some households stopped receiving the reminders, the effect is stronger and its relative effectiveness to T1 also gets larger, raising from the 12 percentage points in phase 2 to 22 percentage points.

Table C shows the DID results without controlling for individual and household characteristics because we have an overall balance sample due to the randomization of treatment assignment. To alleviate any concern in the slight unbalance in variables such as owning a refrigerator or not, we also estimate the equation (1) and (2) with additional individual and household characteristics. The results are shown in Table BB in the Appendix. While a few variables such as some education levels, having a refrigerator and some income levels are associated with waste segregation decision, including these control variables has almost no impact on the size of the treatment effects. Therefore, to utilize the most of the sample size, we focus on the results without these controls in most parts of the analysis.

Overall, these average treatment effect estimations show that our household intervention coupled with a collection service is able to greatly improve the households' voluntary participation in waste segregation.

Table C. Average treatment effect on waste segregation

Overall effect	Effect by phases of the experiment

[10] The pairwise tests between the three coefficients of the three phases of T1 are all significant at 1% level.
[11] The difference is statistically significant at 1 % level.

T1*Post	0.455***	T1*Post Phase 1	0.294***
	(0.0281)		(0.0319)
T2*Post	0.600***	T2*Post Phase 1	0.312***
	(0.0259)		(0.0298)
		T1*Post Phase 2	0.452***
			(0.0304)
		T2*Post Phase 2	0.575***
			(0.0286)
		T1*Post Phase 3	0.523***
			(0.0306)
		T2*Post Phase 3	0.743***
			(0.0272)
Treatment 1	0.00511	Treatment 1	0.00511
	(0.0231)		(0.0231)
Treatment 2	0.00908	Treatment 2	0.00908
	(0.0227)		(0.0227)
Post intervention	0.0311*	Post Phase 1	-0.00762
	(0.0184)		(0.0182)
		Post Phase 2	0.0272
			(0.0194)
		Post Phase 3	0.0507**
			(0.0202)
Constant	0.121***	Constant	0.121***
	(0.0159)		(0.0159)
No. of Obs.	15928	No. of Obs.	15928
R^2	0.296	R^2	0.345

Note: Standard errors clustered at household level in parentheses.
Linear probability models are used to estimate the difference-in-difference models.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.3. Treatment on Weight of Segregated Waste: intensive margin vs. extensive margin

Because of the prevailing low waste segregation rates among Indian households, we designed our experiment aiming to evaluate how to effectively improve segregation rate. The main outcome of interest of this study is whether households engage in household waste segregation or not. However, segregating or not is only one aspect that affects the success of a segregated waste management system and the environmental consequences of waste segregation. Upon segregation, to what extent households segregated, or the quality of waste segregation is also an important question. A larger amount of recyclables that are segregated and collected as a result of the intervention would mean that there are more economic incentives from the recyclables, small cost of waste treatment, fewer landfills and less runoffs that result in environmental pollution and amenity losses. In our particular setting where we mobilized rag-pickers to collect recyclables, the quantity of recyclables also directly links to the economic incentives for the rag-pickers and the potentials to incorporate the informal sector into formal waste management system.

In this section, we estimate the treatment effects of our interventions on the quantity of segregated recyclables and the frequency of segregation. For all the households that segregated, we measured the weight of the segregated recyclables during waste monitoring. For households that did not segregate, we set the weight to be zero, even though their mixed waste still contains recyclables that could be sorted out later at dumpsites as what the rag-pickers usually did, as here we care about the recyclables that were already segregated and could be directly picked up from the households' doorsteps. Frequency of segregation refers to the number of times we find that a household has segregated. Till now we have only looked at whether households segregate or not but not so much at their consistency. Consistency is an important parameter to assess their waste segregation behavior. For all the households, we collected information on segregation every four days.

Table D shows the overall treatment effects on the weight of collected recyclables and the treatment effects by different phases of the experiment for the whole sample, where we replicate the regressions in Table C, but use the weight of segregated recyclables as the dependent variable. Overall, our one-shot campaign increases the segregated recyclables by 0.062 kg per day per household and the campaign reinforced by reminders increases segregated recyclables by 0.081 kg per day per household. The latter is marginally larger than the former (statistically significant at 10% level). The size of the effects looks small because this is the average effect across all households including those who did not segregate. The relative size of the effects is still very large. The weight of recyclables segregated and collected at the baseline monitoring round is only 0.042 kg per day per household. An increase of 0.062 kg per day per households means an increase from the baseline by almost 150%, and over 190% for T2. The phase by phase estimation reveals similar patterns as results for the segregation rate. The effects are relatively small right after the intervention (but still represent almost 100% increase from the baseline level) and similar between the two treatment groups because they received the same material in phase 1. The effects get larger as time goes by, even for the one-shot campaign in T1. The provision of the reminders further increase the effect.

Table D. Average treatment effect on weight of collected recyclables

	Overall effect		Effect by phases of the experiment
T1*Post	0.0619***	T1*Post Phase 1	0.0397***
	(0.00967)		(0.0114)
T2*Post	0.0809***	T2*Post Phase 1	0.0391***
	(0.0108)		(0.0120)
		T1*Post Phase 2	0.0633***
			(0.00995)
		T2*Post Phase 2	0.0795***
			(0.0111)
		T1*Post Phase 3	0.0695***
			(0.00996)

		T2*Post Phase 3	0.0993***
			(0.0111)
Treatment 1	0.00440	Treatment 1	0.00440
	(0.00941)		(0.00941)
Treatment 2	0.00659	Treatment 2	0.00659
	(0.0106)		(0.0106)
Post intervention	-0.009	Post Phase 1	-0.00593
	(0.00652)		(0.00754)
		Post Phase 2	-0.0124*
			(0.00665)
		Post Phase 3	-0.00714
			(0.00663)
Constant	0.0382***	Constant	0.0382***
	(0.00624)		(0.00625)
No. of Obs.	15928	No. of Obs.	15928
R^2	0.102	R^2	0.114

Note: Standard errors clustered at household level in parentheses. The dependent variable is the weight of collected recyclables per day calculated from dividing the weight at the collection by the days since last collection.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

So far, we have shown the average effects of our intervention for the entire sample. However, we have seen in Figure A and Table C, only a fraction of households that segregate waste as a result of our intervention. The changes in the weight of segregated recyclable may come from two sources: more households started to segregate (the extensive margin) and households segregated more conditioning on them segregating their waste (the intensive margin). The content of our intervention in principle can not only influence households' decision to segregate, but also teach them how to segregate properly. Therefore, the effects can come from both the extensive and the intensive margin. We intend to then examine the relative importance of these two sources.

We follow the decomposition method used by Attanasio et al. (2011) and Carranza et al. (2020) the decompose the average treatment effect into effect at the extensive margin and effect at the intensive margin. The effect at the extensive margin represents the changes in weight of segregated recyclables if the segregation rate changes as shown in Figure A but the weight of segregated recyclables stays the same as in the baseline; the effect at the intensive margin is the remaining portion of the total effect, representing the changes in weight of segregated recyclables for those who segregate. Table E shows the decomposition of the overall treatment effects by treatment groups.

Table E. Average treatment effect on weight of collected recyclables

	T1: one-shot campaign	T2: one-shot campaign + reminder

Total effect	0.062***	0.088***
	(0.010)	(0.004)
Extensive margin effect	0.094***	0.127***
	(0.006)	(0.003)
Intensive margin effect	-0.032***	-0.039***
	(0.007)	(0.003)
Conditional effect	-0.053***	-0.052***
	(0.011)	(0.003)

Note: Standard errors clustered at household level in parentheses. The dependent variable is the weight of collected recyclables per day calculated from dividing the weight at the collection by the days since last collection.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

We see the average treatment effects of both treatment conditions are driven by the effects at the extensive margin, i.e., effects on the segregation rates. And the difference in the relative effectiveness of the two treatments also come from the differences in the extensive margin effect, as T2 can better promote participation in waste segregation due to the reminders. Conditioning on segregation, the effects on the weight of segregated recyclables are actually negative, meaning our treatments reduces the weight of recyclables segregated by the households. The sizes of these negative conditional effects are almost the same for both treatments, suggesting the reminders works only at the extensive margin, rather than the intensive margin. The conditional effects are also sizable. Given that on average a household that segregated its waste can generate 0.33 kg recyclables per day, a decrease by 0.05 kg mounts to a 15% decline.

3.4. Behavioral Mechanisms

What actions underlie the observed effect? To what extent do households change their consumption behavior? In particular, do households shift to consuming products that generate less packaging waste? This question is a little difficult to answer but we try to provide some insights into their consumption behavior as well.

A potential model that would explain the behavior is that information provision and dustbins update consumers information sets and reoptimize their consumption behavior. We do see backsliding but it is negligible. The information campaign acts as an exogenous cue, which causes people to pay attention to waste management issues and highlights how their actions can solve part of the problem. This increases their marginal utility from segregated waste disposal. Once the information campaign stops, their marginal utility from segregated waste disposal does not slide back as a result of the collection service provided. Collection service also acts as a cue for households. This cue is further strengthened by the reminder service provided. However, collection service acts as a cue only if households had received the information campaign. It does not have any effect on control group.

The plateauing that we see towards the end suggests that people were habituated to segregated waste disposal. Our results are in line with Laibson (2001) cue model theory which suggests that cues affect marginal utility more powerfully over time. However, it is difficult to say if this habit is conditional on provision of collection service.

There could be other models as well to explain this. For example, waste segregation tips could cause households to look at their contribution to the waste problem and reduce their plastic consumption as a result. Thus, end up changing their waste composition. Our results do hint towards this, however, we cannot provide concrete evidence for it.

3.5. Cost effectiveness of the rag picker service

Provision of a collection service over and above the usual service providers played an important role in ensuring that households do not slide back to their "un-cued" behavior. While this collection service ensured that rag pickers get better quality recyclables as they were less contaminated by organic waste, collecting recyclables in such a manner is also time consuming and labor intensive. Rag pickers will only provide such a service if they earn an income at least at par with their current mode of collection, i.e., collecting recyclables from secondary dumpsites and landfills. In this section, we discuss the financial sustainability and cost effectiveness of the collection service we use in the experiment.

In this study, we employed ten rag pickers to provide the collection service. The rag pickers worked 2-3 hours per day. They were allowed to sell all the recycles they collected as their earnings. For the sake of this study, we paid rag pickers 400INR to ensure they would not skip any day. Because we want to know to what extent such a collection service has the potential to sustain itself, we collected information on the weight of sellable recyclables collected and money earned by selling them. Our discussions with rag pickers revealed that they earn 500-1000INR per day from their present mode of collection, which serves as their reserve wage and the benchmark for our analysis of financial sustainability of the collection service.

The total weight of recyclables sold by all ten rag pickers ranged from 13 kgs per day to 29 kgs per day. The daily total amount of money they received varied from 217INR per day to 390INR per day, or 21.7 – 39 INR per ragpicker per day. This earnings from collection are only a very small fraction of the lower bound of the reserve wage. Even with the 400INR daily wage we paid, the ragpickers earned less from our experiment than their usual operation. In short, without external payment, the collection service used in this experiment is unlikely to sustain itself financially. Of course, as a collector in our study, a ragpicker worked only 2-3 hours a day and collected from on average 30 households. In a full-scale collection operation like this, a ragpicker would have spent the full day collecting from a lot more households. However, even if we allow a ragpicker to collect from 120 households per day, which is 4 times as many as that in the sample, they would still have earned only 87-156 INR, which is still a small fraction of their reserve wage. Under the most generous scenario, one rag picker would need to visit

over 384 households per day to earn 500INR from the waste collection, which is unlikely to be achieve by the ragpickers. Thus, our analysis concludes that provision of a free service, like the one provided, is financially unsustainable. However, the way collection service was provided does highlight that households are open to their plastic waste being picked up twice a week and do not require daily pick up of plastic waste.

Our study highlights that provision of such a service would not be financially sustainable in the absence of support.

3.6 Other Variables

Appendix A1 shows DID results while controlling for individual and household characteristic variables. Variables such as age and gender of the respondent do not have any effect on households' probability to segregate. However, we do find that not having a refrigerator has a negative effect on households' probability to segregate at 10% level of significance. Not owning reduces households' probability to segregate by 5%. An explanation for this could be that households that do not own refrigerator have to throw organic waste more frequently as opposed to those owning a refrigerator.

4. Conclusion and Policy Implication

We study the effect of one-shot provision of information and dustbins on households' waste segregation behavior. We further, look at the incremental effect of reminders on their behavior. Our results provide some striking insights. First, we show that one shot information campaigns and provision of dustbins bring about a significant effect on waste disposal behavior. Secondly, we also see that even in absence of reminders, households continue to segregate over the duration of the experiment, unlike Wadehra and Mishra, 2018. This has an important policy implication. Providing a collection service is pivotal to ensuring households continue with socially desired behavior. Behavior of control group highlights that such a provision is ineffectual in bringing about change or sustaining it without the information campaign. Thirdly, our results show that reminders have an incremental effect on the extensive margin, implying that few households might need more sustained information campaigns to change their behavior.

There are three main policy implications. We demonstrate how policy makers can get households to bring about a change in their behavior and further, how to sustain it over time. Secondly, we also demonstrate how to more households to comply, those who didn't change after receiving the firat information campaign. In this setting, optimal program design would be to continue intervention till a desired target is achieved. Thirdly, our results hint at changes in consumption behavior. This suggests an important research question on disposal behavior to identify whether households change their consumption and how. This agenda is directly in line with making a transition to circular economy.

References

Allcott, H., & Kessler, J. B. (2019). The welfare effects of nudges: A case study of energy use social comparisons. *American Economic Journal: Applied Economics*, *11*(1), 236–276.

Allcott, H., & Rogers, T. (2014). The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation. *American Economic Review*, *104*(10), 3003–3037. https://doi.org/10.1257/aer.104.10.3003

Attanasio, O., Kugler, A., & Meghir, C. (2011). Subsidizing vocational training for disadvantaged youth in Colombia: Evidence from a randomized trial. *American Economic Journal: Applied Economics*, *3*(3), 188–220.

Carranza, E., Garlick, R., Orkin, K., & Rankin, N. (2020). Job Search and Hiring With Two-Sided Limited Information About Workseekers' Skills. *Upjohn Institute Working Paper 20-328. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.* https://doi.org/10.17848/wp20-328

Chetty, R., & Saez, E. (2013). Teaching the tax code: Earnings responses to an experiment with EITC recipients. *American Economic Journal: Applied Economics*, *5*(1), 1–31.

Gallagher, J. (2014). Learning about an infrequent event: evidence from flood insurance take-up in the United States. *American Economic Journal: Applied Economics*, 206–233.

Hussam, R. N., Rabbani, A., Reggiani, G., & Rigol, N. (2017). Habit formation and rational addiction: A field experiment in handwashing. *Harvard Business School Working Paper Series# 18-030*.

Karlan, D., McConnell, M., Mullainathan, S., & Zinman, J. (2016). Getting to the top of mind: How reminders increase saving. *Management Science*, *62*(12), 3393–3411.

Laibson, D. (2001). A cue-theory of consumption. *The Quarterly Journal of Economics*, *116*(1), 81–119.

Nepal, M., Karki Nepal, A., Khadayat, M. S., Rai, R. K., Shyamsundar, P., & Somanathan, E. (2022). Low-Cost Strategies to Improve Municipal Solid Waste Management in Developing Countries: Experimental Evidence from Nepal. *Environmental and Resource Economics*, 1–24.

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, *124*(1), 54.

Wadehra, S., & Mishra, A. (2018). Encouraging urban households to segregate the waste they generate: Insights from a field experiment in Delhi, India. *Resources Conservation and Recycling*, *134*, 239–247. https://doi.org/10.1016/j.resconrec.2018.03.013

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Appendix

Table A1: Robustness Check

	(2) WasteSeg	(4) WasteSeg
T1*post	0.455***	
	(0.0281)	
T2*Post	0.601***	
	(0.0259)	
Treatment=1	0.00362	0.00362
	(0.0235)	(0.0235)
Treatment=2	0.00916	0.00918
	(0.0229)	(0.0229)
Post	0.0308*	
	(0.0184)	
age	-0.000515	-0.000524
	(0.000510)	(0.000510)
gender	0.00509	0.00537
	(0.0176)	(0.0176)

edu=0	0	0
	(.)	(.)
edu=1	-0.0135	-0.0137
	(0.0268)	(0.0268)
edu=2	-0.0000980	-0.000142
	(0.0260)	(0.0260)
edu=3	0.0323	0.0318
	(0.0238)	(0.0237)
edu=4	0.0145	0.0144
	(0.0267)	(0.0267)
edu=5	-0.0607*	-0.0618*
	(0.0331)	(0.0331)
edu=6	0.0707**	0.0704**
	(0.0274)	(0.0274)
edu=7	0.0410	0.0407
	(0.0300)	(0.0299)
hhsize	-0.00300	-0.00303
	(0.00318)	(0.00318)
nofrige	-0.0494*	-0.0504*
	(0.0265)	(0.0266)
microwave	0.0138	0.0145
	(0.0266)	(0.0266)
ownhouse	0.0281	0.0276
	(0.0222)	(0.0222)
T1*Post Phase1		0.294***
		(0.0319)
T1*Post Phase 2		0.453***
		(0.0304)
T1*Post Phase 3		0.523***
		(0.0306)
T2*Post Phase 1		0.312***
		(0.0298)
T2*Post Phase 2		0.576***
		(0.0286)
T2*Post Phase 3		0.744***
		(0.0272)
Post1		-0.00776
		(0.0182)
Post2		0.0269
		(0.0194)
Post3		0.0503**
		(0.0202)

Constant	0.116** (0.0468)	0.117** (0.0468)
Observations	15928	15928
R^2	0.303	0.352