Evaluating Long-term Impact of Waste Separation Pilot Programs in Shanghai, China

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ABSTRACT

Waste separation is the first step to ensure a successful waste management system. Several rounds of pilot programs on promoting waste separation have been implemented in Shanghai, China, though their effect in the long term was not previously studied. The objective of this study is to analyze which kind of pilot program had the most impact over the long term and which demographic factors influence people's waste separation behavior. To collect information on waste separation, attitudes toward the programs, and demographics, I conducted a questionnaire survey. I chose three communities based on distinctive waste sorting categories and promotional schemes in their pilot programs. Survey results showed that the community with the most straightforward sorting categories and the most attractive incentives had the best long-term effect on resident's behaviors, with 76.9% of the respondents still separating waste five years later. Age was the main influencing demographic factor behind respondents' waste separation behavior with the elderly taking the most active role. Meanwhile, gender was no longer an influencing factor behind respondents' behavior, contrary to previous studies' findings. To ensure the success of future pilot programs, incentive type, the convenience of separation and disposal, neighbor pressure, and ample environmental education should be all taken into consideration when designing the program.

KEYWORDS

waste management, environmental behavior, demographical factor, incentive, survey

INTRODUCTION

Waste management has been a major challenge to China due to the ever-increasing amount of waste generated and laggard waste management system. With high economic growth and a rapid urbanization rate, China has seen huge rises in waste generation in recent decades, overtaking the U.S. as the largest waste generator in the world in 2004 (Hoornweg and Perinaz 2012). At that time, only 52.1% of the waste generated in China was treated, with the rest being dumped into open sites, rivers, and ocean. Since then, waste management in China has improved significantly, with 96.6% of the waste being treated in 2016 (Zhang et al. 2010, MOHURD 2018). However, the dominant waste treatment method in China is still landfilling, an unsustainable method (Chen et al. 2010, Zhang et al. 2010, MOHURD 2018). One key reason for the high utilization of landfills is the absence of household waste separation (Chen et al. 2010, Zhang et al. 2010, Tai et al. 2011).

Without proper waste separation, other treatment methods such as incineration, composting, and recycling cannot be employed. Due to high moisture from kitchen waste, incinerating mixed stream of waste can lead to incomplete combustion and lower energy generation, making incineration inefficient (Cheng and Hu 2010). For both composting and recycling, the mix of plastics, metals, and organic waste needs to be manually sorted out at the garbage processing centers which raises the cost and lengthens the processing time (Chen et al. 2010, Tai et al. 2011). Therefore, it is vital to promote and implement household waste separation, which is generally regarded as the base of a successful waste management system (R. McDougall et al. 2001).

Shanghai has had several rounds of pilot programs with different promotion schemes and sorting methods on household waste separation since 2000, though none of them successfully launched a city-wide waste sorting habit (Zhang et al. 2012, Xiao et al. 2017). In February of 2018, Shanghai's local government published an administrative order to implement citywide household waste separation before 2020, as waste generation rates are increasing faster than waste disposal rates (Zhang et al. 2012, Shanghai Municipal Government 2018). Although the past pilot programs have improved community-wide household waste separation in the short term, the lack of continuous monitoring and enforcement after the end of programs left the long-term effects unknown (Zhuang et al. 2008, Huang et al. 2014a). Additionally, due to the different promotion schemes and sorting methods employed by the programs, the participation rate achieved by different programs also varied (Zhang et al. 2012, Zhang and Wen 2014). With most of these

pilot programs ending several years ago, follow-up studies on long-term effects and cross-program comparisons are needed.

Here, I examine whether the pilot programs on waste separation have had long-lasting effects on residents. I explore which type of promotion schemes and sorting methods have had the best long-term effect. I also examine how demographics such as age, gender, and educational background affect people's behavior on waste separation. Finally, I analyze residents' opinions on pilot programs and make recommendations for future policies promoting household waste separation.

Waste management in Shanghai

With 24 million residents, Shanghai is one of the largest metropolitan areas in China. In 2016, 6.29 million tons of municipal waste was generated there. Among all the waste collected and treated, landfill, incineration, and composting/recycling treated 3.29 million tons, 2.73 million tons, and 0.27 million tons of the waste respectively (Figure 1) (MOHURD 2018). To reduce the

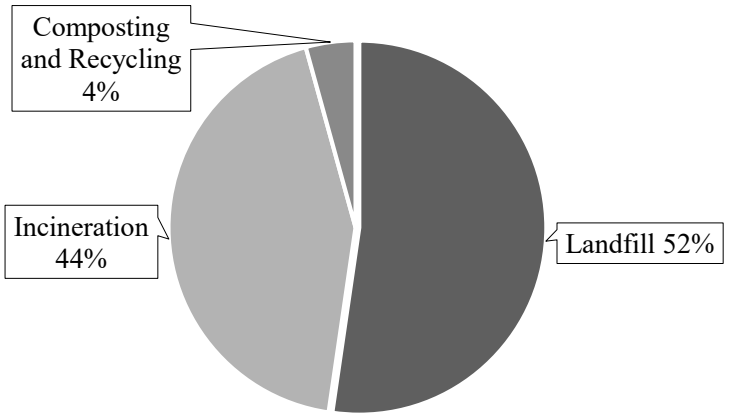

Figure 1. Market share of waste treatment methods in 2016

amount of waste generated and increase the efficiency of waste treatment methods such as incineration and composting, the Chinese government listed Shanghai as one the eight pilot cities to explore the household source-separated collection system in 2000 (Tai et al. 2011). Since then, there have been multiple rounds of city-scale and community-scale pilot programs to promote

household waste separation. Many of these pilot programs had different promotion schemes and waste sorting methods. There were six different sorting methods employing different sorting categories as the pilot programs evolved, as shown in Table 1 (Tencent n.d., Zhang et al. 2012).

Table 1. Different sorting methods over time

Year	Sorting Methods
2000	Organic, Inorganic, Recyclable, hazardous
2002	Compostable, In-compostable, Glass, Hazardous
2007	Recyclable, Kitchen waste, Glass, Hazardous
2010	Dry waste, Wet waste, Recyclable, Hazardous
2011	Dry waste, Wet Waste
2014	Dry waste, Wet waste, Recyclable, Hazardous

As for promotion schemes, there are mainly five methods: installing separated collection bins in community, giving out trash bags and bins to households, giving out incentives such as cooking oil, public education on waste separation, and a point-based reward system for separating waste. Over the years, different pilot programs have employed different pairs of methods with varying levels of success.

Pilot Program Outcomes

Similar to other environmental programs conducted in China, the results of the pilot programs are either vague in detail or not available at all. A study on food waste sorting programs conducted in China suggests that a lack of systematic tracking or analysis afterward has left the actual performance of the pilot programs unknown (Huang et al. 2014b). Nearly all of the past pilot programs on household waste separation in Shanghai shared this problem; news reports covered the beginning period of the pilot programs, but they were not accompanied by formal studies. After the initial period, there was almost no update on their performance from either news report or formal study. Moreover, the reliability of results is questionable among the available news reports.

One news article reported that Jing'an Guihuayuan achieved a 97% participation rate while case studies on Chinese waste separation pilot programs reported an average participation rate of less than 50% (Zhang et al. 2012, Huang et al. 2014b, Administration of Green Shanghai 2017, Xiao et al. 2017). Another news article on Putuo Xin Yangheyuan pilot program reported an average weight of separated waste being 0.5kg per household per day (Administration of Green Shanghai 2018). However, it is estimated on average Shanghai's residents generated 0.8kg of waste per person per day (MOHURD 2018). The reported average weight of the separated waste at Putuo Xin Yangheyuan was less than one person's daily waste generation, let alone households with more than one people.

One possible explanation for this disparity is that the programs are regarded as the political achievements of the officials rather than opportunities to transform the waste management system (Huang et al. 2014b). Another possible explanation is the lack of systematic coordination among the programs and the lack of a fundamental system for data collection and analysis. While the exact reason behind the questionable quality of the results remains unknown, I conduct this study to determine which results are most accurate.

Three communities chosen for study

To conduct a follow-up study on pilot waste separation programs, I chose three communities in Shanghai based on the notable differences among their past pilot programs. The three communities are Caoyang Wucun - Meilingyuan, Hongchu Xincun, and Guihuayuan. All three communities are in the form of Xiaoqu, a Chinese concept of a residential community, which are enclosed by walls with guarded entrance gates. The relative locations and information of the communities are shown in Table 2 and Figure 2.

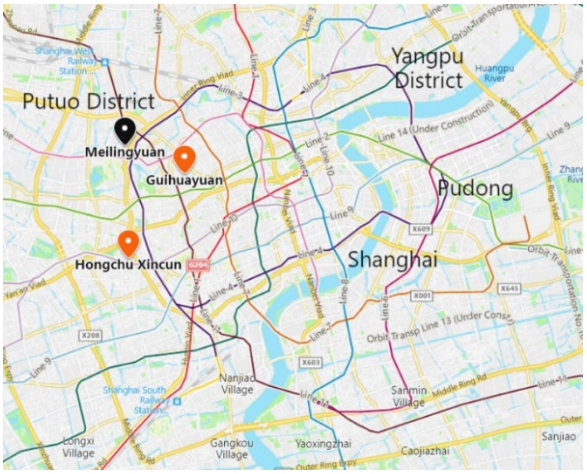

Figure 2. Locations of three communities in Shanghai

Table 2. Characteristics of communities

Category	Community		
	Caoyang Wucun	Hongchu Xincun	Guihuayuan
Built Year	1992	1984	2004
Household	738	1048	168
Program Year	2000	2008	2014
Sorting Method	Recyclable, Hazardous, Compostable, Other	Recyclable, Hazardous, Glass, Kitchen waste	Hazardous, Dry waste, Wet Waste
Promotion Scheme	Installed separate collection facility	Separate collection facility and free trash bags and bins	Separate collection facility and offer incentives such as cooking oil
Initial Participation	99%	99%	97%

Each of the community is representative of a different era in terms of sorting methods. The initial participation rates are from news reports (Administration of Green Shanghai 2017).

Methodology

Generally, studies on waste separation behaviors employ two methods: surveys and waste audits. Among the few studies carried out on waste separation pilot programs in Shanghai and other cities in China, all of them used surveys to measure the performance of the programs (Zhang et al. 2012, Huang et al. 2014b, Zhang and Wen 2014, Xiao et al. 2017). Although the survey

questions and designs varied among the studies, they all covered similar subjects such as current participation, attitudes towards the programs, and demographic information. The 2012 study on public opinion about waste separation conducted by Zhang et al. in Shanghai acted as the base for my survey design due to the similarity in study population and study subjects.

I also used previous studies' results to determine potential influencing factors for household waste separation. Several factors identified are knowledge about waste separation (Zhang et al. 2012), economic incentives (Bernstad 2014), legislation (do Valle et al. 2004) and so on. However, in the context of Chinese waste separation behaviors, major influencing factors are identified as gender (Li 2003), age (Li 2003, Zhang and Wen 2014, Xiao et al. 2017), and education background (Li 2003, Zhang and Wen 2014). Therefore, I developed my survey around these factors to measure how they affect people's attitudes and participation in pilot programs across three communities.

METHODS

Data collection

To measure which type of pilot program was most effective and which demographic factors were most influential, I conducted surveys and interviews with 79 residents from the three chosen communities. The survey was separated into three parts: current waste separation behavior, awareness and willingness to participate in waste separation, and demographic information. The English translation of the survey is included in the appendix A. I adjusted questions in the first two sections accordingly based on each community's past pilot program. All questions in these two sections were binary, yielding yes/no responses. The demographic information section covered gender, educational background, and age group. At the end of the survey, I asked the respondents several open-ended questions regarding their opinions and suggestions on pilot programs and waste policy. Surveys were collected from January 9-13, 2019. My research team and I spent two days at the front gate of each community to survey the passers-by. To avoid double counting from the same households, I recorded unit and room numbers, which were later discarded to ensure confidentiality.

Data analysis

I used the results from the first part of the survey (current waste behavior) to find out which type of pilot program was most effective. To compare three communities, I gathered the overall waste separation rate and waste separation rate of different kind of wastes for each community.

To analyze how demographic factors affected people's behavior, I used Chi-Square tests to establish relationships between demographic factors and current waste separation behavior.

To make recommendations for future pilot programs and policies, I combined results collected from the survey's awareness and willingness to participate in section and open-ended questions. I compared the result from my survey and survey analysis with past studies and news reports.

RESULTS

Characteristics of respondents

Seventy-nine people participated in the survey across the three communities, 36 from Caoyang Wucun, 30 from Hongchu Xiaoqu, and 13 from Guihuayuan respectively. Of the respondents, 44.3% were male, and 55.7% were female. Most respondents were adults; only 7.6% of the sampled population were minors. 36.7% of respondents were between the ages of 31 and 50. 57.0% of the population had a college level education. The detailed demographic information of the respondents is shown in Table 3.

Table 3. Demographic profile of respondents.

Category	Variable	Count	Percentage (%)
Gender	Male	35	44.3%
	Female	44	55.7%
Age	0-19	6	7.6%
	19-30	21	26.6%
	31-50	29	36.7%
	50+	23	29.1%
Education	Less than college	28	35.4%
	College	45	57.0%
	More than College	6	7.6%

Most effective program

I found that the current participation rate in waste separation in all three communities was higher than the city-wide average score. 47.2% of respondents from Caoyang Wucun, 66.7% from Hongchu Xincun, and 76.9% from Guihuayuan answered that they were separating waste at home, while the city-wide score was 43.7% in 2018 (Shanghai Bureau of Statistics 2018). However, the separation rate for each category such as paper, PET bottles, and kitchen waste showed great variations (Table 4). 61.1%, 76.6%, 92.3% of residents from Caoyang Wucn, Hongchu Xincun, and Guihuayuan separated PE bottles while 27.8%, 50.0%, and 61.5% explicitly separated kitchen waste at home. Overall, residents from Guihuayuan participated most actively in waste separation among the three communities.

Table 4. Current waste separation behavior

Behavior	Community		
	Caoyang Wucun	Hongchu Xincun	Guihuayuan
Separate waste	47.2%	66.7%	76.9%
Separate PE bottle	61.1%	76.6%	92.3%
Separate paper	50.0%	70.0%	61.5%
Separate kitchen waste	27.8%	50.0%	61.5%

The survey also showed on average 17.3% of the residents incorrectly classified some waste separation categories, e.g., mistaking used napkins for recyclables. Additionally, some respondents did not report doing waste separation even though they separated PE bottles and newspaper at home to sell to waste pickers.

Influence of demographic factors

I found that age influenced people's waste separation behavior ($\chi^2 = 0.006458$, $p < 0.01$) while gender and educational background did not ($\chi^2 = 0.00668$, $p > 0.10$; $\chi^2 = 1.08959$, $p > 0.10$). Table 5 shows the count and percentage for each category between age groups and waste separation behavior. Residents over 50 years old participated most actively, with 78.3% of them separating waste at home. In contrast, residents between 19 and 30 were least active in waste separation with an average participation rate of 28.5%.

Table 5. Age group versus waste separation.

Category	Age Group							
	0-18		19-30		31-50		50+	
	Count	%	Count	%	Count	%	Count	%
Separate waste	4	66.7%	6	28.5%	19	65.5%	18	78.3%
Do not separate waste	2	33.3%	15	71.5%	10	34.5%	5	21.7%
Total	6	100%	21	100%	29	100%	23	100%

* *P*-value for Chi-Sq test = 0.006548

None of the three demographic factors showed statistical significance in terms of separating kitchen waste: gender ($\chi^2 = 0.7027$, $p = 0.4004$), age ($\chi^2 = 6.4526$, $p = 0.09155$), educational background ($\chi^2 = 1.7219$, $p = 0.4228$). However, participation rate of separating kitchen waste was especially low for the 19 to 30 age group (Table 6).

Table 6. Age group versus kitchen waste separation

Category	Age Group							
	0-18		19-30		31-50		50+	
	Count	%	Count	%	Count	%	Count	%
Separate kitchen waste	4	66.7%	4	19.0%	13	44.8%	11	47.8%
Do not separate kitchen waste	2	33.3%	17	81.0%	16	55.2%	12	52.2%
Total	6	100%	21	100%	29	100%	23	100%
* *P*-value for Chi-Sq test = 0.09155								

Recommendations for future program

I found that 78% of the residents from the three communities were aware of the waste problem in China. However, the awareness did not necessarily translate into action, with the average waste separation rate being 63.6% across three communities. The five most mentioned reasons for not separating waste are listed in Table 7.

Table 7. Top reasons for not separating waste

Reasons	No. of times mentioned
Separating (kitchen) waste is bothersome	5
Separated waste will be mixed later	5
The separated collection bin is full	4
I do not understand the categories	4
My neighbors are not separating.	2

Respondents currently not separating waste showed low willingness to pick up the practice, with only 25% of them would consider separating waste in the near future. Meanwhile, only 10.8% of respondents who were not separating kitchen waste now were willing to participate in separating kitchen waste (Table 8). However, more than half of them were willing to separate kitchen waste if free trash bags were offered.

Table 8. Willingness to separate waste in the future

Category	Yes		No	
	Count	%	Count	%
Want to separate waste	8	25.0%	24	75.0%
Want to separate kitchen waste	5	10.8%	41	89.2%
More willing if given free trash bags	25	54.3%	21	45.7%

Respondents had positive attitudes towards both incentives from Hongchu Xincun and Guihuayuan. Eight people from Hongchu Xincun even explicitly mentioned that they stopped separating waste after no free trash bags were given out once pilot programs ended.

DISCUSSION

I found that pilot programs were effective in terms of promoting waste separation across three communities. Respondents from Guihuayuan participated most actively in separating waste at home compared to the other two communities. Among demographic factors, age was the most influential. Overall, residents were satisfied with the pilot programs, and many were willing to separate waste if given incentives. The findings of this study may help future programs to achieve better performance in promoting waste separation.

Most effective program

With 76.9% of the respondents separating waste and 61.5% of the respondents explicitly separating kitchen waste at home, the pilot program employed by Guihuayuan was the most effective among three communities. Although all three communities with their past pilot programs showed a higher participation rate than the city-wide average score, better incentives and a less ambiguous sorting method employed at Guihuayuan could be the reasons behind its better performance. Generally, incentives can propel waste separation behavior among people (Schultz et al. 1995, Xu et al. 2015, Struk 2017). However, the effect of the incentives could fade due to

loss of the interest from the residents or the effort to separate waste outweighing the reward of the incentives (Schultz et al. 1995). Comparing to the basic incentive of giving out free trash bags and bins from Hongchu Xincun, incentives such as giving out cooking oils and hone improving tools from Guihuayuan were more practical and of higher values, which could be more attractive to the residents. Meanwhile, the lack of incentives at Caoyang Wucun could explain its low average participation score of 47.2%, which was close to the city-wide average score of 43.7%.

Another reason for the better performance at Guihuayuan could be its straightforward waste sorting category of hazardous, dry waste, and wet waste. Complex sorting categories which differentiate between recyclable, hazardous, and kitchen waste could confuse residents and lead to lower participation rate overall. In the 2012 study by Zhang et al., they found that communities showed higher participation rates in waste separation when residents could easily identify the sorting categories. Another study conducted under Chinese social context also linked more complex sorting categories to lower waste separation rate while more straightforward sorting categories yielded higher waste separation rate and higher sorting accuracy (Chen et al. 2017).

Influence of demographic factors

Among the three demographic factors examined, only age had effects on waste separation. I found that older people were more active in separating waste. This finding is similar to other studies conducted under Chinese social context (Li 2003, Zhang and Wen 2014). In China, the elderly tend to sell recyclables to scavengers for money. Therefore, most of them already had habits to separate recyclables. However, having an active role in separating recyclables did not mean the elderly would separate kitchen waste as well. As Figure 3 shows, residents over 50 years old were not the most active age group in terms of separating kitchen waste, though the 19-30 age group was the least active in both separating wastes in general and separating kitchen waste. A combination of unattractive incentives and insufficient environmental awareness could be the explanation. Another explanation for the low participation among young adults between 19-30 is that they were not Shanghai residents. They might have moved to Shanghai for employment or education. Therefore, they might not have experienced pilot programs.

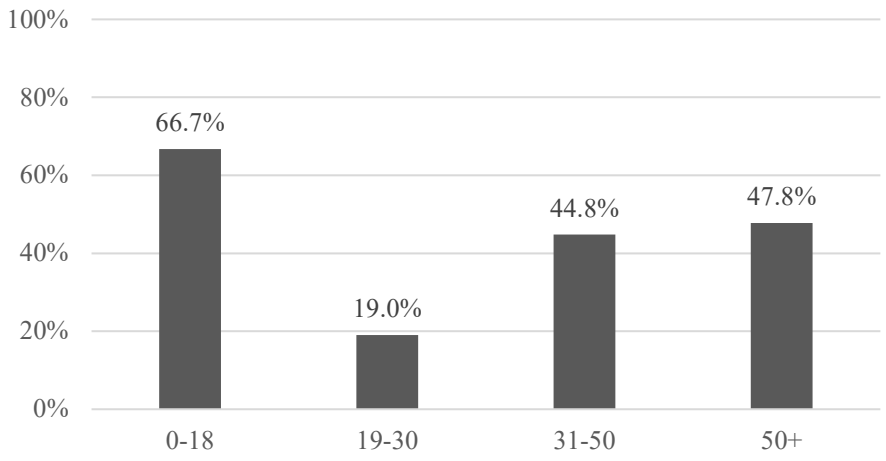

Figure 3. Kitchen waste separation rate based on age group

The effect of gender and educational background on separating waste was negligible. Contrary to the studies of Li (2003) and Schultz et al. (1995), females were not more actively involved in waste separation among the survey population (Figure 4). In both studies, they suggested that females' more active participation in waste separation was due to the tendency of females doing more housework than males. However, in recent years the tradition of females doing most of the housework has changed (Zhang and Wen 2014). Therefore, the distinctive difference between males and females in terms of housework and waste separation behavior was no longer noticeable.

Figure 4. Waste separation behavior based on gender group

Recommendations for future programs

Incentive, the convenience of participating in waste separation, neighbor/peer pressure, and environmental education should all be taken into consideration to ensure the success of future pilot programs. Although residents who were not separating kitchen waste previously showed little interest in separating them in the future, their willingness increased significantly by 40% if free trash bags are offered. This finding echoes previous studies that incentives can have major effect on residents in improving waste separation (Schultz et al. 1995, Zhang and Wen 2014, Xu et al. 2015). Incentives could be especially effective on non-recyclers who are not used to separating (Zhang and Wen 2014). The convenience of participating in waste separation is another factor that can be directly controlled by program design. Besides easier sorting categories, disposal of already separated waste should be convenient as well. Installing separated waste collecting bins for every few buildings or even at each building could return better participation than having a central collecting facility with bins dedicated to each category of waste. A central facility might have one of the dedicated bins overfilled by the whole community if not well maintained. Such instance could discourage residents from separating their waste after they carried the already separated trash bags to the facility and found the bins were already full.

For environmental practices such as waste separation, pressure from neighbors and environmental education can both boost people's understanding and participation. Across three communities several respondents chose to base their opinions of the pilot programs on their neighbors' waste separation behavior for the open-ended question. Two people even explicitly linked their nonparticipation to the fact that their neighbors were also not participating. This kind of peer pressure can encourage people to participate due to the desire to fit in the social norm. However, if people see their neighbors not participating, they could also choose not to participate in creating a negative social norm. Similar kind neighbor pressure is also observed by previous studies (Zhang et al. 2012, Thomas and Sharp 2013, Xiao et al. 2017). Therefore, the strategy of using building leaders to communicate and persuade their neighbors into separating waste can be employed to boost the participation rate (Burn 1991).

Lastly, there needs to be ample environmental education to the residents. The large discrepancy between respondents' awareness of the waste problems in China and their actual behavior can be caused by a lack of environmental education. If respondents do not truly

understand the meaning behind the waste separation, they can view waste separation as insufficient to deal with the large problem (Chen et al. 2017). Being unable to grasp why, how, and when to separate waste is the barrier dividing people who do not separate waste and those who do (Thomas and Sharp 2013). With enough environmental education, residents can come to understand the correct sorting category and the process after the separated waste being collected. They could be more willing to participate after knowing these facts.

Limitations and future directions

Similar to most of the previous studies on waste separation conducted in China, I used questionnaire surveys to study the performance of pilot programs. However, surveying people face to face regarding their behavior can yield Social Desirability Bias (SDB). The respondents might falsely report their behavior in order to fit in the social norm and be viewed as favorable (Nederhof 1985). In this study, the actual waste separation rate could be lower due to false self-reports by some respondents. Future studies can use either anonymous surveys or waste audits to remove this bias. A random telephone or internet survey might prompt more accurate self-reports, though such surveys can be difficult to conduct with specific communities as targets. a waste audit could eliminate the SDB, though it would require more equipment and work.

Disparities in the survey population across three communities along with the low overall survey population could also limit the accuracy of this study. Some of the study's subgroup' populations such as people under 19 who do not separate waste and people under 19 who do not separate kitchen waste had fewer than five respondents. These low values could have an impact on the accuracy of the Chi-Square test. Future studies should be carried out on more communities or with a larger study population to ensure statistical accuracy.

Broader Implications

This study confirms the long-lasting effect of the pilot programs on promoting waste separation. The varying outcomes behind different program designs should prompt policymakers and researchers to plan more carefully for future pilot programs and formal implementation of waste separation. Meanwhile, how different demographical groups react to pilot programs may

also encourage policymakers to use strategies to target each of them specifically to ensure the success of a permanent waste separation program in the future. Although implementing such permanent programs can be difficult, the best combination of promotion schemes and sorting methods verified by trials of pilot programs may finally start the trend of waste separation among people, and hopefully tackle this roadblock in waste management.

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APPENDIX A: Survey Questions

Q_1 Current waste separation behavior

$Q_{1.1}$ Do you currently separate waste at home?

$Q_{1.2}$ Do you have separate bins for kitchen waste?

$Q_{1.3}$ Do you separate kitchen waste in particular?

$Q_{1.4}$ Do you separate plastic bottles at home?

$Q_{1.5}$ Do you separate paper such as documents at home?

Q_2 Waste problem awareness and attitudes towards pilot programs

$Q_{2.1}$ Are you aware of the current waste problems in China?

$Q_{2.2}$ Do you want to separate waste at home?

$Q_{2.3}$ Do you want to separate kitchen waste at home?

$Q_{2.4}$ Are you more willing to separate kitchen waste if given free trash bags?

$Q_{2.5}$ Are you more willing to separate kitchen waste if given incentives such as cooking ingredients?

Q_3 Demographic information

$Q_{3.1}$ What is your gender?

A Male; B Female

$Q_{3.2}$ What is your age group?

A 0-18 B 19-30 C 31-50 D 50+

$Q_{3.3}$ What is your educational background?

A Less than college level B College level C More than college level