

IMPACT OF MUNICIPAL HOUSEHOLD PAY-AS-YOU-THROW ON CONSUMER FOOD WASTE BEHAVIORS AND ATTITUDES IN JAPAN

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ABSTRACT

In Japan, half of the avoidable food waste is generated at home, and municipal household Pay-As-You-Throw (PAYT) policies are expected to reduce it. However, few studies have examined how PAYT influences household food waste, specifically the types of food waste-related behaviors and attitudes affected, the number of people influenced, and those impacted by PAYT. This study uses a questionnaire survey to examine these aspects by targeting residents of cities implementing PAYT. The results revealed that 13-21% of residents perceived a significant influence of PAYT and showed a lower frequency of waste of homemade meals and plate leftovers. They showed a higher frequency of food waste reduction behaviors, such as storing vegetables properly and prioritizing the consumption of near-expiry food. The perceived effect of PAYT was slightly greater for individuals who prefer to consume homemade meals. The results indicated that the overall impact of PAYT was limited and that additional interventions were required. Efforts should target behaviors that were not sufficiently promoted by PAYT, such as checking stock before shopping and planning purchases and meals carefully, as well as developing strategies that reach individuals with low homemade meal orientation. As the study uses self-reported data, findings should be interpreted cautiously. Behavioral changes should be further examined through pre- and post-PAYT longitudinal studies.


1. INTRODUCTION

The issue of food waste is gaining importance because of its impact on global warming and food security. According to FAO's report, food waste from households is a serious problem in Europe, North America, Oceania and East Asia (Gustavsson et al., 2011). Even in Japan, because half of the total avoidable food waste (food that was edible prior to disposal) is generated at home, it is imperative to reduce household avoidable food waste.

As discussed in review papers by Aschemann-Witzel et al. (2015), Nonomura (2018), Schanes et al. (2018), and Vittuari et al. (2023), there has been a lot of research on the factors and consumer behaviors that influence household avoidable food waste. Avoidable food waste relates to a range of behaviors in the home consumption process: purchasing, storing, managing, cooking, eating, and disposing. These behaviors are promoted or restricted by individual attitudes, social norms, knowledge and skills related to food, lifestyle, and the environment surrounding food-relat-

ed housework. To reduce household avoidable food waste, it is important to propose specific measures to change consumer behavior while considering these factors and verifying the effects of these measures. More studies are focusing on interventions to reduce food waste (Reynolds et al., 2019; Stöckli et al., 2018). A major intervention measure is to provide consumers with information, tools and tips to help them reduce food waste and improve their behavior. Stöckli et al. (2018) point out that information provision alone is ineffective.

Local governments have multiple intervention options and they are expected to play an important role in reducing household food waste. According to Wunder et al. (2019), policy options for household food waste reduction can be categorized as follows: 1) information and awareness-raising campaigns; 2) regulation of food sales and food disposal methods; 3) economic instruments, such as fees and taxes; 4) nudges and organization of choice architecture; and 5) strategies and guidelines that present voluntary agreements and action frameworks, such as public-private

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partnerships. The household pay-as-you-throw scheme (PAYT), which is included in (3), is a system in which the local government charges a fee based on the amount of household waste produced. It has been introduced in various countries as local government waste disposal systems (Chalak et al., 2016). In Japan, 62% of the 1,741 cities, towns, and villages have introduced PAYT (MoE, 2024).

PAYT is an economic incentive for consumers to prevent waste. Many studies have demonstrated that PAYT reduces household waste. This is also expected to reduce avoidable food waste (Wunder et al., 2019). Yorimoto et al. (1998) conducted a household waste composition analysis in Yono City before and after the introduction of PAYT and reported that food waste decreased after its introduction. Wheeler & Gregg (2025) report that consumers recognize that economic incentives including PAYT are more effective at reducing food waste than providing information or education. However, Chalak et al.'s (2016) cross-country analysis found that economic measures like PAYT have an impact on the generation of household food waste, but that the impact is small. van der Werf et al. (2020), who measured the amount of food waste in households in Toronto that have implemented PAYT, suggest that Toronto's PAYT did not reduce the amount of food waste, although it did promote recycling of food waste.

For local governments to develop effective policies to reduce household avoidable food waste, it is important to understand the potential and limitations of PAYT. To do this, it is necessary to understand 1) what kinds of behaviors and attitudes are affected by PAYT among the various behaviors and attitudes related to avoidable food waste, 2) how many people are affected by PAYT, and 3) who is affected by PAYT. However, despite the large number of studies on household food waste, few studies focus on the impact of PAYT. The limited existing studies focus on whether PAYT reduces food waste but do not discuss how PAYT influences household food waste. Therefore, this study examines the above three issues regarding PAYT.

2. METHOD

To clarify what kinds of behaviors and attitudes PAYT affects, we compared the behaviors and attitudes related to household avoidable food waste of two groups of people: residents of municipalities that introduced PAYT (intervention group) and residents of municipalities that did not introduce PAYT (control group). To be specific, after selecting municipalities that introduced PAYT (explained in section 2.1), we selected residents of those municipalities as the intervention group through an online survey (explained in 2.2). The control group was selected from residents of municipalities nationwide that did not introduce PAYT through an online survey (explained in 2.2). The behaviors and attitudes to be compared were asked in the online survey and are explained in 2.3. We compared behaviors and attitudes by t-test and an analysis of covariance (explained in 2.4). The selection of the covariates for the analysis of covariance is explained in 2.3 and 2.4.

The intervention group was also asked about their self-perception of the impact of PAYT (explained in 2.3).

Based on their responses, we divided the participants into three groups: those who greatly reduced avoidable food waste, those who somewhat reduced it, and those who did not reduce it. We then compared behaviors and attitudes among these groups by one-way analysis of variance. Based on these results, we further discussed the impact of PAYT and how many people are affected by PAYT. In addition, we analyzed the correlation between the respondents' perceived impact and their characteristics to discuss who is affected by PAYT.

2.1 Selection of local governments

We define PAYT as a system that charges citizen fees based on the amount of household waste produced. We selected three local governments that introduced this system: Chigasaki City in Kanagawa Prefecture, Handa City in Aichi Prefecture, and Hatsukaichi City in Hiroshima Prefecture. The selection criteria were as follows: 1) cities with a population of over 100,000 to ensure a sufficient sample size for an online survey; 2) cities that started PAYT after 2020 as it was expected that the effect of the introduction of the system would be relatively clearly observable; 3) cities where separate collection of food waste was not being implemented as we could focus on the effects of PAYT and excluded the effects of food waste collection that can potentially promote food waste reduction behavior (Cardew, 2019; Morgan et al., 2024); and 4) cities where we could not find campaigns to reduce household avoidable food waste on their websites to exclude the effects of campaigns.

Chigasaki City, Handa City, and Hatsukaichi City have populations of 242,447, 119,590, and 117,045, respectively. PAYT was introduced in Chigasaki in 2022, in Handa in 2021, and in Hatsukaichi in 2020. They collect fees that are included in the price of the designated garbage bags and collect combustible waste, including food waste, twice a week. The fee in Chigasaki is two yen per liter, which is twice as high as that in the other two cities. There was no designated bag system prior to its introduction in Chigasaki.

2.2 Survey of residents

An online questionnaire survey was conducted in February 2024 by a research company, targeting residents of the 3 selected cities and citizens nationwide as a control group. The respondents, aged between 20 and 79 years, lived in their city for at least 2 years, and were mainly responsible for cooking and food management at home. The respondents from the three selected cities were aware of the implementation of each scheme. The numbers of respondents are listed in Table 1.

We selected 141 respondents who answered that their municipality had not introduced PAYT as the control group. The respondents subjectively judged whether PAYT was being implemented. This judgment may not necessarily match our definition, but we considered whether people were aware of PAYT to be important when considering its impact on behaviors and attitudes. We did not exclude the residents of municipalities which implemented food waste collection or campaigns to reduce household avoidable food waste from the control group. This is because only

TABLE 1: Number and attributes of respondents.

Total		Age						Gender		Household size				Policy cooperation
		20~	30~	40~	50~	60~	70~	M	F	1	2	3	4~	
Chigasaki City	252	9	24	49	71	61	38	94	158	81	86	43	42	248
		4%	10%	19%	28%	24%	15%	37%	63%	32%	34%	17%	17%	98%
Handa City	160	1	22	39	44	38	16	48	112	41	51	31	36	158
		1%	14%	24%	28%	24%	10%	30%	70%	26%	32%	19%	23%	99%
Hatsukaichi City	134	7	15	24	32	38	18	32	102	27	51	26	30	134
		5%	11%	18%	24%	28%	13%	24%	76%	20%	38%	19%	22%	100%
Control	141	20	17	29	25	20	30	49	92	61	45	17	18	-
		14%	12%	21%	18%	14%	21%	35%	65%	43%	32%	12%	13%	-

M, male; F, female. Policy cooperation: Respondents who answered that they use designated garbage bags of their municipalities

8% of municipalities have implemented food waste collection (MoE, 2024) and most of them are small (Nakamura & Wada, 2003), and because we estimated that few residents are aware of the campaigns of their municipalities based on National Network Council Against Food Loss and Waste (2021).

2.3 Questions

To create the target variable for the analysis, we asked about food waste behavior, food waste reduction behavior, and attitude related to food waste. We asked 5 questions about food waste behavior and 16 questions about food waste reduction behavior. As we focused on the behavior related to avoidable food waste, 15 questions were selected with reference to Nonomura (2018) regarding food waste reduction behavior at each stage of food procurement, cooking, storage, management, eating, and disposal. Food waste behaviors were assessed using a five-point frequency scale: 1 = Never, 2 = Once every two weeks, 3 = 1-2 times a week, 4 = 3-4 times a week, and 5 = 5 or more times a week. Food waste reduction behaviors were assessed using a five-point frequency scale: 1 = Never to 5 = Always. We asked four questions about attitudes related to food waste, and the degree of agreement was answered on a five-point Likert scale: 1 = strongly disagree to 5 = strongly agree.

As covariates to be considered in the analysis, we asked about gender, age, number of household members, whether they lived with children, household income, and type of residence, which Cardew (2019), Chalak et al. (2016), Koivupuro et al. (2012), Ventour (2008), Stancu et al. (2016), and others have identified as having an impact on food waste. We also asked about working hours, food-related behaviors and attitudes (e.g., frequency of cooking, thriftiness, preference for homemade meals, frequency of receiving food gifts, whether they grew vegetables or fruits at home), frequency of participation in local activities and events, and awareness of local activities regarding food waste reduction (e.g., food donation activities and pamphlets). The questions and answers are listed in Table 2. We also asked the intervention group whether they thought their household avoidable food waste had decreased because of PAYT to know their self-perception of the impact of PAYT. It was answered on a five-point scale: 1 = Decreased greatly, 2 = Decreased somewhat, 3 = Not changed, 4 = Increased

somewhat, and 5 = Increased greatly.

This survey was approved by the Ethics Review Board of the first author's university. Respondents were informed in writing about anonymization, voluntary participation, and consent to participate was obtained. The participants were compensated through the research company. It was unlikely that the incentive had an effect, as all respondents received an incentive, regardless of the content of their answers.

2.4 Analysis of data

We compared the means of attitudes related to food waste, frequency of food waste behaviors, and frequency of reduction behaviors between residents of the cities with PAYT and the control group. We confirmed a significant difference between groups using an independent-samples t-test (Welch's t-test when unequal variances were assumed) and checked the effect size using Cohen's d. Cohen's d is a standardized difference between the means of two groups. It is used to compare the size of the difference. According to Cohen (1988), effect sizes can be interpreted as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$). IBM SPSS Statistics 27 was used for statistical analysis. A post hoc power analysis was conducted using G*Power 3.1 with an alpha error probability of 0.05 (two-tailed). Given the sample sizes of the intervention group ($n = 546$) and the control group ($n = 141$), the power for a t-test was 0.56 for a small effect size and over 0.99 for a medium effect size. We adopted the parametric method according to the idea that parametric testing methods are robust to non-normality and do not pose a major problem when used with ordinal data measured by a rating scale (Norman, 2010).

We also conducted an analysis of covariance to analyze the impact of PAYT, considering the characteristics of the respondents. In the analysis of the PAYT, the covariates were seven basic attributes and three items: frequency of receiving food gifts, frequency of participating in local activities and events, and awareness of local food donation activities. These three items were selected from the various covariates that we considered because the absolute value of Cohen's d between residents of the city with PAYT and the control group was 0.2 or more. Dummy variables distinguishing the cities were included. A post hoc power analysis was conducted for the analysis of covariance. Due

TABLE 2: Questions and answers.

Questions			Answer
Food waste behavior	1) Threw away food.		Frequency (5)
	2) Not aware of the food and it went bad.		
	3) Did not finish the meal I made and threw it away.		
	4) Threw away leftovers on plates.		
	5) Threw away food because the expiry date had passed.		
Food waste reduction behavior	Procurement	1) Check stock of food at home prior to shopping.	Frequency (5)
		2) Purchase food after carefully considering whether we can eat it all.	
	Storage	3) Store vegetables in a way that will keep them fresh for longer.	
		4) Store leftover meals in my fridge.	
	Management	5) Eat near-expiry food first if I find it in my fridge.	
		6) Move near-expiry food to a more visible position in my fridge.	
		7) Set a day to use up the food in the fridge.	
		8) Organize the contents of my fridge to easily see what is in there.	
	Cooking	9) Use the skins and ends of vegetables in cooking.	
		10) Cook meals carefully considering whether we can eat it all.	
	Eating	11) Serve food after carefully considering whether we can eat it all.	
		Disposal	
	13) Eat food as far as possible even if its best-before date has passed.		
14) Have donated food that we could not eat at home.			
15) Share food that we cannot eat with the people around me.			
Other	16) Talk with family and friends about how to use up food.		
Food waste attitude	1) Avoiding throwing food away at home is very important to me.		Degree of agreement (5)
	2) The people around me are careful to avoid throwing food away.		
	3) My local government is proactive in reducing waste.		
	4) My local government is proactive in reducing avoidable food waste.		
Basic attribute	Age		Free
	Gender		Male/female
	Household size		Free
	Living with children		Yes/No
	Working hours		(5)
	Household income		(9)
	Type of residence		Detached house/flat
Food-related attitude	Saving money on food is very important to me.		Degree of agreement (5)
	Saving time and effort on meal preparation is very important to me.		
	Cooking my own meals is very important to me.		
Food-related behavior	Shop for food.		Frequency (5)
	Cook using ingredients such as vegetables, meat, fish, and eggs.		
	Someone other than me buys food or cooks at home.		
	Eat out.		
	Eat out unexpectedly.		Yes/No
	Grow vegetables or fruits at home.		
	Receive food gifts.		
Participation in society	Participate in local activities and events.		Frequency (6)
	Make small talk with people outside the family.		Frequency (5)
Awareness of local activities	Have read a pamphlet about reducing household food waste.		Yes/No
	Have seen awareness-raising activities for reducing food waste at a local store.		
	Have participated in a seminar or cooking class about reducing household food waste.		
	Know about local food donation activities.		
	Have talked with my children or grandchildren about learning about food waste at school.		

(R) denotes a reverse-coded item. (5) means five-point scale. The same applies to the other entries

to missing values in responses to questions of basic attributes, the total sample size was 422. Assuming an alpha error probability of 0.05, the power was 0.54 for a small effect size ($f = 0.10$) and over 0.99 for a medium effect size ($f = 0.25$). The interpretation of effect size f is based on Cohen (1988).

Additionally, we divided the intervention group into three groups based on their self-perception of the impact of PAYT on household avoidable food waste and then compared food waste behaviors, food waste reduction behaviors and attitudes related to food waste among the three groups: "decreased greatly," "decreased somewhat," and "not changed." If the probability of significance was less than 0.05 in a one-way analysis of variance, multiple comparisons were used to determine where significant differences existed. Welch's analysis of variance and the Games – Howell test were used when unequal variances are assumed. We checked the effect size of each pair using Cohen's d . A post hoc power analysis was conducted for the one-way analysis of variance. With a total sample size of 540 across three groups and an alpha error probability of 0.05, the statistical power was 0.53 for detecting a small effect size ($f = 0.10$) and over 0.99 for a medium effect size ($f = 0.25$).

To examine what type of people was affected by PAYT, we checked the correlation between respondents' evaluation of impact ratings (on three levels: decreased greatly, decreased somewhat, and did not change) and basic attributes, food-related behaviors and attitudes, participation in local activities and events, and awareness of local activities regarding food waste reduction using Spearman's rank correlation coefficient. A post hoc power analysis was conducted for the correlation analysis. With a total sample size of 540 and an alpha error probability of 0.05, the statistical power was 0.64 for detecting a small effect size ($\rho = 0.1$) and over 0.99 for a medium effect size ($\rho = 0.3$). The interpretation of effect size ρ is based on Cohen (1988).

3. RESULTS

3.1 Overview of respondents

The numbers of respondents by attribute are listed in Table 1. The proportion of people in each age group in the control group was almost the same as that in the 2020 national census, while the proportion of people in their 20s and 70s was smaller in the 3 cities, and the proportion of people in their 50s and 60s was higher. Compared with the 2020 national census, the proportion of women was higher, and there was a trend of fewer single-person households. This is probably because the respondents were mainly responsible for cooking and food management at home and had lived in the city for more than two years. In the three cities implementing PAYT, almost everyone cooperated with the policy; that is, they used designated garbage bags.

We confirmed the correlation between food waste behaviors and reduction behaviors using Spearman's rank correlation coefficient. The results indicated that 5 reduction behaviors had a significant negative correlation of 0.2 or more with any of the food waste behaviors: 1) check stock of food at home prior to shopping, 2) purchase food

after carefully considering whether we can eat it all, 5) eat near-expiry food first if I find it in my fridge, 10) cook meals carefully considering whether we can eat it all, and 12) throw away the entire vegetable or fruit if it is partly damaged (a reversed item).

3.2 Comparison of food waste-related behaviors and attitudes of residents of the cities with PAYT and the control group

The frequency of food waste behavior among residents of cities with PAYT was higher in all five categories than in the control group (Figure 1). The absolute value of the effect size (Cohen's d) of the four behaviors – 1) threw away food, 3) did not finish the meal I made and threw it away, 4) threw away leftovers on plates, and 5) threw away food because the expiry date had passed – was 0.17 to 0.20. The differences in these behaviors between the two groups were small. For behavior 2) not aware of the food and it went bad, the difference was a little larger compared to other food waste behaviors.

The means of frequency of food waste reduction behavior were almost the same for both groups (the absolute value of Cohen's d : $|d| = 0.05$ -0.17), with no significant differences. The attitude "my local government is proactive in reducing waste" was significantly higher among residents of cities with PAYT, with a medium effect size ($|d| = 0.52$). Other attitudes were almost the same for both groups ($|d| = 0.00$ -0.17).

3.3 Analysis of the impact of PAYT using analysis of covariance

No significant impact of PAYT was observed on any of the five food waste behaviors, whereas household size, frequency of receiving food gifts, and frequency of participation in local activities and events significantly increased the frequency of some food waste behaviors (Table 3). Significantly higher frequencies were observed in Chigasaki and Handa populations. No significant impact of PAYT was observed in food waste attitudes or food waste reduction behaviors (Table 3 and 4). For the attitude "the local government is proactive in waste reduction", the variable "Chigasaki" had a significantly positive impact.

3.4 Respondents' perceived impact of PAYT on their household avoidable food waste

In the 3 cities with PAYT, 13-21% of respondents said that avoidable food waste had "decreased greatly" owing to PAYT, 37-41% said it had "decreased somewhat," and 42-44% said it had "not changed" (Figure 2). In Chigasaki City, more respondents reported that food waste had "decreased greatly" compared to the other two cities.

Although there was no significant difference and the effect size was small, the frequency of food waste behaviors of the "decreased somewhat" group was higher than that of the "not changed" group (Figure 3). In contrast, the "decreased greatly" group discarded less frequently than other groups. The "decreased greatly" group showed significantly lower frequency than the "decreased somewhat" group with effect sizes of 0.3 or greater for two food waste

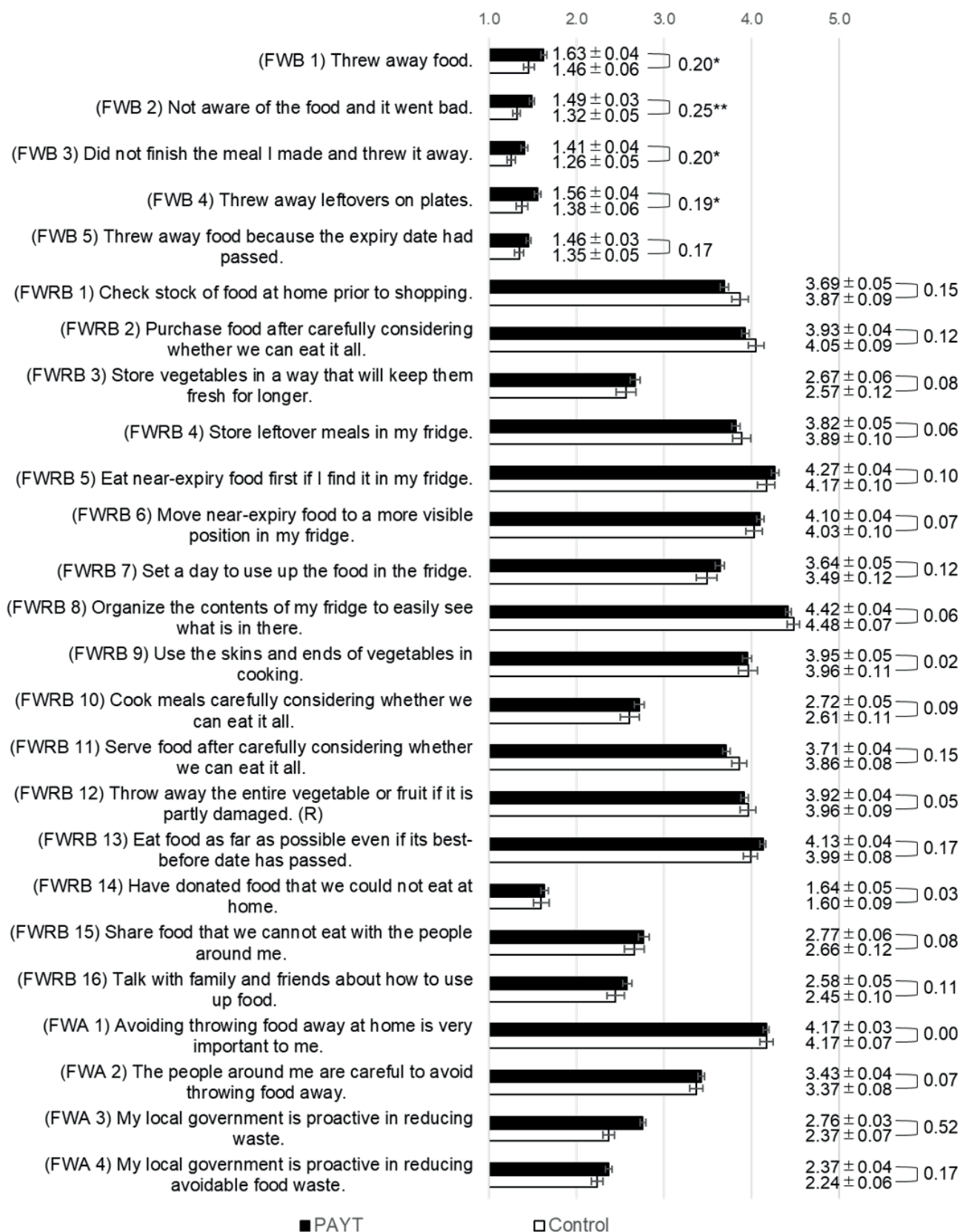


FIGURE 1: Food waste-related behaviors and attitudes of residents of cities with PAYT and the control group. FWB, food waste behavior; FWRB, food waste reduction behavior; FWA, food waste. The scale from 1 to 5 indicates frequency or level of agreement. For FWB: 1 = Never, 2 = Once every two weeks, 3 = 1-2 times a week, 4 = 3-4 times a week, and 5 = 5 or more times a week. For FWRB: 1 = Never to 5 = Always. For FWA: 1 = Strongly disagree to 5 = Strongly agree. Bars represent means. Error bars represent standard errors. Values next to bars are means and standard errors. Values between the means represent the absolute value of Cohen's d. **: $p < 0.01$, *: $p < 0.05$.

TABLE 3: Impact of PAYT on food waste behaviors and reduction behaviors (analysis of covariance).

	FWB					FWRB						
	1) Threw away food.	2) Not aware of the food and it went bad.	3) Did not finish the meal I made and threw it away.	4) Threw away leftovers on plates.	5) Threw away food because the expiry date had passed.	1) Check stock of food at home prior to shopping.	2) Purchase food after carefully considering whether we can eat it all.	3) Store vegetables in a way that will keep them fresh for longer.	4) Store leftover meals in my fridge.	5) Eat near-expiry food first if I find it in my fridge.	6) Move near-expiry food to a more visible position in my fridge.	7) Set a day to use up the food in the fridge.
	β	β	β	β	β	β	β	β	β	β	β	β
PAYT	-0.02	0.04	-0.01	-0.05	0.01	-0.08	-0.04	0.07	-0.02	-0.08	-0.05	0.01
Age	-0.03	0.04	0.00	0.00	-0.04	-0.10	-0.04	0.06	0.01	0.03	0.07	-0.01
Gender (female)	0.06	0.06	0.05	0.03	0.06	-0.04	-0.02	0.09	0.24**	0.09	0.15*	-0.08
Household size	0.03	0.03	0.15*	0.22**	0.01	0.20*	0.10	-0.01	0.03	0.03	0.05	0.16*
Living with children	0.04	0.03	0.05	0.14*	0.04	-0.11	-0.09	-0.07	-0.06	0.01	-0.03	-0.15*
Working hours	0.02	0.10	0.03	-0.05	0.04	-0.04	-0.06	-0.18**	-0.04	-0.05	-0.02	0.02
Household income	0.02	0.03	-0.04	-0.08	-0.04	-0.01	0.03	0.06	0.06	-0.11*	-0.05	-0.07
Type of residence (detached house)	0.01	0.04	-0.02	-0.05	0.01	-0.06	-0.03	0.08	0.07	0.02	0.00	0.04
Awareness of local food donation activities	0.01	-0.02	0.03	0.02	0.00	0.05	0.07	-0.02	-0.01	0.07	0.06	0.02
Frequency of receiving food gifts	0.17**	0.16**	0.03	0.09	0.15**	0.04	-0.02	0.04	-0.01	0.03	0.09	-0.03
Frequency of participating in local activities	0.07	0.07	0.10*	0.07	0.09	0.09	0.00	0.08	0.02	-0.03	0.05	0.19**
Chigasaki City	0.12	0.05	0.12*	0.12*	0.08	-0.03	-0.08	-0.06	0.00	-0.01	-0.04	0.07
Handa City	0.13*	0.05	0.08	0.09	0.09	-0.02	-0.01	-0.09	-0.03	0.02	0.02	0.05

** $p < 0.01$, * $p < 0.05$. FWB, food waste behavior; FWRB, food waste reduction behavior.

behaviors: 3) did not finish the meal I made and threw it away, and 4) threw away leftovers on plates.

Except for behavior 14 (food donation), the frequency of food waste reduction behaviors was highest among the “decreased greatly” group, followed by the “somewhat decreased” group, and lowest among the “not changed” group. Compared to the “not changed” group, the “decreased greatly” group showed significantly higher frequencies in the following behaviors, with medium effect sizes ($|d| = 0.31$ - 0.65): 3) store vegetables in a way that will keep them fresh for longer, 5) eat near-expiry food first if I find it in my fridge, 6) move near-expiry food to a more visible position in my fridge, 8) organize the contents of my fridge to easily see what is in there, 9) use the skins and ends of vegetables in cooking, 15) share food that we cannot eat with the people around me, and 16) talk with family and friends about how to use up food. Among these, behaviors 5, 6, and 9 showed only minimal differences between the “decreased somewhat” and “not changed” groups ($|d| = 0.04$ - 0.10), indicating that the frequency of these behaviors are high only in the “decreased greatly” group. Behaviors 3, 8, 15, and 16 showed medium size differences ($|d| = 0.24$ - 0.41) between the “decreased somewhat” and “not changed” groups. That is, these four behaviors were more frequent in both the “decreased greatly” and “decreased somewhat” groups than in the “not changed” group.

Among the behaviors that showed significant differences between groups, only behavior 5 was a food waste re-

duction behavior that had a significant negative correlation of 0.2 or greater with food waste behaviors (see Section 3.1). Other behaviors – namely behaviors 1, 2, 10, and 12 – which also showed significant negative correlations of 0.2 or greater with food waste behaviors, did not differ significantly between groups and had small effect sizes.

Food waste-related attitudes were higher in the order of the “decreased greatly” group, the “decreased somewhat” group, and the “not changed” group. The differences between the “decreased greatly” and “not changed” groups were significant and showed medium to large effect sizes ($|d| = 0.52$ - 0.83). For 2) the people around me are careful to avoid throwing food away, 3) my local government is proactive in reducing waste, and 4) my local government is proactive in reducing avoidable food waste, the differences between the “decreased somewhat” and “not changed” groups were not small ($|d| = 0.24$ - 0.47). That is, these attitudes were higher in both the “decreased greatly” and “decreased somewhat” groups.

3.5 Correlation between respondents’ perceived impact and characteristics

Respondents’ perceived impact of PAYT was weakly and significantly correlated with homemade orientation measured by “cooking my own meals is very important to me” (Table 5). The second highly and significantly correlated factor was frugality, measured by “saving money on food is very important to me”, although the correlation

TABLE 4: Impact of PAYT on food waste reduction behaviors and attitudes (analysis of covariance).

	FWRB									FWA			
	8) Organize the contents of my fridge to easily see what is in there.	9 Use the skins and ends of vegetables in cooking.	10) Cook meals carefully considering whether we can eat it all.	11) Serve food after carefully considering whether we can eat it all.	12) Throw away the entire vegetable or fruit if it is partly damaged. (R)	13) Eat food as far as possible even if its best-before date has passed.	14) Have donated food that we could not eat at home.	15) Share food that we cannot eat with the people around me.	16) Talk with family and friends about how to use up food.	1) Avoiding throwing food away at home is very important to me.	2) The people around me are careful to avoid throwing food away.	3) My local government is proactive in reducing waste.	4) My local government is proactive in reducing avoidable food waste.
	β	β	β	β	β	β	β	β	β	β	β	β	β
PAYT	-0.02	0.05	-0.02	0.01	-0.01	0.00	-0.06	-0.08	-0.02	-0.01	-0.02	0.09	0.08
Age	0.04	0.08	0.03	0.03	0.17**	-0.05	-0.05	-0.04	0.01	0.03	-0.12*	0.12*	0.01
Gender (female)	0.03	0.05	0.01	0.04	0.16**	0.02	0.01	0.05	0.00	0.05	0.03	-0.01	-0.06
Household size	0.03	0.09	0.10	0.06	0.01	0.07	0.04	-0.04	0.12	0.04	-0.03	-0.15*	-0.02
Living with children	0.08	-0.07	-0.12	-0.05	-0.01	0.02	-0.10	0.10	-0.02	0.05	0.05	0.16*	0.03
Working hours	-0.04	0.02	-0.09	-0.12*	-0.03	0.05	-0.05	-0.02	-0.08	-0.09	-0.17**	-0.05	0.04
Household income	-0.05	-0.04	0.08	0.06	0.02	0.07	0.11*	-0.01	0.02	-0.12*	-0.08	-0.08	-0.16**
Type of residence (detached house)	0.01	0.01	0.03	-0.01	0.01	0.04	0.04	0.13*	0.05	0.04	0.07	0.02	-0.08
Awareness of local food donation activities	0.03	0.00	0.03	0.01	0.01	0.08	0.15**	0.09*	0.08	0.04	-0.03	0.14**	0.18**
Frequency of receiving food gifts	0.01	0.04	0.06	0.04	-0.03	-0.01	-0.04	0.21**	0.15*	-0.01	0.02	0.06	0.05
Frequency of participating in local activities	0.08	0.14**	0.06	0.07	-0.09	0.01	0.32**	0.16**	0.18**	0.01	0.12*	0.07	0.09
Chigasaki City	-0.10	0.02	-0.03	-0.04	-0.02	0.05	0.09	0.05	0.07	-0.03	0.01	0.22**	0.09
Handa City	-0.13*	-0.13*	-0.07	-0.06	-0.02	-0.01	-0.02	0.00	0.04	-0.08	0.00	0.01	-0.05

** $p < 0.01$, * $p < 0.05$. FWRB, food waste reduction behavior; FWA, food waste attitude.

coefficient was small at 0.18. Age, type of residence, frequency of receiving food gifts, participation in local activities, and experience of hearing about children's food waste learning also showed significant correlations, but the correlation coefficients were even smaller.

4. DISCUSSION

4.1 How many people were affected by PAYT?

Between 54% and 57% of the intervention group perceived that they reduced their avoidable food waste somewhat or greatly owing to PAYT, which aligns with the

observation by Wheeler and Gregg (2025) that economic incentives are perceived as effective. It should be noted that there may be a gap between respondents' perceived effects and actual effects. Therefore, by comparing behaviors across groups with different levels of perceived impact, we discuss the influence more objectively. Those who thought that their avoidable food waste had "decreased somewhat" owing to PAYT exhibited a higher frequency of food waste behaviors than those who thought that their food waste had "not changed." Considering that Ventour (2008) and Jörisen et al. (2015) pointed out that consum-

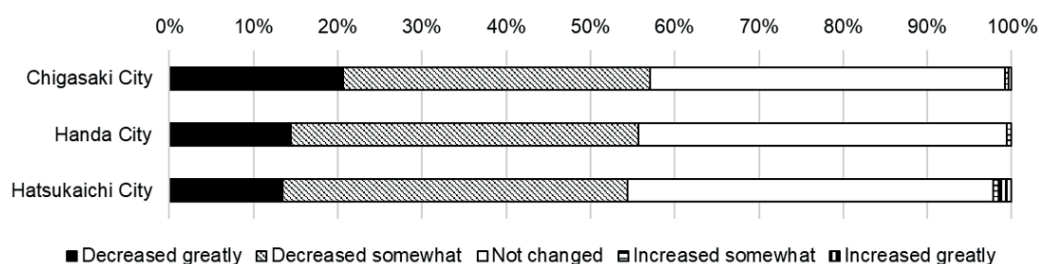


FIGURE 2: Respondents' evaluation of the impact of PAYT on their household avoidable food waste.

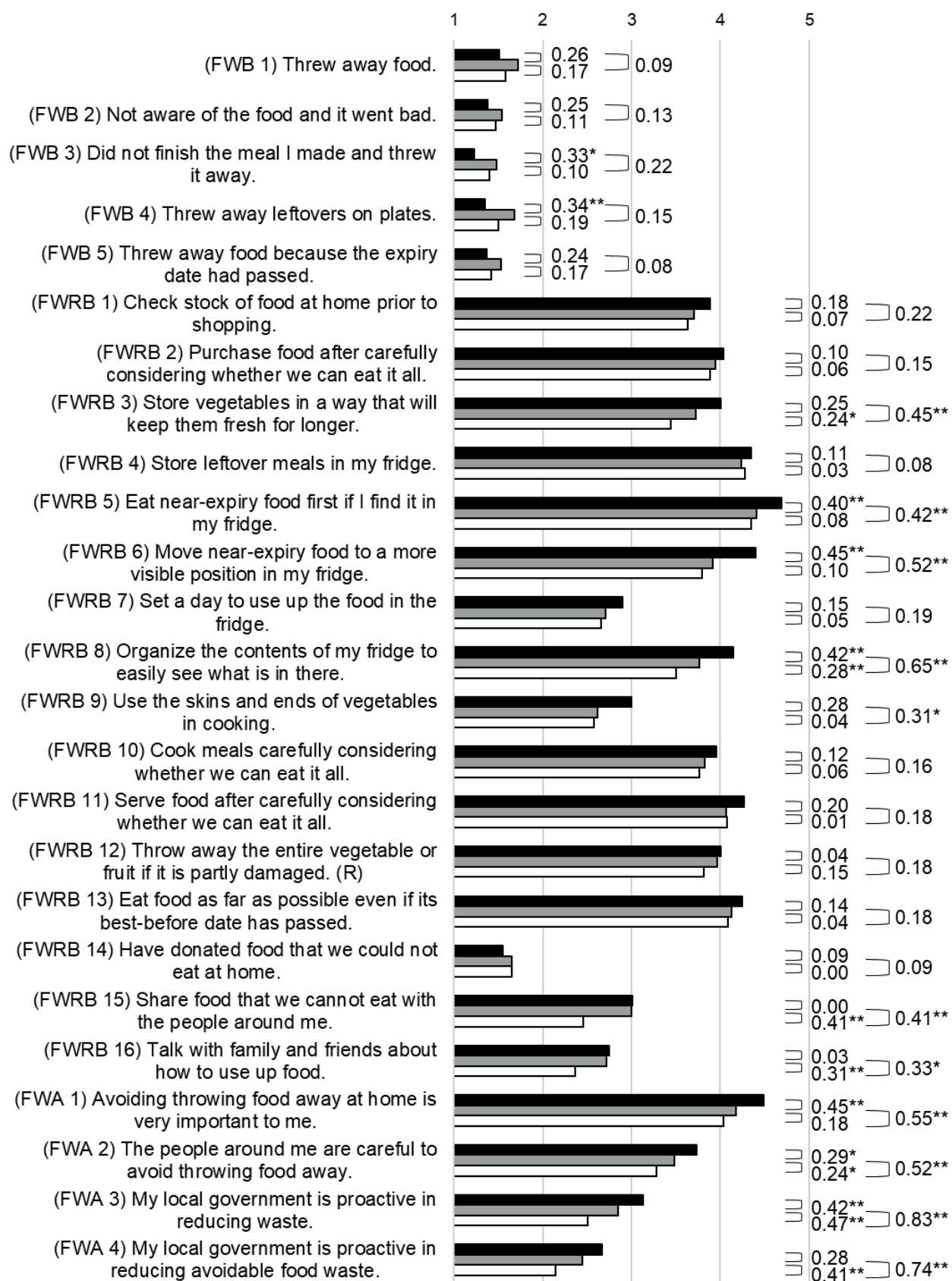


FIGURE 3: Food waste-related behaviors and attitudes based on respondents' evaluation of PAYT's impact. FWB, food waste behavior; FWRB, food waste reduction behavior; FWA, food waste. The scale from 1 to 5 indicates frequency or level of agreement. For FWB: 1 = Never, 2 = Once every two weeks, 3 = 1–2 times a week, 4 = 3–4 times a week, and 5 = 5 or more times a week. For FWRB: 1 = Never to 5 = Always. For FWA: 1 = Strongly disagree to 5 = Strongly agree. Bars represent means. Error bars represent standard errors. Values between the means represent the absolute value of Cohen's d. **: $p < 0.01$, *: $p < 0.05$.

TABLE 5: Corellations between perceived impact of PAYT and basic attributes, food-related behaviors and attitudes.

Variables		Correlation coefficient
Basic attribute	Age	-0.05
	Gender (female)	-0.13**
	Household size	-0.04
	Living with children	-0.06
	Working hours	0.07
	Household income	0.06
	Type of residence (detached house)	0.09*
Food-related attitude	Saving money on food is very important to me.	0.18**
	Saving time and effort on meal preparation is very important to me.	0.07
	Cooking my own meals is very important to me.	0.26**
Food-related behavior	Shop for food.	-0.08
	Cook using ingredients such as vegetables, meat, fish, and eggs.	0.04
	Someone other than me buys food or cooks at home.	-0.01
	Eat out.	-0.01
	Eat out unexpectedly.	-0.01
	Grow vegetables or fruits at home.	0.08
	Receive food gifts.	0.15**
Participation in society	Participate in local activities and events.	0.13**
	Make small talk with people outside the family.	0.11**
Awareness of local activities	Have read a pamphlet about reducing household food waste.	0.13**
	Have seen awareness-raising activities for reducing food waste at a local store.	0.07
	Have participated in a seminar or cooking class about reducing household food waste.	0.05
	Know about local food donation activities.	0.06
	Have talked with my children or grandchildren about learning about food waste at school.	0.12**

** $p < 0.01$, * $p < 0.05$.

ers underestimate avoidable food waste, these results are possibly due to increased awareness of household avoidable food waste that they produce because of PAYT. In contrast, those who thought that their food waste had “decreased greatly” showed a lower frequency of food waste behaviors than those who thought that their food waste had “decreased somewhat” or “not changed.” These results were obtained even though the “decreased greatly” group should also have been more aware of food waste similar to the “decreased somewhat” group. This means that the “decreased greatly” group did reduce their food waste owing to PAYT, as they perceived. The “decreased greatly” group accounted for 13-21% of the intervention group.

The “decreased somewhat” group, which accounted for 37-41% of the intervention group, is also expected to have reduced their food waste as perceived, due to increased awareness of household food waste. This is because Reynolds et al. (2019) pointed out that simply becoming aware of one’s food waste can lead to a reduction in food waste. However, we could not confirm this effect. In summary, 13-21% of residents in municipalities with PAYT were considered to have reduced their food waste, while 37-41% increased awareness of their food waste but did not necessarily reduce waste.

4.2 What kinds of behaviors and attitudes were affected by PAYT?

As mentioned in Section 4.1, the “decreased greatly” group was considered to have reduced avoidable food waste and this reduction was particularly evident in the waste of homemade meals and leftovers on plates. The frequency of reduction behaviors such as storing vegetables properly, prioritizing near-expiry food, organizing the fridge, using vegetable skins, sharing food, and talking with family about using up food was higher in the “decreased greatly” group than in the “not changed” group. This suggests that these behaviors were encouraged by the introduction of PAYT. Behaviors such as storing vegetables properly, organizing the fridge, sharing food, and talking about using up food were also more frequent in the “decreased somewhat” group than in the “not changed” group, indicating that these are behaviors that a relatively large number of people are likely to change. Prioritizing near-expiry food and using vegetable skins were more frequent only in the “decreased greatly” group, suggesting that these behaviors were promoted among a smaller group of individuals.

As shown in previous studies (Jörissen et al., 2015; Mallinson et al., 2016; Stefan et al., 2013; Williams et al., 2012), the food waste reduction behaviors that observed to be related to food waste behaviors in this study includ-

ed checking stock before shopping, purchasing food after careful consideration, prioritizing near-expiry food, cooking after careful consideration, and eating partly damaged food. Except for prioritizing near-expiry food, the differences between the groups were negligible, suggesting that these behaviors were not promoted.

The attitudes that the local government is proactive in waste reduction, that the local government is proactive in reducing avoidable food waste, and that people around me are conscious of reducing avoidable food waste were higher in both the “decreased greatly” group and the “decreased somewhat” group compared to the “not changed” group. This suggests that these attitudes were promoted among a relatively large number of people by PAYT. The attitude that the local government is proactive in waste reduction was higher in the intervention group compared to the control group. An analysis of covariance indicated that the variable “Chigasaki City” had a positive effect on this attitude. Chigasaki City had a higher fee compared to the other two cities. Additionally, the introduction of PAYT may mark a significant change in Chigasaki City because there was no designated garbage bag scheme prior to this. These suggest that the effects of PAYT on the attitude were observed in Chigasaki City.

The attitude that avoiding food waste is important was higher in the “decreased greatly” group, but there was little difference between the “decreased somewhat” and “not changed” groups. This suggests that such an attitude may be promoted only among a limited segment of residents. However, when interpreting the effects on food waste-related attitudes, it is important to consider the possibility of reverse causality — that individuals who were already highly conscious of avoidable food waste may have been more susceptible to the intervention’s influence.

4.3 Who was affected by PAYT?

The results suggest that the effect of PAYT is slightly greater for those who are more inclined to consume home-made meals. We predicted that frugal individuals would be more affected as households that generate less waste pay less under PAYT. However, the correlation between frugality and perceived impact was small. Highly frugal individuals may already be minimizing avoidable food waste (Stancu et al., 2022), leaving little room for further change.

4.4 Implications for future interventions

The means of frequency of food waste behavior among respondents in cities with PAYT — including those who did not recognize the influence of PAYT — were not lower than that of the control group. The means of frequency of food waste reduction behavior were not higher either. This is probably because only a small number of respondents changed their behaviors. This is in line with the claim by Chalak et al. (2016) that the impact of PAYT is limited. This underscores the need for additional interventions. Specifically, it is necessary to implement interventions targeting behaviors that contribute to food waste reduction but are not sufficiently promoted by PAYT, such as checking stock before shopping, purchasing food after careful consideration, cooking after careful consideration,

and making use of partly damaged food. Although PAYT may broadly influence individuals regardless of basic attributes, food-related attitudes and behaviors, or social involvement, it was somewhat less effective for people with low homemade-orientation — those who are not averse to eating processed foods. Therefore, additional interventions could be targeted at this group.

5. CONCLUSIONS

Although there is a significant amount of research on household food waste, few studies examine the impact of PAYT. The existing research focuses on whether PAYT reduces food waste but does not explore how PAYT influences it. Therefore, we conducted an online survey and examined how PAYT influenced food waste-related behaviors and attitudes among Japanese residents, including what kinds of behaviors and attitudes were affected, how many people were influenced, and who was impacted by PAYT.

The results suggest that 13-21% of residents in municipalities with PAYT likely reduced their avoidable food waste, while 37-41% increased their awareness of their avoidable food waste but did not necessarily reduce it. The 13-21% of residents particularly reduced waste of homemade meals and plate leftovers. PAYT was thought to promote their food waste reduction behaviors such as storing vegetables properly, prioritizing near-expiry food, organizing the fridge, using vegetable skins, sharing food, and talking with family about food usage. It also promoted attitudes that others around them care about food waste, that avoiding food waste is important, and that local governments are proactive in waste reduction and food waste reduction.

However, the means of frequency of food waste behaviors among respondents in cities with PAYT were not lower than that of the control group. The means of frequency of food waste reduction behaviors were not higher either. The attitude that avoiding food waste is important was almost the same in municipalities with and without PAYT. These results imply that the overall impact of PAYT is limited and that additional interventions are needed to reduce food waste more effectively. Specifically, efforts should target reduction behaviors such as checking stock before shopping, planning purchases and meals carefully, and making use of slightly damaged food. It is also important to develop strategies that reach individuals with low homemade meal orientation, who are less affected by PAYT.

In this study, we examined the impact of PAYT considering various resident characteristics. However, because we compared residents of specific cities and the control group, we were unable to completely rule out the impact of regional characteristics. It is also possible that the people who were already active in reducing food waste before the introduction of PAYT answered “decreased greatly.” A longitudinal study that tracks changes in food waste behaviors before and after the introduction of PAYT would provide a clearer picture of the true impact of these policies. Future research should also explore the effectiveness of additional measures, such as awareness campaigns and nudges.

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REFERENCES

- Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., & Oostindjer, M. (2015). Consumer-related food waste: Causes and potential for action. *Sustainability*, 7(6), 6457–6477. <https://doi.org/10.3390/su7066457>
- Cardew, T. (2019). Impact of household food waste collections on household food waste arisings. WRAP.
- Chalak, A., Abou-Daher, C., Chaaban, J., & Abiad, M. G. (2016). The global economic and regulatory determinants of household food waste generation: A cross-country analysis. *Waste Management*, 48, 418–422. <https://doi.org/10.1016/j.wasman.2015.11.040>.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum.
- Jörissen, J., Priefer, C., & Bräutigam, K. R. (2015). Food Waste Generation at Household Level: Results of a Survey among Employees of Two European Research Centers in Italy and Germany. *Sustainability*, 7(3), 2695–2715. <https://doi.org/10.3390/su7032695>.
- Koivupuro, H. K., Hartikainen, H., Silvennoinen, K., Katajajuuri, J. M., Heikintalo, N., Reinikainen, A., & Jalkanen, L. (2012). Influence of socio-demographical, behavioural and attitudinal factors on the amount of avoidable food waste generated in Finnish households. *International Journal of Consumer Studies*, 36(2), 183–191. <https://doi.org/10.1111/j.1470-6431.2011.01080.x>.
- MoE (2024). The 2022 Japan municipal waste database: Overall results.
- Mallinson, L., Russell, J., & Barker, M. (2016). Attitudes and behaviour towards convenience food and food waste in the United Kingdom. *Appetite*, 103, 17–28. <https://doi.org/10.1016/j.appet.2016.03.017>
- Morgan, S., Roberts, M., Miller, M., Voxlin, D., Kaur, K., Reiss, H., & Moyseevich, J. (2024). Opportunities for prevention with household food waste collections: Exploring habits around food waste, relationships with food caddies, and ideas to boost prevention efforts. WRAP.
- Nakamura, O., & Wada, M. (2003). Recycling status of raw household garbage in local governments: From the perspective of social technology. *Environmental Studies*. Nagasaki University, 6(1), 17–30.
- National Network Council Against Food Loss and Waste (2021). A database of food waste reduction policies.
- Nonomura, M. (2018). What types of consumer behaviors produce the most household food waste? —A literature review—. *Journal of the Japan Society of Material Cycles and Waste Management*, 29, 152–163. <https://doi.org/10.3985/jjsmcwm.29.152>
- Norman, G. (2010). Likert scales, levels of measurement and the “laws” of statistics. *Advances in Health Sciences Education*, 15(5), 625–632. <https://doi.org/10.1007/s10459-010-9222-y>
- Reynolds, C., Goucher, L., Quested, T., Bromley, S., Gillick, S., Wells, V. K., Evans, D., Koh, L., Carlsson Kanyama, A., Katzeff, C., Svenfelt, Å., & Jackson, P. (2019). Review: Consumption-stage food waste reduction interventions – What works and how to design better interventions. *Food Policy*, 83, 7–27. <https://doi.org/10.1016/j.foodpol.2019.01.009>
- Schanes, K., Dobernig, K., & Gözet, B. (2018). Food waste matters – A systematic review of household food waste practices and their policy implications. *Journal of Cleaner Production*, 182, 978–991. <https://doi.org/10.1016/j.jclepro.2018.02.030>
- Stancu, V., Haugaard, P., & Lähteenmäki, L. (2016). Determinants of consumer food waste behaviour: Two routes to food waste. *Appetite*, 96, 7–17. <https://doi.org/10.1016/j.appet.2015.08.025>
- Stefan, V., van Herpen, E., Tudoran, A., & Lähteenmäki, L. (2013). Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. *Food Quality and Preference*, 28(1), 375–381. <https://doi.org/10.1016/j.foodqual.2012.11.001>
- Stöckli, S., Niklaus, E., & Dorn, M. (2018). Call for testing interventions to prevent consumer food waste. *Resources, Conservation and Recycling*, 136, 445–462. <https://doi.org/10.1016/j.resconrec.2018.03.029>
- van der Werf, P., Gilliland, J. A., & Seabrook, J. A. (2020). How neighbourhood food environments and a pay-as-you-throw (PAYT) waste program impact household food waste disposal in the city of Toronto. *Sustainability*, 12(9), 2908. <https://doi.org/10.3390/su12177016>
- Ventour, L. (2008). The food we waste. WRAP.
- Vittuari, M., Garcia Herrero, L., Masotti, M., Iori, E., Caldeira, C., Qian, Z., Bruns, H., van Herpen, E., Obersteiner, G., Kaptan, G., Liu, G., Mikkelsen, B. E., Swannell, R., Kasza, G., Nohlen, H., & Sala, S. (2023). How to reduce consumer food waste at household level: A literature review on drivers and levers for behavioural change. *Sustainable Production and Consumption*, 28, 1–14. <https://doi.org/10.1016/j.spc.2023.03.023>
- Wheeler, S., Xu, Y., & Gregg, D. (2025). Exploring South Australian households’ perceptions towards various food waste policies. *Ecological Economics*, 227, 108431. <https://doi.org/10.1016/j.ecolecon.2024.108431>
- Williams, H., Wikström, F., Otterbring, T., Löfgren, M., & Gustafsson, A. (2012). Reasons for household food waste with special attention to packaging. *Journal of Cleaner Production*, 24, 141–148. <https://doi.org/10.1016/j.jclepro.2011.11.044>
- Wunder, S., van Herpen, E., McFarland, K., Ritter, A., van Geffen, L., Stenmarck, Å., & Parfitt, J. J. (2019). Policies against consumer food waste: Policy options for behavior change including public campaigns. REFRESH.
- Yorimoto, K., Iwasaki, K., Morohashi, H., & Wada, H. (1998). Changes in the amount and composition of waste in Yono City before and after the introduction of a PAYT system. *Proceedings of the Annual Conference of the Japan Society of Waste Management Experts*, 9(1), 153–155.