Residents' Willingness to Separate Garbage and its Influencing Factors

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ABSTRACT

In order to respond to the national call and promote the work of waste separation in Tongzhou District, Beijing, we conducted a survey and research on the willingness and influencing factors of waste separation in Tongzhou District, Beijing. According to the results of the questionnaire survey, 80.6% of the residents were able to sort their garbage according to the garbage sorting standard, but 9.2% of the residents still did not have knowledge about garbage sorting. The questionnaire data were analyzed and the effect of supervisory guidance and promotional guidance on the analysis of garbage was found to be significant by the chi-square test, indicating that having supervisory and promotional guidance has a positive effect on increasing the willingness to separate garbage. Further, the factors influencing residents' willingness to separate garbage were investigated by regularized multicategorical logistic regression, and it was found that the recognition of responsibility had a significant effect on residents' willingness to separate garbage. Finally, based on the results of data analysis, we propose development opinions.

KEYWORDS: Garbage sorting; Chi-square test; Regularized multicategorical logistic regression

1. INTRODUCTION

In order to speed up the classification of domestic waste in Beijing, the General Office of the Beijing Municipal People's Government put forward the following views. By the end of 2020, the formation of the rule of law-based, government-promoted, universal participation, urban and rural integration, according to local conditions of the garbage classification system, to improve the overall level of garbage classification work, to create an excellent living environment.

In recent years, a large number of scholars have conducted research on waste separation. Chen et al. (2020)[1] investigated the greenhouse gas contribution of a pilot community in Shanghai, China, when disposing of domestic and residual waste under different models of waste separation, and found that greenhouse gas emissions can be effectively reduced by separating food waste under the right model. Alpízar et al.(2015)[2] conducted an experiment on waste segregation with household heads in a Costa Rican city to explore whether non-monetary measures can motivate residents to segregate their waste, and the results showed that both shame and pride can motivate residents to segregate their waste. Han et al.(2019)[3] showed that demonstration projects and public awareness of the need for waste disposal had a significant positive impact on WTP and WTPP. Kuang et al.(2021)[4] investigated public participation in urban waste separation. Liu et al.(2015)[5] study of recyclable household solid waste in Beijing.

In order to respond to the call of Beijing Municipal Government and promote the construction of waste separation facilities in Beijing's urban sub-center, this paper conducts a survey and research on the problem of low motivation and low participation of residents in Tongzhou District to understand the residents' willingness to participate in waste separation and its influencing factors and satisfaction with the current situation of waste separation, so as to improve the residents' willingness to separate garbage and promote the construction of waste separation in Tongzhou District.

2. Data Collection

The questionnaire was designed to understand the situation of waste separation and residents'

willingness to separate garbage in Tongzhou District (including but not limited to: whether to separate garbage, the situation of waste separation, etc.). The questionnaires were collected by distributing questionnaires online to residents in Tongzhou District to obtain real feedback on their satisfaction with waste separation.

A total of 149 questionnaires were distributed and a total of 108 valid questionnaires were collected from residents who are currently or have lived in Tongzhou District in the past two years.

3. Descriptive statistical analysis
3.1. Reliability test and validity analysis

Table 1 Reliability statistics

Cronbach Alpha	Number of items
0.772	5

The reliability analysis can reflect the true extent of the measured characteristics. As shown in Table 1, according to the results of SPSS analysis, the Cronbach Alpha coefficient is between 0.70 and 0.80, which indicates that the structure of this questionnaire and the design of the questions are in line with science and rationality.

Table 2 KMO and Bartlett's test

KMO Sampling suitability quantity		0.734
Bartlett's sphericity test	Approximate cardinality	120.030
	Degrees of freedom	10
	Significance	0.000

Validity refers to the degree to which the thing to be studied can be accurately measured, i.e. validity. We mainly took content validity and structural validity to test the validity of the pre-survey data. As shown in Table 2, the KMO coefficient of the questionnaire is 0.734 and the p-value is 0.000, so the structural design of the questionnaire can be used for analysis.

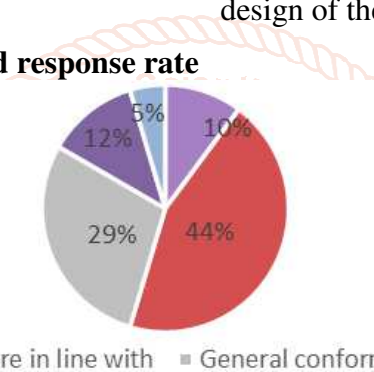### 3.2. Analysis of penetration rate and response rate

Fig 1 Pie chart of the degree of compliance of residents' waste separation behavior in Tongzhou District

First of all, we conducted a statistical survey on whether all residents in Tongzhou District could sort and deliver garbage according to the requirements of garbage sorting. As shown in Figure 1, 83% of the residents around the respondents' residence could sort and deliver garbage according to the requirements of garbage sorting, while the remaining 17% had difficulty in sorting garbage according to the requirements.

Table 3 Descriptive statistical analysis of garbage sorting awareness

Percentage (%)	Perfectly in line with	More in line with	General conformity	Not quite	Not at all
Residents around the area are able to sort and deliver their garbage.	10.19%	44.44%	28.70%	12.04%	4.63%
They usually put out garbage separately	9.26%	37.96%	33.33%	13.89%	5.56%

As shown in Table 3, 81% of the respondents had the awareness of waste separation, and the remaining 19% had no awareness of waste separation. In general, most of the residents were aware of waste separation and were able to follow the standards for delivery. Further, we surveyed those residents who did not separate their garbage and analyzed the reasons that influenced them not to do so. Table 4 shows the percentage analysis of the reasons for not separating garbage. Regarding the reasons for not separating garbage, 42 respondents thought that the lack of community garbage sorting facilities was an influencing factor for not being able to separate garbage, with a response rate of 31.34% and a prevalence rate of 73.68%. It can be seen that the lack of community waste separation facilities, the time consuming and troublesome nature of waste separation and the lack of mandatory requirements by the community and the government are the main reasons for residents in Tongzhou not to separate their waste.

Table 4 Analysis of the percentage of causes of not separating garbage

| Item	Response		Penetration rate （n=57）
	n	Response rate	
Time consuming and troublesome	32	23.88%	56.14%
Don't know how to sort garbage	19	14.18%	33.33%
Community garbage sorting facilities are incomplete, making it impossible to sort and put out garbage	42	31.34%	73.68%
No mandatory requirements by community, government	31	23.13%	54.39%
Nobody else cares	9	6.72%	15.79%
Others	1	0.75%	1.75%
Aggregation	134	100.00%	235.09%
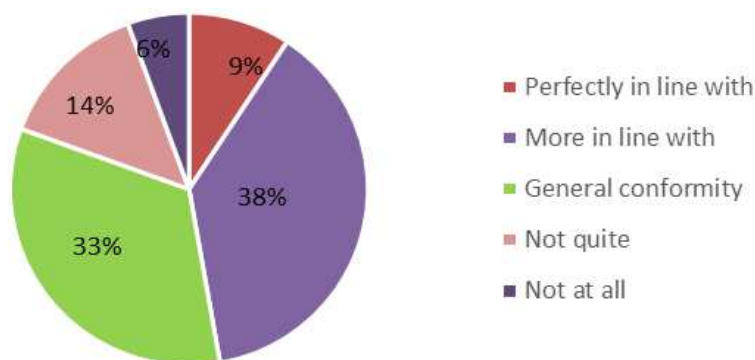
Fig. 2. Pie chart of self-assessed compliance with waste separation behavior of residents in Tongzhou District

In addition, we have calculated whether the surveyed residents themselves usually separate garbage, and the pie chart in Figure 2 shows that most of the residents in Tongzhou District usually put out garbage separately, 80% of the surveyed residents usually put out garbage separately, and 20% of the surveyed residents usually do not separate garbage.
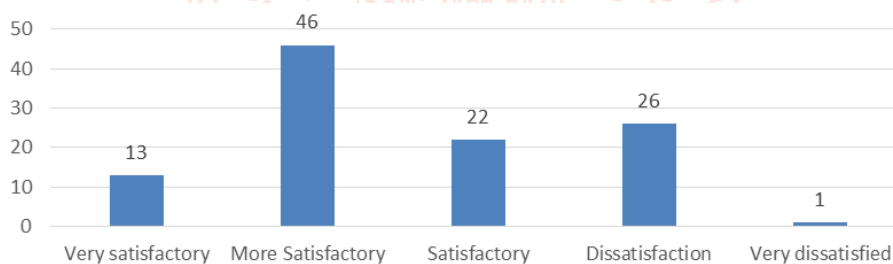
Fig. 3. Bar chart of satisfaction status of the construction of sorting bin drop-off points in Tongzhou District

Table 5 Analysis of the percentage of dissatisfaction with the sorting bin drop-off point

Item	Response		Penetration rate （n=27）
	n	Response rate	
Low number of garbage bins placed	15	19.48%	55.56%
Dumpsters are far away from residential areas and not easy to deliver	20	25.97%	74.07%
The existing garbage drop-off point is not timely and the sanitary environment is poor	23	29.87%	85.19%
Lack of community volunteer oversight	17	22.08%	62.96%
Others	2	2.60%	7.41%
Aggregation	77	100.00%	285.19%

The satisfaction survey study was conducted on the above residents who usually carry out garbage sorting. From Figure 3, it can be seen that most of the residents in Tongzhou District are satisfied with the construction of the existing garbage drop-off points. Considering the unsatisfactory aspects, it can be seen from Table 5 that 23 residents think that the existing dumpster drop-off points are not timely for collection and transportation and have a poor sanitary environment, with a response rate of 29.87% and a prevalence rate of 85.19%. From this, it can be seen that the residents of Tongzhou are dissatisfied with the existing garbage drop-off points because of their untimely collection and transportation, poor sanitary environment, and the fact that the garbage bins are far away from the residential areas and not convenient for delivery.

4. Model construction and solving
4.1. Analysis of Column Tables
Using a columnar analysis, we explore the relationship between willingness to sort garbage and supervisory guidance and promotional guidance.

4.1.1. Willingness to sort waste and supervision guidance
In Table 6, the results of the two variables regarding the lambda coefficient, tau-y coefficient and uncertainty coefficient again with symmetric relationship, asymmetric pair relationship (bootstrap supervision as the dependent variable and categorical willingness as the dependent variable) are given in 8 calculations.

For the lambda coefficient, the calculated results with symmetric relationship, asymmetric pair relationship (bootstrap supervision as the dependent variable and classification willingness as the dependent variable) are 0.375, 0.333,0.41, respectively, with p-values less than 0.05, which means that the correlation between willingness to sort and guidance supervision variables is significant. The tau-y coefficients are 0.195 and 0.195 with p-values less than 0.05, which means that the correlation between waste sorting intention and guidance supervision variables is significant. For the uncertainty coefficient, the p-value is less than 0.05, which also means that the correlation between the willingness to sort garbage and the guidance supervision variable is significant.

Table 6 The lambda coefficient, tau-y coefficient and uncertainty coefficient of waste sorting intention and guidance supervision

			Value	Asymptotic standard error[a]	Approximation T[b]	Asymptotic Significance
Nominal to Nominal	Lambda	Symmetry	.375	.108	2.939	.003
		Induced supervision dependent variable	.333	.130	2.145	.032
		Categorical willingness dependent variable	.412	.101	3.283	.001
	Goodman & Kruskal tau	Induced supervision dependent variable	.195	.076		.000[c]
		Categorical willingness dependent variable	.195	.076		.000[c]
	Uncertainty factor	Symmetry	.147	.060	2.467	.000[d]
		Induced supervision dependent variable	.149	.060	2.467	.000[d]
		Categorical willingness dependent variable	.146	.059	2.467	.000[d]
a. Original assumptions are not assumed.						
b. Use the asymptotic standard error under the assumption of the original hypothesis.						
c. Based on cardinality approximation						
d. Likelihood ratio cardinal probabilities.						

4.1.2. Willingness of waste separation and publicity guidance

Table 7 The tau-y coefficient and uncertainty coefficient of willingness to sort garbage and publicity guidance

			Value	Asymptotic standard error[a]	Approximation T[b]	Asymptotic Significance
Nominal to Nominal	Goodman & Kruskal tau	Propaganda guidance dependent variable	.044	.039		.030[c]
		Willingness to classify dependent variable	.044	.039		.030[c]
	Uncertainty factor	Symmetry	.033	.030	1.112	.029[d]
		Propaganda guidance dependent variable	.034	.030	1.112	.029[d]
		Willingness to classify dependent variable	.032	.029	1.112	.029[d]
a. Original assumptions are not assumed.						
b. Use the asymptotic standard error under the assumption of the original hypothesis.						
c. Based on cardinality approximation						

In Table 7, the tau-y coefficient and uncertainty coefficient again with symmetric relationship, asymmetric pair relationship are given. For the tau-y coefficient with asymmetric pairwise relationship, the calculation results are 0.044, 0.044. P-value = 0.03, which is less than 0.05, that is, the correlation between the willingness to sort garbage and the propaganda guidance variable is significant. The uncertainty coefficient calculation showed the same resuts.

According to the above analysis, the effect of supervisory guidance and publicity guidance on the analysis of garbage is significant, which means having supervisory guidance and publicity guidance have a positive effect on increasing the willingness to sort garbage.

4.2. Regularized Multinomial Logistic Regression Analysis

We developed a regularized multi-category logistic regression model to investigate the effects of eight variables, including age, gender, education level, duty recognition, guidance and supervision, and knowledge of waste separation, on the willingness to separate waste.

The meaning of the interpreted variable: whether you will sort garbage" will be "Not at all" is assigned as 5, "Not quite" is assigned as 4, "Generally" is assigned as 3, "More "The "fully conform" is assigned as 1.

First, the ordered multicategorical logistic regression model was established, and the results of the parallel line test in Table 8 showed that P=0.000, i.e., the original hypothesis was not valid, so the analysis was conducted by unordered multicategorical logistic regression instead.

Table 8 Parallel line test[a]

Models	-2 Log-likelihood	Card side	Degrees of freedom	Significance
Original assumption	195.888			
General	.000	195.888	51	.000

Table 9 Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	287.308			
Final	200.335	86.973	28	.000

Further regularized multicategorical logistic regression was established to achieve model variable selection and model prediction purposes.

From Table 9, the probability p-value is 0.000, indicating that the linear relationship between the explanatory variables all and the generalized Logit P is significant and the model is correctly chosen.

Table 10 Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept	200.335[a]	.000	0	.
Education level	225.019	24.684	12	.016
Guided supervision	217.906	17.571	4	.001
Duty Recognition	233.124	32.789	12	.001

Table 10 shows the changes in the likelihood ratio chi-square values after the introduction (or exclusion) of each explanatory variable in the model. Their chi-square test probability values are 0.016, 0.001, and 0.001, respectively, which means that these three explanatory variables contribute significantly to the generalized linear regression model.

Table11 Pseudo R-Square

Cox and Snell	.553
Nagelkerke	.590
McFadden	.290

From Table 11, the values of Cox and Snell statistic and Nagelkerke statistic are 0.553 and 0.590, respectively, showing the model fits well. The value of McFadden statistic is best in the range of 0.3-0.5, and here it is very close to 0.3, indicating that the regularized logitsic regression model fits well.

Tables 12-13 give the estimation results of the model parameters with the reference category of no garbage sorting at all in normal times. The four generalized Logit equations can be obtained as follows.

$$LogitP_1 = -4.47 + 2.276edu_1 - 15.976edu_2 + 1.243edu_3 + 3.235guida_0 + 0.274duty_2 + 16.729duty_3 + 3.667duty_4 \tag{1}$$

$$LogitP_3 = -1.32 - 1.352edu_1 - 1.947edu_2 + 0.901edu_3 + 2.373guida_0 + 17.619duty_2 + 17.867duty_3 + 3.761duty_4 \tag{2}$$

$$LogitP_4 = 0.478 - 1.997edu_1 - 1.101edu_2 + 0.55edu_3 + 1.113guida_0 - 0.18duty_2 + 15.425duty_3 + 2.8831duty_4$$

Eq. (1) is a log-natural model of the probability ratio of completely sorting garbage in the usual way and not sorting garbage at all in the usual way. From equation (1), it can be seen that the explanatory variable is significant. It can be concluded that, other things being equal, the natural logarithm of the ratio of fully complying is 3.667 units higher than the average of not complying at all, and the probability ratio of fully complying is 2.06 times higher than the average of not complying at all, comparing the residents who accept that it is everyone's responsibility to separate garbage to those who usually completely separate garbage significantly higher than those who usually do not separate garbage at all.

Eqs. (2)-(4) are logarithmic natural models of the probability ratios of the usual frequent garbage sorting, the average compliance with garbage sorting, the relatively non-compliance with garbage sorting, and the usual total non-compliance with garbage sorting, respectively. In Eqs. (3)-(4), the explanatory variables are significant, and it can be concluded that the category of more accepted garbage sorting is everyone's responsibility generally conforming and more non-conforming is significantly higher than not normally sorting garbage at all.

Table 12 Coefficient estimation results1

	Fully compliant			More in line with		
Garbage sorting behavior	B	Std. Error	Sig.	B	Std. Error	Sig.
Intercept	-4.47	2.134	0.036	-19.214	1154.908	0.987
[Education level=1]	2.276	2.096	0.278	0.612	2.099	0.771
[Education level=2]	-15.976	1856.449	0.993	-0.486	1.311	0.711
[Education level=3]	1.243	1.95	0.524	2.038	1.565	0.193
[Guided supervision=0]	3.235	1.715	0.059	4.15	1.623	0.011
[Duty Recognition=2]	0.724	.	.	15.47	12937.549	0.999
[duty=3]	16.729	1364.786	0.99	30.823	1787.862	0.986
[Duty Recognition=4]	3.667	1.798	0.041	18.887	1154.908	0.987

Table 13 Coefficient estimation results2

Garbage sorting behavior	General conformity			Not quite		
	B	Std. Error	Sig.	B	Std. Error	Sig.
Intercept	-1.32	0.971	0.174	0.478	0.733	0.514
[Education level=1]	-1.352	1.92	0.481	-1.997	1.848	0.28
[Education level=2]	-1.947	1.162	0.094	-1.101	0.994	0.268
[Education level=3]	0.901	1.377	0.513	0.55	1.306	0.674
[Guided supervision=0]	2.373	1.27	0.062	1.113	1.224	0.363
[Duty Recognition=2]	17.619	8963.538	0.998	-0.18	10568.782	1
[Duty Recognition=3]	17.867	1364.785	0.99	15.425	1364.785	0.991
[Duty Recognition=4]	3.761	1.288	0.003	2.883	1.165	0.013

5. Conclusion and Recommendations

The research topic of this project is the willingness and influencing factors of garbage sorting in Tongzhou District. The purpose is to understand the level of residents' participation in waste separation and their satisfaction with the existing waste separation work. First, we confirmed the survey format, schedule and offline visit locations. The questionnaires were distributed to the residents of the visited places, and 108 valid questionnaires were collected. The structure and questions of this questionnaire proved to be scientific and reasonable. The results of validity analysis proved that the correlation of the questionnaire data was significant, which indicated that the questionnaire had good content validity to achieve the purpose of this survey. Secondly, SPSS was used to do a column association analysis on residents' waste sorting behavior, and the chi-square test results showed that guidance supervision and publicity and education had significant effects on waste sorting behavior. Further, we developed a regularized multi-category logistic regression model to investigate the effects of age, gender, education level, duty recognition, guidance and supervision, and knowledge of waste separation on the willingness of waste separation. The study found that the degree of responsibility recognition had a significant effect on the willingness to separate garbage.

In summary, we propose the following policy recommendations.

1. It is important to increase the popularity of waste separation, innovate and broaden the publicity channels, and enhance the participation of residents in waste separation.

2. Regularly organize garbage sorting exchange activities to increase residents' sense of responsibility and accomplishment in participating in garbage sorting.

3. An efficient and coordinated management system and operation mechanism should be established. The work responsibilities of relevant departments should be clarified, and the relevant units should follow up and supervise the promotion of waste separation, and provide timely feedback on problems and effects.

4. Build a team of community street garbage sorting supervision volunteers. The team will be trained and managed by the relevant departments to improve the professional level of the supervisory team and guide the residents to complete the garbage separation.

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