



## OPEN ACCESS

## EDITED BY

Steffen Fritz,  
International Institute for Applied Systems  
Analysis (IIASA), Austria

## REVIEWED BY

Maxim A. Dulebenets,  
Florida Agricultural and Mechanical  
University, United States  
Hafizan Juahir,  
Sultan Zainal Abidin University, Malaysia

## \*CORRESPONDENCE

Mohammad Ebrahim Ramazani,  
✉ ramazani\_m\_a@yahoo.com

## SPECIALTY SECTION

This article was submitted to  
Environmental Citizen Science,  
a section of the journal  
Frontiers in Environmental Science

RECEIVED 03 July 2022

ACCEPTED 22 February 2023

PUBLISHED 10 March 2023

## CITATION

Babazadeh T, Ranjbaran S,  
Kouzekanani K, Abedi Nerbin S,  
Heizomi H and Ramazani ME (2023),  
Determinants of waste separation  
behavior Tabriz, Iran: An application of  
the theory of planned behavior at  
health center.  
*Front. Environ. Sci.* 11:985095.  
doi: 10.3389/fenvs.2023.985095

## COPYRIGHT

© 2023 Babazadeh, Ranjbaran,  
Kouzekanani, Abedi Nerbin, Heizomi and  
Ramazani. This is an open-access article  
distributed under the terms of the  
[Creative Commons Attribution License  
\(CC BY\)](#). The use, distribution or  
reproduction in other forums is  
permitted, provided the original author(s)  
and the copyright owner(s) are credited  
and that the original publication in this  
journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# Determinants of waste separation behavior Tabriz, Iran: An application of the theory of planned behavior at health center

Towhid Babazadeh<sup>1</sup>, Soheila Ranjbaran<sup>1</sup>, Kamiar Kouzekanani<sup>2</sup>,  
Sanaz Abedi Nerbin<sup>3</sup>, Haleh Heizomi<sup>4</sup> and  
Mohammad Ebrahim Ramazani<sup>5\*</sup>

<sup>1</sup>Department of Public Health, Sarab Faculty of Medical Science, Sarab, Iran, <sup>2</sup>College of Education and Human Development, Texas, TX, United States, <sup>3</sup>Department of Environmental Health, Tabriz University of Medical Sciences, Tabriz, Iran, <sup>4</sup>Department of Health Education and Promotion, Tabriz University of Medical Sciences, Tabriz, Iran, <sup>5</sup>Islamic Azad University, Tabriz branch, Tabriz, Iran

**Background:** Identifying factors that may influence waste separation behavior can lead to more effective waste separation, better recycling plans in a community, and more effective and efficient waste management interventions. The purpose of the survey was to identify the key factors behind such behavior.

**Methods:** The scientific inquiry was cross-sectional in nature, took place in Tabriz, Iran, and employed multistage random sampling to recruit the study's 360 participants. The data collection process took place between September 2018 and February 2019. A Theory of Planned Behavior-driven questionnaire was developed by the research team for the purpose of data collection. The structural equation modeling (SEM) approach was deployed for data analysis.

**Results:** The structural equation modeling of the data showed the most important determinants of behavioral intention were perceived behavioral control ( $\beta = 0.39$ ,  $p < 0.05$ ), moral commitments ( $\beta = 0.19$ ,  $p < 0.05$ ), and perceived policy effectiveness ( $\beta = 0.12$ ,  $p < 0.05$ ). The strongest determinants of waste separation behavior were behavioral intention ( $\beta = 0.29$ ,  $p < 0.05$ ) and perceived behavioral control ( $\beta = 0.25$ ,  $p < 0.05$ ). In addition, age-group and gender differences were statistically related to waste separation behavior significantly ( $p < 0.05$ ).

**Conclusion:** Recycling investors and other stakeholders should focus on perceived behavioral control and intention in designing and implementing waste separation programs.

## KEYWORDS

theory of planned behavior, waste separation, waste management, recycling, Iran

## Introduction

Population growth and industrial development are major factors for producing huge amounts of Municipal Solid Waste (MSW), especially in developing countries, which have fast population increase and urbanization (Akhtar et al., 2017; Babazadeh et al., 2018a). In many developing countries, in addition to the fast population growing, numerous problems such as lack of cooperation between organizations, insufficient financial resources, and lack

of technical skills in municipal authorities has caused the poor management of MSW (Babazadeh et al., 2018b).

Solid waste that is not properly collected and disposed can be a breeding ground for insects, vermin, and scavenging animals that may result in air- and water-borne diseases (Hoorweg and Bhada-Tata, 2012). For example, surveys conducted by UN-Habitat show that in areas where waste is not collected frequently, the incidence of diarrhea is twice as high and acute respiratory infections six times higher than in areas where collection is frequent (UN-HABITAT, 2010). Additionally, poorly managed waste has negative impacts on fragile terrestrial, coastal and marine ecosystems, tourism (Hoorweg and Bhada-Tata, 2012) and greenhouse gas (GHG) emissions (Chen and Lo, 2016). Post-consumer waste is estimated to account for nearly 5% of total GHG emissions (Wilson et al., 2015).

The proper management of MSW in developed countries (e.g., United States, Germany, Japan) has been due to a move from a landfill-based waste management system to a more integrated one, which is considered to be the key towards a successful treatment of MSW (Zhuang et al., 2008; Memon, 2010). Waste separation is a critical component of a successful integrated waste management system (Adeniran et al., 2017), because it increases the quality of the produced compost and recyclables, and optimizes incineration. Additionally, it enables better financing of waste management activities and minimizes the energy and labor inputs to any downstream processes (Zhuang et al., 2008) and also, it can be used in the tire industry (Fathollahi-Fard et al., 2021), lighting industry (Mirzagoltabar et al., 2021), and walnut industry (Salehi-Amiri et al., 2021) by closed-loop supply chain network. The closed-loop supply chains efficiency is improved by pricing and advertising decisions, strict environmental and social legislations (Asghari et al., 2022) and especially, is affected by during the COVID-19 pandemic (Moosavi et al., 2022).

Previous studies suggest that several factors, namely, pro-environmental attitude, opportunity cost, recycling knowledge, and social norms may be effective in recycling/source separation activities (Matsumoto, 2014; Arkorful et al., 2022), subjective norms, moral norms, convenience, and the cost to recycle (Juliana et al., 2022), financial incentives and frequency of waste collection (Grodzińska-Jurczak et al., 2006; Castagna et al., 2013). The results of the study demonstrated that attitudes, subjective norms, and perceived behavioral control affected the intention of millennial consumers to decrease the use of plastic drinking bottles (Raimondo et al., 2022). An Italian study concluded that waste management process is optimized when both citizens and local government behave appropriately (Agovino et al., 2018). Some reports suggest that effective policies in the field of waste management are instrumental in positively affecting household recycling behaviors (Lee and Jung, 2017; Morlok et al., 2017; Andersson and Stage, 2018). For example, it is reported that collecting food waste separately is more effective than imposing weight-based tariffs to reduce the waste destined for incineration (Andersson and Stage, 2018).

Theory of Planned Behavior (TPB) is a frequently used framework for determining behaviors. The TPB was presented by Fishbein and Ajzen (1980) and has been extensively utilized in the prediction of health-related behaviors and the design of behavior

change interventions (Taghdisi et al., 2016; Babazadeh et al., 2017). In the study conducted in Italy in 2022, the Theory of Planned Behavior (TPB) was successful in predicting behavior regarding reduced plastic drinking bottle consumption (Raimondo et al., 2022). In the study by Wang et al. (2021), environmental regulation played the most important role on behavioral intention for household waste sorting and behavior affected by intention and perceived behavior control for household waste sorting. A study conducted in Thailand revealed knowledge and subjective norm were two important determinants of the respondents' intention that had a strong influence on household waste separation behavior (Pongpunpurt et al., 2022). A study by Bardus and Massoud (2022) showed perceived behavioral control, perceived norms, and current behavior were the strongest predictors of intention toward separating waste. The research of the study conducted utilizing TPB in Shanghai (2022) demonstrated that attitude, subjective norms, and perceived behavioral control were significantly associated with residents' waste sorting intention and proved sorting behavior was affected by sorting intention (Govindan et al., 2022). The results of another study revealed subjective norms and environmental attitudes were significantly associated with pro-environmental intention. Also, pro-environmental intention and perceived behavioral control were related to pro-environmental behaviors (Karimi et al., 2022). Hence, the study outcomes can help policymakers and stockholders in terms of formulating laws and regulations to enhance waste separation behavior and recycling plans in a community.

Despite its success in investigating the determinants of various kinds of behavior, the conventional TPB framework was argued to be necessary for the more explaining complex behavior, such as solid waste source separation, and that additional variables should be incorporated (Ajzen, 1991; Davies et al., 2002). Consequently, in our study, we added moral obligation and effectiveness to the model. The perceived moral commitment is defined as an individual's judgment of moral correctness of performing a specific behavior and was included in the TPB to improve predictive validity (Ajzen, 1991) and explain waste separation behaviors (Pakpour et al., 2014; Xu et al., 2017). The purpose of the study was to examine the determinants of Source Separation of Waste (SSW), utilizing the modified TPB model.

## Methods

### Setting

The study was conducted in Tabriz (capital of East Azerbaijan Province, Iran). The temperature typically ranges from 6.8 to 15.7°C, annual precipitation is approximately 250–300 mm, and the population, as of 2016, was 1,773,033 (Census, 2016). 1,200 tonnes of garbage per person are produced in Tabriz, Iran, according to a study by Zazouli et al. (2012). The most common constituents of this waste are organic materials (58.5%) and recyclable materials (including paper, plastic, metals, and glass) (26.2%). They came to the conclusion that around 85% of Tabriz's waste can be recycled, which could significantly lower environmental pollution (Zazouli et al., 2012).

TABLE 1 Details of the employed TPB questionnaire.

Variables	Number of items	Sample of items	Cronbach's alpha
Attitude towards waste separation <sup>a</sup>	6	Waste separation helps protect the environment and conserve resources; thus, we should do it	0.76
Subjective norm <sup>a</sup>	17	Does your family support you in performing waste separation?	0.84
Perceived behavioral control <sup>a</sup>	10	Do you have enough time to carry out waste separation?	0.74
Perceived moral obligation <sup>a</sup>	3	Waste separation is an ethical behavior and everyone has a duty to do it	0.69
Perceived policy effectiveness <sup>a</sup>	5	informational campaign and provision of convenient separation facilities	0.76
Behavioral intention <sup>b</sup>	2	Starting next week, will you be prepared to carry out waste separation? How many days are you willing to carry out waste separation?	0.68

<sup>a</sup>A 5-point Likert-type scaling (1 = strongly disagree, 5 = strongly agree) was used.

<sup>b</sup>The responses were coded as 1 = totally impossible, 2 = almost impossible, 3 = depends on situation, 4 = very likely, and 5 = definitely will for the first question and 1 = 0 days, 2 = 1–2 days, 3 = 3–4 days, 4 = 5–6 days, and 5 = every day.

## Study design and data collection

This cross-sectional study was conducted between September 2018 and February 2019. Multistage random sampling was employed to recruit the study's participants, who had to be at least 15 years old. Specifically, in each of Tabriz's 10 municipalities, two health centers were randomly selected. The 20 health centers' records were used to randomly select individuals. The sample size based on the study of Babaei et al. (2015), and using G\*Power software,  $p = 0.24$ ,  $d = 0.05$ , and  $z = 1.96$ ,  $\beta = 0.8$ , was estimated 390 people. All of the participants were invited to the study, of which 360 accepted the invitation (response rate = 92.30%), were informed of the purpose of the study, and signed informed consent forms. Face-to-face interviews by three trained interviewers were conducted to collect the data, each lasting approximately 20 min.

## Instrumentation

A TPB-driven questionnaire was developed by the research team for the purpose of data collection, utilizing previously published instruments (Xu et al., 2017; Ma et al., 2018). A panel of experts (12 health educators, 4 environmentalists, and 2 waste management authorities) examined the content validity of the questionnaire and their feedback was used to finalize it, which was then pilot-tested by 30 residents of Tabriz to assess its utility and reliability. A brief description of the questionnaire is as follows:

- Socio-demographic Variables: Data on age, gender, marital status, education, income, and occupational status were collected to describe the sample
- TPB Measures: The TPB constructs were displayed in Table 1.
- Waste separation behavior, the outcome measure, was assessed by obtaining data on how often nine various wastes (i.e., paper, glass, kitchen waste, battery, discarded plastic bottles, cans, metal objects, renewable plastics, and cloths) were separated during the previous 12 months. The responses were coded as 1 = never,

2 = seldom, 3 = occasionally, 4 = regularly, and 5 = always. Cronbach's Alpha for this scale was 0.90.

The sum of the responses to the items in each construct was used to compute the scale score. Higher the score, higher the behavior.

## Data analysis

Descriptive statistics were employed to summarize the data. Median was used for the purpose of missing data imputation. To determine the relationship between attitude, subjective norms, perceived behavioral control, perceived moral obligation with intention and waste separation Structural Equation Modeling (SEM) was conducted, utilizing maximum-likelihood estimates (Sodani et al., 2012). All attitude, subjective norms, perceived behavioral control, and perceived moral obligation variables with intention and waste separation were combined into a single SEM. An acceptable fit was confirmed if root mean square errors of approximation (RMSEA) < 0.08; comparative fit index (CFI) and standardized root mean square residual (SRMR) < 0.05 (Ciftci et al., 2006; Powers et al., 2008). The Stata/SE, version 12.0, software was used for the purpose of data analysis (Stata Corp., College Station, TX, United States). The level of significance was set, *a priori*, at 0.05.

## Ethical considerations

The study received ethical approval from the Tabriz University of Medical Sciences Ethics Committee (Ethical Code/Number, IR.TBZMED.REC. 1,395.864).

## Results

The majority of the 360 participants were less than 29 years old (56.60%), male (55.80%), self-employed (61.40%), and bachelor's degree was the mode for their highest level of

**TABLE 2 Means and standard deviations by selected demographic characteristics for waste separation behavior.**

Variables		F (%)	M (±SD)	p-value
Age-group	<29	204 (56.60%)	26.26 (±9.77)	<0.05**
	29 to 39	105 (29.20%)	29.78 (±10.66)	
	40 to 49	30 (8.30%)	31.71 (±10.77)	
	≥50	21 (5.80%)	30.66 (±10.39)	
Gender	Male	201 (55.80%)	26.65 (±10.05)	<0.05*
	Female	159 (44.20%)	29.61 (10.43)	
Education level	High School Diploma	109 (30.30%)	29.61 (±10.43)	0.25**
	Associate Degree	46 (12.80%)	27.69 (±9.84)	
	Bachelor's Degree	167 (46.40%)	30.78 (±10.13)	
	Graduate Degree	38 (10.60%)	26.86 (±9.68)	
Job	Housewife	84 (23.30%)	27.84 (±9.81)	0.20**
	Government Employee	55 (15.30%)	30.35 (±10.89)	
	Self-employed	221 (61.40%)	27.57 (±10.32)	

\*p-value based t-independent exam.

\*\*p-value based one-way ANOVA, exam.

**TABLE 3 Correlation matrix for all study variables.**

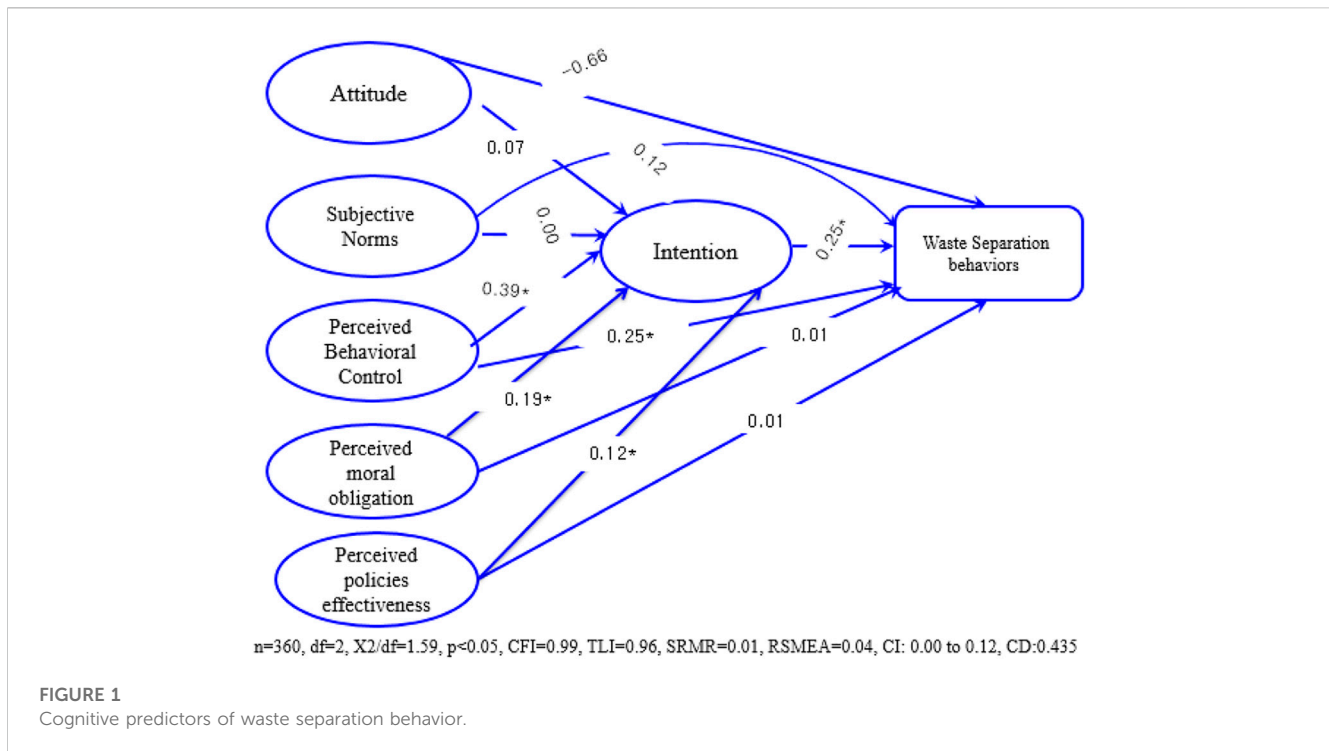
Variable	Attitude	Perceived behavioral control	Subjective norms	Behavioral intention	Perceived moral obligation	Perceived policy effectiveness	Waste separation behavior	M (±SD) theoretical range
Attitude	1							25.24 (±3.42) 6.00–30.00
Perceived Behavioral Control	0.48*	1						29.67 (±6.62) 10.00–50.00
Subjective Norms	0.64*	0.56*	1					39.20 (±6.63) 17.00–85.00
Behavioral Intention	0.40*	0.57*	0.41*	1				6.69 (±2.33) 2.00–10.00
Perceived Moral Obligation	0.56*	0.48*	0.55*	0.48*	1			11.55 (±2.17) 3.00–15.00
Perceived Policy Effectiveness	0.29*	0.40*	0.37*	0.38*	0.40*	1		16.17 (±4.07) 5.00–25.00
Waste Separation Behavior	0.26*	0.47*	0.37*	0.48*	0.31*	0.26*	1	27.96 (±10.31) 9.00–45.00

\*p < 0.05.

education (46.40%). Age-group and gender differences based on the outcome measure of waste separation behavior were statistically significant (See Table 2).

A series of Pearson Product-Moment Correlation Coefficient was performed. As can be seen in Table 3, all bivariate associations among the TPB variables as well as the associations between them and the outcome measure of waste separation behavior were statistically significant at the 0.05 level.

The results of the structural model and fit indices,  $X^2 = 3.18$ ,  $df = 2$ ,  $X^2/df = 1.59$ ,  $N = 360$ ,  $RMSEA = 0.00$ ,  $CFI = 0.99$ ,  $TLI = 0.96$ ,  $SRMR = 0.01$ ,  $RSMEA = 0.04$ ,  $CI: 0.00$  to  $0.12$ , showed a satisfactory fit. The most important determinants of behavioral intention were perceived behavioral control ( $\beta = 0.39$ ,  $p < 0.05$ ), moral commitments ( $\beta = 0.19$ ,  $p < 0.05$ ), and perceived policy effectiveness ( $\beta = 0.12$ ,  $p < 0.05$ ), suggesting that behavioral intention is increased by higher perceived behavioral control,



**FIGURE 1**  
Cognitive predictors of waste separation behavior.

moral commitments, and perceived policy effectiveness. The most powerful determinants of waste separation behavior were behavioral intention ( $\beta = 0.29$ ,  $p < 0.05$ ) and perceived behavioral control ( $\beta = 0.25$ ,  $p < 0.05$ ); that is, the outcome is increased by behavioral intention and perceived behavioral control. The model is depicted in Figure 1.

## Discussion

The results of this study showed that behavioral intention has been most important in the predicting of waste separation behavior. Xu et al. (2017), in their Chinese study, also found strong intention was associated with this behavior. In other studies, Wang et al. (2021) in China, found behavior affected by intention and perceived behavior control for household waste sorting and Pongpunpurt et al. (2022) in Thailand, revealed knowledge and subjective norm were two important determinants of the respondents' intention that had a strong influence on household waste separation behavior. In another study, Zhang et al. (2015) in China indicated that waste separation behavioral intentions had a significant positive influence on waste separation behavior. These findings indicate that increased intention of waste separation behavior can significantly improve the behavior. In this study, it was found that perceived behavioral control was the strongest determinant of behavioral intention, positively affecting the outcome, which is consistent with previous studies (Ari and Yilmaz, 2016; Wan et al., 2017; Bardus and Massoud, 2022; Govindan et al., 2022). The findings reflect that residents' behavioral intentions were largely dependent on their self-control abilities. Furthermore, subjective norms were not associated with the intention of waste

separation at source, which was in line with the results of study conducted by Agovino et al. (2018), although opposite conclusions were also obtained on recycling behaviors in Hong Kong (Wan et al., 2014a), in Italy (Raimondo et al., 2022) and Iran (Pakpour et al., 2014). This may be because waste source-separated collection has not been sufficiently established in Tabriz to provide strong norms so that the respondents did not think they were under significant social pressure for their waste separation behaviors.

Ajzen (1991) had suggested the addition of moral obligations or norms to the TPB model to improve its predictive validity, which we did and found it to be an important determinant of individuals' separation intention. This finding is consistent with previous studies (Zhang et al., 2015; Xu et al., 2017), suggesting that strategies aimed at emphasizing individuals' moral motivations are important in promoting household waste separation behaviors. Cultivating residents' responsibility to protect the environment and promote traditional virtues have the potential to be effective.

Similar to our findings, another study also showed perceived environmental policies could be useful in promoting source separation behaviors (Steg and Vlek, 2009). Wan et al. (2014b) suggested a framework that combined the TPB and the Norm Activation Model (NAM) to determine recycling behaviors, utilizing policy effectiveness as a moderating factor, which had a negative role between subject norm and recycling intention. We also found no relation between perceived policy effectiveness and waste separation behaviors; however, it was correlated with the moderating factor of intention.

To better understand the results, we examined the waste separation behavior in relation to a few selected demographic

variables and found differences due to age and gender. Specifically, older people in our study were more likely to take part in waste separation, which is also supported by Pakpour et al. (2014) in Iran and Pearson et al. (2012) in Texas, because they may have the free time to tend to the task or committed to conserve resources for future generations. Similar to another study (Davies et al., 2002), the prevalence of the behavior among women in our study was more compared to men, suggesting that specific educational materials should be developed to encourage them to actively participate in household waste separation activities.

## Conclusion

We investigated factors that may influence Tabriz residents' source separation intention and behaviors for improving recycling system by extending the Theory of Planned Behavior to include perceived moral obligation and effectiveness policies. We found urban residents' source separation intentions were positively influenced by higher perceived behavioral control, moral commitments, and perceived policies effectiveness, while constructs of intention and perceived behavioral control were useful in predicting waste separation behaviors. These findings show needs of the future research that effective policies and strategies should be developed and implemented to encourage concerned individuals to actively participate in waste separation by promoting environmental awareness messaging, informing them of moral obligations, and focusing on creating a sense of responsibility for environmental protection. There were some limitations in this study. First, as data collection method in the present study was based on self-report by citizens, recall bias is warranted. The second limitation is that the generalizability of the findings is limited to Tabriz city. As well as, as a limitation for the present study, we only used one method for data collection. This means that no other complementary method was used to confirm the findings. Having a mixed approach to triangulate the quantitative findings with qualitative ones may have provided us with a high level of internal validity. Using different methods in data collection could help the team of research in checking the reliability and validity of the data.

## References

- Adeniran, A., Nubi, A., and Adelopo, A. (2017). Solid waste generation and characterization in the University of Lagos for a sustainable waste management. *Waste Manag.* 67, 3–10. doi:10.1016/j.wasman.2017.05.002
- Agovino, M., D'Uva, M., Garofalo, A., and Marchesano, K. (2018). Waste management performance in Italian provinces: Efficiency and spatial effects of local governments and citizen action. *Ecol. Indic.* 89, 680–695. doi:10.1016/j.ecolind.2018.02.045
- Ajzen, I. (1991). The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50 (2), 179–211. doi:10.1016/0749-5978(91)90020-t
- Akhtar, S., Ahmad, A., Qureshi, M., and Shahraz, S. (2017). Households willingness to pay for improved solid waste management. *Glob. J. Environ. Sci. Manag.* 3 (2), 143–152. doi:10.22034/gjesm.2017.03.02.003
- Andersson, C., and Stage, J. (2018). Direct and indirect effects of waste management policies on household waste behaviour: The case of Sweden. *Waste Manag.* 76, 19–27. doi:10.1016/j.wasman.2018.03.038
- Ari, E., and Yilmaz, V. (2016). A proposed structural model for housewives' recycling behavior: A case study from Turkey. *Ecol. Econ.* 129, 132–142. doi:10.1016/j.ecolecon.2016.06.002
- Arkorful, V. E., Shuliang, Z., and Lugu, B. K. (2022). Investigating household waste separation behavior: The salience of an integrated norm activation model and the theory of planned behavior. *J. Environ. Plan. Manag.* 27, 1. doi:10.1080/09640568.2022.2063112
- Asghari, M., Afshari, H., Mirzapour Al-e-hashem, S., Fathollahi-Fard, A. M., and Dulebenets, M. A. (2022). Pricing and advertising decisions in a direct-sales closed-loop supply chain. *Comput. Industrial Eng.* 171, 108439. doi:10.1016/j.cie.2022.108439
- Babaei, A. A., Alavi, N., Goudarzi, G., Teymouri, P., Ahmadi, K., and Rafiee, M. (2015). Household recycling knowledge, attitudes and practices towards solid waste management. *Resour. Conservation Recycl.* 102, 94–100. doi:10.1016/j.resconrec.2015.06.014
- Babazadeh, T., Nadrian, H., Banayejdedi, M., and Rezapour, B. (2017). Determinants of skin cancer preventive behaviors among rural farmers in Iran: An application of protection motivation theory. *J. Cancer Educ.* 32 (3), 604–612. doi:10.1007/s13187-016-1004-7
- Babazadeh, T., Nadrian, H., Mosaferi, M., and Allahverdi-pour, H. (2018). Challenges in household solid waste separation plan (HSWSP) at source: A qualitative study in Iran. *Envr. Dev. Sustain.* 22, 1–16. doi:10.1007/s10668-018-0225-9

## Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee in Tabriz University of Medical Sciences. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

MR and TB: designing the study, conducting the study, administrative support, drafting, and revising the manuscript. KK contributed to the review and revised the manuscript and approved the final manuscript as submitted. SA contributed to the study concept and design, interpretation of the data. SR: designing the study, conducting the study, administrative support, drafting and revising the manuscript. HH contributed to the study concept and design, review and revised the manuscript and approved the final manuscript as submitted.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Babazadeh, T., Nadrian, H., Mosaferi, M., and Allahverdipour, H. (2018). Identifying challenges and barriers to participating in the source separation of waste program in Tabriz, northwest of Iran: A qualitative study from the citizens' perspective. *Resources* 7 (3), 53. doi:10.3390/resources7030053
- Bardus, M., and Massoud, M. A. (2022). Predicting the intention to sort waste at home in rural communities in Lebanon: An application of the theory of planned behaviour. *Int. J. Environ. Res. public health* 19 (15), 9383. doi:10.3390/ijerph19159383
- Castagna, A., Casagrande, M., Zeni, A., Girelli, E., Rada, E. C., Ragazzi, M., et al. (2013). 3R'S from citizens point of view and their proposal from a case-study. *UPB Sci. Bull.* 75, 253–264.
- Census (2016). General census of population and housing: 2016 census. Available at: [http://www.mpo-es.ir/Dorsapax/userfiles/Sub1/g\\_sarshomari95.pdf](http://www.mpo-es.ir/Dorsapax/userfiles/Sub1/g_sarshomari95.pdf).
- Chen, Y.-C., and Lo, S.-L. (2016). Evaluation of greenhouse gas emissions for several municipal solid waste management strategies. *J. Clean. Prod.* 113, 606–612. doi:10.1016/j.jclepro.2015.11.058
- Ciftci, I. H., Karaca, S., Dogru, O., Cetinkaya, Z., and Kulac, M. (2006). Prevalence of pediculosis and scabies in preschool nursery children of Afyon, Turkey. *Korean J. Parasitol.* 44 (1), 95–98. doi:10.3347/kjp.2006.44.1.95
- Davies, J., Foxall, G. R., and Pallister, J. (2002). Beyond the intention-behaviour mythology: An integrated model of recycling. *Mark. theory* 2 (1), 29–113. doi:10.1177/1470593102002001645
- Fathollahi-Fard, A. M., Dulebenets, M. A., Hajiaghaci-Keshteli, M., Tavakkoli-Moghaddam, R., Safaeian, M., and Mirzahasseinian, H. (2021). Two hybrid meta-heuristic algorithms for a dual-channel closed-loop supply chain network design problem in the tire industry under uncertainty. *Adv. Eng. Inf.* 50, 101418. doi:10.1016/j.aei.2021.101418
- Fishbein, M., and Ajzen, I. (1980). Understanding attitudes and predicting social behavior. 1980.
- Govindan, K., Zhuang, Y., and Chen, G. (2022). Analysis of factors influencing residents' waste sorting behavior: A case study of Shanghai. *J. Clean. Prod.* 349, 131126. doi:10.1016/j.jclepro.2022.131126
- Grodzińska-Jurczak, M., Tomal, P., Tarabula-Fiertak, M., Nieszporek, K., and Read, A. (2006). Effects of an educational campaign on public environmental attitudes and behaviour in Poland. *Resour. Conservation Recycl.* 46 (2), 182–197. doi:10.1016/j.resconrec.2005.06.010
- Hoorweg, D., and Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management*. Washington, DC: World Bank.
- Juliana, N., Lada, S., and Chekima, B. (2022). Exploring determinants shaping recycling behavior using an extended theory of planned behavior model: An empirical study of households in sabah, Malaysia. *Sustainability* 14 (8), 4628. doi:10.3390/su14084628
- Karimi, S., Liobikienė, G., and Alitavakoli, F. (2022). The effect of religiosity on pro-environmental behavior based on the theory of planned behavior: A cross-sectional study among Iranian rural female facilitators. *Front. Psychol.* 13, 745019. doi:10.3389/fpsyg.2022.745019
- Lee, S., and Jung, K. (2017). Exploring effective incentive design to reduce food waste: A natural experiment of policy change from community based charge to rfid based weight charge. *Sustainability* 9 (11), 2046. doi:10.3390/su9112046
- Ma, J., Hipel, K. W., Hanson, M. L., Cai, X., and Liu, Y. (2018). An analysis of influencing factors on municipal solid waste source-separated collection behavior in Guilin, China by Using the Theory of Planned Behavior. *Sustain. cities Soc.* 37, 336–343. doi:10.1016/j.scs.2017.11.037
- Matsumoto, S. (2014). The opportunity cost of pro-environmental activities: Spending time to promote the environment. *J. Fam. Econ. Issues* 35 (1), 119–130. doi:10.1007/s10834-013-9354-3
- Memon, M. A. (2010). Integrated solid waste management based on the 3R approach. *J. Material Cycles Waste Manag.* 12 (1), 30–40. doi:10.1007/s10163-009-0274-0
- Mirzalgoltabar, H., Shirazi, B., Mahdavi, I., and Khamseh, A. A. (2021). Sustainable dual-channel closed-loop supply chain network with new products for the lighting industry. *Comput. Industrial Eng.* 162, 107781. doi:10.1016/j.cie.2021.107781
- Moosavi, J., Fathollahi-Fard, A. M., and Dulebenets, M. A. (2022). Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies. *Int. J. Disaster Risk Reduct.* 75, 102983. doi:10.1016/j.ijdrr.2022.102983
- Morlok, J., Schoenberger, H., Styles, D., Galvez-Martos, J.-L., and Zeschmar-Lahl, B. (2017). The impact of pay-as-you-throw schemes on municipal solid waste management: The exemplar case of the county of aschaffenburg, Germany. *Ger. Resour.* 6 (1), 8. doi:10.3390/resources6010008
- Pakpour, A. H., Zeidi, I. M., Emamjomeh, M. M., Asefzadeh, S., and Pearson, H. (2014). Household waste behaviours among a community sample in Iran: An application of the theory of planned behaviour. *Waste Manag.* 34 (6), 980–986. doi:10.1016/j.wasman.2013.10.028
- Pearson, H. C., Dawson, L. N., and Breitkopf, C. R. (2012). Recycling attitudes and behavior among a clinic-based sample of low-income Hispanic women in southeast Texas. *PLoS one* 7 (4), e34469. doi:10.1371/journal.pone.0034469
- Pongpunpurt, P., Muensitthiroj, P., Pinitjitsamut, P., Chuenchum, P., Painmanakul, P., Chawaloesphonsiya, N., et al. (2022). Studying waste separation behaviors and environmental impacts toward sustainable solid waste management: A case study of bang salu housing, samut prakan, Thailand. *Thail. Sustain.* 14 (9), 5040. doi:10.3390/su14095040
- Powers, B. J., Olsen, M. K., Oddone, E. Z., Thorpe, C. T., and Bosworth, H. B. (2008). Literacy and blood pressure—do healthcare systems influence this relationship? A cross-sectional study. *BMC health Serv. Res.* 8 (1), 219–9. doi:10.1186/1472-6963-8-219
- Raimondo, M., Hamam, M., D'Amico, M., and Caracciolo, F. (2022). Plastic-free behavior of millennials: An application of the theory of planned behavior on drinking choices. *Waste Manag.* 138, 253–261. doi:10.1016/j.wasman.2021.12.004
- Salehi-Amiri, A., Zahedi, A., Akbapour, N., and Hajiaghaci-Keshteli, M. (2021). Designing a sustainable closed-loop supply chain network for walnut industry. *Renew. Sustain. Energy Rev.* 141, 110821. doi:10.1016/j.rser.2021.110821
- Sodani, M., Shogaeyan, M., and Neysi, A. (2012). The effect of group logo-therapy on loneliness in retired men. *Res. Cognitive Behav. Sci.* 2 (1), 43–54.
- Steg, L., and Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *J. Environ. Psychol.* 29 (3), 309–317. doi:10.1016/j.jenvp.2008.10.004
- Taghdisi, M. H., Babazadeh, T., Moradi, F., and Shariat, F. (2016). Effect of educational intervention on the fruit and vegetables consumption among the students: Applying theory of planned behavior. *J. Res. health Sci.* 16 (4), 195–199.
- UN-HABITAT (2010). *Solid waste management in the world's cities: UN-HABITAT*. London & Washington, DC: Earthscan.
- Wan, C., Shen, G. Q., and Choi, S. (2017). Experiential and instrumental attitudes: Interaction effect of attitude and subjective norm on recycling intention. *J. Environ. Psychol.* 50, 69–79. doi:10.1016/j.jenvp.2017.02.006
- Wan, C., Shen, G. Q., and Yu, A. (2014). The moderating effect of perceived policy effectiveness on recycling intention. *J. Environ. Psychol.* 37, 55–60. doi:10.1016/j.jenvp.2013.11.006
- Wan, C., Shen, G. Q., and Yu, A. (2014). The role of perceived effectiveness of policy measures in predicting recycling behaviour in Hong Kong. *Conservation Recycl.* 83, 141–151. doi:10.1016/j.resconrec.2013.12.009
- Wang, Y., Long, X., Li, L., Wang, Q., Ding, X., and Cai, S. (2021). Extending theory of planned behavior in household waste sorting in China: The moderating effect of knowledge, personal involvement, and moral responsibility. *Dev. Sustain.* 23 (5), 7230–7250. doi:10.1007/s10668-020-00913-9
- Wilson, D. C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, K., et al. (2015). Global waste management outlook: UnepNEP. Available At: <https://wedocs.unep.org/20.500.11822/9672>.
- Xu, L., Ling, M., Lu, Y., and Shen, M. (2017). Understanding household waste separation behaviour: Testing the roles of moral, past experience, and perceived policy effectiveness within the Theory of Planned behaviour. *Sustainability* 9 (4), 625. doi:10.3390/su9040625
- Zazouli, M. A., Belarak, D., Mahdavi, Y., and Barafrashtepour, M. (2012). A quantitative and qualitative investigation of Tabriz solid waste. *J. Mazandaran Univ. Med. Sci.* 21 (2), 86–90.
- Zhang, D., Huang, G., Yin, X., and Gong, Q. (2015). Residents' waste separation behaviors at the source: Using SEM with the theory of planned behavior in Guangzhou, China. *Int. J. Environ. Res. public health* 12 (8), 9475–9491. doi:10.3390/ijerph120809475
- Zhuang, Y., Wu, S.-W., Wang, Y.-L., Wu, W.-X., and Chen, Y.-X. (2008). Source separation of household waste: A case study in China. *Waste Manag.* 28 (10), 2022–2030. doi:10.1016/j.wasman.2007.08.012