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Promoting Pro-Environmental Behaviors Among Women: A PRECEDE-PROCEED Model-Based Intervention on Waste Segregation at Source

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Abstract

Background: Pro-environmental behaviors are critical to sustainable development and directly influence quality of life at the individual and family levels. This study aimed to design, implement, and evaluate an intervention based on the PRECEDE-PROCEED model to promote waste segregation at source behaviors among female heads of households in Rafsanjan, Iran, in 2021.

Methods: Following the first three phases of the PRECEDE-PROCEED model, key behavioral determinants were identified. Waste segregation at source emerged as the most influential behavior, with predisposing, enabling, and reinforcing factors central to change. A researcher-developed and validated tool was used to assess these variables. In this quasi-experimental study, 120 female heads of households were selected using multistage cluster random sampling and assigned equally to the intervention and control groups. The intervention group received a four-week virtual educational program delivered via WhatsApp. A post-test was conducted two months later. The data were analyzed by SPSS version 18, using descriptive statistics, Chi-square, paired t-test, independent t-test, and ANCOVA at the significance level of 0.05.

Results: Post-intervention analysis revealed significant improvements in the intervention group in predisposing, enabling, and reinforcing factors, as well as in waste segregation at source behavior ($P<0.001$). ANCOVA, adjusted for baseline scores and employment status, confirmed significant between-group differences in all measured variables except enabling factors ($P=0.079$).

Conclusion: The intervention positively affected key behavioral constructs and improved waste segregation practices. Nevertheless, sustaining these behaviors may require additional structural support—such as municipal provision of necessary equipment and facilities—to overcome enabling barriers.

Keywords: PRECEDE-PROCEED, Pro-environmental behavior, Waste segregation, Women, Intervention

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Introduction

The environment plays a vital role in human well-being, and the way individuals interact with their surroundings directly impacts the quality of life (1). However, environmentally harmful human behaviors continue to contribute to global environmental degradation (2,3). Promoting pro-environmental behavior—conscious, responsible actions that reduce environmental harm—is a key strategy for addressing these challenges and enhancing ecological sustainability (4).

Pro-environmental behaviors are shaped by psychological, social, and cultural factors such as awareness, social norms, responsibility, place attachment, and personal or traditional values (5,6). Environmental degradation not only threatens ecosystems but also has profound consequences for public health, economic development, and social well-being (7). Behavioral change through structured education and community engagement is a key strategy for addressing environmental challenges, as it fosters responsible attitudes and sustainable practices

across generations (8,9).

As key decision-makers in household waste management, women play a vital yet often overlooked role in environmental sustainability. Educating and empowering them is essential for fostering long-term behavioral change within families and ensuring the success of environmental interventions (10,11).

Despite growing research on behavior change models, applying theory-based interventions in culturally relevant ways remains a challenge—especially in areas with limited environmental education. In smaller Iranian cities like Rafsanjan, few interventions align theoretical rigor with local needs. Bahrami et al. found that Rafsanjan residents' knowledge and practices regarding municipal waste management were suboptimal, revealing a clear need for targeted, evidence-based education to improve waste-related behaviors (12).

To ensure effectiveness, educational programs aimed at behavioral change should be grounded in established theoretical models. The PRECEDE-PROCEED model is a comprehensive, participatory planning framework that identifies both behavioral and environmental determinants of health-related behaviors (13,14). The PRECEDE component outlines the processes involved in developing an intervention and consists of four phases: (1) Social Assessment, (2) Epidemiological, Behavioral, and Environmental Assessment, (3) Educational and Ecological Assessment, and (4) Administrative and Policy Assessment. The PROCEED component focuses on implementation and evaluation, comprising the following phases: (5) Implementation, and (6–8) Process, Impact, and Outcome Evaluations (15). A systematic review by Khademi and Kaveh confirmed the model's effectiveness in improving behavior, health, and related factors, particularly in women's health contexts (16).

Given the critical role of women in environmental stewardship, the lack of comprehensive and theory-driven interventions in Iran, and the well-documented strengths of educational planning based on behavioral models, this study aimed to design, implement, and evaluate a PRECEDE-PROCEED model-based intervention to promote pro-environmental behaviors among female heads of households in Rafsanjan, Iran. To the best of our knowledge, this is the first study in both Iran and the World that assessed the effectiveness of a PRECEDE-PROCEED model-based intervention specifically targeting pro-environmental behavior. It offers novel insight into the application of this framework among female heads of households as a key target group.

Materials and Methods

Study Design and Setting

This quasi-experimental study was conducted in Rafsanjan, south of Iran, to evaluate a PRECEDE-PROCEED model-based intervention among female heads of households. The intervention was designed in accordance with the eight phases of the model and implemented virtually.

Participants and Sampling

A total of 120 female heads of households (60 in each group) were selected using multistage cluster random sampling. All health centers in Rafsanjan were considered as clusters, and two centers were randomly selected. From each selected center, two residential blocks were randomly chosen. One block from each center was randomly assigned to the intervention group, and the other to the control group, ensuring a balanced distribution. Within each block, 30 eligible participants were randomly selected using Electronic Health Records, resulting in 60 participants per group. Sample size was calculated using the following formula, considering a 10% expected loss:

$$n = \frac{(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2 \times 2\sigma^2}{(\mu_1 - \mu_2)2} \quad (1)$$

Inclusion criteria were: having an age between 20 and 60 years, having at least basic literacy, willingness to participate, and permanent residence in Rafsanjan for a minimum of five years. Exclusion criteria included withdrawal from the virtual education group, unwillingness to continue participation, or prior involvement in a similar intervention within the past year.

Study Procedure and Data Collection

The intervention was designed, implemented, and evaluated across Phases 1 to 7 of the PRECEDE-PROCEED model as follows:

Phase 1 – Social Assessment

Through literature review, database searches, and structured remote interviews with stakeholders (i.e., eight experts in the fields of environmental health engineering and health education and health promotion as well as five female heads of households), the impact of non-compliance with pro-environmental behavior on women's quality of life (physical, psychological, social, economic) was confirmed (Table 1).

Phase 2 – Epidemiological, Behavioral, and Environmental Assessment

Key environmental indices such as per capita waste generation, energy, water, and gas consumption were identified through a review of relevant literature and consideration of stakeholder perspectives. In addition, both behavioral and non-behavioral factors influencing the environment were examined. Using a prioritization matrix based on importance and changeability, waste segregation at the source was identified as the most important target behavior (Table 2).

Phase 3 – Educational and Ecological Assessment

In this phase, the factors influencing waste segregation at the source behavior were categorized as predisposing, enabling, and reinforcing. Based on this categorization, an instrument was developed using scientific sources, a literature review, and remote interviews with experts in the fields of environmental health engineering, health education, and health promotion. The final instrument included 6 demographic items, 33 items on predisposing factors, 17 on enabling factors, 7 on reinforcing factors, and 11 items assessing waste segregation at source behavior.

The instrument demonstrated strong content validity (CVI = 0.96; CVR = 0.90) and face validity, which were confirmed by 10 experts, including five in health education and health promotion, and five in environmental health engineering. Internal consistency was assessed through a test-retest method among 10 women outside the intervention group at an interval of two weeks (ICC = 0.94). Internal consistency was assessed using Cronbach's alpha coefficient (Cronbach's $\alpha = 0.88$). Table 3 presents the detailed specifications of the developed tool.

Phase 4 – Administrative and Policy Assessment

Barriers and facilitators (e.g., available resources, human capital, organizational policies) were identified. Coordination was carried out with the Deputy of Health, and the program was officially introduced to selected health centers.

Phase 5 – Implementation

Participants were contacted by phone and asked to

Table 1. Explaining the Importance of pro-environmental behavior, Inappropriate pro-environmental behavior, and its impact on quality of life from the perspective of the literature review and structured interviews

Dimensions of quality of life	Example	References
Physical dimension	Increased health concerns, dysfunction of all organs, and premature death	(17,18)
Psychological dimension	Negative impact on mental health, changes in mood and behavior, depression, and decreased mental well-being	(19,20)
Social dimension	Decreasing the quality of life, reducing human welfare, affecting life satisfaction score, reducing social relations, negative impact on social, cultural, and political development programs, etc.	(21,22)
Economic dimension	Imposing high costs on both individuals and the government, imposing public health costs, negative impact on economic development programs	(23,24)

Table 2. Behavioral and non-behavioral factors affecting pro-environmental behavior based on literature review and structured interviews

Behavioral factors	Non-behavioral factors
- Waste generation and segregation at source	- Gender, age, level of education, socioeconomic status, religious and political orientation
- Reduce waste production	- Environmental culture of households
- Reduce use of plastic and plastic disposable containers	- Individual responsibility and motivation to protect the environment
- Reduce use of chemicals (including detergents and insecticides)	- Laws of governmental and non-governmental organizations
- Reduce electricity consumption	- Environmental and service structures
- Reduce water consumption	- Environmental organizations
- Reduce gas consumption	- Advertisement and distribution of brochures and magazines
- Reduce fuel consumption and use of public transport	- Lack of facilities in the provision of municipal services in environmental protection, and the lack of fully defined standards for environmental protection
- Buy green products	- Normalization by responsible organizations
- Reduce air pollution from factories and industrial operations	- Environmental education at different educational levels

Table 3. The characteristics of the tools developed in three areas: predisposing, enabling, and reinforcing factors

Variable	No. of items	Response scale	Scoring (range)	CVR	CVI	Cronbach's alpha	Correlation coefficient	Example item
Demographic characteristics*	6	-	-	-	-	-	-	-
Predisposing Factors	33	Multiple choices, five-part Likert	24-138	0.87	0.99	0.92	0.98	Waste segregation at source reduces health-related problems.
Enabling Factors	17	Five-point Likert	17-85	0.89	0.96	0.91	0.95	The free distribution of color-coded garbage bags to residents enhances public participation in waste segregation and management efforts.
Reinforcing Factors	7	Five-point Likert	7-35	0.91	0.90	0.89	0.89	Financial incentives provided by the municipality play a significant role in promoting waste segregation behavior.
Behavior	11	Five-point Likert	11-55	0.92	0.99	0.80	0.96	I separate dry waste from wet waste.

* Demographic variables included age, occupation, education level, spousal education level, and family income.

complete a pre-intervention questionnaire at the health center. Over four weeks, educational content—including images, videos, PowerPoint slides, and texts—was shared daily (excluding weekends) via a WhatsApp group. The content was tailored to the specific needs identified in the pretest. To monitor intervention fidelity and dosage, participant engagement was tracked using WhatsApp's message-read receipts (blue ticks) and group activity logs. Weekly summaries were reviewed to ensure materials were delivered as scheduled, and follow-up messages were sent to participants who had not viewed key content. Additionally, participants were encouraged to ask questions at any time within the group, and the researcher responded promptly to support understanding and maintain active engagement.

During the study period, a banner promoting awareness of wet and dry waste separation and a poster emphasizing the importance of proper waste segregation at source were developed. The banner was installed in a high-traffic area, while the poster was displayed in grocery stores, bakeries, and fruit shops across intervention districts.

No intervention was provided to the control group during the study period. Two months after the intervention, participants completed the follow-up questionnaire either online or in person, according to their preference. All intervention group participants completed the questionnaire online, while control group participants completed it in person. After data collection, control group participants received the educational materials to uphold ethical standards.

Phase 6 – Process Evaluation

Implementation steps were tracked using a Gantt chart. Activities were monitored and adjusted as needed.

Phase 7 – Impact Evaluation

This phase assessed short-term changes in predisposing, enabling, and reinforcing factors and in waste segregation at source behavior two months after the intervention.

Phase 8 – Outcome Evaluation

Due to time limitations, this long-term phase—intended to assess quality-of-life outcomes—was not conducted.

Statistical Analysis

Data were analyzed using SPSS version 16. Descriptive statistics, chi-square tests, independent and paired t-tests, and ANCOVA were used. A *P*-value < 0.05 was considered statistically significant.

Results

A total of 120 women participated in the study, with 60 assigned to each group. The mean age of participants was 40.12 ± 8.80 years in the intervention group and 37.53 ± 7.71 years in the control group. The mean family size was 3.82 ± 0.92 in the intervention group and 3.71 ± 1.06 in the control group. Independent t-tests revealed no significant differences between the groups in terms of participants' age or family size ($P > 0.05$). According to chi-squared tests, there were no statistically significant differences between the two groups in terms of age, education level, or spousal education level. However, a significant difference was observed in employment status ($P < 0.05$), which was statistically adjusted in subsequent analyses (Table 4).

In the intervention group, the mean score for predisposing factors increased significantly from 113.11 at baseline to 124.06 two months after the intervention. Similarly, enabling factors showed a significant increase from 70.54 to 74.76. The mean score for reinforcing factors rose from 29.38 to 32.25, and waste segregation at source behavior improved from 42.71 to 46.13 over the same period. All changes were statistically significant ($P < 0.001$). In contrast, the control group exhibited no significant changes. Interestingly, a slight, non-significant decline was observed in the predisposing and reinforcing factors of the control group after the intervention period. This may reflect normal variability over time or the absence of structured environmental education, underscoring the importance of planned behavioral interventions. When comparing post-intervention enabling factor scores between the intervention and control groups, no statistically significant difference was found ($P = 0.079$). ANCOVA analysis—adjusted for pre-test scores and employment status—revealed significant intra-group differences in the post-intervention scores for all other constructs ($P = 0.004$), confirming the effectiveness of the educational program. Table 5 summarizes the detailed comparison of scores before and after the intervention in both groups. As shown in Figure 1, the educational program had the strongest impact on predisposing and reinforcing factors related to waste segregation at source behavior.

Discussion

In the first three phases of the PRECEDE-PROCEED model—social, epidemiological, and educational and ecological assessments—literature review and remote interviews with female heads of households,

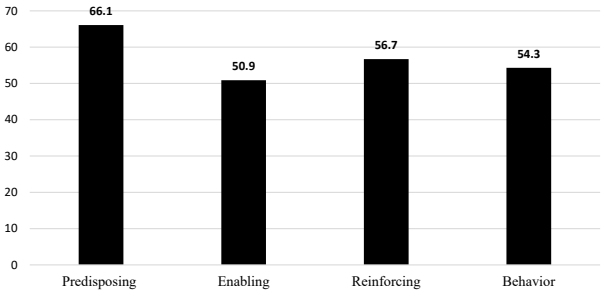

Figure 1. Percentage of changes resulting from the educational program on predisposing, enabling, and reinforcing factors and waste segregation at source behaviors of women

Table 4. Comparison of demographic variables between intervention and control groups

Variables		Intervention group (n=60)	Control group (n=60)	*P* value Chi-square Test
		Number (percent)	Number (percent)	
Employment status	Housewife	43 (71.7)	27 (45)	0.005
	Employed	17 (28.3)	33 (55)	
Education level	Primary school	2 (3.3)	1 (1.7)	0.683
	Middle school	6 (10)	8 (13.3)	
	High school or a diploma	23 (38.3)	18 (30)	
	University degree	29 (48.3)	33 (55)	
Income status	Low	7 (11.7)	4 (6.7)	0.183
	Lower-middle	15 (25)	10 (16.7)	
	Upper-middle	22 (36.7)	19 (31.7)	
	High	16 (26.7)	27 (45)	
Spousal education level	Primary school	2 (3.3)	1 (1.7)	0.511
	Middle school	9 (15)	12 (20)	
	High school or a diploma	28 (46.7)	21 (35)	
	University degree	21 (35)	26 (43.3)	

Table 5. Comparison of the mean score of predisposing, enabling, reinforcing factors, and behavior before and two months after the intervention in two groups

Variable	Group	Before the intervention	After the intervention	*P* value*
		M±SD	M±SD	
Predisposing Factors	Intervention	113.11±10.73	124.06±9.09	<0.001
	Control	114.83±12.11	113.63±12.73	0.201
	P-value**	0.413	<0.001	
	P-value***	-	<0.001	
Enabling Factors	Intervention	70.54±7.74	74.76±6.51	<0.001
	Control	72.20±7.14	72.35±7.22	0.864
	P-value**	0.283	0.079	
	P-value***	-	0.004	
Reinforcing Factors	Intervention	29.38±3.40	32.25±2.05	<0.001
	Control	30.53±3.83	30.50±3.81	0.14
	P-value**	0.085	0.002	
	P-value***	-	<0.001	
Behavior	Intervention	42.71±7.89	46.13±4.25	<0.001
	Control	43.21±6.57	43.66±7.14	0.422
	P-value**	0.707	0.023	
	P-value***	-	0.001	

*Paired t-test. ** Independent t-test. ***ANCOVA.

environmental health engineering experts, and health education specialists revealed that pro-environmental behaviors influence multiple dimensions of QOL, including physical, mental, social, and economic well-being. Among environmental indicators, individual per capita waste generation emerged as a key factor. The target behavior identified was waste segregation at source, which was most influenced by predisposing, enabling, and reinforcing factors.

The findings revealed a statistically significant improvement in waste segregation at source behavior among participants in the intervention group, indicating the effectiveness of the PRECEDE-PROCEED model in promoting pro-environmental actions. This outcome supports the value of structured, theory-driven interventions in influencing household-level environmental behaviors. Notably, to the best of our knowledge, this is the first study that applied the PRECEDE-PROCEED model specifically to promote waste segregation at source behavior, marking a novel application of the framework in an environmental context. Comparable results were reported by Jafarzadeh

et al., whose Theory of Planned Behavior-based program successfully improved waste separation practices among homemakers in Nowshahr (25). Similarly, Sadeghi et al. observed behavioral improvements in housewives following an eight-session educational program on dry and wet waste segregation (26). Although conducted in a different health domain, Rakhshani et al. demonstrated the PRECEDE-PROCEED model's broader applicability, as their intervention improved self-care behaviors and reduced systolic blood pressure in patients with hypertension (27). These findings collectively reinforce the adaptability and impact of theory-based educational interventions across various behavioral domains and populations. Importantly, promoting waste segregation at the source behavior at the household level has practical implications for reducing landfill use, enhancing recycling efficiency, and supporting the long-term sustainability of municipal solid waste systems.

Predisposing Factors

Predisposing factors—such as knowledge, attitudes, and self-efficacy—are critical antecedents that motivate behavior change (15). Educational content targeted key aspects of waste management, including disposal methods, recyclable materials, decomposition timelines, and waste classification, using various formats such as PowerPoint presentations, videos, audio clips, and infographics. These materials were effective in enhancing participants' knowledge and self-efficacy and shaping positive attitudes by highlighting the benefits of proper waste segregation at source and the risks of neglect. In the present study, the intervention group demonstrated a significant improvement in the predisposing score, rising from 113.11 ± 10.73 to 124.06 ± 9.09 out of a maximum of 138. These findings are in line with previous studies. Aksan and Çelikler reported a significant increase in environmental awareness among science teacher candidates following a structured educational course (28). Similarly, Moghaddam et al. found that a mobile-based intervention delivered via WhatsApp significantly increased awareness, attitude, and self-efficacy scores related to waste management among housewives (29). Elbeltagy et al. also reported post-intervention improvements in predisposing factors in the context of preeclampsia education (30). These findings highlight the pivotal role of structured, theory-driven education in equipping individuals— especially female heads of households— with the knowledge, confidence, and attitudes necessary to adopt and sustain pro-environmental behaviors.

Enabling Factors

Enabling factors are structural or contextual elements that support behavior implementation (15). Our intervention did not result in a significant between-group difference in enabling factors. This may reflect that while education can enhance knowledge and motivation, infrastructure, policy support, and service availability, which are core components of enabling factors, often lie outside the control of individual behavior change efforts. For instance, lack of access to sufficient waste segregation bins or inefficient municipal systems may have reduced the comparative gains in enabling conditions. Future interventions may benefit from integrating educational efforts with municipal or governmental support to ensure structural barriers are also addressed. Pallegedara et al. found that the provision of three garbage bins along with leaflets has improved waste segregation behavior of households substantially (by 36%, on average) (31). Alimoradiyan et al. highlighted that government, private sector, and NGO collaboration is essential for the promotion of Reduce, Reuse, and Recycle (3R) practices (32).

Reinforcing Factors

Reinforcing factors refer to the rewards and feedback that sustain a behavior (15). In the present study, the most significant reinforcing factors influencing waste segregation at source among female heads of households were social support and social reinforcement. In the intervention group, the mean (± SD) score for reinforcing factors was 29.38 ± 3.40 (out of a maximum of 35) before the educational program, which significantly increased to 32.25 ± 2.05 following the intervention. Community engagement through rewards and positive feedback can significantly boost waste segregation behavior. Bonrood et al. reported up to a 51% increase in waste segregation behavior when financial incentives were used (33). However, Sun et al. noted that financial incentives alone were insufficient to motivate all residents; for those unresponsive to monetary rewards, educational or regulatory approaches proved more effective (34). This highlights the importance of combining multiple reinforcement strategies to accommodate diverse motivational drivers. Further supporting the role of reinforcement, Jajarmi et al. reported sustained improvements in knowledge, enabling factors, and reinforcing elements among children following a health education intervention on Cutaneous Leishmaniasis (35). These findings collectively suggest that integrating community-based support, feedback mechanisms, and tailored incentives can significantly strengthen the adoption and sustainability of waste segregation at source.

Strengths and Limitations

A key strength of this study is the application of the PRECEDE-PROCEED model, which provides a comprehensive and systematic framework for planning and evaluating health education interventions. This model enabled a detailed needs assessment, guided the development of context-specific educational content, and supported the evaluation of multiple constructs

influencing behavior. Its structured, theory-driven approach allowed for the consideration of behavioral, environmental, and social determinants related to waste segregation at source.

However, several limitations should be noted. Implementing an intervention based on the PRECEDE-PROCEED model can be time- and resource-intensive due to the sequential nature of its phases. Methodologically, the study did not include objective measurements of household per capita waste generation and outcome evaluation, primarily due to time constraints. Therefore, it is recommended that future research consider incorporating them. Additionally, reliance on self-reported data to assess behavioral outcomes introduces potential reporting bias—a common limitation in behavioral studies that depend on subjective self-assessment.

Conclusion

The developed intervention program, based on the PRECEDE-PROCEED model— a community-based, participatory planning framework— effectively improved waste segregation at source behaviors, as well as predisposing, enabling, and reinforcing factors within the intervention group. However, post-intervention scores for enabling factors did not differ significantly between the intervention and control groups. This highlights the need for multi-sectoral collaboration in future interventions. Educational programs should ideally be integrated with improvements in municipal infrastructure, public policy advocacy, and community-level resource allocation. Given the critical role of planning in the success of intervention programs, the use of structured and participatory models such as PRECEDE-PROCEED is recommended for designing similar initiatives. Furthermore, effective waste segregation at source requires not only careful planning but also the integration of interventions across both individual and environmental levels.

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Authors' contributions

Conceptualization: Mostafa Nasirzadeh.
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Methodology: Mostafa Nasirzadeh, Mohammad Asadpour, Hadi Eslami, Leili Mazar.
Project administration: Mostafa Nasirzadeh.
Resources: Mostafa Nasirzadeh, Mohammad Asadpour, Hadi Eslami.
Writing – original draft: Leili Mazar.
Writing – review & editing: Mostafa Nasirzadeh, Mohammad Asadpour, Hadi Eslami.

Competing interests

The authors declare that they have no competing interests.

Ethical issues

The study was approved by the Ethics Committee of Rafsanjan University of Medical Sciences (Ethical code: IR.RUMS.REC.1399.155) and was derived from an M.Sc. thesis (Code: 99143). Written informed consent was obtained from all participants. All methods were carried out in accordance with the Helsinki Declaration.

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