

The effect of the 5Rs with the HBM program on municipal solid waste management knowledge and perceptions among rural residents in Pong District, Phayao Province

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ABSTRACT

Municipal solid waste (MSW) is a continuous environmental challenge in the modern world. Thus, this study aims to compare the knowledge of MSW management (MSWM) and Health Belief Model (HBM)-related perceptions between experimental and control groups before and after implementing the 5Rs (Refuse, Reduce, Reuse, Repair, and Recycle) with the HBM program. Using a quasi-experimental, two-group pretest-posttest design, the experimental group participated in a six-week educational program. Questionnaires covered general information, knowledge of MSWM via the 5Rs with the HBM-based program and HBM-related perceptions. Data analysis included descriptive statistics, means, and standard deviations. The study involved 220 participants, mostly with a primary education level. They were evenly distributed between the experimental and control groups. Results revealed the experimental group demonstrated significantly higher knowledge scores ($\bar{X} = 40.13$, $SD = 1.435$) compared to the control group ($\bar{X} = 31.78$, $SD = 2.435$), with a p-value of < 0.001 . Mean scores for four perceptions of HBM, namely perceived susceptibility and severity of improper waste segregation, as well as perceived benefits and barriers to proper waste segregation, were significantly higher in the experimental group than in the control group, with p-values of < 0.05 for each perception. These findings offer valuable insights for addressing and managing MSW issues sustainably, with potential benefits for environmental impact reduction and human health promotion. Furthermore, these research findings can serve as crucial data for implementing MSWM strategies in the Pong district of Phayao province.

Key words:

municipal solid waste, municipal solid waste management, 5Rs, health belief model

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INTRODUCTION

The problems of municipal solid waste (MSW) have increased significantly worldwide—a trend that appears to be continuing. MSW reflects the culture that produces it and adversely affects both human health and the environment.^{1,2} Annually, the global population produces 2.01 billion metric tons of MSW, and a minimum of 33 percent of that waste is not handled in an environmentally friendly manner.³ Due to insufficient financial and material resources, the issue of solid waste management is more significant in developing countries than in developed ones.⁴

Thailand's MSW generation has grown steadily over the past decade.⁵ The amount of MSW generated in Thailand is the 14th highest in the eastern Asia-Pacific region, and the average amount of MSW generated is 1.08 kilograms per capita per day.⁶ In 2022, Phayao Province produced nearly 100,000 tons of solid waste.⁷ In Pong, where most residents are farmers, chemicals are used in farming, and garbage, including plastics and chemical containers, is inappropriately burned, leading to pollution. Therefore, education is necessary for district residents to manage waste properly, such as by placing chemical containers in hazardous waste bins. Moreover, poor waste management can lead to soil pollution,⁸ water pollution,⁹ floods by decreasing the capacity of the drainage system to carry water,^{10,11} greenhouse gas emissions,¹²⁻¹⁴ ocean plastic accumulation,¹² and hazardous leachate emissions.^{9,15} To prevent these problems, studies on proper waste management should be conducted.

The 5Rs strategy is an effective way to manage waste, and it is important to understand its different applications. For instance, the 5 Rs may consist of Refuse, Reduce, Reuse, Repair, and Recycle. In

other contexts, the 5Rs may include Refuse, Reduce, Reuse, Rot (for composting organic materials), and Recycle,¹⁶ or Reduce, Reuse, Recycle, Repurpose, and Refuse.¹⁷ Previous studies have revealed that implementing the 5Rs can significantly improve individuals' waste management behaviors.^{18,19} In a recent study, the participants revealed a positive attitude toward the 5 Rs.¹⁸ A study in Thailand found that after implementing the 5 Rs program, the experimental group showed improved mean scores in knowledge, motivation, and household waste reduction behavior compared to their pre-experiment scores.¹⁹ Thus, educational initiatives on the 5Rs should be reconsidered to emphasize the program's advantages and the dangers of improper practices, such as refusing to wear masks or reusing masks.

Furthermore, the health belief model (HBM) appears to be effective in emphasizing the role of behavioral change and preventive behaviors.^{20,21} The HBM states that when individuals recognize risks, they understand the benefits of changing their behavior and consider any barriers to adopting healthier habits.²² The HBM consists of different domains: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy.²³⁻²⁵ Initially, the HBM primarily applied to ill patients; however, in recent years, it has been used to predict a wide variety of health-related behaviors.²⁶

The 5Rs framework and the HBM can be integrated to promote sustainable MSW management (MSWM) in residential areas. This integration can influence not only waste management knowledge but also perceptions of its importance and people's willingness to participate in it. Cohen and Uphoff²⁷ classified participation into four types: (1) participation in decision-making, (2) participation in implementation, (3) participation in benefits, and (4)

participation in evaluation. By encouraging participation from residents, community leaders, and related authorities, the program can work with them to achieve their goals.

Most studies in Thailand have focused on implementing 3Rs (Reduce, Reuse, and Recycle) programs in waste management, and the results appear to be effective.^{28,29} While certain studies utilizing the 5Rs approach have not incorporated the Health Belief Model (HBM)^{18,30}, there are limited studies in Thailand that have implemented 5 Rs Programs to improve MSWM knowledge and apply the HBM among rural residents living in Phayao. Thus, this study aims to compare knowledge of MSWM and HBM-related perceptions, including perceived susceptibility and severity of improper waste segregation, as well as perceived benefits and barriers of proper waste segregation, between experimental and control groups before and after implementing the 5 Rs based program. The results provide valuable insights that can be applied to effectively address and sustainably manage MSW issues, thereby reducing environmental impacts and promoting human health.

METHODS

Research Design and Participants

This study employed a quasi-experimental two-group pretest-posttest design to compare knowledge scores and HBM-related perceptions between the experimental and control groups before and after implementing the 5 Rs with the HBM program. To gather data for analysis, the study relied on a quantitative research method, specifically questionnaires administered to both the experimental and control groups. The intervention was implemented in Pong district, Phayao province, Thailand, between January and December 2023.

The population in this study consists of residents from selected sub-

districts in Pong district. In 2023, Pong district, which comprises 7 subdistricts, had a total population of 39,216 and 12,882 households.³¹ Improper waste disposal was a common issue, especially in specific subdistricts within the Pong district. For instance, Oi, Ngim, and Naprang subdistricts experienced improper waste disposal of more than 0.4 tons per day.³² The experimental group sample selection included the Oi subdistrict, Ngim subdistrict, and Na Prang subdistrict. Simple random sampling was conducted by drawing lots. For the control group, sample selection included residents from the Pong subdistrict, Pha Chang Noi subdistrict, Khuan subdistrict, and Khun Khuan subdistrict, and simple random sampling was similarly conducted by drawing lots.

The inclusion criteria were individuals aged 18 and over, both male and female, living in Pong district. They were willing to participate in the research and capable of communicating and providing information during the intervention. The exclusion criteria included residents who were unable to fully participate in the study process, those who relocated over the course of the study, and individuals who expressed a desire to withdraw from the study.

The sample size was determined using Heinisch's formula³³ for calculating independent sample sizes for experimental studies. The results of the sample size calculation indicated that 100 participants per group were initially needed. To account for potential exclusions, an additional 10% was added, resulting in 110 participants for each group in this study. Data were collected from a sample group of one person per household. Using questionnaires, pre-test assessments of knowledge related to the 5 Rs of waste management and perceptions related to the HBM were conducted before the six-week intervention. Post-test assessments were conducted after the intervention.

Research Procedures and Instruments

This study comprised three phases. The first phase involved a literature review of MSWM using the 5Rs principle and the HBM, alongside gathering general information about residents in the study area regarding their MSWM knowledge and behavior. In the second phase, the data collected in the first phase were utilized to develop and implement educational programs. Based on the literature review, questionnaires were developed as data collection instruments. The third and final phase involved pre-test assessments, intervention participation, and post-test assessments.

According to the pre-and post-test assessments, questionnaires were administered with the following structure:

Section 1: Multiple-choice and open-ended questions on demographic factors, such as gender, age, household status, education, occupation, income, household characteristics, number of household members, duration of residency, recyclable waste selling frequency, and general waste disposal methods, totaling 12 items.

Section 2: Items assessing knowledge in managing MSW using the 5Rs strategy. Examples of the items included statements such as “Reusing products can help reduce the amount of municipal solid waste” and “Using shopping baskets instead of plastic bags when making purchases at the market can reduce the amount of municipal solid waste.” This knowledge self-assessment uses a 5-point rating scale, ranging from strongly disagree (1 point) to strongly agree (5 points). There are a total of 10 items, resulting in scores ranging from 10 to 50 points.

Section 3: Items examining four perception components related to the HBM.

These components include perceived susceptibility, severity, benefits, and barriers. Examples of the items included statements such as “Water sources that are contaminated with municipal solid waste can affect human health if the water is used or consumed” (perceived susceptibility) and “Burning garbage is one of the most serious causes of cancer” (perceived severity). Each component consists of 10 items, which are rated using a 5-point rating scale that ranges from strongly disagree (1 point) to strongly agree (5 points). This section comprises a total of 40 items. Each component’s score falls between 10 and 50 points.

The validity of the questionnaire was assessed by three experts, and the Index of Item-Objective Congruence (IOC) was used to determine the validity of each item. The overall IOC was 0.95. Then, a trial was conducted with 30 individuals who were not part of the main sample. Subsequently, Cronbach’s coefficient alpha (α) was calculated for each component of the questionnaire. The reliability coefficient of the first section, MSWM knowledge, was 0.87. Regarding the HBM-related perceptions, the reliability coefficient of the perceived susceptibility was 0.80, the perceived severity was 0.86, the perceived benefits was 0.94, and the perceived barriers was 0.79.

Intervention

The study utilized a program based on the 5Rs (Refuse, Reduce, Reuse, Repair, Recycle) and the HBM for solid waste management, incorporating a rural-development participation approach.²⁷ The 5Rs with HBM intervention in this study was designed, aiming to improve the participants' understanding of MSWM and their perceptions related to the HBM.

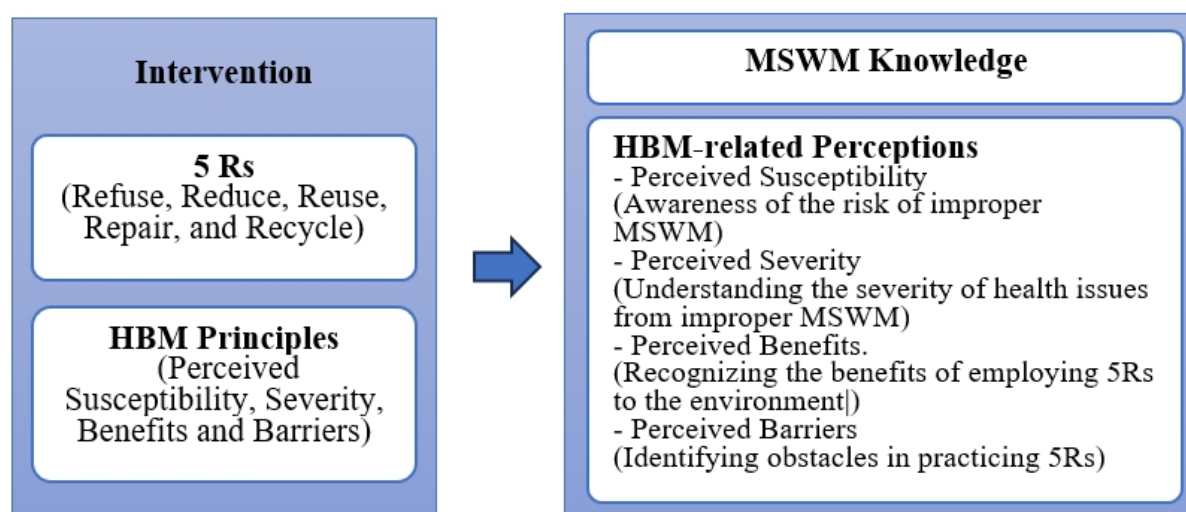


Figure 1. The Study's 5Rs and HBM Integration

Initially, the intervention was designed with information gathered from residents' discussions, and it involved decision-making processes to improve waste management practices. Residents actively implemented waste management strategies aligned with the 5Rs and HBM

principles, exploring the benefits of proper waste management while considering the risks and barriers associated with improper behaviors. The program evaluation involved recapping the intervention with the experimental group.

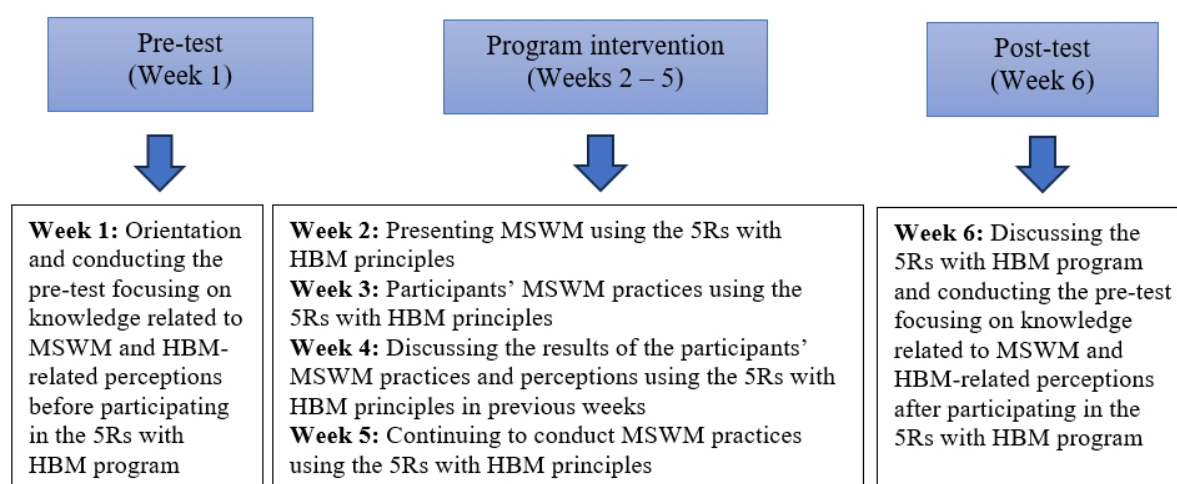


Figure 2. The 5Rs with HBM Program

The experimental group participated in the 6 - week program as outlined below:

Week 1: The intervention program began with an orientation session. The researchers introduced themselves, explained the program's objectives, and

facilitated a discussion on program participation. The participants completed a pre-test questionnaire. These activities took approximately 2 hours.

Week 2: The program focused on educating the participants about MSWM using the 5 Rs and HBM principles. The researchers explained the risks associated with improper waste sorting and demonstrated proper techniques through brochures, posters, videos, and discussions. The participants learned about the diseases caused by exposure to hazardous waste. The benefits of waste separation and the common challenges they may face when separating waste were also highlighted. This 6-hour session aimed to deepen the participants' understanding of the 5 Rs principles and the HBM.

Week 3: The participants applied the ideas they brainstormed during Week 2 into practice in their own homes. They were required to manage solid household waste, considering the 5 Rs principles and the HBM.

Week 4: The participants discussed the results of their home experiments to present and exchange insights. Each participant explained the advantages and disadvantages they encountered. The participants collaboratively identified the most effective waste management practices. This session lasted approximately 3 hours.

Week 5: The participants continued to implement MSWM practices. This allowed them to integrate the knowledge and experience gained from Week 3 and the practical experience shared by other participants in Week 4 into their ongoing waste management efforts.

Week 6: The participants reviewed the program, shared their experiences, and discussed future waste management practices, boosting their confidence in managing MSW effectively. Post-test

assessments using the same questionnaire were conducted during this 3-hour session.

The control group, on the other hand, had two meetings with the researchers. In Week 1, they provided their consent and registered for participation. The researchers conducted an orientation session, outlining the study's objectives, data procedures, and result presentation. Similar to the experimental group, they completed both the pre-test in Week 1 and the post-test in Week 6.

Statistical Analyses

The data gathered in this study were analyzed using IBM SPSS Statistics software. Descriptive statistics were used to portray the characteristics of the participants. The data regarding knowledge scores in solid waste management before and after employing the 5Rs with the HBM program, along with data on HBM-related perceptions, including perceived susceptibility and severity of improper waste segregation, as well as perceived benefits and barriers of proper waste segregation, were analyzed using t-tests for independent samples. The mean scores and standard deviations of both the experimental and control groups are presented. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

This study was approved by the Human Ethics Committee of the University of Phayao, with certification document number UP-HEC 1.2/085/66.

RESULTS

A total of 220 participants were involved in this study, with 110 participants in the experimental group and 110 participants in the control group.

Table 1. Characteristics of the experimental and control groups

Variable	Experimental group (n = 110)		Control group (n = 110)	
	Number	Percentage	Number	Percentage
Gender				
Male	41	37.27	43	39.09
Female	69	62.73	67	60.91
Age groups (years), mean (SD)		35.0 (9.843)		36.0 (9.965)
Education level				
- Primary education	80	72.73	82	74.55
- Secondary education	25	22.73	23	20.91
- High school education/ Vocational certificate	5	4.55	5	4.55
Occupation				
- Agriculture workers	70	63.64	69	62.73
- Employee/ Freelancer	35	31.82	36	32.73
- Merchant	5	4.55	4	3.64
- Government officer / State enterprise officer	0	0	1	0.91
Household status				
- Host	110	100	102	92.73
- Resident	0	0	8	7.27
Monthly family income				
< 5,000 baht/month	80	72.73	80	72.73
5,001 – 10,000 baht/month	27	24.55	24	21.82
10,001– 20,000 baht/month	3	2.73	6	5.45
Residence Time (years), mean (SD)	20 (23.875)		21 (23.985)	
Frequency of selling recyclable waste				
1 time/month	49	44.55	47	42.73
2 times/month	21	19.09	19	17.27
> 2 times/month	40	36.36	44	40.00
Waste separation behavior				
- Disposing household waste in plastic bins	20	18.18	19	17.27
- Disposing household waste in plastic or garbage bags	80	72.73	76	69.09
- Separating household waste into different types of containers, such as biodegradable waste, recyclable waste, and general waste	10	9.09	15	13.64

As shown in Table 1, the participants in both groups are similar, indicating that they could be appropriately assigned as experimental and control

groups. Most of the participants had a primary education level. The average age of participants in the experimental group was 35 years (SD = 9.843), while in the control

group, it was 36 years ($SD = 9.965$). Additionally, a significant portion of the participants were engaged in farming, agriculture, or livestock farming. Furthermore, the participants reported selling recyclable waste once per month, with a frequency of 44.55% in the

experimental group and 42.73% in the control group. Additionally, most of the participants collected MSW by gathering it in plastic or garbage bags, accounting for 72.73% in the experimental group and 69.09% in the control group.

Table 2. Participants' knowledge scores in solid waste management before and after participating the 5Rs program

Variable	Experimental group (n = 110)		Control group (n = 110)		t	df	P-value
	M	S.D.	M	S.D.			
Before the experiment	32.89	3.124	32.75	3.056	0.345	109	.564
After the experiment	40.13	1.435	31.78	2.435	11.500	109	< 0.001*

* p-value < .05

Regarding the first research objective aimed at comparing knowledge scores in MSWM between the experimental and control groups before and after employing the 5Rs in conjunction with the HBM program, positive results were observed. Initially, as depicted in Table 2,

both groups showed similar knowledge scores. However, post-intervention, the experimental group displayed notably higher knowledge scores ($\bar{X} = 40.13$, $SD = 1.435$) than the control group ($\bar{X} = 31.78$, $SD = 2.435$; $t = 11.500$, $p = < 0.001$).

Table 3. Participants' mean scores of HBM-related perceptions before and after participating the 5Rs program

Variable	Experimental group (n = 110)		Control group (n = 110)		t	df	P-value
	M	S.D.	M	S.D.			
Perceived susceptibility							
Before the experiment	32.67	3.657	32.43	3.468	0.267	109	.765
After the experiment	46.67	1.823	32.23	1.324	3.900	109	.003*
Perceived severity							
Before the experiment	30.35	3.729	31.02	3.854	0.178	109	.675
After the experiment	33.48	1.436	30.89	1.876	3.044	109	.002*
Perceived benefits							
	24.23	2.402	24.03	2.580	0.200	109	.435

Variable	Experimental group (n = 110)		Control group (n = 110)		t	df	P-value
	M	S.D.	M	S.D.			
Before the experiment							
After the experiment	35.64	1.008	24.12	1.869	12.001	109	< 0.001*
Perceived barriers							
Before the experiment	33.70	2.718	32.98	2.689	0.164	109	.376
After the experiment	46.20	1.808	31.60	3.784	13.670	109	< 0.001*

* p < .05

For the second research objective, which aimed to compare the mean scores of HBM-related perceptions, as illustrated in Table 3, the findings for each perception were provided.

First, regarding perceived susceptibility to improper waste management, both the experimental and control groups showed similar scores. However, after the experiment, the experimental group displayed a higher perceived susceptibility score ($\bar{X} = 46.67$, $SD = 1.823$) than the control group ($\bar{X} = 32.23$, $SD = 1.324$), with a p-value of 0.003.

Second, regarding the mean scores of the perceived severity related to improper waste segregation, it was found that, before the experiment, the experimental group's perceived severity did not significantly differ from the control group. However, post-experiment assessments revealed that the experimental group exhibited a higher score ($\bar{X} = 33.48$, $SD = 1.436$) than the control group ($\bar{X} = 30.89$, $SD = 1.876$). This disparity was statistically significant ($p = 0.002$).

Third, regarding the perceived benefits of proper waste segregation, intriguing findings emerged. Before the experiment, the experimental group's scores did not differ significantly from the control group, with a p-value of .435. However, following the intervention, a significant difference emerged. The experimental group displayed a higher

score ($\bar{X} = 35.64$, $SD = 1.008$) than the control group ($\bar{X} = 24.12$, $SD = 1.869$), with a p-value of < 0.001.

Finally, concerning perceived barriers to proper waste segregation, the experimental group's perceived barriers before the experiment did not differ significantly from those of the control group ($p = .376$). After the experiment, the experimental group had significantly higher perceived barriers ($\bar{X} = 46.20$, $SD = 1.808$) compared to the control group ($\bar{X} = 31.60$, $SD = 3.784$), with a statistically significant difference ($p < 0.001$).

DISCUSSION

This study investigates the effectiveness of the 5 Rs with the HBM program in enhancing MSWM knowledge and HBM-related perceptions on the implementation of effective waste management practices among residents of Pong district, Phayao. The findings of this study highlight the effectiveness of the intervention program in improving knowledge and perceptions concerning appropriate MSWM practices.

Enhancements in knowledge regarding MSWM were observed, suggesting that the intervention effectively educated the participants about proper MSWM using the 5Rs with HMB principles. The intervention empowered the participants to make decisions on MSWM.

This aligns with previous studies stating that the 5Rs can be used to promote waste management.^{18,19} To illustrate the practices of the participants, the 5Rs program helped them reduce the use of plastic bags when shopping at local markets, avoid using non-biodegradable materials such as foam, reuse water bottles and coffee cups, and repair equipment whenever possible. Once residents understand how the 5Rs can benefit their MSWM, it becomes essential for them to demonstrate pro-environmental behaviors. This entails more than just knowledge about MSWM; it requires active participation. Without such engagement and motivation, there may be little incentive for residents to change their behaviors regarding waste management. Furthermore, the findings emphasize that residents should know how to improve their practices. In line with this, a study by Sanongboon and Thiphom¹⁹ revealed that implementing the 5Rs principle not only enhanced the participants' household waste management knowledge, but also their motivation, and their household waste reduction behaviors.

The intervention not only increases individuals' knowledge of MSWM but also appears to transform their perceptions of waste management according to the HBM. Regarding one of the aspects of HBM, the higher perceived susceptibility indicates that residents became more aware of the potential negative effects of inappropriate waste management on their health. The results are consistent with the study by Eshete, Haddis and Mengistie,³⁴ which claims that, in household settings, people appear to be aware of the consequences of health problems resulting from improper management of solid waste. Environmental and health risks could arise as a result of inappropriate solid waste management, especially in developing countries.⁴ Proper waste segregation not only helps to reduce these harmful effects but also contributes to

sustainable waste management practices for a healthier environment.

The benefits of proper waste segregation behaviors highlight the effectiveness of the 5Rs program. Lou et al.³⁵ mentioned that the societal benefits associated with environmental protection highly impact attitudes toward waste separation behaviors. While this study did not compare scores between residents' environmental and individual benefits, it used questionnaires to explore both aspects. For example, the questionnaire asked respondents to compare waste sorting to reduce the amount of waste burned, thus lessening environmental pollution, and washing hands after waste separation to prevent the spread of infectious diseases. The respondents indicated that both practices are beneficial to waste management.

Finally, the findings showed that a decrease in perceived barriers may be an avenue for pursuing sustainable waste management practices after the intervention. For instance, the participants observed that the process of preparing containers and sorting solid waste was both time-consuming and costly. It is acknowledged that rural residents' monetary situations, such as their earnings, losses, and the availability of free sanitation materials, are important in their waste management practices.³⁵ Moreover, although implementing basic facilities, such as the installation of bins, can greatly enhance the level of waste segregation practices,³⁶ the participants in this study noted that the unavailability of household facilities is a significant barrier. With inadequate facilities, government sectors are expected to be responsible for providing the necessary infrastructure to facilitate waste management.^{37,38}

This study also suggests that collaboration among government agencies, private sector companies, community

leaders, and residents is crucial for improving municipal solid waste management. Together, they can implement comprehensive educational programs to educate residents on the importance of waste management, as highlighted in this research. The study recommends that government entities enhance infrastructure for waste collection across residential areas and ensure an adequate workforce for waste collection. In addition to bins, they can supply additional bags or containers for household use. Community leaders can oversee residents' waste management practices, while businesses can encourage reducing the use of plastic bags during purchases. Furthermore, strategies such as developing regulations and fostering community engagement are necessary to ensure long-term compliance with waste management practices.

CONCLUSION

In conclusion, this study highlights the effectiveness of integrating the 5Rs and HBM frameworks in an MSWM intervention among residents of Pong, Phayao. The results showed a significant improvement in the experimental group's knowledge of the 5Rs compared to that of the control group. Additionally, the experimental group exhibited increased scores in various HBM aspects, such as perceived susceptibility, severity, benefits, and barriers. To ensure ongoing participation, local authorities may need to enhance infrastructure such as waste bins. This study did not examine the cues to the action- and self-efficacy-related aspects of the HBM. Therefore, future research should address all aspects of the HBM. Future research could explore long-term efficacy and engagement strategies, including community initiatives or incentive programs for MSWM.

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REFERENCES

1. Vergara SE, Tchobanoglous G. Municipal solid waste and the environment: a global perspective. *Annual review of environment and resources*. 2012;37(1):277-309. doi: 10.1146/annurev-environ-050511-122532
2. Khan S, Anjum R, Raza ST, Ahmed Bazai N, Ihtisham M. Technologies for municipal solid waste management: Current status, challenges, and future perspectives. *Chemosphere*. 2022; 288: 132403. doi: 10.1016/j.chemosphere.2021.132403
3. World Bank. Trends in Solid Waste Management. The World Bank. 2023 [Internet]. [Cited 2024 July 18]. Available from: https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html
4. Mahajan R. Environment and health impact of solid waste management in developing countries: A review. *Curr World Environ*. 2023;18(1):18-29. doi: 10.12944/CWE.18.1.3
5. Pudcha T, Phongphiphat A, Wangyao K, Towprayoon S. Forecasting municipal solid waste generation in Thailand with grey modelling. *Environ Nat Resour J*. 2023;21(1):35-46. doi: 10.32526/enrj/21/202200104

6. Kaza S, Yao L, Bhada-Tata P, Van Woerden F. What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank Publications. 2018. doi: 10.1596/978-1-4648-1329-0
7. Pollution Control Department. Thailand state of pollution 2022 [Internet]. [Cited 2024 May 25]. Available from: <https://www.pcd.go.th/publication/30311>
8. Alghamdi AG, Aly AA, Ibrahim HM. Assessing the environmental impacts of municipal solid waste landfill leachate on groundwater and soil contamination in western Saudi Arabia. *Arab J Geosci.* 2021;14(5):1-12. doi: 10.1007/s12517-021-06583-9
9. Abubakar IR, Maniruzzaman KM, Dano UL, AlShihri FS, AlShammari MS, Ahmed SMS, et al. Environmental sustainability impacts of solid waste management practices in the Global South. *Int. J. Environ. Res. Public Health.* 2022;19(19):12717. doi: 10.3390/ijerph191912717
10. Nepal M, Karki Nepal A, Khadayat MS, Rai RK, Shyamsundar P, Somanathan E. Low-cost strategies to improve municipal solid waste management in developing countries: Experimental evidence from Nepal. *Environ Resour Econ.* 2023;84(3):729-52. doi: 10.1007/s10640-021-00640-3
11. Pervin IA, Rahman SMM, Nepal M, Haque AKE, Karim H, Dhakal G. Adapting to urban flooding: A case of two cities in South Asia. *Water Policy.* 2020;22(S1):162-88. doi: 10.2166/wp.2019.174
12. Chen DM, Bodirsky BL, Krueger T, Mishra A, Popp A. The world's growing municipal solid waste: Trends and impacts. *Environ Res Lett.* 2020;15(7):074021. doi: 10.1088/1748-9326/ab8659
13. Clarke C, Williams ID, Turner DA. Evaluating the carbon footprint of WEEE management in the UK. *Resour, Conserv Recycl.* 2019;141:465-73. doi: 10.1016/j.resconrec.2018.10.003
14. Ruliana V, Soemantojo RW, Asteria D. Assessing a community-based waste separation program through examination of correlations between participation, information exposure, environmental knowledge, and environmental attitude. *ASEAN J Community Engagem.* 2019;3(1):1-27. doi: 10.7454/ajce.v3i1.120
15. Ratna MV, Kumar GV, Dileep G. The effects of leachate from municipal solid waste landfill dump sites on ground water contamination. *Levant J.* 2021;20(7):194-207.
16. Johnson B. Zero waste home: The ultimate guide to simplifying your life. Penguin UK. 2013.
17. Chook JW, Ferdin AE, Lee CH. Unmasking Malaysian preferences for effective plastic waste management: A choice experiment approach. *J Mater Cycles Waste Manag.* 2024;26(1):512-28. doi: 10.1007/s10163-023-01850-1
18. Pineda JC, Bonsol SGA, Amorante MM, Fucio RL. 5Rs and its impact on Barangay Santa Lucia's community development: Perceptions and attitude. *Puissant.* 2024;5(5):1929-51.
19. Sanongboon C, Thiphom S. The effect of motivation program on knowledge about 5Rs and the behavior of household waste reduction of the people in Muangbangkhlang sub-district, Sawankhalok district, Sukhothai province. *J Saf Health.* 2021;14(2):61-73.
20. Anuar H, Shah S, Gafor H, Mahmood M, Ghazi HF. Usage of health belief model (HBM) in health behavior: A systematic review. *Malays J Med Health Sci.* 2021;16(11):201-209
21. Raheli H, Zarifian S, Yazdanpanah M. The power of the health belief model (HBM) to predict water demand

- management: A case study of farmers' water conservation in Iran. *J Environ Manag.* 2020;263:110388. doi: 10.1016/j.jenvman.2020.110388
22. Rosenstock IM. Historical origins of the health belief model. *Health Educ Monogr.* 1974;2(4):328-35. doi: 10.1177/109019817400200403
 23. Ghorbani-Dehbalaei M, Loripoor M, Nasirzadeh M. The role of health beliefs and health literacy in women's health promoting behaviours based on the health belief model: A descriptive study. *BMC Women's Health.* 2021;21(1):421. doi: 10.1186/s12905-021-01564-2
 24. Glanz K, Rimer BK, Viswanath K. *Health behavior and health education theory, research, and practice* (4 ed.). Jossey-Bass. 2008.
 25. Rezapour B, Sharafkhani N. Explaining the performance of nurses in order to prevent nosocomial infections in Urmia city hospitals: Application of the health belief model. *The Open Public Health J.* 2024;17(1):1-8. doi: 10.2174/0118749445256801231210163327
 26. Ogden J. *Health psychology* (6 ed.). McGraw Hill. 2019.
 27. Cohen JM, Uphoff NT. Participation's place in rural development: Seeking clarity through specificity. *World Dev.* 1980;8(3):213-235. doi: 10.1016/0305-750X(80)90011-X
 28. Banchonhattakit P, Inmuong U, Duangsong R, Phimha S, Prachaiboon T, Padchasuwan NH. Effects of a school-network intervention using reduce, reuse and recycle in Thailand. *Health Education Journal.* 2022;81(3):363-371. doi: 10.1177/00178969221079024
 29. Manipharak T. Waste management in accordance with 3R principles in the eastern Bangkok area. *Journal of Local Governance and Innovation.* 2020;4(1):157-170.
 30. Wangdi D, Tshomo S. Exploring higher secondary school students' knowledge, attitude and practices towards waste management. *Rabsel - the CERD Educational Journal.* 2017;18(2):47-60.
 31. The Bureau of Registration Administration, Department of Provincial Administration. Official statistics registration systems [Internet]. [Cited 2024 April 25]. Available from: <https://www.bit.ly/4cvIooY>
 32. Pollution Control Department. Situation of municipal solid waste disposal sites in Thailand 2022 [Internet]. [Cited 2024 January 5]. Available from: <https://www.pcd.go.th/publication/29509/>
 33. Heinisch O. Cochran, WG: sampling techniques, 2. Aufl. John Wiley and sons, New York, London 1963. Preis s. 1965;7(3):203.
 34. Eshete A, Haddis A, Mengistie E. Investigation of environmental and health impacts solid waste management problems and associated factors in Asella town, Ethiopia. *Heliyon.* 2024; 10(6):e28203. doi: 10.1016/j.heliyon.2024.e28203.
 35. Lou T, Wang D, Chen H, Niu D. Different perceptions of belief: Predicting household solid waste separation behavior of urban and rural residents in China. *Sustainability.* 2020;12(18):7778. doi: 10.3390/su12187778
 36. Moeini B, Ayubi E, Barati M, Bashirian S, Tapak L, Ezzati-Rastgar K, Hashemian M. Effect of household interventions on promoting waste segregation behavior at source: A systematic review. *Sustainability.* 2023;15(24):16546. doi: 10.3390/su152416546
 37. Butarbutar AR, Dewi K, Tahir U, Krisdiyanto A, Suparni S. Household waste management training to improve the economy of rural communities. *J Hum Educ.* 2024;4(2):136-141. doi: 10.31004/jh.v4i2.778
 38. Insee N, Khiawlueng T, Wongwatthanaphong K. Sustainable

community participatory solid waste
management process. J Mod Learn
Dev. 2022;7(11):480-