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RESEARCH ARTICLE

Effects of a Household Solid Waste Management Behavior Promotion Program among Residents in the Service Area of Phato Hospital, Chumphon Province

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Abstract

This one-group pretest-posttest quasi-experimental study aimed to develop a household solid waste management behavior promotion program based on the GREEN & CLEAN Hospital Challenge low-carbon concept, to compare residents' knowledge, attitudes, and behaviors before and after the program, and to assess their satisfaction in the service area of Phato Hospital, Chumphon Province, from May to June 2026. Forty-two residents were selected by simple random sampling. Instruments comprised a 5-activity program, a knowledge test, and questionnaires (CVI = 0.92; reliability 0.81–0.92). Data were analyzed using descriptive statistics and the paired t-test.

The program comprised two educational sessions, one waste separation demonstration and practice session, and two home visits over five weeks. Participants were mostly male (54.76%) and farmers (52.38%), with a mean age of 42.31±10.30 years. After the program, mean scores increased for knowledge (from 10.90±2.37 to 12.02±4.24, out of 20), attitudes (from 3.00±0.45 to 3.19±0.74), and behaviors (from 2.30±0.49 to 2.52±0.74). Knowledge and behavior improved significantly but with small effect sizes (p=0.039 and 0.045; Cohen's dz = 0.33 and 0.32), whereas attitude did not (p=0.051). Overall satisfaction was high (4.15±1.12). The program may modestly improve knowledge and behaviors and may serve as a guideline for agricultural communities with similar contexts, provided structural support and longer follow-up are added.

Keywords: Household solid waste management, GREEN & CLEAN Hospital Challenge, low carbon, environmental health behavior

Introduction

Solid waste is a global environmental crisis that continues to intensify. Worldwide, more than 2.01 billion tons of solid waste are generated each year, of which only 16.00% is properly recycled, while 46.00% is disposed of in an unsustainable manner. The Global Waste Management Outlook 2024 of the United Nations Environment Programme warns that, without urgent action, global municipal waste generation will increase by another two-thirds by 2050 and waste management costs will nearly double. This problem is directly linked to climate change, as the decomposition of organic waste and improper waste disposal are sources of methane and carbon dioxide, which are major greenhouse gases.[1]

In Thailand, 25.70 million tons of solid waste were generated in 2022, of which 7.10 million tons (27.63%) were improperly disposed of.[2] In 2023, the amount rose to 26.95 million tons, or an average of 73,840 tons per day, with an average generation rate of 1.12 kg per person per day, and as much as 7.47 million tons (27.72%) were still improperly disposed of.[3] In the southern region, solid waste increased from 8,384 tons per day in 2021 to 9,705 tons per day in 2023, the highest rate of increase among all regions of the country.[4] In Chumphon Province, solid waste increased from approximately 412.00 tons per day in 2022 to approximately 452.00 tons per day in 2024. The key problems in the area are the lack of waste separation at source and the lack of knowledge about proper waste management among residents of remote and agricultural areas, resulting in open burning and roadside dumping of waste, which cause air pollution and greenhouse gas emissions.[3]

Household solid waste management behavior is influenced by several factors, including knowledge, attitudes, motivation, and environmental enabling factors. Studies have found that knowledge and attitudes are positively associated with household solid waste management behavior,[5] and that motivation, access to information, and social support are associated with household waste reduction and separation behaviors.[6] Waste management based on the 3Rs principle, namely Reduce, Reuse, and Recycle, starting with separation at source, is therefore central to solving the problem. In addition, the GREEN & CLEAN Hospital Challenge concept of the Ministry of Public Health, which aims to improve environmental health in health care facilities, covers the management of all types of waste (GARBAGE), standard restroom development (RESTROOM), energy management (ENERGY), environmental management (ENVIRONMENT), food and water sanitation (NUTRITION), and the development of low-carbon and climate-resilient hospitals (Low Carbon and Climate Resilient Health Care).[7] This concept can also be applied as a framework for promoting environmental management at the community level.

Phato District, Chumphon Province, covers an area of approximately 1,017 square kilometers. Most of the population works in agriculture, particularly fruit orchards and oil palm plantations. Communities are dispersed across mountainous areas and foothill plains, which

limits access to the waste collection services of local administrative organizations. Community solid waste increased from approximately 8.20 tons per day in 2022 to 9.80 tons per day in 2024, with 28.00-32.00% of all waste remaining improperly managed,[3] posing a risk of contaminating natural water sources that are important headwaters of the province. In 2025, Phato Hospital received the GREEN & CLEAN Hospital Challenge award for low-carbon and climate-resilient hospitals, reflecting the organization's capacity to drive environmental work systematically. However, solid waste management in the area has so far relied on occasional campaigns and has lacked systematic and continuous implementation at the household level. Residents still lack sufficient knowledge, do not separate waste at source, and engage in inappropriate waste dumping and burning.

Given this background, the researcher recognized that developing a household solid waste management behavior promotion program applying the GREEN & CLEAN Hospital Challenge concept on low carbon and climate change, through education, demonstration and practice of waste separation, and follow-up of household behaviors, is an important approach to linking the hospital's capacity to concrete solutions for environmental problems at the household level, and would provide information for developing solid waste management systems in agricultural communities with similar contexts. The researcher therefore developed this program and studied its effects on residents' knowledge, attitudes, behaviors, and satisfaction.

Objectives

1. To develop a household solid waste management behavior promotion program applying the GREEN & CLEAN Hospital Challenge concept on low carbon and climate change for residents in the service area of Phato Hospital, Chumphon Province.

2. To compare residents' knowledge, attitudes, and household solid waste management behaviors before and after receiving the household solid waste management behavior promotion program, Phato Hospital, Chumphon Province.

3. To assess residents' satisfaction with the household solid waste management behavior promotion program, Phato Hospital, Chumphon Province.

Methods

This study employed research and development combined with a quasi-experimental one-group pretest-posttest design. It was conducted from May to June 2026, over a total of 8 weeks (including 5 weeks of program implementation), in three phases: Phase 1, pre-intervention assessment and preparation, sample selection, and pretest data collection (week 1); Phase 2, implementation of the household solid waste management behavior promotion program (weeks 2-6); and Phase 3, posttest data collection, satisfaction assessment, and data analysis (weeks 7-8).

Population: Residents in the service area of Phato Hospital, Phato District, Chumphon Province, covering 4 subdistricts and 46 villages,

namely Phato, Pak Song, Pang Wan, and Phra Rak Subdistricts, totaling 650 households.

Sample: The sample size was calculated using G*Power version 3.1[8] for the paired t-test (Means: Difference between two dependent means), with a medium effect size (effect size = 0.50)[9] and a significance level of α = .05, yielding a sample of 42 participants. Participants were selected by simple random sampling using a random number table, with the population registers of the villages in the service area as the sampling frame; one representative was randomly selected from each household. All 42 participants completed the study and were included in the data analysis.

Inclusion criteria: Being listed in a house registration or actually residing in the service area of Phato Hospital; aged 18 years or older; being the person primarily responsible for household solid waste management; able to communicate in Thai; being physically and mentally healthy; residing in the area throughout the study period; and voluntarily consenting to participate in the study.

Exclusion criteria: Having an uncontrolled chronic disease or an acute illness that prevented participation in the activities; concurrently participating in another project related to solid waste management; planning to relocate or travel away from the area for an extended period; being unable to complete all program activities; or requesting to withdraw during the study.

Research instruments: These comprised the intervention instrument and the data collection instruments, as follows.

1. Intervention instrument: The household solid waste management behavior promotion program applying the GREEN & CLEAN Hospital Challenge concept on low carbon and climate change, developed by the researcher based on a literature review, a situational survey, in-depth interviews with residents, community leaders, village health volunteers, and health personnel, and focus group discussions with stakeholders. The program was implemented during weeks 2-6 and consisted of five activities: Activity 1, the first educational session on "The four types of solid waste and their impacts on the environment and health," using videos, flipcharts, and a participatory lecture (60 minutes, week 2); Activity 2, the second educational session on "The 3Rs principle and the GREEN & CLEAN low-carbon concept," using a lecture, group discussion, and examples from farmers' daily lives (60 minutes, week 3); Activity 3, demonstration and practice of separating the four types of solid waste at source in the household using real waste samples from the agricultural community (90 minutes, week 4); Activity 4, the first home visit to observe waste bin arrangement and household waste separation and to provide individual advice (week 5); and Activity 5, the second home visit to continuously follow up on behaviors, provide positive reinforcement to households practicing correctly, and give additional advice to households with remaining shortcomings (week 6). After the program, certificates and a household solid waste management handbook were presented to reinforce the maintenance of correct behaviors (week 8).

2. Data collection instruments: Four instruments were used: 1) a 10-item general information questionnaire, comprising 7 items on personal data and 3 items on solid waste

management; 2) a 20-item test of knowledge of household solid waste management covering four domains, namely types of waste, waste separation, impacts of improper waste management, and the GREEN & CLEAN concept and greenhouse gas reduction, with yes/no answers and a total score of 20, interpreted using criteria adapted from Bloom[10] as high (14-20 points), moderate (8-13 points), and low (0-7 points); 3) a questionnaire on attitudes and behaviors regarding household solid waste management using a 5-point rating scale, consisting of 20 attitude items in four domains, with mean scores interpreted according to Best's criteria[11] into five levels: highest (4.51-5.00), high (3.51-4.50), moderate (2.51-3.50), low (1.51-2.50), and lowest (1.00-1.50), and 20 behavior items covering waste reduction (Reduce), reuse (Reuse), separation for recycling (Recycle), and hygienic waste disposal, with mean scores interpreted using class intervals [(5−1)/3] as high (3.68-5.00), moderate (2.34-3.67), and low (1.00-2.33); and 4) a 20-item program satisfaction questionnaire in four domains, namely content and knowledge gained, activities and implementation methods, facilitators and organizers, and application in daily life, using a 5-point rating scale interpreted according to Best's criteria,[11] with an open-ended question for additional suggestions.

3. Instrument quality assessment: The content validity of the program and instruments was examined by three experts: a public health technical officer experienced in environmental health and community solid waste management, a senior health professional experienced in implementing the GREEN & CLEAN Hospital Challenge, and a representative of a local administrative organization responsible for solid waste management. The Content Validity Index (CVI) was used, with a passing criterion of 0.80 or higher;[12] the CVI values of the individual instruments ranged from 0.90 to 0.94. The instruments were then tried out with 30 residents with characteristics similar to those of the sample in the area of a nearby subdistrict health promoting hospital. The reliability of the knowledge test (KR-20) was 0.81, and the Cronbach's alpha coefficients of the attitude, behavior, and satisfaction questionnaires were 0.87, 0.89, and 0.92, respectively, meeting the criterion of 0.70 or higher.[13]

Data Collection

The researcher collected pretest data in week 1 using the general information questionnaire, the knowledge test, and the attitude and behavior questionnaires. The program was implemented in weeks 2-6, and posttest data were collected in week 7 using the knowledge test and the attitude, behavior, and satisfaction questionnaires. Data were collected through interviews, and qualitative data were collected through observation and in-depth questioning during the program development phase.

Data Analysis

1. The general characteristics of the sample, namely sex, age, education level, occupation, income, number of household members, subdistrict of residence, distance to the waste collection point, availability of separated waste bins, and previous experience of receiving knowledge on solid waste management, were analyzed using frequency, percentage, arithmetic mean, and standard deviation. Qualitative data

from the situational survey and in-depth interviews for program development were analyzed using content analysis.

2. The mean scores of knowledge, attitudes, and household solid waste management behaviors before and after the program within the same group were compared using the paired t-test after testing for normality with the Shapiro-Wilk test (the Wilcoxon signed-rank test was to be used if the data were not normally distributed). The mean difference ($\bar{d}$), 95% confidence interval (95% CI), and effect size (Cohen's dz) were reported. Two-tailed tests were used, with statistical significance set at .05. Analyses were performed using SPSS version 26.0.

3. Satisfaction with the program was analyzed using mean and standard deviation and interpreted according to the criteria by item, by domain, and overall. Suggestions from the open-ended question were summarized by thematic grouping.

Research Ethics

This study was approved by the Human Research Ethics Committee of the Chumphon Provincial Public Health Office and was authorized by the Director of Phato Hospital prior to data collection. The researcher protected participants' rights by informing them in advance of the study objectives, procedures, duration of participation, and expected benefits. Participants had the right to accept or decline participation and to withdraw from the study at any time without any effect on their access to health services or any other rights. Data were kept confidential by using codes instead of real names, and the results were presented only in aggregate for academic purposes. All participants signed informed consent forms before participating in the study.

Results

1. General characteristics of the sample

Of the 42 participants, 23 were male (54.76%). The largest age group was 40-49 years (17 participants, 40.48%), with a mean age of 42.31±10.30 years (range 25-63 years). Most had completed primary education (19 participants, 45.24%). The main occupation was farming (orchards/field crops) (22 participants, 52.38%), followed by general labor (12 participants, 28.57%). The most common monthly household income was 5,000-10,000 baht (18 participants, 42.86%). The mean number of household members was 4.17±1.12. The most common distances from home to the waste collection point of the local administrative organization (LAO) were 3-5 km and more than 5 km (13 participants each, 30.95%), with a mean distance of 3.64±1.95 km. Thirty-one participants (73.81%) had no separated waste bins at home, and equal proportions had and had not previously received knowledge about solid waste management (50.00% each), as shown in Table 1.

Table 1 General characteristics of participants in the household solid waste management behavior promotion program, Phato Hospital, Chumphon Province (n = 42)

Characteristics	Number	Percentage
1. Sex		

Characteristics	Number	Percentage
Male	23	54.76
Female	19	45.24
2. Age (years)		
25-29 years	7	16.67
30-39 years	7	16.67
40-49 years	17	40.48
50-59 years	10	23.81
60 years and over	1	2.38
Age ($\bar{x}$±S.D.) = 42.31±10.30 years (min-max = 25-63 years)		
3. Education level		
Primary school	19	45.24
Lower secondary school	9	21.43
Upper secondary school/Vocational certificate	10	23.81
Diploma/High vocational certificate	2	4.76
Bachelor's degree or higher	2	4.76
4. Main occupation		
Farmer (orchards/field crops)	22	52.38
General laborer	12	28.57
Trader/Own business	6	14.29
Homemaker	1	2.38
Others	1	2.38
5. Average monthly household income		
Less than 5,000 baht	3	7.14
5,000-10,000 baht	18	42.86
10,001-20,000 baht	14	33.33
More than 20,000 baht	7	16.67
Income ($\bar{x}$±S.D.) = 12,559.52±6,780.75 baht		
6. Distance from home to the waste collection point of the local administrative organization (LAO)		
Less than 1 km	6	14.29
1.00-2.99 km	10	23.81
3.00-5.00 km	13	30.95
More than 5 km	13	30.95
Distance ($\bar{x}$±S.D.) = 3.64±1.95 km		
7. Availability of separated waste bins in the household		
Yes	11	26.19

Characteristics	Number	Percentage
No	31	73.81
8. Previous experience of receiving knowledge on solid waste management		
Yes	21	50.00
No	21	50.00

2. Results of the development of the household solid waste management behavior promotion program

The situational analysis based on the literature review, secondary data, in-depth interviews, and focus group discussions identified four key problems: 1) most residents lacked knowledge of waste separation by type, particularly the differences among recyclable, organic, and hazardous waste; 2) waste burning in agricultural areas was still accepted in the community; 3) most households had no separated waste bins; and 4) the waste collection system of the local administrative organizations did not reach remote areas. The researcher therefore designed a program with five components: screening and readiness assessment of participants; content and five behavior promotion activities; duration and frequency (5 weeks, 60-90 minutes per activity); program media and tools, namely videos, flipcharts, a household solid waste management handbook, and a behavior monitoring form; and follow-up and evaluation. The appropriateness of the program was assessed by three experts, yielding an overall S-CVI/Ave of 0.92. The CVI was 0.93 for the appropriateness of program content, the appropriateness of data collection instruments, and the feasibility of implementation, and 0.87 for the appropriateness of activities and implementation methods. The experts suggested adding waste samples from agricultural communities to the demonstration activity, simplifying the wording of the questionnaire items and linking them to the agricultural way of life, and scheduling home visits in line with the farmers' harvest seasons. The researcher incorporated these suggestions before actual implementation.

3. Comparison of knowledge, attitudes, and household solid waste management behaviors before and after receiving the household solid waste management behavior promotion program

3.1 Knowledge of household solid waste management Before the program, the mean knowledge score was 10.90±2.37 out of 20, a moderate level. The domain with the lowest score was knowledge of the impacts of improper waste management ($\bar{x}$ = 2.57 out of 5), and the items with the fewest correct answers were “Recyclable waste can be reused,” “Light bulbs, batteries, and pesticide containers are hazardous waste,” and “Separating wet waste from dry waste allows more hygienic waste disposal” (47.62% correct). After the program, the mean knowledge score increased to 12.02±4.24, remaining at a moderate level. The standard deviation nearly doubled, indicating considerable individual variation in response to the program. Scores increased in all domains, with the highest score in knowledge of GREEN & CLEAN and

greenhouse gas reduction ($\bar{x}$ = 3.12). The item with the greatest change was "Light bulbs, batteries, and pesticide containers are hazardous waste," with correct answers increasing from 47.62% to 69.05%.

3.2 Attitudes toward household solid waste management Before the program, the mean attitude score was 3.00±0.45, a moderate level. The domain with the lowest score was attitudes toward waste separation at source ($\bar{x}$ = 2.94), and the item with the lowest score was "Providing separated waste bins in the household is a worthwhile investment" ($\bar{x}$ = 2.86). After the program, the mean attitude score increased to 3.19±0.74, remaining at a moderate level, with scores increasing in all domains. The domain with the highest score was attitudes toward environmental impacts and climate change ($\bar{x}$ = 3.24), and the items with the greatest change were "Providing separated waste bins is a worthwhile investment" (from 2.86 to 3.19) and "Feeling proud if the household can reduce waste" (from 2.95 to 3.24).

3.3 Household solid waste management behaviors Before the program, the mean behavior score was 2.30±0.49, a low level. The domain with the lowest score was separation for recycling (Recycle) ($\bar{x}$ = 2.22), and the item with the lowest score was composting food and vegetable scraps or using them as animal feed ($\bar{x}$ = 2.10). After the program, the mean behavior score increased to 2.52±0.74, a moderate level, with all domains increasing to a moderate level. Separation for recycling had the highest score ($\bar{x}$ = 2.53) and showed the greatest change. The items with the highest scores were avoiding open burning of waste in the open or around the house and buying only necessary goods to reduce packaging waste ($\bar{x}$ = 2.60), and the item with the greatest change was composting food and vegetable scraps or using them as animal feed, which increased from 2.10 to 2.55, changing from a low to a moderate level.

3.4 Overall difference testing The paired t-test showed that the score differences were normally distributed. After the program, participants had significantly higher mean scores for knowledge ($\bar{d}$ = 1.12, 95% CI = 0.09-2.15, t = 2.128, p=0.039) and household solid waste management behaviors ($\bar{d}$ = 0.22, 95% CI = 0.01-0.42, t = 2.070, p=0.045) than before the program, with effect sizes (Cohen's dz) of 0.33 and 0.32, respectively, which are considered small. The attitude score ($\bar{d}$ = 0.19, 95% CI = 0.00-0.38, t = 2.010, p=0.051) did not differ significantly from before the program (dz = 0.31), as shown in Table 2.

Table 2 Comparison of mean scores of knowledge, attitudes, and household solid waste management behaviors before and after receiving the household solid waste management behavior promotion program (n = 42) (Paired t-test)

Variable (total score)	Before the program		After the program		95% CI of $\bar{d}$	t	dz	p-value
	$\bar{x}$	S.D.	$\bar{x}$	S.D.				
Knowledge (20)	10.90	2.37	12.02	4.24	0.09-2.15	2.128	0.33	0.039*

Variable (total score)	Before the program		After the program		95% CI of $\bar{d}$	t	dz	p-value
	$\bar{x}$	S.D.	$\bar{x}$	S.D.				
Attitudes (5)	3.00	0.45	3.19	0.74	0.00-0.38	2.010	0.31	0.051
Behaviors (5)	2.30	0.49	2.52	0.74	0.01-0.42	2.070	0.32	0.045*

*Statistically significant at p-value <.05

Note: Levels before ⟶ after the program: knowledge, moderate ⟶ moderate; attitudes, moderate ⟶ moderate; behaviors, low ⟶ moderate; df = 41; dz = Cohen's dz

4. Residents' satisfaction with the household solid waste management behavior promotion program

Overall satisfaction with the program had a mean score of 4.15±1.12 out of 5 (83.00%), a high level. All domains were at a high level, with the highest score in application in daily life ($\bar{x}$±S.D. = 4.26±0.37), followed by facilitators and organizers ($\bar{x}$±S.D. = 4.13±0.43), content and knowledge gained ($\bar{x}$±S.D. = 4.10±0.45), and activities and implementation methods ($\bar{x}$±S.D. = 4.09±0.37). By item, the highest score was willingness to recommend the program to household and community members ($\bar{x}$±S.D. = 4.38±0.79), followed by the program raising awareness of the importance of reducing household greenhouse gas emissions ($\bar{x}$±S.D. = 4.36±0.66). The items with the lowest scores, although still at a high level and with widely varying opinions, were the appropriateness of the amount of content ($\bar{x}$±S.D. = 3.95±1.10) and the appropriateness of the venue and timing of activities ($\bar{x}$±S.D. = 3.98±0.92), as shown in Table 3.

Table 3 Residents' satisfaction with the household solid waste management behavior promotion program, Phato Hospital, Chumphon Province (n = 42)

Satisfaction with the program	$\bar{x}$	S.D.	Level
1. Content and knowledge gained	4.10	0.45	High
2. Activities and implementation methods	4.09	0.37	High
3. Facilitators and organizers	4.13	0.43	High
4. Application in daily life	4.26	0.37	High
Overall (total score 5)	**4.15**	**0.20**	**High**

Discussion

The developed program passed expert quality assessment (CVI = 0.92) in terms of content, activities, instruments, and feasibility of implementation. This is because the development process was grounded in a comprehensive analysis of the actual situation in the area, including a literature review, in-depth interviews, and focus group discussions with stakeholders, resulting in content and activities that responded to the problems and context of the agricultural community. This is consistent with the proposition that effective solid waste

management behavior change programs must take into account the causal factors of undesirable behaviors, including lack of knowledge and negative attitudes,[14] and with a systematic review finding that behavioral interventions integrating feedback, social norms, and positive reinforcement are supported by empirical evidence for reducing waste and promoting waste separation.[15] Furthermore, using the GREEN & CLEAN Hospital Challenge low-carbon concept as the framework for program design concretely links the mission of health care facilities with solving environmental problems at the household level.

Regarding knowledge of household solid waste management, participants' knowledge scores increased significantly after the program, although the magnitude of change was small (an increase of 1.12 points, or 5.6% of the total score). This may be because the program used a variety of media, including videos, flipcharts, and examples from the agricultural way of life, which suited the participants, most of whom had primary education and worked in agriculture. This is consistent with a study finding that knowledge about solid waste is positively associated with household solid waste management behavior[5] and with a study finding that, after receiving a health literacy promotion program on solid waste management, the experimental group had significantly higher knowledge than before.[16] However, the overall knowledge score remained at a moderate level both before and after the program, which may be due to the relatively short duration of the program and the fact that content on GREEN & CLEAN and greenhouse gas reduction was new and unfamiliar to the target group. In addition, education level is positively associated with household waste management;[17] therefore, learning approaches specially suited to communities in remote areas need to be designed.

Regarding attitudes toward household solid waste management, attitude scores increased slightly but not significantly and remained at a moderate level. This reflects that attitude change usually takes longer than knowledge gain, as attitudes toward burning waste in orchards and fields and convenient dumping are tied to long-standing beliefs and practices in agricultural communities. This is consistent with a study finding that negative attitudes toward solid waste management are an important causal factor leading to inappropriate behaviors and that attitude change requires programs that take into account the specific context of the community.[14] Nevertheless, attitudes toward environmental impacts and climate change had the highest score after the program, indicating that content linking waste management with climate change can create new awareness among the target group. This is consistent with a study finding that attitudes are an important predictor of household waste reduction and separation behaviors.[6]

Regarding household solid waste management behaviors, behavior scores increased significantly and changed from a low to a moderate level, with separation for recycling showing the greatest change. Factors that may have contributed to this change include demonstrations using real waste samples from the agricultural community, combined with home visits for follow-up and positive reinforcement.

This is consistent with a study finding that, after receiving a health literacy promotion program, the experimental group had significantly better waste management behaviors than before,[16] and with evidence supporting positive reinforcement for changing waste management behaviors.[15]

However, behavior scores after the program remained at a moderate level, which may be due to limited structural enabling factors, as 73.81% of participants had no separated waste bins at home and 61.90% lived 3 km or more from the waste collection point of the local administrative organization. This is consistent with a study finding that good knowledge and attitudes alone are insufficient to bring about desirable waste management behaviors without structural enabling factors, such as waste containers and an accessible collection system.[18] This finding indicates that improving waste management behaviors in agricultural communities requires both individual capacity building and infrastructure support from local administrative organizations.

Regarding satisfaction, residents' overall satisfaction with the program was high. This may be because the program was designed to fit the real-life context of the agricultural community, using waste samples from the community, easy-to-understand language, and activities held at convenient times and places. This is consistent with a study finding that programs adapted to specific contexts and target groups are highly accepted.[16] The domain with the highest satisfaction was application in daily life, particularly the willingness to recommend the program to others and awareness of the importance of reducing household greenhouse gas emissions, reflecting the potential for scaling up through community networks. This is consistent with a study finding that social support is associated with household waste reduction and separation behaviors[6] and with evidence that community-level interventions based on social norms have the potential to sustain desirable behaviors in the long term.[15]

The items with the lowest satisfaction were the appropriateness of the amount of content and of the venue and timing of activities, although these were still at a high level. This suggests that the content was rather extensive relative to the duration of the activities and that activities should be scheduled in line with farmers' seasons and workloads. This is consistent with the suggestion that program design for remote communities with limited income and education must pay particular attention to the appropriate amount and depth of content.[17]

This study has several limitations: 1) it was a one-group study without a comparison group, so the results may have been influenced by other factors, such as environmental campaigns by other agencies and repeated administration of the same measures (testing effect); 2) behaviors were self-reported and may be subject to social desirability bias; 3) the observed effect size (dz of approximately 0.3) was smaller than that used for the sample size calculation (0.50), so the study may have been underpowered, particularly for the attitude variable; and 4) outcomes were measured only 1 week after the end of the activities, so the sustainability of behavior change cannot yet be concluded.

Conclusion

The household solid waste management behavior promotion program applying the GREEN & CLEAN Hospital Challenge concept on low carbon and climate change consisted of five activities over five weeks and was assessed as appropriate by experts. After the program, residents' knowledge and household solid waste management behavior scores increased significantly but with small effect sizes, with behaviors changing from a low to a moderate level, whereas attitudes did not change significantly. Residents were highly satisfied with the program. Its implementation should therefore be supplemented with structural enabling factors, such as separated waste bins and a collection system, together with long-term follow-up.

Recommendations

1. Recommendations for applying the research findings

1.1 Provincial and health region public health agencies should consider scaling up the household solid waste management behavior promotion program applying the GREEN & CLEAN Hospital Challenge low-carbon concept to other community hospitals serving agricultural communities dispersed in remote areas, incorporating it into environmental health work and allocating continuous budget support.

1.2 Local administrative organizations should integrate their solid waste management plans with Phato Hospital by supporting the provision of separated waste bins to households that still lack them, developing a waste collection system that reaches remote areas, and considering the issuance of local ordinances on waste management appropriate to the context of agricultural communities.

1.3 Health personnel and village health volunteers should be trained as leaders in promoting waste separation in the community, and learning media suited to the target group should be developed, such as illustrated leaflets, short videos, and waste separation guide signs installed in households, while adjusting the amount of content and the timing of activities to fit farmers' seasons and way of life.

1.4 A continuous monitoring and evaluation system should be established using household waste separation behavior records and home visits, together with a collaborative network among hospitals, subdistrict health promoting hospitals, local administrative organizations, schools, and farmer groups, to ensure the continuous and sustainable promotion of solid waste management behaviors.

2. Recommendations for future research

2.1 Future studies should use a research design with a control group, conduct long-term follow-up of at least 6 months to 1 year, and measure quantitative outcomes, such as reductions in waste weight and household greenhouse gas emissions, as well as explore the application of digital technologies, such as LINE Official Account, for monitoring and reinforcing behaviors in remote areas.

2.2 The sample size should be calculated based on the effect size found in this study (dz of approximately 0.3), and hypothesis testing

methods should be pre-specified to ensure adequate statistical power.

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