RESEARCH ARTICLE

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Environmental Management for *Opisthorchis viverrini* and Cholangiocarcinoma Prevention in a High-Risk Area of Thailand: The KALMeFS Model

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Abstract

Objective: Despite the Ministry of Public Health's initiative to involve local governments in waste management through the establishment of sewage treatment ponds aimed at disrupting the life cycle of *Opisthorchis viverrini* (OV), the majority of areas still lack adequate sewage treatment facilities. This action research sought to develop an environmental management model (EMM) to prevent OV and cholangiocarcinoma (CCA) in a high-risk region of Thailand. **Methods:** The study identified two primary target groups: a process development group comprising 20 participants and an evaluation group comprising 32 participants. Research tools involved structured interviews using questionnaires and focus group discussions. Quantitative data were analyzed using descriptive and inferential statistics, with a paired t-test employed for specific comparisons. Qualitative data were examined through content analysis. **Results:** The findings were categorized into three key aspects: (1) The contextual factors and challenges related to OV and CCA were analyzed using an epidemiologic triangle framework. (2) Model development: The Appreciation-Influence-Control (A-I-C) method facilitated several activities, including knowledge dissemination, raising awareness among local administrators, training environmental surveillance volunteer leaders (ESVL), developing public relations materials, conducting food waste management training, and constructing a sewage treatment system. (3) Model evaluation: Significant improvements ($p<0.05$) were observed in participants' knowledge, attitudes, behaviors, and health beliefs regarding OV and CCA prevention. The outcome of these efforts led to the creation of a new model, termed the "KALMeFS Model," which comprises K=Knowledge; A=Authority (raising awareness among administrators); L=Leader (establishing ESVLs); Me=Media development; F=Food waste management; and S=Sewage management. **Conclusion:** The initial steps toward establishing an effective EMM for OV and CCA prevention involved comprehensive planning, knowledge dissemination, standard-setting, and implementation. Monitoring and evaluation are critical to ensuring the long-term success of CCA prevention efforts in Thailand.

Keywords: *Opisthorchis viverrini*- cholangiocarcinoma- environmental management- sewage

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Introduction

Cancer is the leading cause of death in Thailand, according to public health statistics collected in 2022. Among the various types of cancer, liver and bile duct cancers have the highest mortality rate, particularly in Northeastern Thailand, where the death rate is 29.7 per 100,000 people [1]. Ubon Ratchathani Province has the highest prevalence of *Opisthorchis viverrini* (OV) and cholangiocarcinoma (CCA) in Thailand, with a 2009 survey reporting a prevalence rate of 28.7% [2]. This rate declined to below 10% in a 2019 survey [3]. Additionally, a study of behavioral risk factors found a 1.61-fold higher risk of OV infection compared to a reference area [4]. The primary cause of CCA is the consumption of undercooked freshwater fish contaminated with OV larvae, which invade the bile ducts, eventually leading to CCA [5]. This correlates with the dietary habits of the Northeastern population, who traditionally consume raw and fermented fish products, such as fermented and pickled fish, which contain nitrosamines known to accelerate cancer formation [6].

Given the established link between OV infection and CCA, it is crucial to investigate the causes of OV

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transmission to effectively prevent and control the disease [7, 8]. The main factors contributing to OV spread can be summarized as follows: (1) Water sources: OV completes its life cycle in snails and fish, which cohabit with water bodies and become vectors for humans, dogs, and cats. (2) Dietary habits: Consuming raw or undercooked white-scale freshwater fish. (3) Food waste management: Discarded raw fish is often fed to dogs and cats. (4) Waste management: Inadequate sanitation practices, including open defecation and the discharge of untreated sewage into the environment by vacuum trucks [9]. These factors perpetuate the OV life cycle and facilitate its transmission to humans [10].

A literature review indicates that most studies on OV and CCA prevention have focused on modifying individual behaviors [11, 12]. However, there has been limited research on environmental management as a strategy to prevent OV and CCA. Although the Ministry of Public Health has encouraged local governments to engage in waste management by constructing sewage treatment ponds to disrupt the OV life cycle, most areas lack such facilities. An assessment of local government organizations across Thailand's 12 health zones revealed that over 90% lack sewage treatment plants. Similarly, 95.82% of Ubon Ratchathani Province lacks a sewage treatment system [13]. There is no sewage treatment system in Huai Kha Subdistrict, Buntharik District, Ubon Ratchathani Province, and vacuum trucks discharge untreated waste directly into the environment.

These challenges are evident in Huai Kha Subdistrict, a rural area with 23 villages. The region is home to over 30 significant natural and artificial water sources, including the Dom Noi River, streams, reservoirs, and weirs, all providing white-scale freshwater fish. The local population adheres to Isan (Northeastern) cultural practices, including consuming raw, fermented, and pickled fish [14], putting them at elevated risk for OV infection and CCA. Regarding waste management, the Huai Kha Subdistrict Administrative Organization has contracted two private companies for garbage collection. However, there are ongoing concerns regarding the illegal disposal of waste by vacuum trucks in rural areas. Given these challenges, this study aims to develop an environmental management model to prevent OV and CCA in Huai Kha Subdistrict, Buntharik District, Ubon Ratchathani Province.

Materials and Methods

Study design

This study employed the PAOR (Planning, Action, Observation, Reflection) framework, a form of action research aimed at developing an environmental management model for the prevention of OV and CCA in Huai Kha Subdistrict, Buntharik District, Ubon Ratchathani Province. The research setting is represented by green areas (Figure 1). The model was constructed using both the Appreciation-Influence-Control (A-I-C) and Health Belief Model (HBM) frameworks.

Study participants

The study population comprised 17,847 residents of the Huai Kha Subdistrict, from which two target groups were selected. Group 1, involved in process development, consisted of 20 individuals chosen through purposive sampling, representing the academic sector (including one district public health officer, one environmental academic, one director of a sub-district health promotion hospital, one public health educator, and five village health volunteers), the political sector (the President of the Subdistrict Administrative Organization, the Permanent Secretary, Deputy Permanent Secretary, the Head of the Permanent Secretary's Office, and a council

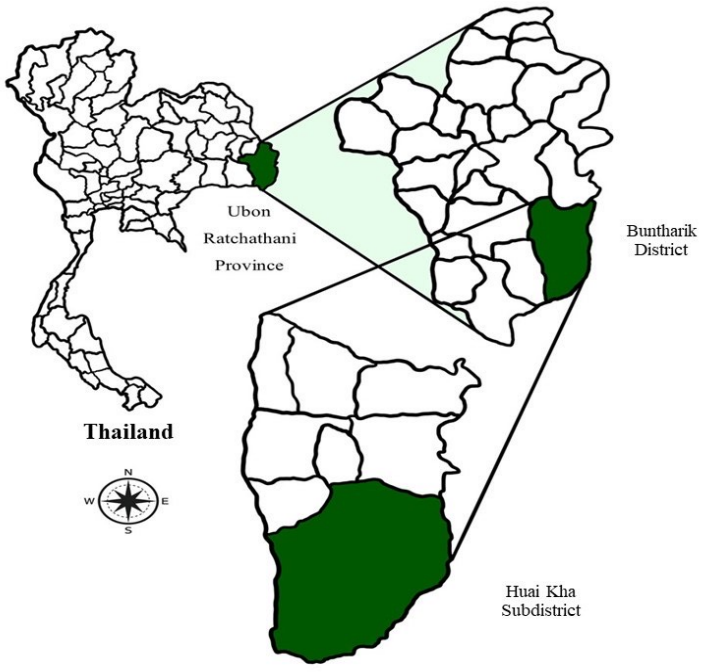

Figure 1. Determination of the Research Area. The green areas reflect the study setting.

member), and civil society (a village headman and five civil society representatives). Group 2, comprising 32 randomly selected residents, was used for evaluation and data collection.

Research tools and quality validation

The research instruments were divided into two categories: tools for conducting the research and tools for data collection.

Research Conduction Tools

These focused on the context and problems related to OV and CCA and the environmental management model developed through the PAOR cycle.

Data Collection Tools

Focus group discussions and a structured questionnaire, developed based on existing literature, were divided into five sections:

■ Demographic information (e.g., age, gender, education level)

■ Knowledge assessment of environmental management for OV and CCA prevention (20 questions; Index of item objective congruence (IOC) = 0.95, Kuder-Richardson 20 (KR-20) = 0.72)

■ Attitudes toward environmental management (15 questions on a 3-point scale; IOC = 0.91, Cronbach's Alpha Coefficient = 0.73)

■ Behavioral assessment (10 questions on a 4-point scale; IOC = 0.98, Cronbach's Alpha Coefficient = 0.72)

■ Health beliefs regarding environmental management (15 questions on a 5-point scale; IOC = 0.97, Cronbach's Alpha Coefficient = 0.72)

Data collection

Data collection was based on the PAOR cycle, divided into four phases:

Planning (P)

Relevant studies, concepts, and theories were reviewed, followed by community engagement to discuss research objectives, challenges, and potential interventions. Initial evaluations of knowledge, attitudes, behaviors, and health beliefs were conducted, and training sessions were organized for participants.

Action (A)

Six development activities were implemented, including knowledge dissemination, administrator awareness programs, environmental surveillance, media creation, community food waste management training, and the construction of a sewage treatment system.

Observation (O)

Monitoring and evaluation were conducted through participatory observation of the target groups, focusing on changes in knowledge, attitudes, behaviors, and health beliefs.

Reflection (R)

The development process's outcomes were summarized in a community forum, where challenges and recommendations for future improvements were discussed.

Statistical analysis

A statistical software package was employed to conduct descriptive analyses, including calculating percentages, means, and standard deviations. Before performing the statistical tests, the data were thoroughly checked for accuracy and completeness, with any missing or inconsistent values addressed. The assumptions for paired-sample t-tests were verified before proceeding with inferential analyses. Paired-sample t-tests ($p<0.05$) were used to compare pre-and post-intervention scores for knowledge, attitudes, behaviors, and health beliefs. Qualitative data were analyzed using content analysis, supplemented by data classification and synthesis to support the model development.

Results

Context and Problems of OV and CCA in the Study Area

Of the 32 participants, the majority were female (68.80%) and aged 41–50 (25.13%). Most were married (71.88%) and engaged in agriculture (78.13%). The study area, comprising 573 square kilometers of fertile forest and 23 villages, exhibited significant environmental management challenges. The primary issues were identified using the epidemiologic triangle:

Host

Lack of proper sanitation, consumption of raw fish, and limited knowledge.

Agent

OV larvae in raw fish and OV eggs in waste from humans, dogs, and cats.

Environment

Poor waste management practices, lack of sanitation infrastructure, and inadequate community cooperation.

Environmental Management Model for OV and CCA Prevention

The environmental management model was developed through the following four phases:

Planning (P)

Community engagement and participatory planning workshops were conducted based on the HBM and A-I-C frameworks. The focus was on assessing and enhancing the target group's knowledge, attitudes, behaviors, and health beliefs.

Action (A)

Six activities were implemented to address environmental management issues.

Observation (O)

The project was closely monitored, and post-intervention evaluations revealed significant improvements in knowledge, attitudes, behaviors, and health beliefs.

Table 1. The Levels of Knowledge, Attitudes, Behaviors, and Health Beliefs Regarding Environmental Management for Opisthorchiasis and Cholangiocarcinoma Prevention before and after the Model Development.

Related factors	Before		After	
	Number	Percentage	Number	Percentage
Knowledge				
High	12	37.5	29	90.63
Moderate	14	43.75	3	9.38
Low	6	18.75	0	0
	Mean=14.22, Min=4, Max=20		Mean=18.47, Min=15, Max=20	
Attitudes				
High	8	25	28	87.5
Moderate	15	46.88	4	12.5
Low	9	28.13	0	0
	Mean=20.84, Min=15, Max=30		Mean=27.31, Min=21, Max=29	
Behaviors				
High	4	12.5	30	93.75
Moderate	19	59.38	2	6.25
Low	9	28.13	0	0
	Mean=18.81, Min=11, Max=28		Mean=27.22, Min=22, Max=29	
Health beliefs				
High	13	40.63	30	93.75
Moderate	19	59.38	2	6.25
Low	0	0	0	0
	Mean=51.97, Min=40, Max=63		Mean=65.72, Min=53, Max=71	

Reflection (R)

A community forum summarized the lessons learned and provided recommendations. This led to the creation of the "KALMeFS Model."

Additionally, the development of the environmental management model for OV and CCA prevention in Huai Kha Subdistrict, Buntharik District, Ubon Ratchathani Province, led to the creation of a new model called the "KALMeFS Model." This model includes the following components: K (Knowledge) for providing education, A (Authority) for raising awareness among administrators, L (Leader) for establishing environmental surveillance volunteer leaders, Me (Media creation) for developing public relations materials, and F (Food waste management). The success of this environmental management strategy relied on the active participation of community members, who worked collaboratively to create a healthier environment and promote overall community well-being (Figure 2).

Evaluation of Environmental Management Model for OV and CCA Prevention

Before the development of the model, the target group's mean scores for knowledge, attitudes, behaviors, and health beliefs regarding environmental management for OV and CCA prevention were moderate: 43.75%, 46.88%, 59.38%, and 59.38%, respectively. Following the model's implementation, most of the target group demonstrated high mean scores: 90.63% for knowledge, 87.50% for attitudes, 93.75% for behaviors, and 93.75% for health beliefs (Table 1).

In terms of specific statistical measures, the target group's mean scores for knowledge, attitudes, behaviors, and health beliefs were found to be at a moderate level before the model development (Mean = 14.22, S.D. = 4.24; 20.84, S.D. = 4.62; 18.81, S.D. = 4.74; and 51.97, S.D. = 7.39, respectively). However, after the model was developed, these scores significantly increased, reaching high levels: 18.47 (S.D. = 1.48) for knowledge, 27.31 (S.D. = 2.15) for attitudes, 27.22 (S.D. = 1.83) for behaviors, and 65.72 (S.D. = 5.29) for health beliefs, with the differences being statistically significant at the 0.05 level (Table 2).

Discussion

In this study, we utilized the PAOR cycle of action research to develop an environmental management model for the prevention of OV and CCA in Huai Kha Subdistrict, Buntharik District, Ubon Ratchathani Province. The resulting ecological management model aligns with findings from a similar study conducted in the Pornsamran Sub-district, Khumuang District, Buriram Province, which focused on participatory prevention of OV [15]. Additionally, it reflects the efforts of Suriyut et al. [16], who developed a model to promote fruit and vegetable consumption for CCA prevention in high-risk Thai populations. Both studies adopted the PAOR cycle, using the A-I-C technique to achieve their objectives.

The success of this study's participatory OV prevention model was attributed to several key factors. Engaging relevant agencies, network partners, and the public in

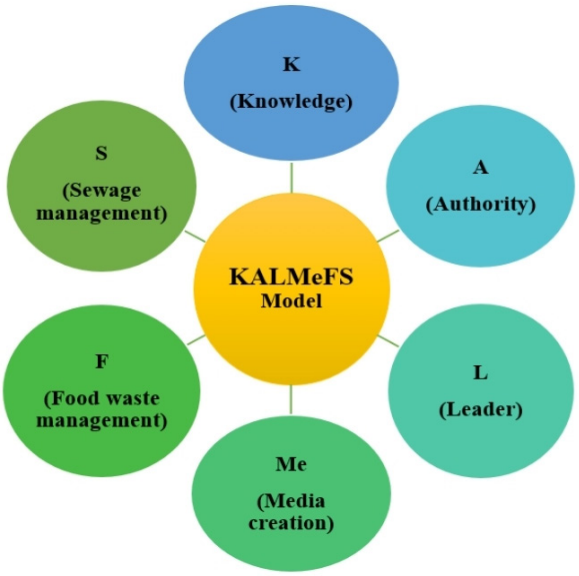

Figure 2. The Environmental Management Model for Opisthorchiasis and Cholangiocarcinoma Prevention in Huai Kha Subdistrict, Buntharik District, Ubon Ratchathani Province, Thailand: The "KALMeFS Model."

Table 2. Comparison of the Mean Scores of Knowledge, Attitudes, Behaviors, and Health Beliefs Regarding Environmental Management for Opisthorchiasis and Cholangiocarcinoma Prevention before and after the Model Development.

Factors	n	Mean	S.D.	Mean Difference	95% CI	p-value
Knowledge						
Before	32	14.22	4.24	4.25	2.91 - 5.59	<0.001
After	32	18.47	1.48			
Attitudes						
Before	32	20.84	4.62	6.47	5.06 - 7.87	<0.001
After	32	27.31	2.15			
Behaviors						
Before	32	18.81	4.74	8.41	7.08 - 9.72	<0.001
After	32	27.22	1.83			
Health beliefs						
Before	32	51.97	7.39	13.75	12.06 - 15.44	<0.001
After	32	65.72	5.29			

every stage—acknowledging issues, identifying solutions, and conducting follow-up and evaluation was essential. This mirrors the findings of Wayru et al. [17] in their study on OV prevention and control in Ban Yuat Sub-district, Udon Thani Province. Their success was attributed to the D-H-B principle: Development tailored to local issues, Harmony among all stakeholders, and Best Behavior to empower the community.

The improvement in the mean knowledge score can be attributed to a comprehensive training program that provided knowledge on environmental management for OV and CCA prevention, trained volunteer leaders, and developed public relations media. This approach is consistent with previous studies that demonstrated significant improvements in knowledge following targeted educational interventions for OV prevention [15]. Similarly, Ketrum [18] reported significant increases in knowledge among community leaders trained in OV prevention, with the experimental group outscoring the control groups by 2.35 points.

The shift in the mean attitude score was attributed to training initiatives that provided knowledge on environmental management for OV and CCA prevention, the training of surveillance volunteer leaders, and the creation of public relations media. This is consistent with a study on developing a community-based model for preventing and controlling OV in Lahan Sub-district, Chatturat, Chaiyaphum. In that study, a traveling parasite project was introduced to raise awareness of OV prevention, which reduced risky behavior related to raw fish consumption, decreasing from 36.3% to 9.7% [19]. Similarly, a study on health education programs that applied the health belief model, supported by social engagement, to prevent OV and CCA in individuals aged 40 and above in Muangmai Sub-district, Sriboonruang District, Nongbua Lamphu Province, also reported

significant improvements. After the intervention, the experimental group exhibited significantly better behaviors than their pre-intervention status and the control group [20].

The enhanced health belief scores following the model's development were driven by the same factors influencing attitude scores: training, public relations efforts, and the involvement of community leaders. This result is consistent with research by Intanam and Muangsom, [21], who found that health education programs based on the health belief model and social support significantly improved perceptions of severity, vulnerability, self-efficacy, and preventive behaviors among schoolchildren. Similarly, Chayngam et al. [20] observed significant improvements in health beliefs and behavior after applying the health belief model to OV and CCA prevention in a high-risk population.

Strength and Limitations

The main strength of this study is the active involvement of local executives and the community, which fostered genuine awareness of the area's environmental problems. However, limitations include research time and budget constraints, with some activities, such as constructing a sewage treatment pond, still pending due to budgetary considerations.

In conclusion, this study represents the first attempt to develop an environmental management model to prevent the spread of liver flukes (OV), a precursor to CCA. The model's creation involved several steps: planning, community education, guideline development, and implementation through six key activities—public relations, awareness-building, environmental surveillance leader training, food waste management, and sewage treatment. The "KALMeFS Model" emerged as a result of this effort, with its success driven by collaboration across academic, political, and public sectors, all contributing to improved public health outcomes.

Author Contribution Statement

All authors participated in the study design. JJ, PC, and NS conceived and designed the research. JJ, PC, and NS connected and coordinated the fieldwork. JJ collected the data. JJ, CT, and WC carried out the analyses. JJ reviewed drafts of the paper. All authors contributed to the writing and revisions of the manuscript and approved the final version.

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Ethical approval

This study has received approval from the Ubon Ratchathani Rajabhat University Ethics Committee for Human Research, based on the Declaration of Helsinki and the ICH-GCP Guidelines (Reference Number: HE662051). Before participating in the study, The researcher asked the participants to sign a consent form. The researcher thoroughly explained the objectives, study design, potential risks, and benefits. All participants can withdraw anytime if they are inconvenienced during the research.

Availability of data (if apply to your research)

Data will be available upon request.

Conflict of interest

The authors declare no competing interests.

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