

RESEARCH ARTICLE

Editorial Process: Submission:04/26/2025 Acceptance:10/02/2025 Published:10/19/2025

Prevalence and Factors Affecting the Prevention of *Opisthorchis viverrini* Infection in Khon Kaen Province, Northeast Thailand

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Abstract

Backgrounds: *Opisthorchis viverrini* is a significant risk factor for bile duct cancer and poses a public health problem in Southeast Asia. In northeastern Thailand, the consumption of raw freshwater fish is a common practice and a cause of *O. viverrini* infection. This study investigated the factors influencing the consumption of raw freshwater fish. **Methods:** This analytical cross-sectional study was conducted between September and December 2024, covering areas in Khon Kaen Province with varying prevalences of liver fluke disease. Stratified multistage cluster sampling, proportional to size, was used to select representative participants from different sex and age groups. The eligibility criteria included individuals aged 18 years and older living in Khon Kaen who were interviewed using a structured questionnaire. The questionnaire included sections on sociodemographic characteristics, health beliefs regarding liver fluke disease, preventive behaviors, and knowledge of *O. viverrini* prevention. Preventive behaviors were defined as avoiding the consumption of 10 types of staple raw freshwater fish. Multiple logistic regression was used to identify potential factors influencing preventive behaviors. **Results:** Among the 980 participants, 896 (91.4%) reported consuming raw freshwater fish at least once per month. Of these, 299 participants lived in areas with an *O. viverrini* infection prevalence of $\geq 3.3\%$. More than half of the participants were agriculturists (53.2%), 23.7% were daily laborers, and 8.3% were unemployed. Factors independently associated with the prevention behaviors include age ≤ 50 years, with specific groups as follow: 18–30 years (AOR 6.2, 95% CI: 2.7-14.0); age 31–40 years (AOR 2.6, 95% CI: 1.1-6.2); and 51–60 years (AOR 2.9, 95% CI: 1.3-6.2), compared to the older age group (>60 years); living outside municipality (AOR 1.8, 95% CI: 1.1-2.9); Agriculturist (AOR 5.0, 95% CI: 2.4-14.9), Unemployment/No information (AOR 5.0, 95% CI: 1.6-15.0); Trading/Civil officer/Private sector employee (AOR 4.0, 95% CI: 1.6-10.0), compared to daily laborer; Never or stopped consumed alcohol (AOR 3.4, 95% CI: 1.8-6.3); higher perceived benefit (AOR 2.4, 95% CI: 1.2-4.9); higher perceived severity (AOR 2.6, 95% CI: 1.5-4.3) and higher self-efficacy (AOR 2.9, 95% CI: 1.3-6.7). **Conclusion:** The consumption of raw freshwater fish is common in the northeastern Thai population. Health education campaigns should focus on promoting the benefits of prevention, severity of the infection, and enhancing participants' self-efficacy. Targeting vulnerable groups such as the elderly, residents of municipal areas, and individuals with lower socioeconomic status is strongly recommended.

Keywords: *Opisthorchis viverrini*- Consumption of raw freshwater fish- Prevention behavior- Liver fluke

Asian Pac J Cancer Prev, 26 (10), 3785-3795

Introduction

Southeast Asian Liver Fluke disease is caused by *Opisthorchis viverrini*, a public health problem in the Great Mekong Subregion (GMS). The GMS prevalence of *O. viverrini* was 21.11% [95% confidence interval (CI): 17.74-24.47%]. Pooled prevalence estimates were highly observed in Laos (34.06%, 95% CI: 26.85-41.26%), followed by Thailand (18.19%, 95% CI: 13.86-22.51%),

and Cambodia (10.48%, 95% CI: 5.52-15.45%) [1]. *O. viverrini* infection is a significant risk factor for the development of cholangiocarcinoma (CCA) or bile duct cancer. Its incidence is increasing in China, Korea, and Thailand, particularly in northeastern Thailand [2], which has the highest worldwide incidence (85 per 100,000 per year) [3-4]. Despite advances in treatment, survival rates remain low. The 3-year survival rate averages 21.7% (95%CI: 12.0 to 33.2) [5], while the 3-year relative

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survival rate is 10.6% (95%CI: 9.3–12.0) for ages 51–61 [6]. The consumption of raw freshwater fish, mainly carp species infected with metacercariae, is common in northeastern Thailand and is linked to the transmission of *O. viverrini* [7–8]. This includes eating raw or undercooked freshwater fish in various forms, such as Fish Salad, Koi, Pickled Fish, Raw Orange Fish, other preserved raw fish, Spicy Minced Raw Fish Salad, Raw Minnows in Papaya Salad, all of which contribute to the persistent *O. viverrini* infection in the region [9].

Several other risk factors, including age, education, place of residence, medical history, knowledge, health beliefs (i.e., perceptions of the risk and severity of liver fluke disease), misconceptions, unhealthy eating habits, and sanitary conditions, also contribute to the development of opisthorchiasis [8,10]. A recent systematic review and original research on factors associated with *O. viverrini* infection concluded that demographic, environmental, and geographic factors; health behaviors; treatment with praziquantel; and history of *O. viverrini* infection were all linked to an increased infection risk [10–14]. Misconceptions, such as the belief that using lime or red ants in koi pla or eating koi pla with white whiskey can ‘cook’ the fish or that early stage cholangiocarcinoma can be cured, have been associated with an increased risk of *O. viverrini* infection in high-risk populations [8]. Changing health beliefs and eating habits are essential for reducing the risk of *O. viverrini* infection and its potential progression to cholangiocarcinoma [8].

Khon Kaen province had the highest prevalence of CCA and liver fluke infection globally [3–4]. Fish from lakes in Khon Kaen province showed a prevalence of *O. viverrini* infection as high as 70% [15]. According to the latest national survey on the consumption of raw freshwater fish, people in the northeastern region consume raw freshwater fish the most (18.7%), which is higher than the national average (10.9%) [16]. The main reasons for consuming these dishes were eating with close family members or relatives (55.5%), eating during festivals or special occasions, ease of obtaining these dishes (41.1%), and belief that the taste is better than cooked fish (37.9%) [16].

This study aimed to explore the factors associated with liver fluke prevention behaviors using the Health Belief Model (HBM). Modifying health beliefs and dietary habits is crucial for reducing *O. viverrini* infection and the associated risk of cholangiocarcinoma. The findings could help promote health education in the population of Khon Kaen as well as in Thailand and neighboring countries.

Materials and Methods

Study design

We conducted an analytical cross-sectional survey to assess liver fluke prevention behavior using the Health Belief Model (HBM) framework, which suggests that people’s beliefs about their health problems, perceived benefits, cues to action, barriers, and self-efficacy explain engagement (or lack thereof) in health-promoting behavior. Also cue to action must also be present to trigger health-promoting behaviors [17].

Sample size calculations

A sample size calculation for proportion was used to determine the sample size [18] based on a previously reported 55% [16] proportion of households consuming raw freshwater fish, with a design effect of 1.5, precision of 4%, and adjusted for 10% non-participation. A total of 980 individuals participated in this survey.

A stratified multistage cluster sampling method, proportional to size was used from September to December 2024 to select a representative sample of participants living in areas where eating uncooked freshwater fish was common. In the first stage, areas in Khon Kaen province were categorized into three groups based on the prevalence of *O. viverrini* infection diagnosed during the past year: $\leq 1\%$, 1.1%–3.2%, and $\geq 3.3\%$ [19]. Three districts were randomly selected from each group, using simple random sampling without replacement. One sub-district was randomly selected from each district, and two villages were randomly selected from each sub-district. Nine districts were included in the study, and each district was randomly chosen.

Using the census list of household residents obtained from the Sub-district Health Promotion Hospital, the required number of participants was selected random systematically according to their age and sex. If more than one participant was selected from a household of the same age group or sex, only one individual was chosen.

Data collection

An interview questionnaire consisting of four parts (sociodemographic characteristics, prevention behaviors regarding raw freshwater fish consumption, knowledge of *O. viverrini* infection, and HBM domains) was developed based on a literature review. Three experts evaluated the questionnaire to assess overall item-objective congruence for content validity. Each expert rated the alignment of each item with the research objectives using a scale ranging from -1 to 1 (1 = consistent, 0 = somewhat consistent, -1 = not consistent). Items with an IOC value of 0.5 or higher were retained. Using the method proposed by Rovinelli and Hambleton [20], the overall IOC (i.e., the mean IOC across all items) was calculated to be 0.91.

The wording was edited to reflect the local dialect and to prevent potential misinterpretations. Prior to the data collection, a pilot study was conducted to assess the reliability of the questionnaire. A sample of 30 participants from the same province, all of whom met the study’s inclusion criteria, was used. The reliability test showed that all subscales of HBM had good internal consistency (Cronbach’s alpha coefficient, $\alpha = 0.7 - 0.9$), with an overall $\alpha = 0.8$.

Perceived susceptibility, and severity each consisted of six items. The higher the score for each item (the closer it is to 5), the more likely the respondent perceives themselves as susceptible to the infection (or to feel that it is severe). The possible scores for each domain ranged from 6 to 30. Perceived benefit and cue to action consisted of seven items each. The higher the score for each item (closer to 5), the more likely the respondent perceived the benefits of action to prevent the infection (or was more likely to accept a recommended health action). The

possible scores for each domain ranged between 7 and 35. Perceived barriers and self-efficacy comprised eight items. The higher the score for the barrier (closer to 5), the less likely the respondent was to engage in preventive behavior. The higher the score for self-efficacy (closer to 5), the more likely the respondent was to engage in preventive behaviors. The possible scores for each domain ranged between 8 and 40.

The outcome of interest was measured by self-reports of not eating any uncooked freshwater fish in the usual manner, including the following: pla ra bong (Fermented fish chili sauce), jaew prik dib with raw fermented fish (Fermented fish spicy dip), som tam with raw fermented fish (Papaya salad), som pla (Picked raw fish), som pla noy (Picked raw small fish), pla jom (Picked raw minnow), som kai pla (Picked raw egg of fish), mum kee pla (Picked raw fish intestines), koi pla (spicy raw fish salad), and lab pla (spicy chopped raw fish salad).

Statistical methods

Frequencies and proportions were used to describe variables measured on a nominal scale, such as socio-demographic characteristics. The mean (standard deviation) or median (interquartile range) were used to describe variables measured on interval or ratio scales based on normality.

Diagram 1 showing the conceptual framework of the analysis. Factors associated with not eating uncooked freshwater fish were evaluated using Multiple Logistic Regression, and those with a p-value ≤ 0.10 in the bivariate analysis were included in the multivariable analysis [21].

Owing to the multicollinearity between the district and area group variables, only the area group variable was included in the logistic model. Similarly, only the age

group variable was included because of multicollinearity between the age group and education variables. The same rationale was applied to cigarette smoking and alcohol consumption, as well as household distance from the pond and family consumption of uncooked fish, with only alcohol consumption and distance variables retained in the model. Statistical significance was set at $P < 0.05$. All analyses were performed using STATA® (version p-value 18, 2023; Stata Corp., College Station, Texas, USA).

Results

Participant and household characteristics

Table 1 presents the participants' sociodemographic characteristics. A total of 980 individuals participated in this study. Of these, 299 (30.5%) resided in areas with a prevalence of *O. viverrini* infection of $\geq 3.3\%$. The participants were distributed across Khon Kaen province, with percentages ranging from 9.1% in Phra Yuen district to 14.1% in Mancha Khiri District. They were also evenly distributed in the municipal areas, with 47.8% of the participants living within the municipality. Approximately eight out of ten participants (78.2%) lived in households 1 and 5 km from the pond. Approximately two-thirds of participants resided in households with a monthly income of at least 5000 THB. (Thai Baht or ~150 USD)

Nearly half of the participants were male for individual characteristics (49.0%). The median age of the participants was 47 years, with 21.4% in the 18-30 age group. A small majority of the participants had secondary or vocational education (55.1%), while nearly 40% reported having less than a primary school education (39.4%). More than half of the participants reported working in agriculture (53.2%), 23.7% were engaged in daily labor, and 8.3%

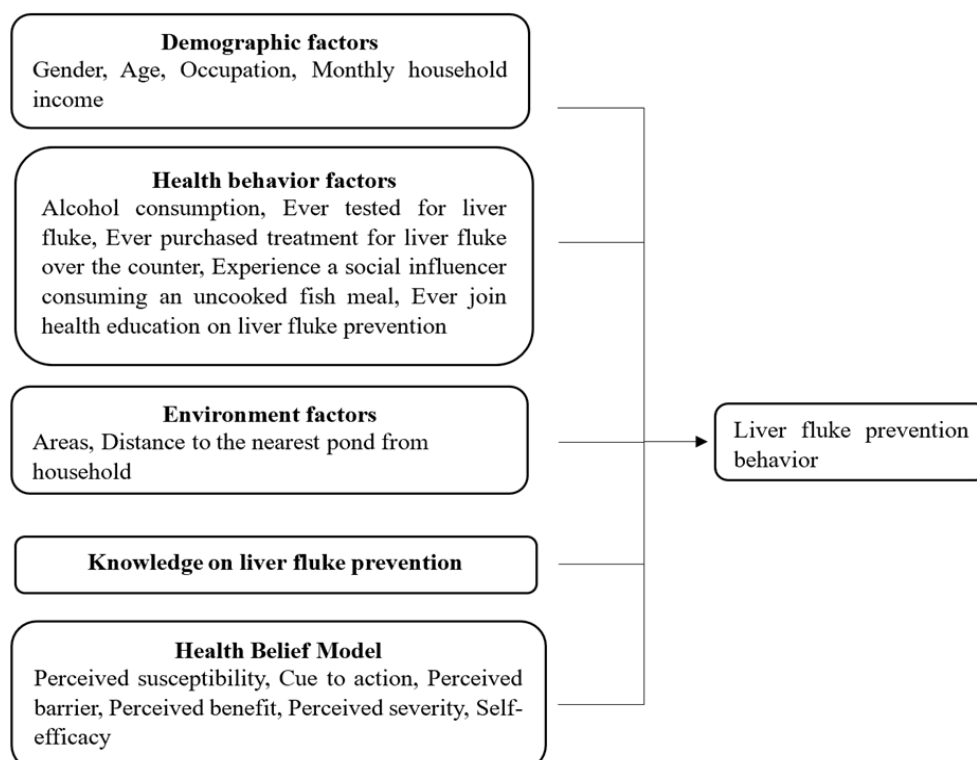


Diagram 1. Conceptual Framework for the Analysis

Table 1. Sociodemographic Characteristics of Participants in the Study of Prevalence and Factors Related to Liver Fluke Prevention Behavior in Khon Kaen Province, Thailand, 2024

Characteristics	Number	%	Median	Interquartile Range
Overall	980	100		
District				
Sam Sung	97	9.9		
Phon	92	9.4		
Phra Yuen	89	9.1		
Si Chomphu	103	10.5		
Kranuan	101	10.3		
Ubolratana	95	9.7		
Mancha Khiri	138	14.1		
Waeng Noi	135	13.8		
Ban Fang	130	13.3		
Area group				
Prevalence $\geq 3.3\%$	299	30.5		
Prevalence 1.1%-3.2%	403	41.1		
Prevalence $\leq 1.0\%$	278	28.4		
Area				
Inside municipality	468	47.8		
Outside municipality	512	52.2		
Distance to a nearest pond from household (km.)			1	1, 2
< 1 km.	185	18.9		
1-5 km.	766	78.2		
> 5 km.	29	3		
Gender				
Male	480	49		
Female	500	51		
Age (years)			47	33, 59
Age group (years)				
18-30	210	21.4		
31-40	170	17.3		
41-50	185	18.9		
51-60	183	18.7		
> 60	232	23.7		
Education complete				
No school/Primary school	386	39.4		
Secondary/Vocational school	540	55.1		
Bachelor/higher	54	5.5		
Occupation				
Unemployment	81	8.3		
Agriculturist	521	53.2		
Trading	54	5.5		
Daily laborer	232	23.7		
Civil officer	30	3.1		
Private sector employee	55	5.6		
No information	7	0.7		
Monthly household income (THB)			5,000	3,500 -10,000
< 5000	356	36.3		
≥ 5000	624	63.7		

were unemployed.

Most participants reported neither drinking alcohol nor smoking cigarettes (55.9% and 76.1%, respectively). One-third of participants (32.9%) reported being tested for *O. viverrini* infection. Among those tested, 40 (12.4%) were diagnosed with *O. viverrini* and 34 of them received treatment. However, approximately one-fourth of the participants (24.1%) reported purchasing treatment for liver fluke infection over-the-counter, 70.1% reported that their family members consumed uncooked fish, and 35.1% reported participating in health education on liver fluke prevention.

Only 6.2% of all participants had good knowledge of the prevention of *O. viverrini* infection, whereas nearly half (47.6%) had an unfavorable level of knowledge (i.e., poor or correctly answered <60%), as measured by our questionnaire. Among the 60 participants with a high level of knowledge, 34 (56.7%) lived outside the municipality, while 26 (43.3%) lived inside the municipality (data not shown). Less than 10% of participants reported that they did not eat uncooked freshwater fish. The distribution of HBM domains among the participants is presented in Table 2.

Factors associated with the practice of poor prevention behaviors

More than 90% of participants reported eating raw freshwater fish at least once a month or more frequently. Regarding household characteristics, participants living outside municipality areas were more likely to report not eating uncooked freshwater fish (AOR 1.8, 95% CI: 1.1, 2.9) than those living in households located within municipality areas, which served as the reference group. Not eating any uncooked freshwater fish was also associated with age, with 14.3% in the 18–30 years group reporting this behavior (AOR 6.2, 95% CI: 2.7, 14.0), 7.1% in the 31–40 years group (AOR 2.6, 95% CI: 1.1, 6.2), and 10.9% in the 51–60 years group (AOR 2.9, 95% CI: 1.3, 6.2) compared to the older age group (>60 years), which served as the reference group. The avoidance of uncooked freshwater fish was correlated with occupation: 9.1% of the unemployed reported this behavior (AOR 5.0, 95% CI: 1.6, 15.0), 9.4% of agriculturists (AOR 6.0, 95% CI: 2.4, 14.9), and 14.4% of trading/civil officer/private sector employees (AOR 4.0, 95% CI: 1.6, 10.0), in comparison to the daily laborer, which served as the reference group. Participants who reported not drinking

Table 2. Health Behaviors Reported by the Participants in the Study of Prevalence and Factors Related to Liver Fluke Prevention Behavior in Khon Kaen Province, Thailand, 2024.

Characteristics	Number	%	Median	Interquartile Range
Overall	980	100		
Alcohol consumption				
Yes	380	38.8		
Number of times per month			3	2, 5
No	548	55.9		
Stop drinking	52	5.3		
Cigarettes smoking				
Yes	200	20.4		
Number of cigarettes per day			5	4, 10
No	746	76.1		
Stop smoking	34	3.5		
Ever tested for <i>O. viverrini</i> infection				
Ever	322	32.9		
Diagnosed for <i>O. viverrini</i>				
Yes	40	12.4		
Received treatment				
Yes	34	85.0		
No	6	15.0		
No	268	83.2		
Not sure	13	4.3		
Never	607	62.0		
Not sure	51	5.1		
Ever purchased treatment for liver fluke infection over the counter				
Yes	236	24.1		
No	744	75.9		
Experience social influencer consume uncooked fish				
Yes	545	55.6		

Table 2. Continued

Characteristics	Number	%	Median	Interquartile Range
Number of times per month			2	1, 3
No	435	44.4		
Experience family member consume uncooked fish				
Yes	687	70.1		
No	293	29.9		
Ever join health education on liver fluke prevention				
Yes	344	35.1		
Number of times Health educator			1	1, 2
Public Health office	303	88.1		
Village Health Volunteer	39	11.3		
Other	2	0.6		
No	636	64.9		
Knowledge score			6	4, 7
Knowledge on liver fluke prevention				
Poor	467	47.6		
Moderate	453	46.2		
Good	60	6.2		
Behaviors score				54, 68
Consumption of uncooked freshwater fish				
Not at all	84	8.6		
Monthly or more often	896	91.4		
HBM: Perceived Susceptibility				
Low susceptible	104	10.6		
Moderate	658	67.1		
High susceptible	218	22.2		
HBM: Cue to action				
Not engaged (Low)	4	0.4		
Moderate	156	15.9		
Engaged (high)	820	83.7		
HBM: Perceived Barrier				
Less barrier	462	47.1		
Moderate barrier	437	44.6		
High barrier	81	8.3		
HBM: Perceived Benefit				
Low benefit	6	0.6		
Moderate	539	55.0		
High benefit	435	44.4		
HBM: Perceived Severity				
Low severity	71	7.2		
Moderate	611	62.3		
High severity	298	30.4		
HBM: Self-efficacy				
Low self-efficacy	16	1.6		
Moderate	617	63.0		
High self-efficacy	347	35.4		

alcohol or had already stopped drinking were more likely to report not eating uncooked freshwater fish than those who had consumed alcohol. Specifically, 11.7% of non-drinkers or those who had already stopped drinking

reported this behavior, compared to 3.7% of alcohol drinkers (AOR 3.4, 95% CI: 1.8, 6.3).

Several HBM domains were not associated with the consumption of uncooked freshwater fish. Participants

Table 3. Factors associated with Prevention Behavior among Participants in the Study of Prevalence and Factors Related to Liver Fluke Prevention Behavior in Khon Kaen Province, Thailand, 2024.

Factors	Consume uncooked freshwater fish No. (%)		OR	p-value	Multivariable Analysis	
	Not at all 84 (8.6)	Monthly/More often 896 (91.4)			AOR	95% CI
Area group				0.17		
Prevalence >=3.3%	18, 6.0	281, 94.0	0.6			
Prevalence 1.1%-3.2%	39, 9.7	364, 90.3	1			
Prevalence <=1.0%	27, 9.7	251, 90.3	Ref			
Area				0.06		
Outside municipality	52, 10.2	460, 89.8	1.5		1.8	1.1, 2.9
Inside municipality	32, 6.8	436, 93.2	Ref		Ref	
Distance to the nearest pond from household				0.74		
≤5 km	82, 8.6	869, 91.4	1.3			
> 5 km	2, 6.9	27, 93.1	Ref			
Gender				0.62		
Male	39, 8.1	441, 91.9	0.9			
Female	45, 9.0	455, 91.0	Ref			
Age group (years)				<0.01		
18-30	30, 14.3	180, 85.7	2.8		6.2	2.7, 14.0
31-40	12, 7.1	158, 92.9	1.3		2.6	1.1, 6.2
41-50	9, 4.9	176, 95.1	0.9		1.4	0.6, 3.5
51-60	20, 10.9	163, 89.1	2.1		2.9	1.3, 6.2
> 60	13, 5.6	219, 94.4	Ref		Ref	
Occupation				<0.01		
Unemployment/No information	8, 9.1	80, 90.9	3.2		5	1.6, 15.0
Agriculturist	49, 9.4	472, 90.6	3.3		6	2.4, 14.9
Trading/ Civil officer/ Private sector employee	20, 14.4	119, 85.6	5.4		4	1.6, 10.0
Daily laborer	7, 3.0	225, 97.0	Ref		Ref	
Monthly household income (THB)				0.28		
< 5000	26, 7.3	330, 92.7	0.8			
≥5000	58, 9.3	566, 90.7	Ref			
Alcohol consumption#				<0.001		
No/ Already stopped	70, 11.7	530, 88.3	3.4		3.4	1.8, 6.3
Yes	14, 3.7	366, 96.3	Ref		Ref	
Ever tested for liver fluke				0.28		
Ever	32, 9.9	290, 90.1	1.3			
Never/ Not sure	52, 7.9	606, 92.1	Ref			
Ever purchased treatment for liver fluke over the counter				0.03		
Yes	72, 9.7	672, 90.3	2		1.7	0.9, 3.4
No	12, 5.1	224, 24.9	Ref		Ref	
Experience a social influencer consuming an uncooked fish meal				0.28		
Yes	42, 7.7	503, 92.3	0.8			
No	42, 9.7	393, 90.3	Ref			
Ever join health education on liver fluke prevention				0.02		
Yes	39, 11.3	305, 88.7	1.7		1.2	0.7, 2.0
No	45, 7.1	591, 92.9	Ref		Ref	
Knowledge on liver fluke prevention				0.38		
Poor/ Moderate	77, 8.4	843, 91.6	0.7			
Good	7, 11.7	53, 88.3	Ref			

Due to multicollinearity between the district and area group variables, only the area group variable was included in the logistic model. Similarly, because of multicollinearity between the age group and education variables, only the age group variable was included. The same rationale applied to cigarettes smoking and alcohol drinking, as well as household distance from the pond and family consumption of uncooked fish, with only the alcohol drinking and distance variables retained in the model. OR, Odd Ratio; AOR, Adjusted Odd Ratios; CI, Confidence Interval; ± p-value = 0.06

Table 3. Continued

Factors	Consume uncooked freshwater fish No. (%)		OR	p-value	Multivariable Analysis	
	Not at all 84 (8.6)	Monthly/More often 896 (91.4)			AOR	95% CI
Knowledge on liver fluke prevention				0.38		
Poor/ Moderate	77, 8.4	843, 91.6	0.7			
Good	7, 11.7	53, 88.3	Ref			
HBM: Perceived Susceptibility				<0.001		
High susceptible	52, 12.6	359, 87.4	2.4		1.6	1.0, 2.7 ±
Low & Moderate susceptible	32, 5.6	537, 94.4	Ref		Ref	
HBM: Cue to action				0.25		
Engaged (High)	74, 9.0	746, 91.0	1.5			
Not engaged (Low/Moderate)	10, 6.2	150, 93.8	Ref			
HBM: Perceived Barrier				0.13		
Less/Moderate barrier	83, 8.9	853, 91.1	4.2			
High barrier	1, 2.3	43, 97.7	Ref			
HBM: Perceived Benefit				<0.001		
High benefit	74, 10.5	629, 89.5	3.1		2.4	1.2, 4.9
Low/Moderate benefit	10, 3.6	267, 96.4	Ref		Ref	
HBM: Perceived Severity				<0.001		
High severe	61, 12.3	436, 87.7	2.8		2.6	1.5, 4.3
Low/ Moderate severe	23, 4.8	460, 95.2	Ref		Ref	
HBM: Self-efficacy				<0.01		
High self-efficacy	77, 10.2	681, 89.8	3.5		2.9	1.3, 6.7
Low/ Moderate self-efficacy	7, 3.1	215, 96.9	Ref		Ref	

Due to multicollinearity between the district and area group variables, only the area group variable was included in the logistic model. Similarly, because of multicollinearity between the age group and education variables, only the age group variable was included. The same rationale applied to cigarettes smoking and alcohol drinking, as well as household distance from the pond and family consumption of uncooked fish, with only the alcohol drinking and distance variables retained in the model. OR, Odd Ratio; AOR, Adjusted Odd Ratios; CI, Confidence Interval; ± p-value = 0.06

with a high perception of benefits were likelier to engage in this behavior (AOR 2.4, 95% CI: 1.0, 4.9). Similarly, those with a high perception of severity were more likely to engage in this behavior (AOR 2.6, 95% CI: 1.5, 4.3). Additionally, participants with high self-efficacy were also more likely to engage in this behavior (AOR 2.9, 95% CI: 1.3, 6.7) (Table 3).

Discussion

Our study found that fewer than one in ten individuals refrained from eating raw freshwater fish, a prevention behavior against *O. viverrini* infection. This behavior is prevalent among those living outside municipal areas, individuals aged 18–40 and 51–60 years, and those who are unemployed, agriculturists, traders, civil officers, private sector employees, or alcohol drinkers. Additionally, individuals with a high perception of preventive benefits, disease severity, and self-efficacy were more likely to avoid consuming uncooked freshwater fish.

Khon Kaen, a province in northeastern Thailand, is known for being an endemic area of human opisthorchiasis, with a persistently high prevalence [3]. The ongoing challenge in eradicating this disease is likely due to the local consumption of raw or undercooked fish [7]. Health

education campaigns to discourage the consumption of raw fish have been the mainstay of control programs [15].

Misconceptions, such as the belief that adding lime or red ants to koi pla or consuming it with white whisky can ‘cook’ the dish or that the early stage of CCA could be cured, must be addressed as they are closely linked to the risk of *O. viverrini* infection among high-risk populations. Our findings indicate that dietary behavior is a public health concern. Therefore, it is crucial to promote changes in health beliefs and dietary practices to reduce the incidence of *O. viverrini* infection, a significant risk factor for CCA, which remains a leading cause of death in northeastern Thailand [8].

The primary reason for continued raw fish consumption is the deeply embedded cultural practices associated with the lifestyle of northeastern Thailand. Moreover, demographic characteristics, such as sex and age, are also influenced [10, 22]. However, our results indicated that sex was not a significant factor in raw fish consumption. This contrasts with the findings of Wang et al. [23], who showed that males consume raw fish dishes, such as koi pla, pla som, and pla ra, more frequently than females. One possible explanation is that dishes, such as fermented fish chili sauce, fermented fish spicy dip, papaya salad, which are more commonly consumed by women, are included

among the ten raw or undercooked fish types.

In addition, sharing raw fish dishes is often accompanied by alcohol consumption. Consistent with our findings, alcohol drinkers were more likely to consume uncooked freshwater fish. As alcohol drinkers tend to share meals, the opportunity to share uncooked freshwater fish increases with the number of alcohol-sharing partners and variety of meals shared [24, 25].

Participants living outside the municipality demonstrated better preventive behaviors than those living within the municipality. This can be attributed to the significant role played by village health volunteers in disseminating information and providing consistent public health messages, which are essential for effective health campaigns [22, 26]. Village health volunteers conduct door-to-door health education, reaching 10 to 15 households each, ensuring that their designated members receive proper health guidance. Additionally, knowledge dissemination occurs at the sub-district and village levels, especially in areas where district-level health officials and volunteers implement public health campaigns, infection testing, and follow-up activities [26]. This coordinated effort is crucial for promoting better preventive behaviors, particularly in rural areas. Consistent with our results, participants who lived outside of municipal areas had a higher level of knowledge than those who lived inside municipal areas. Therefore, expanding health education in municipal areas may promote changes in dietary practice.

Younger age was associated with a lower likelihood of consuming undercooked or raw fish, which aligns with the findings of several studies that identified individuals over 50 years of age as being at a higher risk of *O. viverrini* infection and CCA in Thailand [27]. Although our study did not directly assess infection, we used 10 types of raw fish consumption as a dependent variable. This suggests that the consumption of raw or undercooked fish may be less prevalent among the younger generation. This may be due to the cultural significance of raw fish consumption, which is a more profound practice in older generations. Elderly people tend to be more passionate about eating raw fish and are more familiar with their taste as they have been a staple in their diets for a longer time [25, 28].

Our findings align with those of Chuangchaiya et al. [25], who indicated that individuals with a lower socioeconomic status, such as laborers or farmers, have a higher risk of infection. In Khon Kaen province, daily laborers may include many young ethnic Laotians searching for job opportunities, who may have different eating habits than the local population [25, 29]. Raw freshwater fish are often more affordable and easier to acquire in rural areas, where daily laborers work. Local fishing can make it more accessible, especially for laborers with limited financial resources. In addition, raw fish dishes are quick and easy to prepare, making them convenient for people with busy schedules.

In the present study, participants' perceptions of the consumption of uncooked freshwater fish, including susceptibility, cues to action, and barriers, were not significantly associated with preventive behaviors. Participants did not perceive themselves as at risk, lacked awareness or motivation to change, and identified

obstacles to adopting preventive behaviors. This may be due to the relatively common availability of uncooked freshwater fish in northeastern Thailand [7] and the cultural significance of raw fish consumption, a deeply rooted practice among the locals [22]. Additionally, raw fish consumption is a more ingrained cultural practice in older generations.

Our results differ from those of a previous study that found that perceived susceptibility, severity, and barriers were significantly related to CCA prevention. This disparity may be attributed to differences in participants' profiles, as Phatisena et al. [29] enrolled a predominantly female population (80%) and included a higher proportion of individuals aged ≥ 60 years (33%). Additionally, methodological differences may have contributed to this difference, as Phatisena (2016) [30] used a pre- and post-test design.

Advantages and Disadvantages of the study

Advantages

A key strength of this study was the representativeness of the participants, as we used multistage random sampling to select participants from areas with varying prevalence levels and living areas (in and outside municipality) according to age and sex. Moreover, ten types of raw fish consumption were asked as a dependent variable.

Disadvantages

First, our HBM items were measured by their frequency on a Likert scale and were therefore subject to measurement errors due to recall bias. We did not directly measure *O. viverrini* infections, but assumed that poor behavior caused *O. viverrini* infections. Finally, behaviors were assessed using self-reports, which may have been influenced by a social desirability bias.

In conclusion, our study has significant implications for public health campaigns aimed at improving preventive behaviors in Khon Kaen, Northeast Thai population. Therefore, we strongly recommend promoting changes in dietary habits to reduce the risk of *O. viverrini* infection and CCA.

Author Contribution Statement

Conceptualization: PS, JS, SK (1), WR; Data curation: PS, WR, SK (2); Funding acquisition: PS, JS, PK, WR, SK (1); Investigation: PS, WR, SP; Methodology: PS, WR, SK (1); Supervision: JS, PK; Writing ± review & editing: PS, JS, PK, WR, SP, SK (2), SK (1); ; First draft of manuscript: PS, SP.

Acknowledgements

This research was accomplished with great kindness from village health volunteers and public health officers of sub-district health promotion hospitals under the Khon Kaen Provincial Administrative Organization, namely Ban Ang Thong, Huai Jot, Na Kham, Phon Pek, Non Khong, La Han Na, Kham Mad, Pek Yai, and Phra Bu Sub-district Health Promotion Hospital, who provided assistance in data collection and facilitation for the research team

throughout. We would like to thank Assistant Professor Dr. Tawee Saiwichai, Assistant Professor Dr. Natnapa Hibkaew Patchasuwan, and Dr. Paitoon Phromthep, who kindly acted as experts in checking the content validity of the instruments used in the research.

We would like to thank all the participants who cooperated in answering the interview forms and Mr. Bryan Roderick Hamman under the aegis of the Publication Clinic, Khon Kaen University for assistance with the English-language presentation of the manuscript.

Finally, this study was partially financially supported by Faculty of Public Health, Mahidol University, Thailand.

Funding Statement

This study was partially financially supported by Faculty of Public Health, Mahidol University, Thailand.

Ethical Declaration

We obtained written informed consent from all participants. The study was reviewed and approved by the Ethical Review Committee for Research in Human Subjects of the Faculty of Public Health, Mahidol University (MUPH 2024-046). Permission for field work was obtained from the local health center and village heads. Meetings were held with health center staff, village heads, and health volunteers to explain the purpose, procedures, risks, and benefits of the study, so they could inform the villagers about the survey in advance.

Data Availability

The datasets are not publicly available but are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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