

Predictors of hookworm and *Opisthorchis viverrini* infection among adolescents in urban Laos: a cross-sectional study

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Itsuko Yoshida¹
Osamu Horie²
Kongsap Akkhavong³

¹Department of Nursing Science, Yasuda Women's University, Hiroshima, Japan; ²Department of Clinical Laboratory Science, Tenri Health Care University, Tenri, Nara, Japan; ³Lao Tropical and Public Health Institute, Ministry of Health, Vientiane, Laos

Purpose: Infection with hookworm and *Opisthorchis viverrini* are serious health problems among children and adolescents in Laos. In this study, we demonstrated the factors related to hookworm and *O. viverrini* infection, including primary school health programs, among secondary school students in Vientiane city of Laos.

Material and methods: A cross-sectional survey and stool examination were conducted among secondary school students in Vientiane. One stool sample from each participant was examined using two Kato-Katz smears. Data of 164 participants were analyzed and the associations among parasitic infections, sociodemographic characteristics, and the school health program in primary school were assessed in a univariate logistic regression analysis. Predictors with $p < 0.25$ were retained in a multivariate logistic regression model. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. The significance level was set at $p < 0.05$.

Results: The infection rates of *O. viverrini* and hookworm were 39.0% and 36.0%, respectively. Older students (OR=1.55, 95% CI: 1.01–2.37, $p=0.046$) and those whose father had irregular income (OR=0.47, 95% CI: 0.13–0.93, $p=0.036$) had a higher risk for hookworm infection. Students whose mother had irregular income (OR=0.30, 95% CI: 0.13–0.69, $p=0.005$) had a higher risk for *O. viverrini* infection. Higher primary school health program scores were associated with a lower risk for hookworm infection in the univariate model but not in the multivariate model.

Conclusion: Sociodemographic factors have a strong influence on infections with both hookworm and *O. viverrini*. Current school health programs in Laos may be insufficient to reduce *O. viverrini* infections. Other approaches, such as supporting parents in finding employment with regular income, may be needed.

Keywords: hookworm, *Opisthorchis viverrini*, adolescents, Laos

Introduction

Infections owing to soil-transmitted helminths and foodborne trematodes are serious public health problems in Laos.^{1–3} Previous studies have reported a high prevalence of intestinal parasitic infections among school-aged children and young people in Laos. For example, the reported prevalence of intestinal helminths among children aged 6–11 years is 70.3%, and this is 71.2% among young people aged 12–19 years in northern Laos.⁴ Among children under 15 years of age in Bolikhamxay Province, this prevalence is 56.7%.⁵ Recent studies show that the main parasitic infections among the general population are hookworm and *Opisthorchis viverrini* infections.^{2,6,7} This tendency has also been observed among children and young people, with 80.0% of

Correspondence: Itsuko Yoshida
Department of Nursing Science, Yasuda Women's University, 6-13-1 Yasuhigashi Asaminami-ku, Hiroshima, Hiroshima, Japan
Tel +81 804 600 4381
Fax +81 82 872 2896
Email yoshida-i@yasuda-u.ac.jp

the children aged 6–15 years infected by hookworm and 64.6% by *O. viverrini* in Champasack Province,⁸ and 87.0% infected by hookworm and *O. viverrini* in Saravane Province.² The impact of helminth infections is significant predictors of malnutrition, iron deficiency anemia, and poor academic performance among schoolchildren.^{9–12} Additionally, *O. viverrini* infection is associated with cholangiocarcinoma and bile duct cancer.^{13,14}

Therefore, a successful parasite control program for students at school is necessary to improve their health status, increase their chances of optimal growth and learning,¹⁵ and avoid future early death. According to the National School Health Policy formulated by the Ministry of Education (MoE) and Ministry of Health (MoH) in Laos, the school health program consists of five components: personal health and life skills, healthy school environment, health and nutrition services, control and prevention of common diseases, and school and community partnership.¹⁶ Therefore, helminths control is also included in the program and has been implemented as the school deworming campaign for all primary school-aged children since 2005.¹⁷ This campaign has covered 93% of the country.¹⁸ The school-based program is expected to provide schoolchildren with proper knowledge, attitudes, and practices for maintaining better health status throughout their entire life. However, the influence of this program during primary school and the factors related to parasitic infection among secondary school students has not been sufficiently investigated.

In the present study, we sought to identify factors, including primary school health programs, related to infection with hookworm and *O. viverrini* among secondary school students in a large city of Laos.

Material and methods

Study area

The study was conducted in Vientiane, the largest city in Laos. Vientiane is located on the banks of the Mekong River near the border with Thailand, at elevation 174 m above sea level. Vientiane has a tropical monsoon climate, with the rainy season occurring between May and October.¹⁹ Vientiane has nine districts. The study site was a secondary school in Sikottabong District, which is located at about 9 km from the center of the city and urban area. The students of the target school were mainly from nine villages located in the vicinity of the school. The total number of students at the school was around 230. The gross enrollment rate in secondary schools in Laos is 66.5%.²⁰

Study population and sample size

As of the 2015 census, Vientiane city had a population of 820,000, with 8.9% of the population aged 10–14 years.¹⁹ We selected one secondary school located in an area where we have implemented a school health program since 2002.

The sample size was determined using the A-priori Sample Size Calculator for Multiple Regression (available from <http://www.danielsoper.com/statcalc>) with a 0.15 anticipated effect size, 80% statistical power, 15 predictors, and 0.05 probability level. The calculated minimum sample size was 139.

Study design

We conducted a cross-sectional survey in September 2013. First, schoolteachers and students were informed about the study objectives and procedures. A total of 197 students agreed to voluntarily participate and signed consent forms. Students in first grade were not included because they were in the process of admission during the study period.

Questionnaire survey

The questionnaire included sociodemographic characteristics, perception of the primary school health program, and status of water and sanitation in the student's home. This questionnaire was translated into the Lao language, and any discrepancies in terms of wording were settled through discussions with Laotian senior researchers from the Lao Tropical and Public Health Institute. Finally, the translated questionnaires were pre-tested. To collect data, first, a Laotian researcher explained the questionnaire to the students and instructed them on how to complete the questionnaire. The students then completed the self-administered questionnaires in the Lao language.

Sample collection and stool examination

All students participated were provided with a stool container labeled with an identification number on the day before the survey. Students were requested to provide their own fresh stool sample on the sample collection day. The research team visited classrooms at the target school between 8:00 a.m. and 9:00 a.m. to collect the stool samples together with the completed questionnaire. All collected samples were kept in a cool box and were transferred by car to the laboratory of the Lao Tropical and Public Health Institute within an hour after collection. For each stool sample, two Kato–Katz thick-smear slides were prepared, using standard 41.7 mg templates. After a

clearing time of 30 mins, the slides were examined under a light microscope (100× magnification). All samples were examined on the day of collection.

Data analysis

In total, 178 participants submitted a stool sample, and samples were analyzed for the prevalence of helminths among study participants. Among 178 students, 164 completed the questionnaire. The data from these 164 participants were used to analyze associations among sociodemographic characteristics, primary school health program score, status of hygiene and sanitation in the student's home, and parasitic infection. The items addressing the perception of the school health program were from a previous study on school health program evaluation in Laos.²¹ Response options to the survey questions were “yes” or “no”, and “yes” responses were summed to obtain the overall primary school health program score (Table 1). The intensity of helminth infections was expressed in fecal eggs per gram (EPG). According to the previous studies,^{2,6,22} for hookworm and *O. viverrini* infections, the following light-, moderate-, and high-intensity groups were established based on the EPG counts: hookworm; 1–1,999 EPG, 2000–3,999 EPG, and ≥4,000 EPG and *O. viverrini* and *T. trichiura*: 1–999 EPG, 1,000–9,999 EPG, and ≥10,000 EPG.

Data analysis was performed using IBM SPSS, version 22.0 (IBM Corp., Armonk, NY, USA). The association among parasite infections (hookworm and *O. viverrini*), sociodemographic characteristics, and the school health program available during primary school were assessed in a univariate logistic regression analysis. Predictors with

$p < 0.25$ were retained in a multivariate logistic regression model. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. The significance level was set at $p < 0.05$.

Ethics approval and consent to participate

Ethical approval was obtained from the Tenri Health Care University Ethics Committee (Project no. 27) and the National Ethics Committee on Health Research, MoH, Lao PDR (Ethical Clearance No. 045/2013 NECHR). Permission for the survey was obtained from the MoH, as well as the school committee and director. Meetings were held with students' parents or guardians in which they were given a detailed explanation of the study aims, procedures, potential risks, and benefits. Written informed consent was obtained from the parents or guardians of participants. In cases where a parent or guardian was illiterate, students signed the consent form, witnessed by a parent or guardian.” Participants were free to withdraw from the study at any time.

Results

Sociodemographic characteristics of participants

The data of 164 students were included in the analysis; mean student age was 13.7 years (SD 1.3; range 10–18 years). The mean student age when entering primary school was 6.0 years (SD 1.0; range 3–9 years), and the mean age when entering secondary school was 11.5 years (SD 1.0; range 9–15 years). A total of 49.4% of the students were male, and most students (86.0%) attended

Table 1 Questionnaire items for primary school health program score

Items	%
There was water available in primary school	70.6
There was boiled or bottled water for students to drink	87.1
There was a latrine in primary school	93.3
The latrine was always kept tidy	78.5
The primary school had a good fence to prevent animals from entering the schoolyard	91.4
Health personnel visited the primary school to check students' health condition	87.1
Primary school teachers instructed students to wash hands before eating	98.2
Primary school teachers instructed students to wash hands after using the latrine	95.1
Primary school teachers instructed students to wash hands after returning from outside	69.9
Primary school teachers instructed students on how to clip fingernails	97.5
Primary school teachers instructed students on how to keep eyes and ears clean	88.3
Total score (range: 5–11)	Mean (SD) 9.57 (1.33)

Abbreviation: SD, standard deviation.

primary school in Vientiane. Among the total, 41.4% of the students' fathers and 52.4% of the students' mothers had fewer than 6 years' education. The most common occupations among fathers were farmer (33.5%) and government employee (24.5%); the most common jobs among mothers were farmer (28.1%) and trader (26.8%). A total of 86.0% of the students reported having a latrine at home and 87.2% of the used a water-sealed latrine; only 21.3% of the students had tap water available at home. Among the total, 89.0% of the students belonged to the Lao-Thai ethnic group (Table 2).

Parasitic infection

The most frequently encountered parasitic infection was *O. viverrini*, with a positive rate of 39.0%. Hookworm, *Trichuris trichiura*, and *Taenia* spp. were found in 36.0%, 4.3%, and 2.4% of the participants, respectively. Most cases of *O. viverrini* infection were categorized as light intensity, with no cases of heavy intensity infection found. Most cases of hookworm infection were also light intensity; in addition, three cases were classified as moderate intensity and one case as heavy intensity (Table 3).

Factors related to hookworm infection

Univariate logistic regression analysis resulted in 10 predicted variables: age, age entering primary school, age entering secondary school, primary school health program score, father's education level, father's occupation; mother's occupation, type of latrine, source of daily-use water, and frequency of deworming. The results of multivariate logistic regression analysis showed that two variables were identified as significantly related to hookworm infection; older age (OR=1.55, 95% CI: 1.01–2.37, $p=0.046$) was significantly associated with higher infection risk and the student's father having an occupation with regular income was associated with significantly lower risk (OR=0.47, 95% CI: 0.13–0.93, $p=0.036$) for hookworm infection. The primary school health program score was not significant in the multivariate model (OR=0.76, 95% CI: 0.56–1.02, $p=0.068$) although it was significant (OR=0.69, 95% CI: 0.53–0.88, $p=0.003$) in univariate logistic regression (Table 4).

Factors related to *O. viverrini* infection

Univariate logistic regression analysis resulted in nine predicted variables; school health score, location of primary school attended, student's sex, father's education, mother's education, father's occupation, mother's

occupation, ethnicity, and source of daily-use water. The results of multivariate logistic regression analysis showed that only the mother having an occupation with regular income was significantly associated with lower risk (OR=0.30, $p=0.005$) for *O. viverrini* infection (Table 5).

Discussion

In this study, we found that infection with *O. viverrini* and hookworm were the most prevalent parasitic infections among secondary students in Vientiane, Laos. Our findings confirmed previous studies.^{2,7,8,22} Compared with countries surrounding Laos, the prevalence rates of hookworm infection (36.0%) in our study were similar to those in Cambodia, with 34.9% among schoolchildren²³ and 34.8% among young people aged 11–16 years.²⁴ The prevalence among schoolchildren was slightly lower in Vietnam, 22.8% in the southern part of the country²⁵ and 5.3% in the northern part.²⁶ In contrast, only 0.5% of the schoolchildren in Bangkok, Thailand have hookworm infection.²⁷ Risk factors of hookworm infection include walking barefoot in contaminated soil. In our study, students usually use beach sandals, which cover the soles of their feet. Although 87.2% of the participants had a water-sealed latrine in their dwelling, every rainy season, these flood and overflow with waste, which contaminates the soil. In addition, even in urban areas of Laos, only the main roads are paved and other areas where students walk and play are unpaved. These factors lead to the high prevalence rate of hookworm infection in Vientiane. The prevalence rates of *O. viverrini* (39.0%) in our study were also at the same levels as those in Cambodia, with 40.0% among young people aged 10–19 years.²⁸ However, in northeastern Thailand, only 0.0–2.1% of those aged less than 20 years are infected.^{29,30} *O. viverrini* infection is caused by ingesting raw or inadequately cooked fish. Suburban areas of Vientiane city still have fishponds and people catch fish for daily consumption. This may lead to frequent raw fish consumption and the subsequent high prevalence of *O. viverrini* infection.

The World Health Organization (WHO) categorizes populations with prevalence rates between 10% and 50% as requiring preventive chemotherapy.¹⁶ Most participants in this study were covered by a national deworming program. The intensity of hookworm infection showed that most infected cases were categorized as light intensity. This suggests that deworming programs can maintain lower hookworm infection intensity. However, reinfection after mass deworming programs has been frequently reported.^{31–33} The medication that was distributed in

Table 2 Sociodemographic characteristics of participants

Variables	n (Mean)	% (SD)	(Range)
Age, y	13.7	1.3	10–18
Age entering primary school, y	6.0	1.0	3–9
Age entering secondary school, y	11.5	1.0	9–15
Location of primary school			
Vientiane city	141	86.0	
Outside of Vientiane city	20	12.2	
Missing	3	1.8	
Student's sex			
Male	81	49.4	
Female	83	50.6	
Father's education			
Primary school or no schooling	68	41.4	
Lower secondary school or higher	92	56.0	
Missing	4	2.4	
Mother's education			
Primary school or no schooling	86	52.4	
Lower secondary school or higher	75	45.7	
Missing	3	1.8	
Father's occupation			
Unemployed	4	2.4	
Farmer	55	33.5	
Trader	17	10.4	
Government employee	40	24.5	
Driver	9	5.5	
Other	38	23.2	
Missing	1	0.6	
Mother's occupation			
Unemployed	31	18.9	
Farmer	46	28.1	
Trader	44	26.8	
Government employee	14	8.5	
Seamstress	11	6.7	
Other	17	10.4	
Missing	1	0.6	
Latrine			
Latrine present at home	141	86.0	
Share latrine with neighbors	20	12.2	
No latrine	3	1.8	
Type of latrine			
Water-sealed latrine	143	87.2	
Pit latrine or other	21	12.8	
Source of water for daily use			
Tap water	35	21.3	
Other (river/well/rainwater)	129	78.7	

(Continued)

Table 2 (Continued).

Variables	n (Mean)	% (SD)	(Range)
Ethnicity			
Lao-Thai	146	89.0	
Hmong	13	8.0	
Other	3	1.8	
Missing	2	1.2	

Abbreviation: SD, standard deviation.

primary schools for a long time was single-dose mebendazole 500 mg, which has low efficacy against hookworm.³⁴ The study in Laos by Soukhathammavong et al, showed that the cure rate and egg reduction rate with single-dose mebendazole treatment was 17.6% and 76.3%, respectively; these rates with albendazole treatment were 36.0% and 86.7%, respectively.⁷ A study in China showed that triple-dose albendazole treatment has high efficacy against hookworm, with a 96.7% cure rate, a 99.1% egg reduction rate, and a low reinfection rate (5.1%) at 6 months after treatment.³⁵ To reduce the infection rate and number of cases with heavy intensity, the medication used in deworming programs should be reconsidered. Additionally, mebendazole is less effective for *O. viverrini* infection.^{4,7} Praziquantel is the only medicine recommended by the WHO for the treatment of *O. viverrini* infection and it should be administered in certain doses according to students' weight.³⁶ Such administration is not easy for schoolteachers; therefore, measures for controlling *O. viverrini* infection is not included in national school health programs in Laos. For safety, the MoH in Laos recommends that medical personnel should supervise and monitor treatment and follow-up when praziquantel is administered. Therefore, good collaboration between MoH and MoE is needed if praziquantel is to be introduced in the school health program.

The results of univariate logistic regression in this study showed that a lower primary school health program score was a risk factor of hookworm infection. The primary school questions in our study mainly queried participants about the contents of health education and the school environment during their primary school years. This score possibly includes recall bias; however, hygiene education such as washing hands, using the toilet, eating clean food, wearing clean clothes, and cleaning the environment, may increase students' awareness and improve behaviors, such as the use of regular medication and

hygiene practices to prevent hookworm infection. In the other hand, the multivariate model showed that primary school health program scores were not significant factors but sociodemographic factors had a greater influence on hookworm infection. Our findings showed that older students were at greater risk of hookworm infection. This tendency was also found in the previous studies from southern Laos.^{7,9,37,38} Older students may engage in more agriculture work to help their parents, resulting in greater hookworm infection. The data in our study that students whose father was unemployed or a farmer had a greater risk of hookworm infection also support this result. With respect to the father's occupation, the percentage of students whose father worked as a farmer was the highest in this study, even in Vientiane city.

Our study findings suggested that having a mother who was employed and had regular income was associated with lower risk of *O. viverrini* infection. Several studies in Laos have shown that low economic status is associated with *O. viverrini* infection.^{7,37} In addition, previous studies on female economic empowerment have demonstrated that women who have financial resources tend to spend their income on their children's diet, education, and health.^{39,40} The main cause of *O. viverrini* infection is eating raw or partially cooked fish. Fish is a low-cost food, in comparison with meat. Therefore, a mother may spend her money to buy meat rather than fish and her children may thus have a lower risk of infection with *O. viverrini*.

Our study clarified the situation of *O. viverrini* and hookworm infections, as well as social factors predicting both infections, among adolescents in Vientiane, the largest city in Laos. However, this study has several limitations. First, the participants in our study were from a purposely selected school in an urban area; therefore, generalization of the study findings is limited. Second, our study was intended to evaluate the effect of a school health program conducted when participants were in

Table 3 Prevalence and intensity of parasitic infection by gender and age group (n=164)

	n (%)	Gender		Age groups				
		Female	Male	10-11	12-13	14-15	16-18	
<i>Opisthorchis viverrini</i> Intensity of infection: Negative Light (1-999 EPG) Moderate (1,000-9,999 EPG) Heavy (≥10,000 EPG)	100 (61.0) 62 (37.8) 2 (1.2) 0	45 (54.2) 37 (44.6) 1 (1.2) 0	55 (65.4) 25 (30.9) 1 (1.2) 0	3 (50.0) 3 (50.0) 0 (0.0) 0	48 (66.7) 23 (31.9) 1 (1.4) 0	43 (57.3) 31 (41.3) 1 (1.3) 0	6 (54.5) 5 (45.5) 0 0	
Hookworm Intensity of infection: Negative Light (1-1,999 EPG) Moderate (2,000-3,999 EPG) Heavy (≥4,000 EPG)	105 (64.0) 55 (33.5) 3 (1.8) 1 (0.6)	52 (62.7) 29 (34.9) 1 (1.8) 1 (1.8)	53 (65.4) 26 (32.1) 2 (2.5) 0	6 (100.0) 0 0 0	56 (77.8) 16 (22.2) 0 0	37 (49.3) 36 (48.0) 1 (1.3) 1 (1.3)	6 (54.5) 3 (27.3) 2 (18.2) 0	
<i>Trichuris trichiura</i> Intensity of infection: Negative Light (1-999 EPG) Moderate (1,000-9,999 EPG) Heavy (≥10,000 EPG)	157 (95.7) 6 (3.7) 1 (0.6) 0	79 (95.2) 3 (3.6) 1 (1.2) 0	78 (96.3) 3 (3.7) 0 0	6 (100.0) 0 0 0	69 (95.8) 3 (4.2) 0 0	72 (96.0) 2 (2.7) 1 (1.3%) 0	10 (90.9) 1 (9.1) 0 0	
<i>Toenia</i> spp.	4 (2.4)	2 (2.4)	2 (2.5)	0	2 (2.8)	2 (2.7)	0	

Abbreviation: EPG=egg per gram of stool.

Table 4 Factors associated with hookworm infection in logistic regression

Independent variables	Univariate			Multivariate		
	OR	95% CI	p-value	OR	95% CI	p-value
Age	1.58	1.19–2.09	0.002	1.55	1.01–2.37	0.046
Age entering primary school	1.49	1.04–2.13	0.031	1.37	0.82–2.30	0.234
Age entering secondary school	1.29	0.93–1.81	0.132	0.68	0.40–1.16	0.154
Primary school health program score	0.69	0.53–0.88	0.003	0.76	0.56–1.02	0.068
Location of primary school attended						
Vientiane	1.00					
Outside of Vientiane	0.57	0.20–1.66	0.303			
Sex						
Male	1.00					
Female	1.13	0.60–2.14	0.711			
Father's education						
6 years or more	1.00					
Less than 6 years	1.92	1.00–3.68	0.051	1.03	0.44–2.42	0.943
Mother's education						
6 years or more	1.00					
Less than 6 years	1.39	0.73–2.66	0.321			
Father's occupation						
Unemployed/farmer	1.00					
Job with regular income	0.47	0.24–0.91	0.025	0.34	0.13–0.93	0.036
Mother's occupation						
Unemployed/farmer	1.00					
Job with regular income	0.68	0.36–1.29	0.239	1.11	0.43–2.91	0.828
Ethnicity						
Lao-Thai	1.00					
Hmong/other	0.77	0.26–2.35	0.651			
Latrine at home						
Latrine available in the home	1.00					
Share with neighbors/no latrine	0.94	0.37–2.37	0.898			
Type of latrine						
Water-sealed latrine	1.00					
Pit latrine or other	1.92	0.72–5.14	0.195	1.73	0.51–5.87	0.376
Source of daily-use water						
Tap water	1.00					
Other (river/well/rainwater)	1.83	0.79–4.22	0.157	1.25	0.43–3.63	0.679
Frequency of deworming						
Regular deworming medication	1.00					
No deworming medication	3.56	1.13–11.20	0.030	1.98	0.53–7.49	0.313

Abbreviations: OR, odds ratio; CI, confidence interval.

primary school; therefore, recall bias was unavoidable. More accurate measures must be developed to evaluate school health programs for preventing hookworm and *O. viverrini* infection. Third, our study could not determine

students' habits of raw fish consumption. Because participants' daily food is prepared by parents or guardians, students' habits may be influenced by those of their parents or guardians. Further studies are required to determine

Table 5 Factors associated with *Opisthorchis viverrini* infection in logistic regression

Independent variables	Univariate			Multivariate		
	OR	95% CI	p-value	OR	95% CI	p-value
Age	1.08	0.8–1.39	0.542			
Age entering primary school	0.92	0.66–1.28	0.628			
Age entering secondary school	1.16	0.84–1.61	0.358			
Primary school health program score	1.17	0.92–1.50	0.207	1.20	0.90–1.61	0.221
Location of primary school attended						
Vientiane	1.00					
Outside of Vientiane	0.34	0.11–1.06	0.063	0.42	0.10–1.76	0.236
Student's sex						
Male	1.00					
Female	1.79	0.95–3.37	0.074	1.29	0.62–2.68	0.496
Father's education						
6 years or more	1.00					
Less than 6 years	1.50	0.79–2.84	0.216	1.12	0.47–2.65	0.803
Mother's education						
6 years or more	1.00					
Less than 6 years	1.49	0.79–2.82	0.219	1.05	0.44–2.49	0.909
Father's occupation						
Unemployed/farmer	1.00					
Job with regular income	0.42	0.22–0.81	0.010	0.77	0.33–1.81	0.550
Mother's occupation						
Unemployed/farmer	1.00					
Job with regular income	0.29	0.15–0.55	<0.001	0.30	0.13–0.69	0.005
Ethnicity						
Lao-Thai	1.00					
Hmong/other	0.49	0.15–1.60	0.238	0.81	0.19–3.45	0.780
Latrine at home						
Latrine available in the home	1.00					
Shares with neighbors/no latrine	1.01	0.41–2.48	0.991			
Type of latrine						
Water-sealed latrine	1.00					
Pit latrine or other	0.56	0.19–1.67	0.300			
Source of daily-use water						
Tap water	1.00					
Other (river/well/rainwater)	2.59	1.09–6.13	0.031	2.17	0.80–5.85	0.127
Frequency of deworming						
Regular deworming medication	1.00					
No deworming medication	1.18	0.39–3.57	0.774			

Abbreviations: OR, odds ratio; CI, confidence interval.

whether there is an association between *O. viverrini* infection in children and the consumption frequency of raw fish prepared by parents or guardians. Fourth, our study was conducted in 2013; therefore, some variables might not

indicate the present situation, especially parents' occupation and hygienic and sanitary facilities at home, owing to rapid economic development in Laos. Further evaluation is needed in future studies.

Conclusions

This study highlights that *O. viverrini* and hookworm infection are prevalent among secondary school students in Vientiane city. Improving primary school health programs is effective in reducing the risk of hookworm infection among secondary students, although sociodemographic factors have an influence on both infections. *O. viverrini* infection is associated with mothers having an occupation with regular income, which is a factor associated with lower risk. Hookworm infection is associated with age and father's occupation. Older students have greater infection risk, and students whose father is employed and has regular income have lower risk. Current primary school health programs may be insufficient to reduce *O. viverrini* infections, and different approaches may be needed, such as encouraging mothers to seek jobs that provide regular income for their family.

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The authors report no conflicts of interest in this work.

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