

Raw fish consumption in liver fluke endemic areas in rural southern Laos

Vilavanh Xayaseng^{a,b,c}, Khampheng Phongluxa^{a,b,c}, Peter van Eeuwijk^{c,d}, Kongsap Akkhavong^a, Peter Odermatt^{b,c,*}

^a National Institute of Public Health, Ministry of Health, Vientiane, Lao People's Democratic Republic

^b Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland

^c University of Basel, Basel, Switzerland

^d Institute of Social Anthropology, Basel, Switzerland

* Corresponding author: Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Socinstrasse 57, P.O. Box, 4002 Basel, Switzerland, Tel. +41 61 284 82 14, E-mail: peter.odermatt@unibas.ch

Abstract

Consumption of raw or insufficiently cooked fish is a major public health concern in Southeast Asia, and in Lao People's Democratic Republic (Lao PDR), in particular. We aimed to assess the knowledge, attitudes, perceptions and practices of villagers in liver fluke endemic areas related to raw fish preparation, consumption and its health consequences. In February 2010, eight focus group discussions (FGDs, 35 men and 37 women total) and direct observations were conducted in four randomly selected villages in Saravane District, Saravane Province (Lao PDR). FGDs distilled the knowledge, attitudes, perceptions and practices of adult community members on raw fish preparation, consumption and its consequences for health. Conversations were transcribed from notes and tape-recorders. MaxQDA software was used for content analysis. Knowledge regarding the health effects of raw fish consumption was heterogeneous. Some participants did not associate liver fluke infection with any ill health, while others linked it to digestive problems. Participants also associated vegetables and tree leave consumption with liver fluke infection. The majority of FGD participants considered fish flesh that had been prepared with weaver ant extract to be safe for consumption. Visual appearance, taste, smell and personal preference were given as reasons for consuming raw fish dishes. Moreover, participants considered it a traditional way of food preparation, practiced for generations in Laos. Ten different fish dishes that use raw or fermented fish were identified. All FGD participants reported consuming dishes with raw fish. This study reveals a low degree of knowledge among local people on the health risks related to frequent consumption of raw or insufficiently cooked fish. Fish dishes were considered to be 'well-prepared' (that is, 'cooked') even though the fish had not been heated. In future, successful health education campaigns

will have to address the specific knowledge, attitudes, perceptions and practices of the concerned population.

Key words: raw or insufficiently cooked fish dishes, food preparation, raw fish consumption, liver fluke, Laos, *Opisthorchiasis*, *Opisthorchis viverrini*

1. Introduction

Raw and insufficiently cooked food consumption is very common in Southeast Asia (Grundy-Warr et al., 2012). In Lao People's Democratic Republic (Laos, Lao PDR) raw food consumption has deep cultural roots. For instance, in the southern Saravane Province, up to 90% of village populations regularly consume raw or insufficiently cooked fish (Sayasone et al., 2007). Food transmitted parasitic infections are, as a matter of course, very common in Laos. Of major public health concern is infection with the liver fluke *Opisthorchis viverrini*, a food-borne trematodiasis transmitted through the consumption of raw or insufficiently cooked fish. *O. viverrini* infection may lead to severe hepatobiliary pathologies, depending on the duration and intensity of infection (Mairiang and Mairiang, 2003; Mairiang et al., 2012; Sayasone et al., 2012). A most severe complication is cholangiocarcinoma, a fatal bile duct cancer (Sripa et al., 2011; Sripa et al., 2012).

O. viverrini infection is endemic in several countries in Southeast Asia (Sithithaworn et al., 2012) and in all provinces of Laos (Rim et al., 2003). It is highly prevalent in central and southern Laos, reaching infection rates of more than 90% in adult populations (Forrer et al., 2012; Sayasone et al., 2007; Sayasone et al., 2011). It is estimated that 1.7 million Laotians are currently infected with liver flukes (WHO, 2011). Mixed infection (multiparasitism) with food-borne trematodiasis, such as *O. viverrini*, and minute

intestinal flukes, such as *Haplorchis taichui* and others, is also very common in Laos PDR (Sato et al., 2010; Sayasone et al., 2009).

To combat the problem, the Ministry of Health employs an intervention strategy of preventive chemotherapy using praziquantel (single dose 40 mg/kg body weight) combined with health education and promotion of latrine use. However, in the presence of widespread and frequent consumption of raw or insufficiently cooked fish dishes, rates of re-infection with *O. viverrini* are rapid and high. Hence, food consumption behaviour change is a prerequisite for sustainable control of liver fluke infection and associated diseases (Ziegler et al., 2011).

To advance our understanding of how best to achieve food consumption behaviour change in this context, we studied villagers' knowledge, attitudes, perceptions and practices related to the consumption of raw and insufficiently cooked fish dishes in rural communities in southern Laos that are highly endemic for liver fluke infections. We conducted a qualitative study using focus group discussions (FGD) and direct observation in four villages in Saravane Province.

2. Methodology

2.1 Study design and area

This research was part of a larger project in Saravane District, Saravane Province, on “Rolling out preventive chemotherapy to achieve rapid and sustained impact on opisthorchiasis and soil-transmitted helminthiasis in Lao PDR: an intervention study in Saravane District”, which was launched in January 2010. We used direct observation and FGDs (Dawson et al., 1993; Silverman, 2007) to collect qualitative information on

the knowledge, attitudes, perceptions and practices related to liver fluke infection and raw and insufficiently cooked fish consumption.

The study was carried out in February 2010 in four randomly selected villages in Saravane District, namely in Hangphounoy, Napheng-Gnai, Songkhon and Nongboua-Gnai. Saravane District is located in the low plain of Saravane Province (in the southern part of Lao PDR) and has a total population of 94,965 people (48,636 women) living in 179 villages and 13,239 households; the average income is 762 USD/person/year; 674 families are categorised as poor (4.8%); and the annual fertility rate is 2.4%. Saravane District is located around the provincial capital Saravane, where a provincial hospital with 70 beds is located. This district has 9 health centres, 19 pharmacies, 91 village drug kits and 67 health workers (unpublished report of Saravane District Health Office, 2009). In 2007, exceedingly high *O. viverrini* infection prevalence rates of 80.0% per village were observed in Saravane District, latrines were barely available and knowledge of liver fluke infection was scarce. Most people harboured two worm species (Sayasone et al., 2007).

2.2 Characteristics of study population

FGD participants were adults aged 16-59 years from randomly selected households in four study villages. They had lived in the village for at least one year. Each FGD included 8-10 local participants. Two FGDs were conducted in each of the four villages: one with men and the other with women.

2.3 Data collection

Direct observation was carried out during visits to the four villages and results were noted. Observations focused on the cleanliness of houses, the type of water supply available, the distribution of information, education and communication campaigns (e.g.,

poster), and food preparation and consumption practices. FGDs were held at the Buddhist temple or at another appropriate protected public space. FGDs were led by a moderator and an assistant who took notes. All FGDs were conducted in Lao language and recorded by a digital tape recorder. Four FGDs with 35 men and four FGDs with 37 women were carried out.

A moderator led the discussion, using a discussion guide. An explanation of the parasite and its transmission was not provided to FGD participants beforehand. Using open-ended questions, participants were asked about their knowledge of liver fluke infection and associated health problems. The main questions posed in this discussion were: (i) describe “*san tap*” or “*pha yat bai mai nai tap*” (liver fluke – opisthorchiasis); (ii) how is it transmitted to humans and what diseases and symptoms does it cause? (iii) what other worms do you know, how are they transmitted to humans and what diseases and symptoms do they cause?; and (iv) explain how worms cause health problems in your community. Discussions about the participants’ attitudes and perceptions focused on judgements and experiences regarding raw or insufficiently cooked fish preparation and consumption. Discussions about related practices centred on the mode of preparation of fish dishes and their consumption. For these two discussions, the main questions asked were: (i) tell us about the kind of food you eat most often; (ii) where do you find your food? (iii) describe how you prepare beef and pork? (iv) explain how you cook fish; (v) give details of your raw fish consumption; what type of dish do you eat most often? When and on which occasions do you eat raw fish? Why do you eat dishes made of raw fish? (vi) tell us about raw fish consumption in your family.

2.4 Data management and analysis

Notes and tape-recorded discussions were transcribed into Lao the day after the discussion. Subsequently, the transcripts were translated into English and imported into MaxQDA (version 10, VERBI Software). The statements were coded in different groups and categories; all coded data were retrieved and exported to Excel form for frequency analysis and content exploration.

2.5 Ethical considerations

Province, district and village authorities were informed about the study and their approval was obtained. The objectives and procedures of the study were explained in detail to FGD participants. It was made clear that discussions would be tape-recorded. All participants gave their written informed consent prior to enrolment. Ethical clearance was obtained from the Ethical Board of WHO and the National Ethics Committee for Health Research (NECHR), Ministry of Health, Vientiane, Lao PDR (Reference No. 169/NECHR, 1 April 2008).

3. Results

3.1 Observations

On several occasions, we observed villagers eating raw fish dishes. For instance, during our field visit to Napheng-Gnai, we observed people preparing and consuming a sticky raw fish dish, which was also served with Lao alcohol. The villagers, irrespective of their ethnic group or age, commonly consumed papaya salad with raw fermented fish sauce. The fish species used for these dishes were tracked and photographed in the Saravane market.

We looked at health education posters on the walls of village authorities' houses and health centres. Posters were distributed by the Saravane District Health Office. They displayed information on bird flu prevention, hand washing with soap and latrine use, impregnated mosquito bed net use and rapid diagnostic tests, breastfeeding, vaccination, and family planning. We did not find posters on raw food consumption, liver flukes or related diseases.

Inhabitants engaged in a number of good hygiene practices. For example, we observed that people drank boiled water (water was mainly taken from rivers or unprotected wells due to preference for its taste, except for in Songkhon village where water was taken from public pumps), kept their livestock sheltered, and had a few sanitation facilities available (in Hangphounoy and Napheng-Gnai).

3.2 Characteristics of FGD participants

Seventy-two participants attended the eight FGDs: 51.4% were women; the mean age was 38.5 years (SD 11.1 years, age range 16-59 years). The majority (75.0%) were Buddhists whereas 25.0% were animists; 75.0% belonged to the Laoloum ethnic group; others belonged to *Xuoi* (23.6%) and *Katang* (1.4%) ethnic group. Thirty-four point seven had never attended school; more than half of them had finished primary school (55.6%), and some had graduated from secondary school (9.7%). Almost all participants (94.4%) were farmers; other occupations included labourer at the wood factory, gardener, and manager of a retail shop.

3.3 Focus group discussion results

In colloquial Lao language 'liver fluke' was referred to as "*pha yat bai mai nai tap*", which means the 'leave in liver' disease. In Saravane Province, liver fluke was well-known as

“*san tap*”, which means ‘white oval spot in liver’ or simply ‘liver disease’. This term was commonly used by laypersons and health personnel at the provincial hospital and other health facilities, e.g. for explaining the diagnosis and for communication with patients.

3.3.1 Knowledge of liver flukes

Forty-one participants (57.8%) indicated that they were aware of liver flukes, in general. Liver fluke transmission was attributed to the consumption of raw or insufficiently cooked food such as beef, pork, shrimp and vegetables or foliage from vegetables and trees. Some of those who had heard about liver flukes described its symptoms, such as severe illness, big abdomen, pale or yellow eyes, and a very thin body. More than half of the statements collected (52.0%) mentioned the health consequences of consumption of raw or insufficiently cooked fish, such as digestive problems (e.g. cramps and abdominal pain, diarrhoea, nausea or vomiting [40.0%]).

Nevertheless, 48.0% of the participants said that they had not experienced any health problems related to raw fish consumption. None of the participants had ever visited health services to treat an illness related to raw and insufficiently cooked fish consumption.

3.3.2 Attitudes on raw fish consumption

When discussing food preparation, the majority of participants specified that the preparation of fish with weaver ant extract (i.e., a ‘sour juice’ made from squeezed adult weaver ants) (Figure 2a) was effective as a form of ‘cooking’. Participants explained that weaver ant extract tastes sour and when fish is mixed thoroughly with this extract it is then safe and ready for consumption, particularly after the fish flesh turns white and/or the flesh becomes firmer. Participants thought that this mode of preparation was

equivalent to boiling or heating fish. Most participants in Hangphounoy village (60.0%) stated that fish prepared with weaver ant extract was equivalent to well-cooked food and, thus, not harmful to health.

Fish salad (*koi pa*) is a dish that contains raw or insufficiently cooked fish flesh (Figure 1c). Some participants believed that by adding ingredients such as spices (e.g. chilli, pepper or ginger), salt, monosodium glutamate, alcohol, or warm water, the fish would become a well-prepared ('cooked') and healthy dish.

“To squeeze fish flesh with weaver ant extract only makes fish flesh hard, but it is not equivalent to well-prepared food and it [ant extract] cannot kill the disease, unlike ingredients such as chilli, salt, or glutamate; it is only through adding these that it [fish] becomes equivalent to a cooked dish – and this can kill the disease”

(Woman, 58 years).

3.3.3 Perception

When asked why they consumed raw fish dishes, the majority of participants argued and emphasised that it was due to personal preference for these dishes, which was shaped by sensory qualities such as visual appearance, flavour, and taste. Some stated that these dishes provide physical energy and strength necessary for hard work. All participants said that they ate raw fermented fish; when asked to discuss why they did so, all participants strongly emphasised that the addition of raw fermented fish (*pa daek*) (Figure 1d) in papaya salad has been a traditional formula in Lao cuisine for generations.

“I like to eat raw fish, I can work and go everywhere tirelessly after consuming raw fish”

(Man, 45 years).

The majority of participants (75.0%) felt safe consuming raw fish dishes because it is a long-standing tradition that has been practiced for many generations. Some (45.0%) mentioned that the use of raw fish in various dishes is a traditional Lao cooking style, which has been passed on from generation to generation and that it is important to serve these dishes at many social and cultural ceremonies.

“If everybody consumes raw fish dish during that event except for me, it is impossible to eat cooked food alone” (Man, 45 years).

3.3.4 Practice

When discussing liver fluke transmission in connection with raw fish consumption, 11.1% of the participants conceded that they definitely ate raw fish. Moreover, 12.5% of the participants consumed several types of raw fish dishes, even though they were well aware of the risks of parasitic infections such as taeniasis. The majority of participants (75.0%) consumed raw fish dishes once per month, particularly “*koi pa*” (fish salad) or “*lap pa nuew*” (sticky fish salad) (Figure 1b).

Participants mentioned ten different raw or insufficiently cooked fish dishes, such as *lap pa nuew* (sticky fish salad), *som pa juom/som pa jao* (fermented fish), *pa daek nuew* (sticky fermented fish or Lao fish sauce or), *koi pa/koi kuan som* (fish salad), *loi pa siew/koi pa siew/koi kun som* (small fish salad), *lap pa* (Lao fish salad), *soy soth* (Lao fish soup), *soi cham* (wrap fish flesh with sauce), *chew pa dek nuew* (sticky fermented fish sauce), *tam mak hung* (papaya salad) (see Table 1). Few fish dishes were ‘well-prepared’ with raw fish flesh treated with weaver ant extract, while several dishes were prepared with raw fermented fish. All participants reported that they commonly

consumed at least two types of the above-mentioned fish dishes; *pa deak nuew* (sticky fermented fish) was the most important flavouring substance for papaya salad.

When comparing the raw fish consumption between men and women, we found that men consumed more raw fish dishes than did women. Men showed a particular preference for *la pa nuew* (sticky fish salad), while women preferred insufficiently cooked fish for its sour taste, for example *koi pa* (fish salad). Young children, in general, were not allowed to consume raw fish as they may not withstand the respective diseases. From 14 year onwards, children were allowed to consume raw fish dishes.

“I do not allow my kids to eat raw fish, they are still young (3 and 5 years old), they would catch a disease; but if my kids were older than 14 years then I would allow them to eat it”
(Woman, 25 years).

Participants who did not consume raw or insufficiently cooked fish had previously had an illness episode that they had perceived to be a consequence of raw fish consumption. Eight participants had stopped eating raw fish a few years before the FGDs, whereas three other participants continued to eat it from time to time. They particularly enjoyed consuming raw fish salad and raw sticky fish salad. However, all participants stated that they sometimes consumed green papaya salad with raw fermented fish. Some participants commented that they disliked the appearance of bright fish scales as they had often observed in *la pa nuew* (sticky fish salad) and *koi pa siew* (small fish salad).

4. Discussion

Our qualitative research contributes to understanding raw fish consumption in liver fluke *O. viverrini* endemic settings in Lao PDR. In order to develop appropriate health interventions in endemic rural communities, we need to understand people’s knowledge,

attitudes, and perceptions of liver fluke infection in relation to practices of raw and insufficiently cooked fish consumption, preparation of fish dishes and potential health consequences.

Our results showed that (i) Knowledge of health risks related to raw fish consumption was rather low and misconceptions were widespread; many villagers were unaware of the existence of liver flukes; those individuals who knew of it were uncertain about the origin of infection and/or its latent health consequences. (ii) Fresh fish prepared with weaver ant extract or spices was considered to be 'well-cooked', comparable to boiled, fried or grilled fish dishes, and therefore safe for consumption. (iii) Study participants reported a wide variety of raw fish dishes. Many villagers mentioned the long tradition of preparing and consuming these dishes and argued that this long-standing practice did not put people at any risk. In addition, these dishes are frequently prepared and served during feasts, celebrations or other social or religious gatherings where refusing to consume them is socially unacceptable.

In Southeast Asia, including Southern China, raw or insufficiently cooked fish consumption is a high-risk nutritional behaviour and, therefore, also a major public health concern. Liver fluke infections, i.e., *O. viverrini* and *Clonorchis sinensis*, are highly prevalent in rural communities where raw fish consumption is widely practiced (Sithithaworn et al., 2012). A high prevalence rate of *O. viverrini* infection (85.0%) was also reported in the present study area in 2010 (K. Phongluxa, unpublished results).

The majority of these infections are asymptomatic. Severe hepatobiliary disease is associated with long-lasting infections (Mairiang and Mairiang, 2003; Mairiang et al., 2012). Both liver fluke species were recognised as carcinogenic agents by WHO and may lead to cholangiocarcinoma (CCA), a bile duct cancer with a very poor prognosis

(Sripa et al., 2012). Today, the highest CCA rates in the world are reported in Southeast Asia, where high liver fluke infection rate also exist. For instance, in Khon Kaen Province, Northern Thailand, more than 1,000 new CCA cases are diagnosed each year (Sripa et al., 2012). Participants in the present study were unaware of the signs and symptoms related to *O. viverrini* infection. Therefore, health education explaining the links between *O. viverrini* infection and its related diseases in rural endemic communities of Laos is of utmost importance; this is even more relevant since this disease is life threatening and not curable in its late stages.

Community-based interventions against liver fluke are currently based on preventive chemotherapy and information, education and communication (IEC) programmes. However, if raw fish consumption behaviour is not changed, liver fluke re-infection rates will remain high. For instance, after several decades of liver fluke control in Northeast Thailand, high liver fluke infection rate and high CCA incidence persist (Sripa et al., 2012). Hence, building awareness of the health risks of raw fish consumption and changing food consumption behaviour are prerequisites for sustainable control of liver fluke in rural endemic areas. Changing food consumption behaviour in this context requires formalised health education, as well as (i) information sharing networks within local peer-groups – for instance, from mother to mother on how to safely prepare fish dishes and on the life cycle of *O. viverrini* infection, its mode of transmission and associated health risks – where the implementation of information is socially controlled; (ii) the engagement of prominent ‘agents of change’ in a village, such as the head of village, village health volunteers, and the head of the Lao Women’s Union, who apply safe fish preparation and consumption practices and spread knowledge of *O. viverrini* infection, resulting in behavioural changes triggered by imitation and adoption; (iii)

stronger political commitment to ending raw fish consumption, actively promoted by politicians, health professionals, and media figures at national, regional and local levels.

In Lao PDR, the epidemiological conditions for liver fluke transmission and its health impacts are similar to endemic settings in Thailand. However, information on community knowledge, attitudes and practices related to liver fluke infection and raw fish consumption is scarce in Lao PDR. A previous survey conducted in central Laos showed a low degree of knowledge of liver fluke infection and its associated health problems (Strandgaard et al., 2008). The finding is not very different from that of the present study, although the *O. viverrini* infection rate in the current study area was higher, namely 88.7% in adult population (K. Phongluxa unpublished data).

The present study identifies some important local conceptions about raw fish consumption. Many participants considered raw fish dishes such as “*koi pa*” to be safe and well-cooked food, equivalent to boiled, fried or grilled fish, because the fish flesh turned white after it was mixed with weaver ant extract, different spices (like chilli), alcohol and/or warm water. This result is consistent with observations by Wang who mentioned that male villagers liked to consume raw fish with alcohol, which they perceived as “a way of life for generations” (Wang, 2012). In fact, this so-called ‘well-cooked’ dish is not safe for consumption as metacercariae, the infectious stage of liver fluke, survive. Unless fish is cooked over fire – frying, boiling, roasting, and grilling – it remains infectious (Abdussalam and Kaferstein, 1994).

Another common conception was that one felt vigorous and able to work tirelessly after eating raw fish. This conception is corresponding to the high percentage of raw fish salad consumption “*koi pa*” among the general population in this study district, which was reported in 2007 (75.2%) (Sayasone et al., 2007) and in 2010 (75.4%) (K.

Phongluxa unpublished data). Eating raw fish salad may indeed transmit *O. viverrini* infection. A recent study confirmed that in “*koi pa*”, *O. viverrini* metacercariae remain viable for considerable time (Prasongwatana et al., 2012). Promoting safe fish dishes and demonstrating their preparation, combined with establishing accurate knowledge of *O. viverrini* life cycle and route of transmission is a promising approach to addressing this problem.

In our study we found that raw fish dishes are often served at secular and religious events and cannot be refused by the attendees; eating the same food means keeping the bonds of friendship and kinship. In other words, “The offering and distribution of food and the act of commensality create bonds between the giver and the receiver, so helping to shape our sense of identity, belonging and hierarchy” (Weichart and van Eeuwijk, 2008). Traditional dishes are of particular importance in religious and community festivities and are special offerings to guests. Refusing to eat these dishes is socially unacceptable and can be interpreted as not participating in the community.

The rich list of raw or insufficiently prepared fish dishes identified in the study reflects a long tradition of raw fish consumption in rural communities in Laos. Many participants stated that they regularly consume several types of raw fish dishes. In rural settings where the population has a relatively low formal educational level, raw fish consumption is widely practiced. Our results correspond to findings from Northeast Thailand that show that eating raw fish salad, “*koi pa*”, is common in fishermen and peasant communities. It is an inexpensive source of protein for the local population and it is well adapted to the livelihoods of local communities (Grundy-Warr et al., 2012). In our study, almost all participants were rice farmers, dependent on fish for protein and on wild vegetable collection (mainly bamboo and mushroom) in the surrounding forests. In general, during

the rainy season (from July to October) a lot of fish is available in pond and rivers (Figure 2b) and, thus, villagers consume a lot of fish dishes during this season.

The preparation technique for sticky fish salad, "*lap pa nnew*", might allow for viable *O. viverrini* metacercariae to survive because the preparation techniques do not differ much from those for raw fish salad, "*koi pa*", *O. viverrini* metacercariae have been scientifically confirmed for "*koi pa*" (Prasongwatana et al., 2012). Raw fish salad, "*koi pa*", requires a bigger quantity of fish than does sticky fish salad, "*lap pa nnew*".

Therefore, when villagers have only a few fish at hand and want to serve many people (Figure 1a), they opt for sticky fish salad, "*lap pa nnew*". "*Hor som pa*" is a sour fermented fish wrapped in banana leaves that can be kept for a couple of days. It is another fish dish in which the presence of viable *O. viverrini* metacercariae was confirmed in liver fluke endemic villages (Prasongwatana et al., 2012). Though this fish dish is not reported in our study, Grundy-Warr et al. (2012) presented it in their study paper. "*Hor som pa*" is also available and popular in other areas of Lao PDR. Hence, in order to deter this habit of eating raw and insufficiently cooked fish dishes, IEC campaigns must emphasise that even if a dish is prepared according to long-standing traditions, it might still represent a health risk. Health consequences are mostly invisible and symptoms may start only years after raw fish consumption. These factors must be fully addressed in any future interventions targeting behavioural change regarding food consumption and preparation.

We limited our in-depth study to four villages in Saravane Province. Different areas in Lao PDR or in other liver fluke endemic settings might provide further relevant findings. However, our study results show that a qualitative approach provides relevant insights into the knowledge, attitudes, perceptions and practices of communities, which can improve the quality of future health interventions.

5. Conclusion

This study assesses the knowledge, attitudes, perceptions and practices of raw and insufficiently cooked fish consumption as it pertains to liver fluke infection in a southern province of Laos. Communities have poor knowledge of the mode of transmission for liver fluke infection and of the health consequences of eating raw fish dishes. Local perceptions suggest that preparing raw fish flesh with weaver ant extract, spices like chilli, ginger, and salt, alcohol and/or warm water is equivalent to well-cooked fish. Raw fish consumption is a long-standing nutritional tradition in Laos and such dishes are served to welcome guests at home and at all social and cultural festivities. Popular dishes served at such events include raw fish salad “*koi pa*”, sticky raw fish salad “*lap pa nuew*”, Lao fish soup “*soy soth*”, and wrapped raw fish flesh with vegetables and dipped in the sauce “*soy cham*”. These raw fish dishes cannot be refused by guests; to eat the same food means to keep the bonds of friendship and kinship. Additionally, raw fermented fish – fish soaked in salty water for more than two months – is widely used as a main ingredient for papaya salad, raw fish salad, and other dishes. These qualitative findings underscore the importance of public health interventions in endemic communities, particularly health education. Shaping the knowledge of community members (i) on the transmission of liver fluke infection, (ii) on the diseases related to raw and insufficiently cooked fish consumption, and (iii) on safely preparing fish dishes will be an important feature of such health education programmes. Trained health centre staff and village health volunteers are the appropriate mediators through which to provide the right health messages in their own communities and to ensure the sustainability of such a soft intervention.

Acknowledgements

We express our thanks for the support to all FGD participants, to the village authorities, and to the authorities of District Health Office and Provincial Health Department of Saravane. Our thanks also go to Drs. K. Akkhavong, S. Keodouangchanh, C. Schaetti and Mrs. A. Bochaton for their help. Mrs. A. Briet efficiently edited English language. The study was funded by WHO. Drs. V. Xayaseng and K. Phongluxa received support from the City of Basel and the Rudolf Geigy Foundation.

References

- Abdussalam, M. and Kaferstein, F.K., 1994. Food safety in primary health care. *World Health Forum* 15, 393-399.
- Dawson, S., Manderson, L., and Tallo, V.L., 1993. A manual for the use of focus groups. Boston: International Nutrition Foundation for Developing Countries (INFDC).
- Forrer, A., Sayasone, S., Vounatsou, P., Vonghachack, Y., Bouakhasith, D., Vogt, S., Glaser, R., Utzinger, J., Akkhavong, K., and Odermatt, P., 2012. Spatial distribution of, and risk factors for, *Opisthorchis viverrini* infection in southern Lao PDR. *PLoS Negl Trop Dis* 6, e1481.
- Grundy-Warr, C., Andrews, R.H., Sithithaworn, P., Petney, T.N., Sripa, B., Laithavewat, L., and Ziegler, A.D., 2012. Raw attitudes, wetland cultures, life-cycles: socio-cultural dynamics relating to *Opisthorchis viverrini* in the Mekong Basin. *Parasitol.Int.* 61, 65-70.
- Mairiang, E., Laha, T., Bethony, J.M., Thinkhamrop, B., Kaewkes, S., Sithithaworn, P., Tesana, S., Loukas, A., Brindley, P.J., and Sripa, B., 2012. Ultrasonography assessment of hepatobiliary abnormalities in 3359 subjects with *Opisthorchis viverrini* infection in endemic areas of Thailand. *Parasitol.Int.* 61, 208-211.
- Mairiang, E. and Mairiang, P., 2003. Clinical manifestation of opisthorchiasis and treatment. *Acta Trop.* 88, 221-227.
- Prasongwatana, J., Laummaunwai, P., Boonmars, T., Pinlaor, S., 2012. Viable metacercariae of *Opisthorchis viverrini* in northeastern Thai cyprinid fish dishes as

part of a rational program for control of *O. viverrini*-associated cholangiocarcinoma. Parasitol. Res.

Rim, H.J., Chai, J.Y., Min, D.Y., Cho, S.Y., Eom, K.S., Hong, S.J., Sohn, W.M., Yong, T.S., Deodato, G., Standgaard, H., Phommasack, B., Yun, C.H., and Hoang, E.H., 2003. Prevalence of intestinal parasite infections on a national scale among primary schoolchildren in Laos. Parasitol.Res. 91, 267-272.

Sato, M., Pongvongsa, T., Sanguankiat, S., Yoonuan, T., Dekumyoy, P., Kalambaheti, T., Keomoungkhoun, M., Phimmayoi, I., Boupha, B., Moji, K., Waikagul, J., 2010. Copro-DNA diagnosis of *Opisthorchis viverrini* and *Haplorchis taichui* infection in an endemic area of Lao PDR. Southeast Asian J. Trop. Med. Public Health 41, 28-35.

Sayasone, S., Odermatt, P., Phoumindr, N., Vongsaravane, X., Sensombath, V., Phetsouvanh, R., Choulamany, X., and Strobel, M., 2007. Epidemiology of *Opisthorchis viverrini* in a rural district of southern Lao PDR. Trans.R.Soc.Trop.Med.Hyg. 101, 40-47.

Sayasone, S., Vonghajack, Y., Vanmany, M., Rasphone, O., Tesana, S., Utzinger, J., Akkhavong, K., Odermatt, P., 2009. Diversity of human intestinal helminthiasis in Lao PDR. Trans. R. Soc. Trop. Med. Hyg. 103, 247-254.

Sayasone, S., Mak, T.K., Vanmany, M., Rasphone, O., Vounatsou, P., Utzinger, J., Akkhavong, K., and Odermatt, P., 2011. Helminth and intestinal protozoa infections, multiparasitism and risk factors in Champasack province, Lao People's Democratic Republic. PLoS Negl Trop Dis 5, e1037.

- Sayasone, S., Rasphone, O., Vanmany, M., Vounatsou, P., Utzinger, J., Tanner, M., Akkhavong, K., Hatz, C., and Odermatt, P., 2012. Severe morbidity due to *Opisthorchis viverrini* and *Schistosoma mekongi* infection in Lao People's Democratic Republic. *Clin.Infect.Dis.* 55, e54-e57.
- Silverman, D., 2007. Doing qualitative research. London: Sage Publications.
- Sithithaworn, P., Andrews, R.H., Nguyen, V.D., Wongsaraj, T., Sinuon, M., Odermatt, P., Nawa, Y., Liang, S., Brindley, P.J., and Sripa, B., 2012. The current status of opisthorchiasis and clonorchiasis in the Mekong Basin. *Parasitol.Int.* 61, 10-16.
- Sripa, B., Bethony, J.M., Sithithaworn, P., Kaewkes, S., Mairiang, E., Loukas, A., Mulvenna, J., Laha, T., Hotez, P.J., and Brindley, P.J., 2011. Opisthorchiasis and *Opisthorchis*-associated cholangiocarcinoma in Thailand and Laos. *Acta Trop.* 120 Suppl 1, S158-S168.
- Sripa, B., Brindley, P.J., Mulvenna, J., Laha, T., Smout, M.J., Mairiang, E., Bethony, J.M., and Loukas, A., 2012. The tumorigenic liver fluke *Opisthorchis viverrini* - multiple pathways to cancer. *Trends Parasitol.* 28, 395-407.
- Strandgaard, H., Johansen, M.V., Agaard-Hansen, J., Petlueng, P., and Ornbjerg, N., 2008. Local perceptions and practices in regard to opisthorchiasis in two villages in Lao PDR. *Southeast Asian J.Trop.Med.Public Health* 39, 19-26.
- Wang, Y.-C., 2012. Examining landscape determinants of *Opisthorchis viverrini* transmission. *Ecohealth* 9, 328-341.
- Weichart, G. and van Eeuwijk, P., 2008. Food chains: eating, drinking, feeding - framing social relations. Preface. *Anthropology of Food* S3, 1-5.

WHO, 2011. Report of the WHO Expert Consultation on Foodborne Trematode Infections and Taeniasis/Cysticercosis. p.
http://www.who.int/neglected_diseases/preventive_chemotherapy/WHO_HTM_NTD_PCT_2011.3.pdf.

Ziegler, A.D., Andrews, R.H., Grundy-Warr, C., Sithithaworn, P., and Petney, T.N., 2011. Fighting liverflukes with food safety education. *Science* 331, 282-283.

Figure legends

Figure 1a: Welcome lunch of rural villagers served with sticky raw fish salad

Figure 1b: Sticky raw fish salad

Figure 1c: Raw fish salad

Figure 1d: Raw fermented fish sauce sold in Saravane market

Figure 2a: Weaver ant colony on a mango tree

Figure 2b: Cyprinoid fish in the market of a village