



Controlling parasites, understanding practices: The biosocial complexity of a One Health intervention for neglected zoonotic helminths in northern Lao PDR



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ABSTRACT

A parasitological survey in northern Lao PDR showed a remote ethnic minority village to be hyper-endemic for *Taenia solium*, a Neglected Tropical Disease (NTD) that impacts human and pig health. An intervention combining human Mass Drug Administration (MDA) with porcine vaccination and anti-helminthic treatment was then implemented, targeting both *T. solium* and other soil-transmitted helminths. To understand the biosocial complexity of this integrated One Health intervention, we conducted a rapid ethnographic study exploring the transmission dynamics of *T. solium* and locally acceptable long-term control options. Informed by two years of project work in the village, this included six focus group discussions, 35 semi-structured interviews, a latrine survey, a school-based education meeting, participant observation and many unstructured interviews conducted over two weeks in October 2013. We found that risk behaviours were mediated by various social determinants including limited market access, interrelationships between alcohol, ancestral sacrifices and the consumption of raw pork, seasonal variations and poor latrine coverage. Only sixteen percent of households had latrines, attributed to the unacceptability of dry latrines, lack of water access, poor building techniques and poverty. Whilst women could explain *T. solium* transmission, most men and children could not, revealing that distributed posters/leaflets relied too heavily on text and ambiguous images. Compliance with MDA was high due to trust between project staff and village leaders. However understandings of pharmacology, minor side effects, human migration and children's fear of worms may lead to resistance in future programmes. Our research highlights the complexities of controlling *T. solium* and other soil-transmitted helminths in a remote ethnic minority village and the need to integrate biomedical and participatory approaches. Although we showcase the heuristic value of using rapid ethnography to inform intervention strategies as part of a One Health/NTD agenda, we also identify several possible paradoxes and conundrums in embedding locally-grounded biosocial analysis into NTD programmes. These need to be acknowledged and negotiated by multidisciplinary teams.

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1. Introduction

Caused by the zoonotic tapeworm *Taenia solium*, the taeniasis/cysticercosis complex is a Neglected Tropical Disease (NTD) endemic throughout the global south, including Southeast Asia (Willingham et al., 2010). People can become infected with both the adult tapeworm (*taeniasis*) and the more serious larval stage of the

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parasite (*cysticercosis*). Without adequate sanitation, *T. solium* eggs are shed in the faeces of human tapeworm carriers and contaminate the environment. Human cysticercosis occurs when these tapeworm eggs are accidentally ingested, via unhygienic food preparation or other contact with human faeces, leading to the development of larval cysts in different body tissues. The most significant clinical manifestation occurs when these cysts develop in the brain; neurocysticercosis (NCC) is a leading cause of preventable epilepsy worldwide. Where pigs ingest infected human faeces, the subsequent development of larval cysts (*porcine cysticercosis*) significantly reduces the market value of pigs, impacting the livelihoods of smallholder pig producers. The transmission cycle is completed via human consumption of raw/undercooked cyst-infected pork, which leads to adult tapeworm development in the human intestine.

Control strategies for taeniasis/cysticercosis are divided between biomedical and behavioural change approaches. This includes treating individuals or populations with antihelmintics (with an added effect on other soil-transmitted helminths), the mass treatment of pigs with antihelmintics and more recently, the development of porcine anti-cysticercosis vaccines such as TSOL18 (Lightowers, 2013). Promoting behavioural changes in pig management, food safety, meat consumption and hygiene and sanitation practices can also disrupt transmission (Kyvsgaard et al., 2007). Among poor and marginalised communities where NTDs are clustered, both biomedical and behavioural strategies have different strengths and weaknesses in application. However emphasis has tended to be biomedical; behaviour change has seldom been the focus of taeniasis/cysticercosis activities, with the few reported health education interventions (in India, Tanzania, Kenya and Mexico) demonstrating mixed impacts (Alexander et al., 2012; Ngowi et al., 2008; Sarti et al., 1997; Wohlgemut et al., 2010).

This situation is not unique to *T. solium*. Allotey et al. (2010) and Spiegel et al. (2010) have recently argued that there is a continued “neglect” of social science perspectives in NTD control and a corresponding lack of intervention strategies that engage with broader social pathologies and determinants. NTD transmission and community responses to interventions are invariably influenced in a multitude of ways by local social, cultural, political, economic and environmental contexts (Aagaard-Hansen and Claire, 2010). A number of contemporary studies on soil-transmitted helminths, and other NTDs, have shown a lack of considering these complexities in control programmes as well as an over-emphasis on preventative chemotherapy (mass drug administration, or MDA) in comparison to more integrated strategies (Bardosh et al., 2014; Parker and Allen, 2011, 2013a).

Over a billion people (the so-called “bottom billion” of the global population) are thought to suffer from parasitic worms. Despite contemporary emphasis on MDA by large-scale donor programmes, many scholars and practitioners increasingly argue for trans-disciplinary One Health approaches to address this global burden, linking together human, animal and ecosystem health and integrating biomedical and behavioural change strategies (Gazzinelli et al., 2012; Min et al., 2013; Vandemark et al., 2010; WHO, 2012; Zinsstag et al., 2012). However the One Health movement has itself suffered from a relatively marginal social science contribution and a preoccupation with global pandemic threats (Scoones, 2010). There is an ever-growing call to translate One Health from rhetoric into a tangible set of programmes that showcase the feasibility and benefits of cross-sectoral solutions for endemic diseases in developing countries (Gibbs, 2014; Okello et al., 2011, 2014a; WHO, 2009). As a policy goal the WHO has, for example, acknowledged the need to develop a set of validated taeniasis/cysticercosis control strategies by 2015 in order to promote scale-up, with the possibility of future disease elimination in developing economies (Maurice, 2014).

As efforts expand to control NTDs, including *T. solium*, there is a need to better engage social science perspectives in thinking critically about the challenges of disease control in marginalised communities and how One Health approaches can best be adapted to local contexts. Here we report the results of a rapid ethnographic study done to explore, and identify areas for further improvement in, an integrated One Health NTD intervention in Lao PDR where intestinal parasites (*T. solium* and other soil-transmitted helminths) are widely endemic (Conlan et al., 2012a; Sayasone et al., 2009). In 2011, a serological survey in 59 villages across four provinces showed several hyper-endemic “hotspots” of *T. solium*, including a remote ethnic minority village (Unpublished data). Follow-up human faecal sampling confirmed human *T. solium* prevalence of 26.1% in this village, one of the highest confirmed prevalences found to date in Southeast Asia (Okello et al., 2014b). Prevalence for other soil-transmitted helminths was also extremely high. Faced with this discovery, an integrated One Health intervention was implemented. Based on work by Lightowers (2013) and Kyvsgaard et al. (2007), this simultaneously targeted pigs and people, including a pig intervention package (TSOL18 vaccine and antihelmintic administration), a Mass Drug Administration (MDA) protocol of 400 mg Albendazole over three consecutive days, and the distribution of educational material.

The specific objectives of our study were to identify and investigate the socio-cultural drivers and major transmission pathways of *T. solium*, assess community responses to the intervention and explore locally-acceptable strategies for long-term sustainable parasite control in this “hot spot” village. Through this locally-grounded analysis, this paper contributes to broader policy debates about the need to integrate disciplines and approaches in NTD control, as motivated by the One Health concept.

2. Methods

2.1. Study area

A single party state, the Lao People's Democratic Republic (PDR) is one of the poorest countries in Asia (Rigg, 2005). Approximately 64% of the rural population lacks improved sanitation, while 40% do not have access to safe water (Lahiri and Chanthaphone, 2003). The country is predominately rural and mountainous, made up of some 49 official ethnic groups (FAO, 2005). Many ethnic minorities inhabit the remote and mountainous northern region where poverty is most acute and an estimated 70 percent of households keep pigs (Epprecht et al., 2008). A Tai-speaking people from the Lao Loum (lowland Lao) ethnic group, the Tai Dam (or Black Tai) are found in northern Lao PDR, Vietnam, Thailand and China with a migrant population in the United States. Similar to other ethnic minority groups in the region, the Tai Dam are suspicious of government interventions and, unlike the majority of lowland peoples, are animists with distinct spiritual and medical beliefs (Bell and Whiteford, 1987; Kashinaga, 2009; Scott, 2009).

Our study community included an isolated village in Phongsali province close to the Vietnamese border, in the northern region. Unlike other ethnically-diverse villages in the area, this village is home exclusively to some 330 Tai Dam in 62 households. Agriculture revolves around upland rice, cassava, maize and other crops as well as pigs, poultry and buffalo while wild plants and meats are widely collected from surrounding forests. Access to the village requires travelling up a steep dirt road with two river crossings, making wet season access largely impossible. The mountain village is bordered on three sides by a stream, with forests and fields for non-irrigated rice cultivation interspersed among the surrounding hills. Despite power lines running through the village, there is no

electricity, although there is a primary school. Wooden houses are built on stilts and the rains occur from May to November.

2.2. Fieldwork

Our rapid ethnographic study was done over two weeks during phase one of a control intervention in October 2013 (described above). The study team included an applied anthropologist, a veterinarian with prior experiences in qualitative research (both international), a Lao veterinarian and a Lao medical doctor. We divided into male and female research teams. The study built on two years of previous work in the village as part of a smallholder pig project funded by the Australian Centre for International Agricultural Research (ACIAR). This had generated considerable trust between researchers and the community; many past informal discussions and observations had been unsystematically conducted that informed our research.

Moving away from trying to “capture” knowledge, attitudes and practices through reductionist KAP surveys (Launiala, 2009), we aimed to use ethnographic techniques to generate what Gibbons et al. (1994) have called “Mode 2” knowledge; knowledge based around solving specific problems, being task-oriented and multidisciplinary. In line with critiques on rapid ethnography and the possible biases introduced from our position as project actors (Manderson and Aaby, 1992), we paid particular attention to seeking out multiple, divergent perspectives and triangulating our data over our short study period. In total, we combined six focus group discussions (FGDs), 35 semi-structured key informant interviews (KII) (based on both purposive and snowball sampling), participant observation and many unstructured interviews with a latrine survey and an educational meeting with school children. We explored disease knowledge and control options through one focus group with women, children and teenagers while two male FGDs on these same topics were done, complemented with an additional male FGD on pig management. We conducted six semi-structured interviews with household heads with a latrine and six without. Interviews were also done with the village women’s group leader, a local healer, the new and old village chiefs, two teachers, two district-level government officials, a medical outreach worker and three of the wealthiest, and four of the poorest, households in the village (according to visible material assets). Finally, four taeniasis and three cysticercosis positive individuals identified in the January 2013 survey were also interviewed. Furthermore, during part of our research we slept in the village and spent much time eating, drinking and casually conversing with a range of village households.

2.3. Data analysis

All data collection involved translation of Lao to and from English and manual recording (all Tai Dam in our study village spoke fluent Lao). Nightly reviews of our data played an important role in flexibility, where we engaged with emerging themes and actively discussed possible ways in which our own stance as “outsiders” and “project actors” (implementers of the broader One Health intervention) could be influencing our research and how to address these issues. Formal data analysis involved manual coding, generating lists of codes, memo-writing and then conceptual matrixes done by the first author away from the field. The accuracy of this analysis was then reviewed by other team members.

2.4. Ethical approval

All approached individuals were informed of the purpose behind the study and were actively willing to participate. The study

was approved by the Animal, Food and Health Sciences Human Research Ethics Committee (CAFHS HREC) of Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO); approval number 13/10. The study was also approved by the Lao PDR Ministry of Health’s Council of Medical Science National Ethics Committee for Health Research (NECHR); approval number 013/NEHCR.

3. Results

3.1. Understanding parasite transmission

3.1.1. Hygiene and sanitation infrastructure

One of the major drivers of *T. solium* transmission is open defecation, which contaminates the environment with *T. solium* eggs and allows pigs to consume human faeces, thus completing the transmission cycle. Only sixteen percent of households in our study village had latrines; all were simple pour-flush latrines with bamboo, cement or wood superstructures. It was uncommon to defecate directly into crop fields or in the village itself; men predominantly used the surrounding forest and women the village stream to “clean oneself and avoid long walks” (Female, middle-aged, FGD). Preparation of the staple food (sticky rice) involved women mixing the rice with their hands, however the women were rarely seen to wash their hands when preparing meals in the village. Although some wealthier households did use soap for hand washing (which was observed on a few occasions), and some had an outdoor tap for washing dishes and pans, these practices were not present in the majority of households. Similarly, dogs (a known source of zoonotic hookworm infection) were regularly observed to lick plates and the fingers of children, being allowed uninterrupted access to the inside of people’s homes.

Hygiene practices in *sanaams* (agricultural fields) differed from those used in the village. Situated between ten minutes to five hours walk from the village, families and their livestock moved to their *sanaams* for the entire rice planting and harvest season (May to November). The ACIAR project team observed that no toilets or running water existed in any of the various *sanaams* visited over the two-year project period. However the relatively common reported practise of boiling drinking water – motivated in part by the memory of a deadly cholera outbreak twenty years previously – was dependent upon “how busy and tired you are from the fields” (Female, middle-aged, FGD).

Two past NGO funded subsidy-based sanitation projects had occurred in the village. In 2004, each household was given a cement flush slab with an attached water seal and a bag of cement to construct latrines. Cheaper dry latrine models were considered unacceptable since they were “too smelly to use”; local concepts of hygiene and disease emphasised the need to separate oneself from the smell of faeces, also noted by Rheinlander et al. (2010) in neighbouring Vietnam. Not all thirty or so households existing at the time had constructed latrines; roughly half used the materials for other purposes, citing water shortages along with a lack of education provided by the NGO on how to construct them. Despite the supply of six water taps in 2004, water pressure was low and prone to breaking; as one elderly man stated, “There was not enough water for the whole village and it was so far to walk. We created a law that you could not use too much.” In 2009 the NGO returned, constructing an elaborate gravity-fed system. Water could be then easily be transported from the tap to the latrine for flushing; wealthier families even linked pipes to their latrine. However most slabs had broken by then: “After they built the new system, I really wanted to use my latrine but it had broken. So now we have water but no slabs” (Male, middle-aged, FGD).

In households where latrines had been maintained, respondents felt that the advantages far outweighed the inconveniences. These included helping to “prevent all sorts of diseases”, avoiding the embarrassment of being seen defecating (especially when suffering from diarrhoea), and the unnerving experience of “disturbing forest spirits” at night. However, it was wealthier families that predominantly owned and maintained latrines. For those that did not, some were “simply lazy to build a latrine even though the water tap is next to their house” (Male, middle-aged, FGD). Others emphasised a lack of knowledge on how to build long-lasting structures, and lack of money. The high population density of the village (despite its remoteness, the village was situated between a stream and a mountain slope) was also identified as a problem; villagers cited insufficient space to allow every household to construct a toilet at a suitable distance from the house, which was needed to avoid the potential for “bad odours” to spread disease. In focus groups, latrine collapse was linked to the brittleness of the flush slab as well as “people not digging deep enough” and “placing the latrines on slopes and poor soils.” A significant reason repeatedly given by married women was that “men control most of the household income but desire latrines less than us” (Female, middle-aged, FGD), revealing a clear gender dimension to sanitation infrastructure.

3.1.2. Indigenous pig management

Transmission of *T. solium* depends on pigs having easy access to human faeces. With important cultural roles and acting as an important source of ancillary income, over 90% of households owned at least one local breed *Moo Laht* pig (unpublished data). Pigs were sold opportunistically to traders from the district capital and across the border with Vietnam for small cash needs such as school fees and health costs. Farmers were found to prefer selling younger, smaller pigs as they are less likely to die from disease, have fewer feed inputs, are considered to taste better and fetch higher prices; 25,000 KIP/kg (\$3.5) compared to 15,000 KIP/kg (\$2) for larger pigs at the time of research. Smaller pigs were also in high demand by traders due to their ease of motorbike transport on the steep mountain roads and suitability to fattening enterprises.

Pig management involved seasonal variation as pigs were moved with families to the *sanaams* for the rice planting/harvest season. Although there was a “village law” that pigs had to be penned, this only really occurs during the harvest to avoid crop damage. Pigs were then confined in locally-made wood and bamboo pens, fed cassava and rice husks. Smaller pigs (up to 10 kg) were observed to be mostly free ranging, even in the wet season, as holes in the pens allowed them to escape; hence smaller pigs were able to consume potentially-contaminated human faeces year-round. People emphasised the better taste of free ranging pigs and the fact that, with a sporadic market, pig production was merely one facet of a diversified local agricultural system, where maintenance with as little input as possible made sense.

3.1.3. Rituals, raw pork and alcohol

Important religious practices centred on raw pork were found to play a major role in *T. solium* transmission. To the Tai Dam, the dead ascend to the celestial world where, through ancestral worship, they act as protectors of their patrilineal descendants (Kashinaga, 2009). Three types of animistic ceremonies were described in our study village, all of which involved the sacrificial killing, offering and eating of raw pork (attributed to ancestral spirits “preferring the taste”). Over three days, the *Boun Phi Ban* or “village spirit” ceremony is performed to correspond with the rice season, as “this protects us from bad things like sicknesses and poor harvests and brings peace and wealth to the village” (Male, elder, KII, local healer). During the first day, a specifically-coloured buffalo or pig is sacrificed by male elders at a ritual point in the forest, after which the

heart and lungs are consumed raw. The meat is then distributed through the village, with the more influential households receiving better quality portions. This sacrificial meat “traditionally must be eaten raw and everyone in the village has to participate, to make peace with the village spirits” (Male, 67, KII, village chief). Two days of dancing, drinking and eating then follows where more pork is consumed and surrounding villages invited. With copious amounts of locally-brewed rice alcohol, known as *Lao Lao*, these celebrations mimicked the second smaller *Boun Kin Chieng* or New Year ceremony where the sacrifice of a large pig and a chicken is prepared and served at the homes of two respected families for all villagers.

Pork was also required for the *Boun Phi Hean* or household ancestral ceremony. According to Kashinaga (2009) rituals for dead parents are performed by the Tai Dam every five to ten days fixed to an ancient Chinese lunar calendar. We found that pigs were only sacrificed (and subsequently consumed raw) on average two to five times a year for this ceremony, during the death anniversary of the ancestor, or when other problems such as illness and food shortages occurred in the household. Although ceremonies were considered to be more likely to be initiated by wealthier households, neighbours and friends were always invited, thus increasing the amount of potential parasite exposure.

We found that pork was not widely consumed outside of a sacrificial or festival context (pork was also, for example, consumed during wedding celebrations, mimicking the New Year ceremony). The large variety of bushmeat from the surrounding forests provides a major alternative protein source that is also consumed raw. There were various reasons for the preference of raw over cooked meat outside a religious context. Our research showed that raw meat was believed to “give people power and makes them strong while cooking destroys the power of the meat” (Male, middle-aged, FGD). This was related to notions of masculinity given healthy men who did not eat raw meat were “not 100% a man! A man drinks, smokes, hunts and eats raw meat!” (Male, middle-aged, FGD). As another man stated to us over a casual meal of raw wild deer:

“We know that drinking beer will get you drunk but we still drink. Also, the doctor may tell you not to drink after you take a medicine, but from the clinic you are at the bar and still healthy up to now! It doesn't matter – today I am having fun. If I get a worm or even die I don't care. I will still eat this meat!”

Due to taste preferences, women preferred cooked meat, although many would eat raw pork during weddings and sacrifices. Parents insisted that children were restricted from raw pork due to health concerns since “[eating raw pork] causes illnesses if you are not strong. The body [of a child] cannot defend itself” (Female, middle-aged, FGD). Despite the insistence of parents (including households with children positive for *T. solium*), this was clearly not always the case:

“Some children eat raw pork since they want to copy their parents. For laap [raw meat] you get strong. I started eating it at seven years since I wanted to be strong. My parents let me but others will just go and eat it during the ceremonies when no one is looking. But if you can eat it and not get sick then you are allowed.” (Male, Teenager, FGD)

Most respondents admitted to seeing tapeworm cysts in the meat; “if you slaughter twenty pigs you will get at least one or two with many cysts” (Male, middle-aged, FGD, village leader). There appeared a vague association between cysts and “some kind of disease”, with most people claiming to “take out the bad parts and cook them and only eat the good parts raw” (Male, elder, FGD). However, in addition to our epidemiological results, we found a

number of potential pathways that likely contributed to cystic meat consumption on a regular basis. Women would do most of the cooking; however the method of roasting the outside of the meat for “two to three minutes” would not effectively kill cysts. Knives and boards used to prepare pork and vegetables were rarely washed between uses, as observed elsewhere in Lao PDR (Suwansrinon et al., 2007). In addition, it was mostly the men tasked with preparing raw meat during large village ceremonies. Without electricity and with most men and some women drunk from *Lao Lao* during ceremonies, there were inherent difficulties in seeing whether pork had cysts or not. Poverty itself also likely played a major role; as one married woman explained in a FGD, “You have only small money so you cannot throw [cystic meat] away”.

3.2. Identifying locally-acceptable control options

Given these various disease drivers, what *T. solium* control options could ensure long-term control in this rural village? This section explores local attitudes to, and perceptions of, different biomedical and behaviour change strategies.

3.2.1. Pig vaccination: acceptable but logistically challenging

While porcine vaccination generated the most community support, there are inherent implementation challenges in remote regions such as northern Lao PDR. Acceptability largely stemmed from the fact that, in the words of the village chief; “It is the easiest option since we don't do it, you do!” Low human capacity and supply chain problems currently inhibit sustainable animal vaccination outside a donor-funded project; most farmers are not (yet) willing-to-pay for either the TSOL18 or Classical Swine Fever (CSF) vaccination (previously undertaken by the project). Economic drivers, such as an official cross-national trade agreement with Vietnam that penalised cystic meat (through fines, for example), could potentially help drive demand for a combined TSOL18 and CSF vaccination protocol. However the ongoing issue of lack of access to ‘formal’ markets, particularly for isolated villages, does not guarantee success.

Mass vaccination is also a labour-demanding task. The first vaccine intervention occurred during the rice harvest when pigs were in *sanaams*. At the time of the booster vaccine one month later, most pigs had returned to the village but were more difficult to vaccinate since even breeding stock were free range. Ongoing suspicion that the vaccine could kill pigs required project staff to agree to compensation for any ill or dead pigs up to three days after vaccination; trust increased after none died. In accordance with vaccine guidelines, pregnant breeding stock and piglets less than one month old were not vaccinated, which excluded around 40 percent of pigs. In short, the dependence on external financial and human resources for TSOL18 vaccination threatens its long-term impact if not coupled with other strategies.

3.2.2. Community responses to MDA

Our research corresponded with three days of MDA offered to everyone in the village over six years old. We estimated that around 60 percent of eligible villagers received tablets (unpublished data); however not all completed the recommended three-course dose required to kill 100 percent of *T. solium* (Steinmann et al., 2010). Many asked for “more medicines please” as they had felt “so good afterwards ... my appetite is so big” (Male, elder, FGD) and were “happy to take medicine to get rid of worms” (Female, middle-aged, KII). This relatively high compliance was facilitated by two years of trust building project work. Echoing Parker and Allen's work on MDA in Africa (2011, 2013a), if mass treatments are continued in this village, or indeed rolled out to a district or provincial level, a number of factors could lower compliance, as discussed below.

High dose cysticidal anthelmintic drugs can induce seizures in people with neurocysticercosis. Although no Extreme Adverse Reactions (EARs) were reported, likely due to the lower drug dosages given over three consecutive days, abdominal pain, headache, constipation, tiredness, coughing, difficulty breathing, bloating, high heart rate and vertigo were all reported. While these were managed by a local medical officer (who stayed in the village for the duration of MDA), these minor side effects could create reluctance for people to undergo future treatments. A second issue involved local notions of pharmacology. Repeated interviews showed that local interpretations emphasised that medicines, taken when not ill, become “stored” in the body causing “toxins” to accumulate; similar observations have been noted by anthropologists working on pharmaceutical use in Asia and elsewhere (Craig, 2002; Whyte, Van der Geest and Hardon, 2002). Hence repeated MDA may elicit resistance if education and trust building is not emphasised. A third issue involves logistical challenges of coverage. Regular seasonal migration of village members, driven by the strong familial relationships with other parts of Lao PDR and across the Vietnamese border, was found to be responsible for low coverage in some households. Similarly, intra-village migration to remote *sanaams* during the wet season cultivation period (described above) creates its own set of challenges for ensuring high MDA coverage.

A fourth concern involved compliance of school-aged children, as related to an existing school deworming programme (part of a long-standing donor-funded nutrition project) where all students in the district receive a biannual dose of Mebendazole 500 mg (the project intervention used three consecutive 400 mg doses of Albendazole). Three of four interviewed *T. solium* individuals were children who had not participated in the project-led MDA; one was too young to comply with the ethical requirements, and two had recently taken anthelmintics at school. Moreover, a number of parents did not consent to their school-aged children taking anthelmintics during the project-led MDA, citing the existing school programme as sufficient. The efficacy of these treatments is questionable given our parasitological surveys and other studies in the region showing the low efficacy of single dose mebendazole against some soil-transmitted helminths – presently used in all Lao PDR school programmes (Steinmann et al., 2011). The local schoolteachers also indicated their concern of the programme's coverage, estimating that only 35 percent of children were regularly ingesting these tablets. There were several reasons for this. The first involved the reported emphasis by donors that, although distributed at school, dewormers should be taken before bed, which allowed children to “toss them in the bush” (Female, young adult, KII, teacher). Second, the aforementioned fear of “toxins” building up in the body, possibly reflected by the parents' unwillingness for their children to be dosed under the project, was evident in discussions with the school children. Presentation of formalin-fixed tapeworms to a class was met with disgust; even the more animated young boys covered their noses and mouths. Stories of children vomiting roundworms in the classroom, and negative experiences of “something moving inside me [after taking anthelmintics] ... which makes me scared” (Male, child, FGD) also likely played a role in the suspected low compliance of school children.

3.2.3. Behaviour change and passive educational strategies

Local knowledge of helminths was already widespread in the village, associated with faeces, water, insects, food and hygiene. Intestinal worms were considered to cause major health problems, including abdominal pain, dizziness and nausea, with many sourcing local anthelmintic treatments at the district hospital; “They can give you serious problems in your health by eating your

blood and taking away your food” and “kill a child by taking a lot of blood and eating the stomach” (Two Females, middle-aged, FGD).

Lao language posters and pamphlets developed by a previous project were distributed during the intervention. While these helped relate porcine cysts to worms, they had limitations. Women could detail the general transmission cycle in posters but most men and children could not, either because they were illiterate, the pictures were unclear or they had not looked at them. Despite the labour-intensive control activities, the male village leadership still did not understand how pigs got cysts, while the two school-teachers had not been informed about the project altogether. Confusion was also expressed by all three interviewed cystercosis-positive individuals, who remained unsure about how they became infected. The links between penning pigs (advocated in the posters), vaccinating pigs and distributing human medicines was unclear – were we targeting one disease or many? With low literacy, the printed materials focused too heavily on text with conventional biomedical images. However, posted on the inside and outside of most houses, they were clearly valued.

The four main human behaviours discussed in the posters and pamphlets emphasised common interventions for *T. solium* control: washing hands, cooking pork, penning pigs and using latrines. However discussions with villagers emphasised the embedded challenges to address these, with gender appearing to be a crucial micro-social barrier to achieving a number of proposed behavioural changes. Although hand washing to prevent the spread of tapeworm eggs through general contact and food preparation was considered an “easy solution”, it was quickly acknowledged that: “it is very difficult to actually follow due to our farming lifestyle” (Female, middle-aged, KII). Second, despite some women claiming, as a result of the distributed posters, that they would now refrain from consuming raw pork, this option found no support from the men. Poverty and religious norms would clearly hamper the desire and ability to discard cyst-infected meat and/or thoroughly cook it to avoid ingestion of viable cysts – especially during ritual sacrifices. Many cysts were also acknowledged to be “hard to see” (Female, middle-aged, FGD) given pork was prepared in dim kitchens, often with copious amounts of alcohol. Third, villagers expressed that it would be unlikely that they would confine pigs, which is currently emphasised by various agricultural development programmes given its role in preventing a number of transmissible diseases. The existing village management system emphasises low input practices due to poverty, lack of market access and the relatively high risks of pig loss due to disease outbreaks. The lack of willingness to pen pigs – and eat the meat from penned pigs – was also driven by beliefs that close contact of pigs with their own faeces, and each other, promotes disease and is unhygienic.

A final option emphasised in the posters/leaflets was increased latrine use, which was framed by two competing narratives. The first narrative, emphasised by wealthier households, was that socio-economic changes would soon drive improved sanitation. Three-wheeled tractors had recently replaced buffalo use in rice cultivation in wealthier households, and a construction company has started to improve the current access road from the village through to the Vietnamese border. As with other areas of northern Laos, coffee and rubber promoted by Chinese and Vietnamese traders are also altering local livelihoods (Sturgeon et al., 2013), which may subsequently drive endogenous sanitation improvements, and wider social change.

The second contrasting narrative emphasised that latrine coverage would not improve without subsidised inputs; “You need to talk to the men about building latrines ... otherwise these [worms] will never end but where to find the money?!” (Female, middle-aged, KII). According to some, especially men, desire for latrines was also reduced by the social acceptability of open defecation as embedded

within local livelihoods and perceptions of latrines as “dirty places” where “faeces mixed and diseases spread.” Most were unwilling to pay for the necessary flush slabs and cement. Although the aforementioned socio-economic changes may precipitate willingness-to-pay (emphasised by Van Minh et al., 2013), this is not certain. Unless a local strategy for making flush latrines is introduced, supply of hardware (together with water provision) is a major limiting factor. A more complex livelihood challenge is that, even if all households built latrines in the village, existing practices at farms would likely reinforce *T. solium* transmission during the rice season.

4. Discussion

This paper has focused on the biosocial complexity of parasitic disease transmission and control in a remote ethnic minority village, northern Lao PDR. Our analysis has unpacked the likely epidemiological drivers of an unusual hyper-endemic focus of *T. solium* and explored the challenges involved in implementing a sustainable One Health intervention that targets both pigs and people. Whilst our epidemiological research has been fundamental in identifying and quantifying the depth of the parasite problem, our subsequent rapid ethnographic data has provided the vital social context to explain our epidemiological findings as well as local understandings and responses to our intervention strategy and potential future avenues for developing more culturally-appropriate interventions. In this way, our rapid appraisal has aided our consideration of the unique biosocial determinants of *T. solium* control in this context, serving as an example of the trans-disciplinary perspectives increasingly recommended under a One Health approach to NTDs. Grounded in this analysis, our research also points to some possible tensions in, or at least the need to re-consider, how interventions are designed and implemented if the social and biomedical sciences are to move towards greater collaboration in NTD control. This also has broader relevance to policy debates about One Health given that NTDs, in many cases very well suited to integrated approaches, can be seen as proxies for the relevance and feasibility of the One Health concept among the world’s “bottom billion”. Here we discuss some of these broader issues in relation to specific findings about *T. solium* transmission and control.

Our study showed important interrelationships between alcohol, ancestral sacrifice and the consumption of raw (and cyst-infested) pork. Lévi-Strauss (1969) hypothesised an inverse relationship between the level of transformation of food, and the social status it brings; the further food is transformed from its natural state (boiled or stewed), the lower the social status of consumers. In this way, the consumption of raw meat is associated with higher social standing, good health as well as “the masculine world”. Such perceptions clearly complicate efforts to deter the consumption of raw meat, whether from domestic or wild animals, in zoonosis control efforts. Furthermore, our research showed that culinary, cultural and socio-economic preferences regarding the consumption and sale of smaller pigs together with the greater propensity for them to be free range, and thus more exposed to infective human faeces, indicates *T. solium* transmission could be largely maintained by the smaller weaned piglets and grower pigs. Successful policies or behavioural change strategies deterring the consumption of raw pork and/or the need to fence young and grower pigs are unlikely to be successful in this village. This highlights the inherent challenges of integrating social science findings with “correct” epidemiological recommendations. Many biomedical scientists continue to view anthropological contributions to public health as finding ways to make “culture” work for interventions (Napolitano and Jones, 2006); however we have shown the reverse: that intervention strategies need to be chosen and

adapted to cultural settings (see [Leach and Scoones \(2013\)](#) on Ebola and H5N1 avian influenza).

Importantly, our study reveals the lack of “magic bullet” solutions to *T. solium* and other soil-transmitted helminths and the need to integrate biomedical and participatory approaches. While community compliance with MDA and pig vaccination was sufficiently high in our control project, their current financing and implementation by a donor-initiated programme was found to be problematic. Suspicions and concerns that could have lowered participation were carefully negotiated by the project team; however similar to [Parker and Allen's observations in East Africa \(2011, 2013a\)](#), our findings point to the need to consider local pharmacological ideas, human migration, child perceptions and drug side-effects in helminth control programmes. It is unlikely that biomedical approaches alone (whether MDA or pig vaccination) can sustainably reduce *T. solium* long-term in our study village. For example, even if the current programme is successful in decreasing prevalence, without improvements in risk behaviours the parasite will easily re-establish itself through imported pigs, human migration, villagers who did not receive MDA and people attending neighbouring village sacrifices.

However we found both opportunities and challenges with educational strategies aimed at changing behaviours, related to hand washing, latrine usage, cooking pork and fencing pigs. Our distributed posters were somewhat effective and certainly valued – as shown by their impact on women's knowledge – but there were significant shortcomings in their efficacy for children and men. This shows the need to better engage men in health education, who are considered key “gatekeepers” in changing health behaviours in such remote communities and would be instrumental in fostering school-based education, the promotion of child compliance with MDA and the construction and use of latrines. As our research showed, however, there was clearly a gender inequality dimension to the transmission of *T. solium*. Gender relationships would likely play a crucial micro-level social barrier in any community-driven intervention, and would need to be negotiated.

Similarly, the fact that village teachers had not been informed about the purpose of our control activities suggests that local leaders do not always disseminate information widely, revealing the need to engage teachers and schools more directly. A larger question surrounds the efficacy of “passive” educational strategies more generally (see [Khun and Manderson \(2007\)](#) on Cambodia's dengue control programme). Reflecting on the challenges of using education to foster behaviour change, [Panter-Brick et al. \(2006\)](#) showed the need to move beyond didactic methods in order to be “culturally compelling”; messages should be reinforced over time using different mediums where it is imperative to gain community support, focus on positive outcomes and adapt strategies to sub-groups, while also addressing constraints to people's agency. More engaging and empowering methods – for example participatory media development where community members are involved in designing, filming and showcasing an educational video (as described by [Catalani and Minkler, 2010](#)) – could be very effective in localised, remote ethnic minority settings.

Our findings show that education should be integrated with community mobilisation approaches that link with larger health and livelihood concerns. This could include promoting local and cross-border markets for pork and live animals by integrating public health concerns with agro-business development. The greater transport connections and economic integration that is presently taking place between Lao PDR, China and Vietnam may promote this, although such macro-level processes have their own accompanying risks for the livelihoods for ethnic minority groups (see [Rigg, 2005](#); [Sturgeon et al., 2013](#)). This has been noted in

livestock market dynamics in Asia with Avian Influenza where the politics of cross-border animal disease surveillance has occasionally further marginalised smallholders who are unable to abide by national regulations ([Scoones, 2010](#)).

Apart from livestock development, in many ways sustainable control of *T. solium*, and other similar pathogens, requires improvements in sanitation and hygiene. The provision of free flush slabs, however, has been ineffective in the past for various reasons. Among other activities, the development of community-based health groups (see [Waterkeyn and Cairncross's \(2005\)](#) study in Zimbabwe) could possibly foster the development of a locally-acceptable alternative to the flush slab with the ability to be constructed and maintained by households themselves. Such participatory approaches have been advocated in neighbouring Vietnam for ethnic minorities and could lead to long-term health improvements in *T. solium* endemic villages ([Rheinlander et al., 2010](#)).

Paradoxically, however, our analysis also shows that participation may not be a public health panacea given the multitude of other challenges in people's daily life and the embedded nature of risk behaviours (see [Bardosh et al. \(2013\)](#) on sleeping sickness in Uganda). Given the continued debate about the narrow focus of current MDA programmes and the need to integrate more holistic interventions ([Parker and Allen, 2011, 2013b](#)), studies should explore the feasibility and “added-value” of engaging broader social determinants in the control of parasitic worms. Our study shows that combining participatory approaches in conjunction with shorter-term therapeutic strategies should be trialled and evaluated in a range of contexts to allow for extrapolation and wider policy recommendations. This is especially important given the WHO's goal of validating cysticercosis control strategies by 2015 and the current global campaign to control soil-transmitted helminths through MDA.

Furthermore, unlike other studies in Lao PDR where raw beef consumption was shown to be widespread ([Conlan et al., 2012a](#)), sacrificial religious practices of the Tai Dam, and other ethnic minorities in Southeast Asia (see [von Geusau, 2000](#)), are likely to focus almost exclusively on raw pork consumption in specific areas of Lao PDR and neighbouring countries. Due to the high clustering of *T. solium*, broad-based epidemiological investigations are likely to overlook hyper-endemic hotspots unless ethnicity is considered. We recommend that areas of suspected high raw pork consumption (as opposed to raw beef or fish consumption) should form the basis of any future *T. solium* sampling strategy. However this insight – the relationship between raw pork consumption and ethnicity – and the recommendations for “scaling-up” the findings of our study also risks the unintended possibility of having these ethnic minority communities labelled “backwards” and in need of coercive public health measures; such communities have long been subject to the disciplining power of nation states in Southeast Asia ([Scott, 2009](#); [Rigg, 2005](#); [Rheinlander et al., 2010](#)). We strongly reject this approach not only on political and moral grounds, but also because it would unlikely achieve any long-term public health benefit.

These analytical findings reveal some of the challenges of embedding biosocial analysis into mainstream, large-scale NTD programmes. While integrating biomedical and participatory approaches that target multiple NTDs and adapt strategies based on local contexts through multidisciplinary teams are certainly desirable and needed, our study questions the feasibility of resource-poor countries adopting such approaches outside a small-scale donor-funded project. Building adaptability to local contexts into large-scale interventions for helminths requires a willingness to experiment, the integration of robust social analysis into the planning process and the building of learning into programmes over time. However given resource-constraints, working norms,

the tendency for passive education and the lack of a social research component in many large-scale country-led initiatives, this may be easier said than done (see Bardosh et al., 2014; Khun and Manderson, 2007). One Health approaches to NTDs are also beholden to the politics of funding in large donor projects; Parker and Allen (2013b) discussed the tendency for anthropological analysis of operational challenges in MDA programmes to be effectively “controlled” in the fear that donor-funding would be cut. Hence integrating rapid ethnography into scaled-up One Health NTD programmes requires a strong emphasis on using social research data to shape implementation, the value of critical self-reflection and the acceptance that intervention approaches (including the proposed biomedical strategies) may need to change in the field.

Despite the conundrums in linking an understanding of local realities into global health programmes, there are clear opportunities of using the One Health concept to guide NTD control in Lao PDR and elsewhere towards greater engagement with complexity. Through identifying and building on motivators for the government medical sector, water and sanitation departments and other development actors to become involved in the integrated control of *T. solium* and other soil-transmitted helminths, the applicability of One Health interventions can be highlighted. This may ultimately help disentangle zoonoses control from its historical “veterinary” mandate, highlight the need to link biomedical and participatory approaches in developing countries and showcase the added-value of integrating broader social determinants into NTD control. Promoting the relevance of rapid ethnographic studies as part of One Health approaches is one way to realise these goals in the Southeast Asian region, and beyond.

5. Conclusion

Our study has generated important insights into the epidemiology and control of *T. solium* and other soil-transmitted helminths in a hyper-endemic village in northern Lao PDR, with significant recommendations for future studies and One Health approaches. Through our locally-grounded biosocial analysis, we have showcased that rapid assessments based in anthropology have important roles in mediating between time and budget constraints and the increasing need to engage local realities in NTD control. The continued challenges that inhibit the heuristic value of social inquiry as well as the integration of biomedical and participatory approaches need to be negotiated as part of a wider One Health agenda for NTDs in developing countries.

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