Health status of villagers in rural Attapeu Province, Lao PDR, with a focus on risk factors for intestinal helminth infections

Master thesis submitted to the Charité – Universitätsmedizin Berlin
in partial fulfilment of the requirements for the award of a
Master of Science degree in International Health

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August 2012

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List of abbreviations

Abbreviation	Meaning
a. s. l.	Above sea-level
BMI	Body mass index
95% CI	95% Confidence interval
FBT	Food-borne trematodiasis
GAHI	Global Atlas of Helminth Infection
H/A	Height for Age
HDI	Human Development Index
L/A	Length for Age
Lao PDR	Lao People's Democratic Republic
NGO	Non-government organization
NTD	Neglected tropical diseases
MDGs	Millennium Development Goals
MoH	Ministry of Health
MUAC	Mid-upper arm circumference
OR	Odds ratio
SD-score	Standard deviation score
SFE	*Service Fraternel d' Entraîde*
STH	Soil transmitted helminths
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
W/A	Weight for Age
W/H	Weight for Height
W/L	Weight for Length
WFP	World Food Programme
WHO	World Health Organization

Tables and Figures

1. Executive summary

Background: Malnutrition and neglected tropical diseases such as intestinal helminth infections are of substantial public health concern affecting mainly the poorest populations in the world. Poverty and health are closely interrelated. Marginalized populations in rural areas are especially prone to suffer from ill health. Lao PDR is one of the least developed countries worldwide. Malnutrition is still of serious public health concern in Lao PDR.

To date, there is a lack of information about marginalized populations and their state of health in Lao PDR. A cross-sectional baseline health survey was thus, conducted by the non-government organization *Service Fraternel d' Entraîde (SFE)* in ten rural villages, Attapeu Province, Lao PDR between November 2010 and February 2011. The overall study objective was to assess the villagers' state of health in each of the remote villages including the assessment of risk factors for intestinal helminthic infections of the villagers. The survey also serves as a baseline against which future project achievements will be compared. The following two specific study objectives were pursued: First, to describe and to evaluate the health status of the villagers in relation to: (i) reported health problems in the last month preceding the survey, (ii) nutritional status including anemia and (iii) intestinal helminth infection; Second, to identify risk factors for intestinal helminth infections of this neglected population.

Methodology: The survey included a random sample of 783 villagers belonging to ten remote villages located in Attapeu Province, Lao PDR. Frequency distributions were assessed for socio-demographic and health status related indicators. Malnutrition was classified according to World Health Organization (WHO) - standards. Stunting, wasting and underweight were diagnosed according to age and gender adapted WHO-growth reference tables. A standard deviation-score (SD-score) below -2 SD was considered as a cut-off value for malnutrition indicators throughout the analysis for all growth reference categories. Indicators with SD-scores below -3 SD were regarded as severe malnutrition. A hemoglobin cut-off value of 11 g/dl was considered anemic. Helminth infection status was diagnosed microscopically using a single Kato-Katz thick smear examination. Bivariable analysis was performed in which any helminth infection was associated with potential risk factors. Odds ratio (OR) and 95% confidence interval (CI) were calculated and reported as a measure of strength of the association. X^2 and Fisher's exact test were applied for discrete variables. A p-value of 5% and below was considered statistically significant. Multivariable logistic regression analysis was applied to assess the independent relative contribution of the different potential risk factors to helminth

infections. Variables which are potential risk factors or confounders for helminth infection were included in the multivariable model. All potential risk factors associated with the outcome with a p-value of 20% or below in bivariable analysis were incorporated in the multivariable model. Advanced analysis focused on fitting a random effect regression model for clustered data. Crude prevalence rates were adjusted according to the sample distributions across villages and households, taking into account the clustering by village and household. A weighted analysis was performed to account for the unbalanced sample distributions across villages.

Results: Complete data records were obtained for 601 of the 783 villagers, which were considered for further analysis. High prevalence rates were found for malnutrition in the remote villages of Attapeu Province. Children aged 0 to 5 years showed an adjusted prevalence of 56.0% (65/113 children) for stunting, 19.9% for wasting according to W/L and W/H (20/113 children), 22.0% (27/113) for wasting according to mid-upper arm circumference (MUAC) for age, 48.8% (54/113 children) for underweight according to weight for age (W/A) and 22.1% (27/113 children) for anemia. Stunting was 59.5% (207/340) for children and adolescents ranging from 0 to 19 years of age, underweight according to W/A was 50.2% (101/206) for children belonging to the age group 0 to 10 years. 26.2% (67/261) of the adults suffered from underweight according to the body mass index (BMI) for adults and 11.7% (35/261) suffered from anemia.

Concerning reported health problems in the last month preceding the survey, 60.7% (385/601 persons) reported to have had at least one health problem. 32.2% (212/601 persons) suffered from fever, 25.3% (169/601 persons) had a cough, 20.1% (117/601 persons) had general body problems such as pain and tiredness, 14.6% (91/601 persons) had a cold and 1.7% (9/601 persons) had severe lung problems. 7.0% (43/601 persons) mentioned to have had abdominal problems, 12.0% (79/601 persons) to have had diarrhoea. 1.4% (7/601 persons) suspected themselves to have had malaria in the last month prior to the survey and 1.4% (9/601 persons) mentioned to have had jaundice.

Intestinal helminth infections were highly prevalent in rural Attapeu Province with 60.3% (373/601 persons) being infected by at least one helminth species and 12.5% (80/601) were affected by multiparasitism. The most prevalent helminth infections according to species were *Ascaris lumbricoides*, hookworms and *Trichuris trichiura* (20.7%, 19.2% and 12.1%). Further infections included *Taenia* spp. (9.6%), *Opisthorchis viverrini* (6.2%) and *Paragonimus* spp. (3.2%). Prevailing helminth species differed by location. *Ascaris lumbricoides* showed highest prevalence with 62.3% (33/53 persons) in the village Nonghin. Hookworm and *Opisthorchis viverrini* prevalence peaked in the riverside village

Hatnhiay with 49.3% (36/73 observations) and 24.7% (18/73 observations), respectively. Taeniasis was predominantly detected in the Sansai District with prevalence rates reaching up to 39.4% (26/66 persons) in the village Maythavone.

According to the manual model building strategy of the multivariable logistic regression model, independent predictors of helminth infections included living in the villages Maythavone (OR 28.3, 95% CI 9.76-82.09, p=0.001), Daklakao (OR 10.35, 95% CI 3.91-27.38, p=0.001) and Dakyat (OR 59.6, 95% CI 14.83-239.5, p=0.001) and ethnicity. People belonging to the ethnic minority groups Niaheun (OR 10.65, 95% CI 1.58-71.82, p=0.015) and Lavaen (OR 13.57, 95% CI 2.69-68.48, p=0.002) were significantly positively associated with helminth infections when compared to Lao Loum as reference populations. Age and gender were not significantly associated with helminth infections of villagers.

Conclusions: Malnutrition including anemia, general health problems and helminth infections remain a serious public health concern regarding the marginalized population of Attapeu Province. Intensified efforts to advance the villager's access to public health care, safe water supply and sanitation as well as to improve the health and nutritional status of the people in rural villages of Attapeu Province, Lao PDR, are vitally needed. Regular deworming including treatment for cestodes and trematodes is urgently required in the affected villages.

2. Introduction

2. 1. Background situation in Lao PDR

Lao People's Democratic Republic (Lao PDR) is a landlocked Southeast Asian country bordering to China, Vietnam, Cambodia, Thailand and Myanmar. It has a population of 6.2 million inhabitants. With a Human Development Index (HDI) of 138 of 187 countries, Lao PDR is considered to be one of the least developed countries. Life expectancy at birth is approximately 67.5 years; under-five mortality rate is around 59 per 1,000 live births; maternal mortality ratio is estimated to be 580 per 100,000 live births (UNDP, 2011).

The Lao economy has progressed over the recent years with national poverty rates decreasing from 46% in 1992/1993 to 27% in 2007/2008. Nonetheless, this progress is still unevenly distributed with inequalities remaining regionally and between different population groups. The main employment opportunities are garment manufacture, tourism and handicrafts, food and wood processing. Mining and hydroelectricity are other natural resource based industries. Few people are currently employed by these industries. The countries main income is still based on subsistence farming. More than three quarters of the Lao population are engaged in agrarian livelihoods - often at impoverished levels. Productive and remunerative employment is low in Lao PDR. Poverty is reinforced by low labor productivity in the agrarian sector and few work opportunities in the industrial and service sectors. Rural and marginalized populations are especially troubled by poverty (Ministry of Planning and Investment and UNPD Lao PDR, 2009).

Chronic malnutrition is still a major problem in Lao PDR. 47.6% of children below the age of five are estimated to suffer from stunting, 31.6% from underweight and 7.3% from wasting (World Health Organization, 2012a).

Lao PDR is a diverse and multi-ethnic country with citizens belonging to 49 main ethnic groups and more than 100 subgroups. There are three main ethnic groups in Lao PDR based on place of residence, linguistic family and agricultural production habits: Low land Lao (Lao Loum; Tai-Kadai linguistic family), mid- or upland Lao (Lao Theung; Mon Khmer Austro-Asiatic linguistic family) and highland Lao (Lao Sung; Sino-Tibetan and Hmong-Myan linguistic family). With approximately 65%, the Lao Loum represent the majority of citizens throughout Lao PDR (Ministry of Health Lao PDR and Japan International Cooperation Agency Study Team, 2001).

Malnutrition rates of children below the age of 5 have been shown to be higher in ethnic minority groups when compared to the Lao Loum ethnic group as reference population.

Parental education, access to local health services, water and sanitation as well as household wealth have been identified to be determinants of the nutritional status of children below the age of 5 (Kamiya, 2011). Poverty is highest in rural areas inhabited primarily by ethnic minority groups. In Lao PDR, ethnic minorities have been shown to be economically poorer than the majority Lao-Thai mainly because of unequal access to resources and for demographic reasons (Engvall, 2007).

2. 2. Poverty, malnutrition and anemia

Health and poverty are closely interrelated. A complex vicious cycle of poverty, lack of clean water and sanitation, malnutrition, common infections, such as diarrhoeal and respiratory infections, impair the well-being of impoverished people and especially of children. Access to safe drinking water and adequate sanitation facilities are insufficient in many less developed countries. Adverse environmental conditions hamper development, health and nutritional status and support poverty (Prüss-Üstün and World Health Organization, 2008). Malnutrition is related to anemia, thereby hindering the physical capacity and work performance. In addition, malnutrition and anemia contribute to impaired cognitive and physical growth of people. Maternal and overall infant mortality as well as the risk of premature birth increase when anemia and malnutrition are present. Malnutrition and anemia impair the function of the immune-system which in turn aggravates infections and morbidity of all age groups (World Health Organization, 2001). Chronic under-nutrition is associated with shorter adult height, lower educational status and reduced economic productivity. Prevention of undernourishment during childhood benefits the human capacity in the long-term by increasing their health, educational, and economic status in later life (Victora et al., 2008).

By the year 2000, the United Nations submitted the Millennium Declaration which states the right of every individual to a life with dignity, equality and equity. A basic standard of living including freedom from hunger, diseases and violence as well as a healthy life in tolerance, solidarity and shared responsibility is encouraged (United Nations, 2000a). The Millennium Development Goals (MDGs) followed the Millennium Declaration. The targets and indicators for poverty reduction are operationalized in the eight MDGs which aim to foster development and to improve social, economic and health related circumstances in the poorest countries of the world, especially in the most vulnerable and neglected areas. Target 1 c of the MDGs refers directly to malnutrition. The goal is to diminish the proportion of people who suffer from hunger by half between 1990 and 2015

(United Nations, 2000b). Even though progress has been made towards reaching the MDGs, it is still unevenly distributed.

In all developing countries, children are generally more underweight in rural as opposed to urban areas. Significant disparities and inequalities remain between rich and poor people, urban and rural areas as well as concerning those who are disadvantaged due to age, gender, ethnicity and location in isolated geographic areas. Nevertheless, the MDGs may still be achieved. Continued international commitment is needed to focus on the most important promise ever made to the world's vulnerable people (United Nations, 2010).

The survey conducted in the remote villages in Attapeu Province is an example for the above described situation. Living in remote areas of Lao PDR means living in a marginalized situation where poverty and poor health status prevail.

2. 3. Marginalized populations and neglected tropical diseases

Since rural and marginalized populations, in particular ethnic minority groups, are especially affected by poverty, they are particularly at risk for ill health such as neglected tropical diseases (NTD) and often face isolation in remote environments with extremely limited access to health care. Information on the health status of ethnic minorities in remote areas is scarce as well as difficult and labor intense to obtain. In poor countries, resources are insufficient to assess health status information of populations in hard-to-reach areas (Schratz et al., 2010). Another facet of the vulnerability of ethnic minorities to NTD is social marginalization which itself includes various, interrelated causes such as culture, religion, education, poverty, ethnicity and disease. Stigma is one of the limiting factors in health seeking behavior among other causes including structural, economic and political reasons (Muela Ribera et al., 2009).

Neglected tropical diseases (NTD) are of substantial educational, economic and public health concern affecting primarily marginalized populations living below the poverty line (Hotez et al., 2009). Intestinal helminth infections such as soil-transmitted helminths (STH), food-borne trematodes (FBT) as well as cestodes are among the most disregarded NTD. The helminth species differ in their transmission cycles, geographical distribution, in their specific clinical symptoms if present and in their drug susceptibility (Hotez and Ehrenberg, 2010). Nonspecific symptoms like abdominal discomfort, poor appetite, nausea and fatigue impede infected persons. Chronic helminth infections intensify malnutrition and anemia and impair the physical and cognitive development of children (World Health Organization, 2010b).

Globally more than one billion people are estimated to be infected with at least one species of STH (de Silva et al., 2003). *Ascaris lumbricoides, Trichuris trichiura* and hookworms are the most common STH worldwide (Bethony et al., 2006). STH are particularly prevalent when sanitary conditions are poor. Lack of safe water supply and of effective sanitation lead to fecal contaminated environments, thus fostering the infection and reinfection with STH (World Health Organization, 2010b). Morbidity is associated with chronicity of infection and worm burden.

WHO recommends preventive chemotherapy against STH in endemic countries as a short-term strategy since reinfection occurs rapidly under unsanitary conditions. Long-term sustainability endorses the improvement of access to safe water supply and sanitation, improved hygiene-behavior and better health education. Long-term sustainability thus, aims at interrupting the transmission cycle and is difficult to achieve. Primary targets for regular deworming with e.g. benzimidazole drugs are school-aged children and high risk groups, i.e. preschool-aged children after the first year of life, women in child bearing age, pregnant women after the first trimester and occupational groups at risk (Partners for Parasite Control. Meeting [3rd : 2004 : Geneva Switzerland] and World Health Organization. Strategy Development and Monitoring for Parasitic Diseases and Vector Control Team, 2005, Albonico et al., 2006).

FBT, e.g. *Opisthorchis viverrini* and *Paragonimus* spp. and cestodes, such as *Taenia* spp., are not effectively treated by benzimidazole drugs. For these species, treatment with praziquantel is required (Crompton and World Health Organization, 2006). Therefore the recommended preventive chemotherapy using the benzimidazole drugs mebendazole or albendazole has no effect on cestodes and trematodes. In endemic countries such as Lao PDR, people infected with cestodes and FBT remain even more neglected than people who are infected with STH.

2. 4. Burden of intestinal helminth infections in Lao PDR

In Lao PDR, STH and FBT are highly prevalent. Recently, a nation-wide survey of schoolchildren showed that 61.9% (18,462/29,846) of the pupils were infected with any intestinal helminth; in detail 34.9% were infected with *Ascaris lumbricoides*, 25.8% with *Trichuris trichiura*, 19.1% with hookworms and 10.9% with *Opisthorchis viverrini* (Rim et al., 2003). FBT are most prevalent in central and southern Lao reaching prevalence rates of 80% and higher (Forrer et al., 2012, Sayasone et al., 2007). Multiparasitism, in particular infections with STH and FBT, are highly prevalent in Lao PDR (Sayasone et al., 2011).

Public health actions have been enhanced in Lao PDR. A nationwide deworming program with regular mebendazole administration was launched in 2005 targeting school-aged children through the school system. Good results were reported by the Ministry of Health (MoH). Within the first year of deworming, *Ascaris lumbricoides* and *Trichuris trichiura* rates declined from 60% to 20% and from 42% to 31%, respectively (Phommasack et al., 2008). Deworming efforts still need to be extended to pre-school children. A survey conducted in Savannakhet Province highlighted high infection rates of preschool-aged children with 28.4% suffering from monoparasitic infections. 9.3% of these children were affected by polyparasitic infections (Kounnavong et al., 2011).

Lack of information about geographical variation, prevalence and intensity of helminth infections however, still exists especially with regard to isolated, remote communities (Jex et al., 2011). Marginalized populations and specifically ethnic minorities have no or only limited access to health services and public health support such as deworming programmes.

2. 5. Attapeu Province and *SFE* Community Health Development Project

Attapeu Province, Lao PDR, is a rural province with a tropical monsoon climate and a rainy season lasting from May to October. Agriculture is the main source of income. 60% of Attapeu Province is mountainous with mountains surrounding the province borders. The central part of Attapeu Province comprises of a plain along the Xe Khong River. Poverty is highest in the most remote, mountainous areas which are predominantly inhabited by ethnic minority groups. The under-five mortality rate is almost double the countries average in Attapeu Province (97 per 1,000 live births). There are thirteen ethnic groups living in Attapeu Province of whom twelve belong to the Mon Khmer ethnic minority group and one belongs to the lowland Lao (Lao Loum) which is widespread throughout Lao PDR (Lao People's Democratic Republic Peace Independence Democracy Unity Prosperity, 2003). The Lao Loum ethnic group, which is mainly based in Attapeu town and the river plains in the lowlands, constitutes 36.9% of the population in Attapeu Province (Mekong Integrated Water Resource Management Project, 2010). In rural Attapeu Province, 47% of the population is estimated to live below the national poverty line. With respect to the total population of Attapeu Province, 95% are estimated to have no sustainable access to improved water sources; 39% lack access to improved sanitation (Ministry of Planning and Investment and UNPD Lao PDR, 2009).

Health and nutrition related indicators characterize the human well-being and environmental conditions. Information on malnutrition rates is scarce in Attapeu Province

and depends on the different locations according to village and district level (Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme, 2006).
The main source of daily calorie intake is glutinous rice. According to a recent study on nutrition and livelihoods at village level, food supplies are uncertain in Attapeu Province mainly because of low productivity. Particularly, annual rice shortages strongly affect the food availability. Most communities eat diets which are nutritionally unbalanced. Principally, diets tend to be low in protein and fat and contain insufficient amounts of micronutrients e.g. of vitamin A, iron and iodine. Additionally, traditional food behaviors such as feeding pre-chewed rice to newborns and food taboos that forbid pregnant and lactating women to eat meat, fruit and vegetables may to some extend contribute to malnutrition in the region (Meusch, 2003, Barennes et al., 2009).
Today's information relate mainly to accessible populations living in the plain. Health information on ethnic minorities living in the mountainous part of the province is scarce.

In February 2010 a community health development project was initiated by the non-government organization *SFE* in Attapeu Province. The baseline health survey conducted intends to establish a reference point for subsequent project activities and their achievements. Ten remote villages with limited access to health care were enrolled. Health promotion is one of the main project goals including the improvement of sanitary conditions, strengthening healthy behavior and improving education as well as agriculture and farming practices. *SFE* works together with the village population in a participatory approach building on priority setting, capacity building, local ownership and shared responsibility for agreed project goals. Building and maintaining water and sanitation improvements such as toilets are joint responsibilities. People are encouraged to commitment. Villagers participate actively in educational training. Training focuses on a variety of health related topics, ranging from improvement of hygiene behavior and nutrition to prevention and management of infectious diseases, sustainable farming and agricultural techniques, care of livestock, water safety, sanitation and to the organization of the local school system.

2. 6. Aims and objectives of the study

The cross-sectional baseline health survey was conducted to establish a baseline against which the achievements of the community health development project will be compared.
The overall thesis objective was to assess the villagers' state of health in each of the remote villages including the assessment of risk factors for intestinal helminthic infections of the villagers. The first specific objective was to describe and to evaluate the health

status of the villagers in relation to reported health problems in the last month preceding the survey, to nutritional status including anemia and to intestinal helminth infections. The second specific objective was to identify risk factors for intestinal helminth infections of this neglected population.

3. Methods

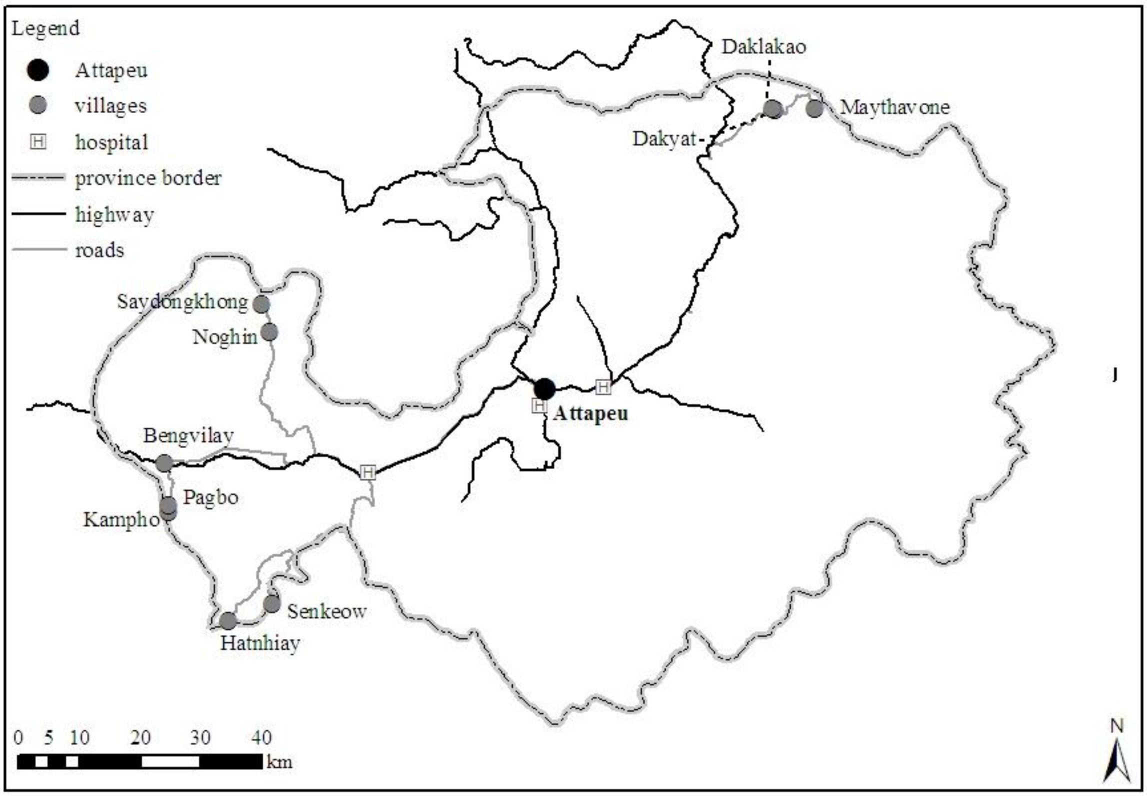
3. 1. Study design

3. 1. 1. Study type, study population and study area

The study followed the logic of a cross-sectional survey. It was conducted in ten rural villages, Attapeu Province, Lao PDR, between 1st of November 2010 and 25th of February 2011. The study population included a random sample of 783 villagers belonging to seven different ethnic groups of whom six were considered to be Mon Khmer ethnic minorities, namely: Sou, Ta-Oi, Alak, Tariang, Niaheun and Lavaen.

Attapeu Province is the southeastern province of Lao PDR bordering to Vietnam and Cambodia (Map 8.3, Annexes) and has a population density of less than 11 people/km² with an estimated total population of 127,285 (Lao Statistics Bureau, 2005). The provincial capital Attapeu is located approximately 900 km away from the capital Vientiane. The *SFE* office is situated at the provincial hospital compound in Attapeu town. Coordination and outreach activities were organized from here. The study villages were Dakyat, Daklakao, Maythavone in the Sansai District and Saydongkhong, Nonghin, Hatnhiay, Senkeo, Bengvilay, Pagbo and Kampho located in the Sanamxay District. Together, they had a total population of 3334 inhabitants. The locations of the surveyed villages are shown in Figure 1.

Figure 1: Map showing the surveyed villages, Attapeu Province, Lao PDR



Sansai-District:

The villages Dakyat, Daklakao and Maythavone are located in a remote mountainous area northeast of Attapeu town. Depending on weather and road conditions, it took a minimum of 3 up to 8 hours to reach these villages by car from Attapeu town. The travel distance of Attapeu town to Dakyat and Daklakao was approximately 90 km, while the distance to Maythavone was around 100 km. Altitude levels are over 1000 meters a.s.l. (Maythavone 1070 m a.s.l., Dakyat 1080 m a.s.l., Daklakao 1090 m a.s.l.).

Sanamxay District:

Hatnhiay and Senkeo are located in the Xe Khong riverside area southwest of Attapeu town at an altitude of 80 m a.s.l. The travel time was a minimum of 2.5 hours by car starting from Attapeu town. The travel distance of Attapeu town to Hatnhiay was approximately 85 km; the distance of Attapeu town to Senkeo was around 75 km. Both villages were accessible by car throughout the year. Bengvilay, Pagbo and Kampho are located southwest of Attapeu town. These villages were only accessible by car in the dry season that lasts 5 months per annum due to the seasonal flooding of several rivers which need to be crossed. Transport by car took at least 3.5 up to 9 hours from Attapeu town. The travel distance to Attapeu town was approximately 85 km (Pagbo, Kampho) and around 75 km (Bengvilay). Altitude levels are: 120 m a.s.l. (Bengvilay), 100 m a.s.l. (Pagbo), 70 m a.s.l. (Kampho). Saydongkhong and Nonghin are located west of Attapeu town. The travel distance of Saydongkhong to Attapeu town was approximately 82 km; the distance of Nonghin to Attapeu town was about 77 km. It took at least 3 hours by car to reach Saydongkhong and Nonghin from Attapeu town. These villages were accessible only 6 months a year by car during the dry season. Altitude levels are: 420 m a.s.l. (Saydongkhong), 300 m a.s.l. (Nonghin).

3. 1. 2. Sampling strategy and sample size calculation

During the survey setup, all villages were mapped. Households were numbered and listed on a household list. A simple random sample of households was drawn from the household list. All members of the sampled households were included in the survey without any age restriction. The households were enrolled until the sample size per village was reached. In order to minimize selection bias such as the temporary absence of household members, all households chosen were informed the day before the visit to stay at home during the next morning until the survey team arrived. Since the survey took place in remote areas, the possibility of people being temporarily absent for example by going to the market was negligible. The survey commenced early in the morning to enable the survey participants to return to their rice fields as soon as possible.

Sample size was calculated for each village separately using an expected helminth infection rate of 50%, a confidence level of 95% and an acceptable margin of error of 10%. In addition, the sample size was adjusted for the total population size of each village. A total of 783 individuals was obtained. Details about the sample sizes are provided in Table 1 (Annexes).

3. 2. Survey conduct and questionnaire

Every village was informed about the baseline health survey and several village meetings were held. In depth information about the conduct and purpose of the survey was given, discussed and questions were answered. Village meeting locations were provided by the village chiefs who were present during these meetings. Villagers agreed to participate on a well informed and voluntary basis with the right to withdraw at any time. Confidential data handling and anonymous data processing was guaranteed by the use of unique identification numbers. The results of the survey were communicated to the villagers consecutively. Prior to the start of the baseline survey an additional meeting with all heads of households, who participated in the survey, took place in each village. Detailed instructions about stool specimen collection were provided.

During each household visit interviews were conducted and hemoglobin-level, height, weight and mid-upper arm circumference of children up to the age of 5 were measured and recorded on the questionnaire form. A separate questionnaire form was used for each person interviewed. Results of individual stool analysis were written down on the same questionnaire form.

Questionnaires were pretested at the Attapeu hospital. Interviews were conducted by trained project staff. The questionnaire included notification of the health survey number, a unique identification number, the name and surname of the person interviewed, the name of the interviewer, the date of the interview, the name of the village and of the district, gender, age, date of birth, ethnicity and occupational status. Information about general health problems in the month preceding the survey and about diarrhoea, fever, jaundice or cough in the last month prior to the survey was collected. If people mentioned to have had any health problem, they were asked to describe the symptoms. Care takers of children or children themselves were questioned about previous deworming. Previous treatment against lymphatic filariasis was explored.

3. 3. Assessed indicators

Age and sex: Age was recorded in years; for children below the age of 2, age was recorded in months. Date of birth was registered, if known to the person. Sex was noted.

Anemia: Hemoglobin levels were measured using a hemoglobin card test (Haemoglobin Colour Scale Starter-Kit, COPACK GmbH, Germany). The scale contains a card with different shades of red that correspond to different hemoglobin levels. A drop of blood was applied on the test strip. After 30 seconds the color of the blood spot was matched instantly against the red shades on the scale (Dobson and World Anesthesia, 2002). Measurements of each examination were validated by two survey team workers. A hemoglobin cut-off value of 11 g/dl was considered as anemic (World Health Organization, 2001).

Anthropometric indicators:

- *Height* was measured in centimeters with a measuring pole in upright standing position. For children younger than two years, height was measured in recumbent position.

- *Weight* was measured in kilograms with a standardized balance. Children who were not able to stand upright were measured with a standardized hanging scale.

- *Mid-upper arm circumference (MUAC)* was measured in centimeters for children up to the age of 5 using a standardized measuring band (TALC, St Albans, Herts, UK).

Ethnic group: Ethnicity was recorded according to individual self-assessment.

Food security: Food availability was noted according to the reported average number of meals eaten per day in the last year prior to the survey. The reported average number of servings of protein-rich food (meat, egg or fish) per week in the year preceding the survey was noted. For example, if a person reported to consume protein-rich food two to three times per week, this was reported as two “and a half” servings per week. The number of months when rice was lacking was recorded for the last year prior to the survey.

Health problems: Reported health problems were assessed in an open answer question.

Helminth infection status: Intestinal helminth species were identified microscopically using a single stool sample. Multiparasitism was noted, if a person was infected with more than one intestinal helminth species at the same time.

History of treatment: Previous treatment against lymphatic filariasis and previous deworming were investigated.

Location: Place of residence was registered according to village, district and elevation. Villages were located in two districts (Sansai and Sanamxay District). Elevation above sea-level (a.s.l.) was measured for each of the villages using a handhold GPS-device

(Garmin, eTrex Vista C). The elevation level was categorized into three classes: above 1000 m a.s.l., between 300 m and 420 m a.s.l. and between 70 m and 120 m a.s.l.

Occupation: Occupational status was recorded in terms of the individual open answer given and was consecutively categorized into 5 classes: farmers, officially employed people, persons staying at home, pupils and children staying at home.

Water source: The safety of the water sources used in the villages was categorized according to the presence or absence of a water pump.

3. 4. Data collection

Anthropometric indicator data collection: During each household visit height, weight and MUAC of children up to the age of 5 were measured.

Hemoglobin-level assessment: Hemoglobin-levels were examined during the household visits. Fingertips were disinfected with alcoholic solution before piercing with an individual sterile lancet. Young children were examined in company of their care-takers.

Stool examination: Every person sampled received an individually labeled plastic container for stool collection with an instruction on how to collect a stool sample which was to be returned the next day. All fecal samples were examined by light microscopy with a magnification of 100 and 400 on the collection day using the Kato-Katz thick smear technique (Katz et al., 1972). All slides were allowed to clear for 30 minutes prior to examination and were examined in less than 2 hours after slide preparation. Fecal specimens were examined directly on-site in 8 of the 10 villages by an experienced parasitologist from the Attapeu provincial hospital who accompanied the survey-team. Fecal probes were transported to the hospital laboratories for examination of 2 out of the 10 villages. Of these fecal specimens, 50% were analyzed at the Attapeu provincial hospital and 50% were analyzed at the Sanamxay district hospital. Time for transport from stool collection in the villages to handover to the hospital laboratories was 1 to 2 hours. Immediate laboratory examination followed on the same day within 2 hours for all fecal specimens.

3. 5. Data management and analysis

3. 5. 1. Data management

Data was double-entered and validated with EpiData Version 3.1 (EpiData Association; Odense, Denmark). Data analysis was performed with the statistical software package STATA Version 10 IC (Stata Corp., College Station, TX, USA). Participants were classified according to five age groups: (i) preschool-aged children (0-5 years), (ii) school-aged children (6-15 years), (iii) adolescents and younger adults (16-30 years), (iv) adults (31-55 years) and (v) elderly (>55 years). Body mass index (BMI) was computed according to the standard formula: BMI= weight (in kilogram)/height^2 (in meter). Z-scores and standard deviation (SD) scores were calculated for wasting, stunting and underweight for children aged 0 to 5 years using international growth standards of the WHO Multicentre Growth Reference Study (World Health Organization, 2006). For school-aged children and adolescents WHO growth reference standards for the 5-19 years age group were applied (de Onis et al., 2007). Nutritional status was defined as follows:

(i) Wasting: “Weight for Length” (W/L) from birth to the age of 2 or “Weight for Height” (W/H) from 2 to 5 years of age with a cut-off value of -2 SD were considered as wasting. Additionally, a “MUAC for Age” cut-off value of -2 SD was regarded as wasting.

(ii) Stunting: “Length for Age” (L/A) of children from birth to 2 years of age and “Height for Age” (H/A) of children and adolescents from 2 up to 19 years of age with Z-scores below -2 SD were rated as stunting.

(iii) Underweight: “Weight for Age” (W/A) of children from birth up to 10 years of age and “BMI for Age” of children and adolescents ranging from 5 up to 19 years with Z-scores below -2 SD were considered as underweight. For adults, a BMI below 18.5 kg/m^2 was regarded as underweight for both sexes (Bailey and Ferro-Luzzi, 1995). Wasting, stunting and underweight were further sub-classified to be either severe or moderate according to SD-score. SD-scores below -3 were considered as severe malnutrition, a SD-score below -2 SD and down to -3 SD was considered as moderate malnutrition (World Health Organization, 2012b).

Health problems were categorized according to the prevailing reported signs and symptoms. If a person stated to have had at least one health problem in the month preceding the survey, this person was classified positive for “any health problem - present”. Any severe lung problem such as suspicion of tuberculosis, pneumonia, exacerbated asthma bronchiale and bloody expectoration was classified as “lung problem - present”. Fever, diarrhoea, cough, cold, jaundice and suspicion of malaria were recorded according to their self-reported presence in the last month prior to the survey. The following problems mentioned to have occurred in the last month preceding the survey were classified as “abdominal problems - present“: stomach ache, abdominal discomfort, problems while defecating, visible helminth expulsion in stool, gastritis, nausea and flatulence. “General health problems - present” was included as a category in order to summarize the various general exhaustion related symptoms mentioned by villagers to have been present in the last month preceding the survey such as various sorts of back and joint pain, headache, dizziness and tiredness.

3. 5. 2. Descriptive part - study population and health status of the villagers

The study population was characterized according to age, sex and place of residence. All participants with complete data records were included in the analysis. The data was summarized in a table. The health status of the villagers was described by frequency counts. Summary tables were presented for the following health status indicators: reported health problems in the last month preceding the survey, nutritional status and anemia. For helminth infection status a summary table was provided specifying all diagnosed infections according to age, sex and place of residence.

3. 5. 3. Analytic part 1 - risk factor assessment of helminth infections

Bivariable analysis was performed in which any helminth infection was associated with potential risk factors. The following potential risk factors were considered: age, sex, ethnicity, occupational status, reported health problems in the last month prior to the survey, safety of the water sources in each village, history of deworming and of treatment against lymphatic filariasis, nutritional status, anemia, location according to place of residence (village, district) and elevation above sea-level (a.s.l.). Odds ratio (OR) and 95% confidence interval (CI) were calculated as a measure of strength of the association. In addition, the p-value was reported. A p-value of 0.05 and below was considered to be statistically significant. Bivariable analysis was conducted prior to multivariable analysis with the purpose to examine, if there was a sufficient overlap of the potential confounders. X^2 or Fisher's exact test were applied in comparison of discrete variables. Multivariable logistic regression analysis was applied to assess the independent relative contribution of different potential risk factors (predictors) to the helminth infection status (outcome: absent/present) (Hosmer and Lemeshow, 2000). All potential risk factors associated with the outcome "any helminth infection present" with a p-value of 20% or below in bivariable analysis were included in the multivariable model. Variables which were risk factors or potential confounders for helminth infection based on theory, prior research and empirical findings were included in the multivariable model. Variables which are not on the causal pathway to the outcome, redundant variables and variables with a lot of missing data were excluded from the multivariable model (Katz, 2011).

3. 5. 4. Analytical part 2 - advanced analysis

Given the clustered nature of the data, in particular within households and villages, advanced analysis focused on fitting a random effect regression model for clustered data (Hedeker et al., 1994). In addition, a weighted analysis was performed to account for unbalanced sample distribution across villages. The inverse probability of an individual being included in the sample is termed the base weight which accounts for the differential probabilities of being selected into a sample and therefore minimizes selection bias (Korn and Graubard, 1999). Considering the sampling procedure of this survey, the weighting accounted for the otherwise biased results towards small villages. Overall, these additional analyses were performed to provide further insight into the validity of the precedent results. For estimation of descriptive proportions of health surveys, a weighted estimation with weights representing the sample weights is recommended. The weighted proportions ($\bar{y}$) were calculated according to the formula: $\bar{y} = \frac{\sum_{i=1}^{n} \omega_i y_i}{\sum_{i=1}^{n} \omega_i}$ where $y_i = 1$ or 0 depending on the i^{th} case being in the category of the outcome any helminth infection present or absent; ω_i is the sample weight for the i^{th} case being sampled into the total study population. The sums are over n sampled cases. The weighted proportions ($\bar{y}$) lead to larger confidence intervals for the proportions thereby representing valid estimators for the assessed proportions (Korn and Graubard, 1999). Concerning the analytical part of this analysis, the weighted and unweighted bivariable and multivariable associations of the potential risk factors with the outcome “any helminth infection present” were assessed (Korn and Graubard, 1999).

3. 6. Feasibility and ethical issues

Ethical clearance was obtained from the Ethical committee of the Ministry of Health (MoH) Vientiane, Lao PDR. Field work permission was given by MoH, the Provincial and the District Health Offices.

All villages, households and individuals were informed in detail in the local language about the goals and processes of the study. Written informed consent was obtained by all heads of households and oral informed consent by every person taking part in the survey. For children, consent was given by the parents or legal care takers. A witness observed the consenting and co-signed the informed consent. One district health official accompanied each village tour. In case villagers could not read, write or speak Lao, the district health official translated Lao into the particular ethnic language spoken.

Ill study participants were treated or referred to the next adequate health service. All identified helminth infections were treated according to Lao national and WHO treatment guidelines (Ministry of Health Lao PDR, 2004, Crompton and World Health Organization, 2006). When praziquantel treatment was necessary, thorough information about possible side-effects was provided. In case of side-effects, people were instructed to immediately contact either the survey-team or the next health center.

4. Results

4. 1. Study population

The study population comprised of 601 persons with complete data sets for stool examination and health status indicators (76.8%) out of a total survey population of 783 people (Figure 2). Compliance for stool examination was 80.9% (634/783).

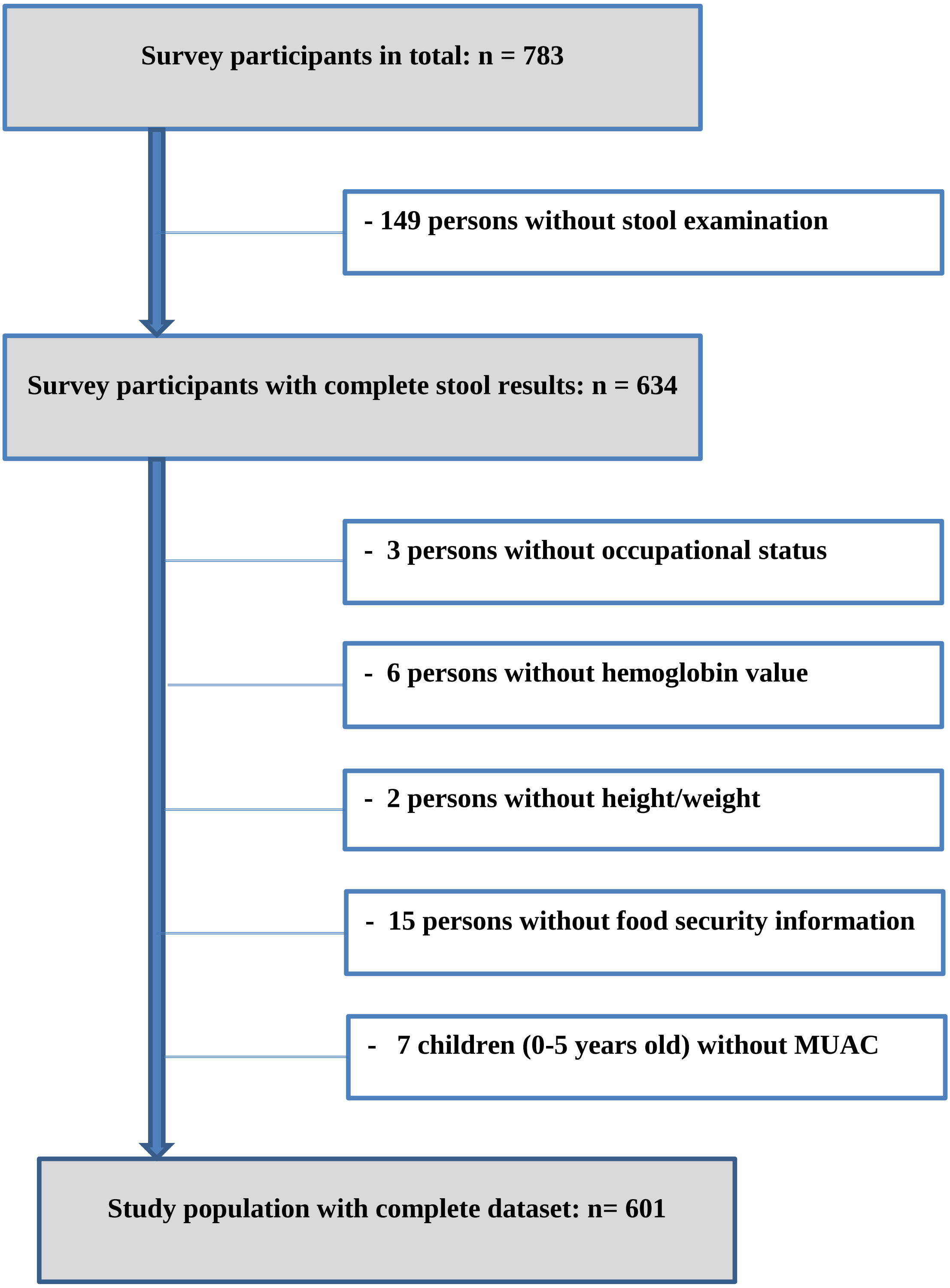


Figure 2: Study population

The description of the study population by age, gender and location is shown in Table 2.

Table 2: Description of the study population (n=601)

Village	Total	Sex		Age (in years)				
	n (%)	male n (%)	female n (%)	0-5 n (%)	6-15 n (%)	16-30 n (%)	31-55 n (%)	>55 n (%)
Maytha-vone	66 (11.0)	33 (11.5)	33 (10.5)	16 (14.2)	20 (10.4)	9 (7.7)	17 (12.4)	4 (9.8)
Dak-lakao	54 (9.0)	28 (9.7)	26 (8.3)	9 (8.0)	18 (9.3)	9 (7.7)	13 (9.5)	5 (12.2)
Dakyat	52 (8.7)	25 (8.7)	27 (8.6)	9 (8.0)	14 (7.3)	9 (7.7)	13 (9.5)	7 (17.1)
Saydong-khong	65 (10.8)	25 (8.7)	40 (12.8)	16 (14.2)	18 (9.3)	15 (12.8)	12 (8.8)	4 (9.8)
Nonghin	53 (8.8)	25 (8.7)	28 (9.0)	10 (8.9)	18 (9.3)	13 (11.1)	7 (5.1)	5 (12.2)
Hatnhiay	73 (12.2)	31 (10.8)	42 (13.4)	13 (11.5)	19 (9.8)	18 (15.4)	18 (13.1)	5 (12.2)
Senkeo	59 (9.8)	35 (12.2)	24 (7.7)	10 (8.9)	18 (9.3)	15 (12.8)	13 (9.5)	3 (7.3)
Beng-vilay	67 (11.2)	38 (13.2)	29 (9.3)	7 (6.2)	26 (13.5)	12 (10.3)	18 (13.1)	4 (9.8)
Pagbo	59 (9.8)	30 (10.4)	29 (9.3)	12 (10.6)	22 (11.4)	11 (9.4)	13 (9.5)	1 (2.4)
Kampho	53 (8.8)	18 (6.3)	35 (11.2)	11 (9.7)	20 (10.4)	6 (5.1)	13 (9.5)	3 (7.3)
Total	601 (100.1)	288 (100.2)	313 (100.1)	113 (100.2)	193 (100.0)	117 (100.0)	137 (100.0)	41 (100.1)

Prevalence rates were adjusted according to the sampling design taking into account the different sample sizes by village (Table 3).

Table 3: Inverse probabilities according to the sample sizes in each village (n=601)

Village	Number of individuals (n) sampled from the total village population (N), n/N	Probability P= n/N	Inverse probability I= $\frac{1}{P}$
Maythavone	66/259	0.25	3.92
Daklakao	54/222	0.24	4.11
Dakyat	52/339	0.15	6.52
Saydongkhong	65/488	0.13	7.51
Nonghin	53/379	0.14	7.15
Hatnhiay	73/351	0.21	4.81
Senkeo	59/152	0.39	2.58
Bengvilay	67/347	0.19	5.18
Pagbo	59/545	0.11	9.24
Kampho	53/ 252	0.21	4.75
Total	601/3334	0.18	n.a.

4. 2. Frequency distribution of health status and nutrition related indicators

The following prevalence tables (Tables 4a/b - 10a/b) report assessed crude and adjusted prevalence rates.

4. 2. 1. Reported health problems

The reported health problems in the month prior to the survey were categorized according to the prevailing symptoms and are shown in Table 4a/4b. 60.7% of the study population mentioned to have had at least one health problem in the month preceding the survey. The most frequently reported health problems were fever (32.2%), cough (25.3%) and general problems (20.1%); (Table 4a).

Table 4a: Reported health problems in the last month prior to the survey (n=601) - crude and adjusted prevalence

Health problem present	Total n	Crude prev. (%)	95% CI	Adjusted prev. (%)
Total	601	100		
Any health problem	385	64.1	60.2-67.9	60.7
Cold	91	15.1	12.3-18.0	14.6
Cough	169	28.1	24.5-31.7	25.3
Lung problem	9	1.5	0.5-2.5	1.7
Abdominal problem	43	7.2	5.1-9.2	7.0
Diarrhoea	79	13.1	10.4-15.9	12.0
Fever	212	35.3	31.4-39.1	32.2
General problem	117	19.5	16.3-22.6	20.1
Malaria	7	1.2	0.3-2.0	1.4
Jaundice	9	1.5	0.5-2.5	1.4

Abbreviations: prev. = prevalence

Fever was most common in Senkeo (76.3%) while cough prevailed in Maythavone (74.2%); (Table 4b).

The highest prevalence for people having had any health problem in the month prior to the survey was found in Senkeo (93.2%). More than two thirds of the population in the three villages of the Sansai District mentioned to have had any health problem in the month preceding the survey (Daklakao: 70.4%, Dakyat: 78.9% and Maythavone: 78.8%).

General health problems were most common in the oldest age group of villagers who were older than 55 years (48.8%) and in the villages of the Sansai District (Daklakao: 22.2%, Dakyat: 30.8% and Maythavone: 30.3%); (Table 4b).

Table 4b: Reported health problems in the last month prior to the survey by sex, age and location (n=601) - crude prevalence

Health problem present	Total	Sex		Age (in years)					Study location									
	n (%)	Male n (%)	Fe-male n (%)	0-5 n (%)	6-15 n (%)	16-30 n (%)	31-55 n (%)	>55 n (%)	Dak-lakao n (%)	Dak - yat n (%)	May-thav. n (%)	Say-dong. n (%)	Non-ghin n (%)	Hat-nhiay n (%)	Sen-keo n (%)	Beng-vilay n (%)	Pag-bo n (%)	Kam-pho n (%)
Total n (%)	601 (100)	288 (100)	313 (100)	113 (100)	193 (100)	117 (100)	137 (100)	41 (100)	54 (100)	52 (100)	66 (100)	65 (100)	53 (100)	73 (100)	59 (100)	67 (100)	59 (100)	53 (100)
Any health problem	385 (64.1)	188 (65.3)	197 (62.9)	81 (71.7)	98 (50.8)	74 (63.3)	98 (71.5)	34 (82.9)	38 (70.4)	41 (78.9)	52 (78.8)	34 (52.3)	28 (52.8)	51 (69.9)	55 (93.2)	33 (49.3)	29 (49.2)	24 (45.3)
Cold	91 (15.1)	45 (15.6)	46 (14.7)	33 (29.2)	27 (14.0)	9 (7.7)	17 (12.4)	5 (12.2)	10 (18.5)	7 (13.5)	19 (28.8)	11 (16.9)	5 (9.4)	5 (6.9)	8 (13.6)	8 (11.9)	8 (13.6)	10 (18.9)
Cough	169 (28.1)	81 (28.1)	88 (28.1)	32 (28.3)	52 (26.9)	28 (23.9)	41 (29.9)	16 (39.0)	13 (24.1)	16 (30.8)	49 (74.2)	8 (12.3)	6 (11.3)	20 (27.4)	20 (33.9)	11 (16.4)	14 (23.7)	12 (22.6)
Lung problem	9 (1.5)	4 (1.4)	5 (1.6)	0 (0)	2 (1.0)	3 (2.6)	2 (1.5)	2 (4.9)	0 (0)	2 (3.9)	0 (0)	2 (3.1)	0 (0)	0 (0)	0 (0)	1 (1.5)	1 (1.7)	3 (5.7)
Abdominal problem	43 (7.2)	21 (7.3)	22 (7.0)	3 (2.7)	4 (2.1)	10 (8.6)	20 (14.6)	6 (14.6)	2 (3.7)	2 (3.9)	3 (4.6)	2 (3.1)	9 (17.0)	6 (8.2)	9 (15.3)	4 (6.0)	4 (6.8)	2 (3.8)
Diarrhoea	79 (13.1)	43 (14.9)	36 (11.5)	29 (25.7)	19 (9.8)	8 (6.8)	16 (11.7)	7 (17.1)	8 (14.8)	13 (25.0)	7 (10.6)	4 (6.2)	5 (9.4)	16 (21.9)	16 (27.1)	1 (1.5)	5 (8.5)	4 (7.6)
Fever	212 (35.3)	102 (35.4)	110 (35.1)	43 (38.1)	62 (32.1)	36 (30.8)	54 (39.4)	17 (41.5)	12 (22.2)	28 (53.9)	28 (42.4)	22 (33.9)	16 (30.2)	29 (39.7)	45 (76.3)	12 (17.9)	9 (15.3)	11 (20.8)
General problem	117 (19.5)	44 (15.3)	73 (23.3)	2 (1.8)	13 (6.7)	34 (29.1)	48 (35.0)	20 (48.8)	12 (22.2)	16 (30.8)	20 (30.3)	11 (16.9)	13 (24.5)	9 (12.3)	5 (8.5)	14 (20.9)	12 (20.3)	5 (9.4)
Malaria	7 (1.2)	6 (2.1)	1 (0.3)	1 (0.9)	5 (2.6)	1 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (6.2)	0 (0)	0 (0)	0 (0)	3 (4.5)	0 (0)	0 (0)
Jaundice	9 (1.5)	5 (1.7)	4 (1.3)	0 (0)	3 (1.6)	1 (0.9)	4 (2.9)	1 (2.4)	1 (1.9)	3 (5.8)	2 (3.0)	0 (0)	0 (0)	0 (0)	1 (1.7)	0 (0)	1 (1.7)	1 (1.9)

Abbreviations: Maythav. = Maythavone, Saydong. = Saydongkhong

4. 2. 2. Helminthiasis

The most frequently detected helminth species according to the adjusted prevalence rates were *Ascaris lumbricoides* (20.7%), hookworms (19.2%) and *Trichuris trichiura* (12.1%). 60.3% of the study population were infected with at least one helminth species. Multiparasitism was detected for 12.5% of the study population (Table 5a).

Table 5a: Helminth prevalence (n=601) - crude and adjusted prevalence

Parasite	Total n	Crude prev. %	95% CI	Adjusted prev. %
Total n (%)	601	100		
Any helminth inf. present	373	62.1	58.2-66.0	60.3
Multiparasitism	80	13.3	10.6-16.0	12.5
Nematodes				
Hookworm	120	20.0	16.8-23.2	19.2
A. lumbricoides	118	19.6	16.4-22.8	20.7
T. trichiura	80	13.3	10.6-16.0	12.1
E. vermicularis	5	0.8	0.1-1.6	0.8
S. stercoralis	12	2.0	0.9-3.1	2.1
Cestodes				
Taenia spp.	65	10.8	8.3-13.3	9.6
Trematodes				
O. viverrini	38	6.3	4.4-8.3	6.2
Paragonimus spp.	23	3.8	2.3-5.4	3.2

Abbreviations: helminth inf. = helminth infection, prev. = prevalence

Species specific infection rates by sex, age category and place of residence according to each village are demonstrated in Table 5b. Prevalence of being infected with at least one helminth species in the remote surveyed villages of Attapeu Province was 53.1% for preschool-aged children, 59.6% for school-aged children, 65.0% for adolescents and adults aged 16-30 years, 67.9% for adults between 31-55 years and 70.7% for seniors older than 55 years (Table 5b). With respect to village locations, lowest helminth prevalence was found in Saydongkhong (29.2%), while the highest helminth prevalence corresponded to Dakyat (94.2%). Species specific prevalence differed by location. Highest prevalence of different species were found in Hatnhiay (hookworm 49.3%; *Opisthorchis spp.* 24.7%), Nonghin (*Ascaris lumbricoides* 62.3%), Bengvilay (*Trichuris trichiura* 43.3%), and Maythavone (*Taenia* spp. 39.4%). *Paragonimus* spp. were detected in the Sansai District (Maythavone 10.6%; Daklakao 18.5%, Dakyat 11.5%) only.

Table 5b: Helminth prevalence by sex, age and location (n=601) - crude prevalence

Parasite	Total	Sex		Age (in years)					Study location									
	n (%)	Male n (%)	Fe-male n (%)	0-5 n (%)	6-15 n (%)	16-30 n (%)	31-55 n (%)	>55 n (%)	Dak-lakao n (%)	Dak-yat n (%)	May-thav. n (%)	Say-dong. n (%)	Non-ghin n (%)	Hat-nhiay n (%)	Sen-keo n (%)	Beng-vilay n (%)	Pag-bo n (%)	Kam-pho n (%)
Total n (%)	601 (100)	288 (100)	313 (100)	113 (100)	193 (100)	117 (100)	137 (100)	41 (100)	54 (100)	52 (100)	66 (100)	65 (100)	53 (100)	73 (100)	59 (100)	67 (100)	59 (100)	53 (100)
Any helminth inf. present	373 (62.1)	185 (64.2)	188 (60.1)	60 (53.1)	115 (59.6)	76 (65.0)	93 (67.9)	29 (70.7)	40 (74.1)	49 (94.2)	58 (87.9)	19 (29.2)	40 (75.5)	52 (71.2)	27 (45.8)	47 (70.2)	25 (42.4)	16 (30.2)
Multi-parasitism	80 (13.3)	34 (11.8)	46 (14.7)	8 (7.1)	25 (13.0)	15 (12.8)	23 (16.8)	9 (22.0)	9 (16.7)	11 (21.2)	22 (33.3)	0 (0)	7 (13.2)	10 (13.7)	2 (3.4)	13 (19.4)	5 (8.5)	1 (1.9)
Nematodes																		
Hookworm	120 (20.0)	57 (19.8)	63 (20.1)	12 (10.6)	35 (18.1)	28 (23.9)	37 (27.0)	8 (19.5)	1 (1.9)	2 (3.9)	11 (16.7)	14 (21.5)	10 (18.9)	36 (49.3)	18 (30.5)	15 (22.4)	10 (17.0)	3 (5.7)
A. lumbricoides	118 (19.6)	56 (19.4)	62 (19.8)	29 (25.7)	43 (22.3)	22 (18.8)	17 (12.4)	7 (17.1)	12 (22.2)	23 (44.2)	24 (36.4)	1 (1.5)	33 (62.3)	1 (1.4)	3 (5.1)	9 (13.4)	8 (13.6)	4 (7.6)
T. trichiura	80 (13.3)	42 (14.6)	38 (12.1)	12 (10.6)	29 (15.0)	13 (11.1)	17 (12.4)	9 (22.0)	12 (22.2)	16 (30.8)	16 (24.2)	0 (0)	1 (1.9)	1 (1.4)	1 (1.7)	29 (43.3)	1 (1.7)	3 (5.7)
E. vermicularis	5 (0.8)	4 (1.4)	1 (0.3)	2 (1.8)	3 (1.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.7)	2 (3.0)	1 (1.7)	1 (1.9)
S. stercoralis	12 (2.0)	4 (1.4)	8 (2.6)	1 (0.9)	2 (1.0)	4 (3.4)	5 (3.7)	0 (0)	0 (0)	1 (1.9)	0 (0)	2 (3.1)	0 (0)	5 (6.9)	2 (3.4)	0 (0)	2 (3.4)	0 (0)
Cestodes																		
Taenia spp.	65 (10.8)	30 (10.4)	35 (11.2)	9 (8.0)	15 (7.8)	15 (12.8)	19 (13.9)	7 (17.1)	14 (25.9)	14 (26.9)	26 (39.4)	2 (3.1)	1 (1.9)	4 (5.5)	0 (0)	2 (3.0)	2 (3.4)	0 (0)
Trematodes																		
O. viverrini	38 (6.3)	20 (6.9)	18 (5.8)	0 (0)	11 (5.7)	6 (5.1)	16 (11.7)	5 (12.2)	0 (0)	0 (0)	0 (0)	0 (0)	2 (3.8)	18 (24.7)	4 (6.8)	4 (6.0)	6 (10.2)	4 (7.6)
Paragonimus spp.	23 (3.8)	9 (3.1)	14 (4.5)	3 (2.7)	5 (2.6)	6 (5.1)	6 (4.4)	3 (7.3)	10 (18.5)	6 (11.5)	7 (10.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Abbreviations: inf. = infection, Maythav. = Maythavone, Saydong. = Saydongkhong

4. 2. 3. Nutritional status of children aged 0 to 5 years

Nutritional status of children aged 0-5 years showed an adjusted prevalence of 56.0% for stunting, 22.0% for wasting according to MUAC for age, 19.9% for wasting according to W/L and W/H and a combined wasting prevalence of 34.7% according to MUAC for age, W/L and W/H. Underweight according to W/A was 48.8%. The adjusted prevalence for anemia was 22.1% for this age group.

Table 6a: Nutritional status of children aged 0-5 years: stunting, wasting, underweight and anemia (n=113) - crude and adjusted prevalence

Nutritional Status	Total n	Crude prev. %	95% CI	Adjusted prev. %
Children (0-5 years); Total n	113	100		
Stunting (0-5 years)				
Stunting acc. to L/A and H/A	65	57.5	48.3-66.8	56.0
- severe stunting	38	33.6		32.7
Wasting (0-5 years)				
Wasting acc. to W/H and W/L	20	17.7	10.6-24.8	19.9
- severe wasting	2	1.8		2.2
Wasting acc. to MUAC	27	23.9	15.9-31.9	22.0
- severe wasting	3	2.7		2.0
Wasting-combined	39	34.5	25.6-43.4	34.7
- severe wasting	5	4.4		4.2
Underweight (0-5 years)				
Underweight acc. to W/A	54	47.8	38.4-57.1	48.8
- severe underweight	18	15.9		17.7
Anemia (0-5 years)				
Anemia acc. to hb <= 11 g/dl	27	23.9	15.9-31.9	22.1

Abbreviations: acc. = according, prev. = prevalence, hb = hemoglobin

The malnutrition intensity was further sub classified: Severe stunting according to L/A and H/A was detected in 32.7% of the study population, severe wasting according to MUAC for age was found in 2.0% of the study population, severe wasting according to W/L and W/H was shown in 2.2% of the study population and severe underweight according to W/A corresponded to 17.7% of the study population (Tables 6a).

The malnutrition rates according to sex and location (village) are specified in Table 6b.

Table 6b: Nutritional status of children aged 0-5 years: stunting, wasting, underweight and anemia by sex and location (n=113) - crude prevalence

Nutritional Status	Total	Sex		Study location									
	n (%)	Male n (%)	Fe-male n (%)	Dak-lakao n (%)	Dak-yat n (%)	May-thav. n (%)	Say-dong. n (%)	Nong-hin n (%)	Hat-nhiay n (%)	Senkeo n (%)	Beng-vilay n (%)	Pagbo n (%)	Kam-pho n (%)
Children (0-5 years) Total	113 (100)	59 (100)	54 (100)	9 (100)	9 (100)	16 (100)	16 (100)	10 (100)	13 (100)	10 (100)	7 (100)	12 (100)	11 (100)
Stunting (0-5 years)													
Stunting acc. to L/A and H/A	65 (57.5)	37 (62.7)	28 (51.9)	6 (66.7)	4 (44.4)	7 (43.8)	7 (43.8)	7 (70.0)	9 (69.2)	5 (50.0)	6 (85.7)	5 (41.7)	9 (81.8)
- severe stunting	38 (33.6)	22 (37.3)	16 (29.6)	2 (22.2)	2 (22.2)	4 (25.0)	4 (25.0)	3 (30.0)	5 (38.5)	4 (40.0)	3 (42.9)	4 (33.3)	7 (63.6)
Wasting (0-5 years)													
Wasting acc. to W/H and W/L	20 (17.7)	14 (23.7)	6 (11.1)	0 (0)	2 (22.2)	3 (18.8)	1 (6.3)	1 (10.0)	3 (23.1)	1 (10.0)	2 (28.6)	6 (50.0)	1 (9.1)
- severe wasting acc. to W/H and W/L	2 (1.8)	2 (3.4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (7.7)	0 (0)	0 (0)	1 (8.3)	0 (0)
Wasting acc. to MUAC for age	27 (23.9)	15 (25.4)	12 (22.2)	4 (44.4)	3 (33.3)	5 (31.3)	3 (18.8)	0 (0)	5 (38.5)	2 (20.0)	0 (0)	2 (16.7)	3 (27.3)
- severe wasting acc. to MUAC for age	3 (2.7)	3 (5.1)	0 (0)	0 (0)	0 (0)	2 (12.5)	0 (0)	0 (0)	1 (7.7)	0 (0)	0 (0)	0 (0)	0 (0)
Wasting-combined	39 (34.5)	23 (39.0)	16 (29.6)	4 (44.4)	4 (44.4)	6 (37.5)	3 (18.8)	1 (10.0)	5 (38.5)	3 (30.0)	2 (28.6)	7 (58.3)	4 (36.4)
- severe wasting-combined	5 (4.4)	5 (8.5)	0 (0)	0 (0)	0 (0)	2 (12.5)	0 (0)	0 (0)	2 (15.4)	0 (0)	0 (0)	1 (8.3)	0 (0)
Underweight (0-5 years)													
Underweight acc. to W/A	54 (47.8)	28 (47.5)	26 (48.2)	6 (66.7)	3 (33.3)	7 (43.8)	3 (18.8)	6 (60.0)	5 (38.5)	3 (30.0)	5 (71.4)	9 (75.0)	7 (63.6)
- severe underweight acc. to W/A	18 (15.9)	7 (11.9)	11 (20.4)	0 (0)	2 (22.2)	3 (18.8)	1 (6.3)	2 (20.0)	2 (15.4)	0 (0)	1 (14.3)	4 (33.3)	3 (27.3)
Anemia (0-5 years)													
Anemia acc. to hemoglobin < = 11 g/dl	27 (23.9)	19 (32.2)	8 (14.8)	0 (0)	0 (0)	3 (18.8)	4 (25.0)	5 (50.0)	7 (53.9)	6 (60.0)	1 (14.3)	1 (8.3)	0 (0)

Abbreviations: Maythav. = Maythavone, Saydong. = Saydongkhong, acc. = according

4. 2. 4. Nutritional status in different age groups

Regarding different age groups according to WHO-reference standards, the following crude and adjusted prevalence rates for malnutrition indicators were found (Table 7a-10a). Crude prevalence by sex, age group and location are shown in Tables 7b-10b.

21.6% of children and adolescents aged 5 to 19 years were underweight according to BMI for age (Table 9a), 26.2% of the adults aged 20 years and older were underweight according to a BMI less than 18.5 kg/m²; (Table 8a).

Table 7a: Stunting and anemia in children and adolescents aged 0-19 years (n=340) - crude and adjusted prevalence

Nutritional Status	Total n	Crude prev. %	95% CI	Adjusted prev. %
Children and adolescents 0-19 years; Total	340	100		
Stunting (0-19 years)				
Stunting according to L/A and H/A	207	60.9	55.7-66.1	59.5
- severe stunting	84	24.7		24.6
Anemia (0-19 years)				
Anemia according to hb <= 11 g/dl	72	21.2	16.4-25.1	18.1

Abbreviations: prev. = prevalence, hb = hemoglobin

Table 8a: Underweight (BMI<18.5 kg/m²) and anemia in adults >19 years (n= 261) - crude and adjusted prevalence

Nutritional Status	**Total n**	**Crude prev. %**	**95% CI**	**Adjusted prev. %**
Adults >19 years of age; Total	261	100		
Underweight in adults (BMI <18.5 kg/m²)	67	25.7	20.3-31.0	26.2
Anemia in adults acc. to hb <= 11 g/dl	35	13.4	9.2-17.6	11.7

Abbreviations: hb = hemoglobin, acc. = according, prev. = prevalence

Table 9a: Underweight (BMI for age) in children and adolescents aged 5-19 years (n=249) - crude and adjusted prevalence

Nutritional Status	Total n	Crude prev. %	95% CI	Adjusted prev. %
Children and adolescents 5-19 years; Total	249	100		
Underweight according to BMI for age	49	19.7	14.7-24.7	21.6

Table 10a: Underweight (weight for age) for children aged 0-10 years (n=206) - crude and adjusted prevalence

Nutritional Status	Total n	Crude prev. %	95% CI	Adjusted prev. %
Children 0-10 years; Total	206	100		
Underweight according to W/A - severe underweight	101 41	49.0 19.9	42.1-55.9	50.2 21.2

Table 7b: Stunting and anemia in children and adolescents aged 0-19 years by sex and location (n=340) - crude prevalence

Nutritional Status	**Total**	**Sex**		**Study location**									
	n (%)	**Male n (%)**	**Female n (%)**	**Dak-lakao n (%)**	**Dak-yat n (%)**	**May-thav. n (%)**	**Say-dong. n (%)**	**Nong-hin n (%)**	**Hat-nhiay n (%)**	**Senkeo n (%)**	**Beng-vilay n (%)**	**Pagbo n (%)**	**Kam-pho n (%)**
Children and adolescents 0-19 years; Total	340 (100)	175 (100)	165 (100)	29 (100)	27 (100)	39 (100)	38 (100)	29 (100)	35 (100)	33 (100)	36 (100)	41 (100)	33 (100)
Stunting (0-19 years)													
Stunting acc. to L/A and H/A	207 (60.9)	116 (66.3)	91 (55.2)	21 (72.4)	16 (59.3)	19 (48.7)	20 (52.6)	19 (65.5)	22 (62.9)	24 (72.7)	22 (61.1)	22 (53.7)	22 (66.7)
- severe stunting	84 (24.7)	51 (29.1)	33 (20.0)	4 (13.8)	6 (22.2)	7 (18.0)	11 (29.0)	5 (17.2)	6 (17.1)	14 (42.4)	11 (30.6)	12 (29.3)	8 (24.2)
Anemia (0-19 years)													
Anemia acc. to hb <= 11 g/dl	70 (20.6)	37 (21.1)	33 (20.3)	1 (3.5)	1 (3.7)	5 (12.8)	8 (21.6)	7 (24.1)	20 (57.1)	17 (51.5)	6 (16.7)	2 (5.0)	3 (9.1)

Abbreviations: acc. = according, hb = hemoglobin, Maythav. = Maythavone, Saydong. = Saydongkhong

Table 8b: Underweight (BMI<18.5 kg/m²) and anemia in adults >19 years by sex and location (n= 261) - crude prevalence

Nutritional Status	**Total**	**Sex**		**Study location**									
	n (%)	**Male n (%)**	**Fe-male n (%)**	**Dak-lakao n (%)**	**Dak-yat n (%)**	**May-thav. n (%)**	**Say-dong. n (%)**	**Nong-hin n (%)**	**Hat-nhiay n (%)**	**Senkeo n (%)**	**Beng-vilay n (%)**	**Pagbo n (%)**	**Kam-pho n (%)**
Adults >19 years of age; Total	261 (100)	113 (100)	148 (100)	25 (100)	25 (100)	27 (100)	27 (100)	24 (100)	38 (100)	26 (100)	31 (100)	18 (100)	20 (100)
Underweight in adults (BMI <18.5 kg/m²)	67 (25.7)	24 (21.2)	43 (29.1)	6 (24.0)	8 (32.0)	10 (37.0)	8 (29.6)	5 (20.8)	4 (10.5)	8 (30.8)	7 (22.6)	7 (38.9)	4 (20.0)
Anemia in adults acc. to hb <= 11 g/dl	35 (13.4)	12 (10.6)	23 (15.5)	0 (0)	2 (8.0)	2 (7.4)	0 (0)	2 (8.3)	17 (44.7)	5 (19.2)	5 (16.1)	0 (0)	2 (10.0)

Abbreviations: acc. = according, hb = hemoglobin, Maythav. = Maythavone, Saydong. = Saydongkhong

Table 9b: Underweight (BMI for age) in children and adolescents aged 5-19 years by sex and location (n=249) - crude prevalence

Nutritional Status	Total	Sex		Study location									
	n (%)	Male n (%)	Fe-male n (%)	Dak-lakao n (%)	Dakyat n (%)	May-thav. n (%)	Say-dong. n (%)	Non-ghin n (%)	Hat-nhiay n (%)	Senkeo n (%)	Beng-vilay n (%)	Pagbo n (%)	Kam-pho n (%)
Children and adolescents 5-19 years; Total	249 (100)	125 (100)	124 (100)	23 (100)	21 (100)	25 (100)	25 (100)	21 (100)	23 (100)	24 (100)	31 (100)	32 (100)	24 (100)
Underweight acc. to BMI for age (5-19 years)	49 (19.7)	33 (26.4)	16 (12.9)	2 (8.7)	1 (4.8)	3 (12.0)	5 (20.0)	4 (19.1)	2 (8.7)	7 (29.2)	7 (22.6)	14 (43.8)	4 (16.7)

Abbreviations: acc. = according, Maythav. = Maythavone, Saydong. = Saydongkhong

Table 10b: Underweight (weight for age) for children aged 0-10 years by sex and location (n=206) - crude prevalence

Nutritional Status	Total	Sex		Study location									
	n (%)	Male n (%)	Female n (%)	Dakla-kao n (%)	Dakyat n (%)	May-thav. n (%)	Say-dong. n (%)	Non-ghin n (%)	Hat-nhiay n (%)	Senkeo n (%)	Beng-vilay n (%)	Pagbo n (%)	Kam-pho n (%)
Children 0-10 years; Total	206 (100)	109 (100)	97 (100)	18 (100)	17 (100)	29 (100)	26 (100)	20 (100)	20 (100)	20 (100)	16 (100)	20 (100)	20 (100)
Underweight acc. to W/A (0-10 years)	101 (49.0)	53 (48.6)	48 (49.5)	8 (44.4)	4 (23.5)	17 (58.6)	9 (34.6)	11 (55.0)	8 (40.0)	9 (45.0)	9 (56.3)	16 (80.0)	10 (50.0)
- severe underweight	41 (19.9)	21 (19.3)	20 (20.6)	0 (0)	3 (17.7)	5 (17.2)	4 (15.4)	4 (20.0)	4 (20.0)	5 (25.0)	2 (12.5)	8 (40.0)	6 (30.0)

Abbreviations: acc. = according, Maythav. = Maythavone, Saydong. = Saydongkhong

4. 3. Risk factors for intestinal helminth infections

4. 3. 1. Bivariable analysis

The bivariable associations of each potential risk factor with being helminth infected are shown in Tables 11-14. Crude and adjusted OR with 95% CI and p-value are reported for each association. The following variables were significantly associated with the outcome in bivariable analysis (Table 11 and 12): Location according to village, district, elevation a.s.l., ethnicity and occupational status.

In detail, the statistically significantly positive associations between helminth infections of people and villages as detected in bivariable analysis were as follows (Table 11): Dakyat (OR 39.54, 95% CI 8.57-182.5, p = 0.001), Maythavone (OR 17.55, 95% CI 6.26-49.20, p = 0.001), Daklakao (OR 6.91, 95% CI 3.03-15.81, p = 0.001), Nonghin (OR 7.45, 95% CI 2.72-20.37, p = 0.001), Hatnhiay (OR 5.99, 95% CI 2.98-12.06, p = 0.001) and Bengvilay (OR 5.69, 95% CI 2.73-11.84, p = 0.001).

The bivariable analysis revealed that people living in the Sansai District were associated with a 6.1-fold increased risk of being helminth infected as compared to people living in Sanamxay District (95% CI 3.48-10.82, p = 0.001).

Living at an altitude of more than 1000 m a.s.l. was associated with a 5.9-fold increased risk of being helminth infected (95% CI 3.31-10.35, p = 0.001) than villagers living at an altitude of 120 m a.s.l. or below (Table 11).

In comparison to the Lao Loum population, bivariable analysis (Table 11) highlighted a significant 4.7-fold increase of helminth infections for people belonging to the Tariang ethnic group (95 % CI 2.31-9.72, p-value 0.001), a 11.7-fold increase of helminth infections for people belonging to the Lavaen ethnic minority (95 % CI 4.35-28.19, p = 0.001) and a 10.3-fold increase of helminth infections for people of the Niaheun ethnic minority group (95% CI 3.87-27.50, p-value 0.001). Belonging to the Sou ethnic minority group was associated with a 2.4-fold increased risk (95% CI 1.43-4.0, p = 0.001) and belonging to the Ta-Oi ethnic minority group corresponded to a 3.4-fold increased risk (95% CI 1.46-7.96, p = 0.005) for helminth infections.

Age and gender were not significantly associated with the outcome “helminth infection present” in bivariable analysis (Table 11).

Having access to a safe water source was not statistically significantly associated with people being helminth infected in bivariable analysis (Table 11): The availability of a water pump in the villages showed an OR 0.80 (95% CI 0.48-1.35) and a statistically not significant p-value (p = 0.402).

Table 11: Associations with any helminth infection (bivariate analysis, n=601)

Any helminth infection present vs.	Infection rate n / total (% infected)	Biv. OR	95% CI	p-value	Biv. OR adj.	95%CI adj.	p-value adj.
Total	**373/601 (62.1)**						
Sex							
Male	185/288 (64.2)	1.0					
Female	188/313 (60.1)	0.84	0.60-1.17	0.293	0.83	0.58-1.19	0.303
Age-categories	global category p-value: 0.090						
0-5 years	60/113 (53.1)	1.0					
6-15 years	115/193 (59.6)	1.30	0.82-2.08	0.269	1.06	0.63-1.76	0.834
16-30 years	76/117 (65.0)	1.64	0.96-2.78	0.068	1.50	0.92-2.46	0.104
31-55 years	93/137 (67.9)	1.87	1.12-3.12	0.017	1.73	0.98-3.03	0.056
> 55 years	29/41 (70.7)	2.13	0.99-4.60	0.053	2.02	0.90-4.55	0.088
Ethnicity	global category p-value: 0.001						
Lao Loum	22/70 (31.4)	1.0					
Sou	101/184 (54.9)	2.65	1.48-4.75	0.001	2.40	1.43-4.00	0.001
Ta-Oi	48/75 (64.0)	3.88	1.94-7.74	0.001	3.41	1.46-7.96	0.005
Alak	2/6 (33.3)	1.09	0.19-6.41	0.923	1.06	0.68-1.66	0.793
Tariang	156/213 (73.2)	5.97	3.31-10.76	0.001	4.74	2.31-9.72	0.001
Niaheun	13/16 (81.3)	9.45	2.44-36.58	0.001	10.32	3.87-27.50	0.001
Lavaen	31/37 (83.8)	11.27	4.11-30.93	0.001	11.70	4.35-28.19	0.001
Villages	global category p-value: 0.001						
Saydongkhong	19/65 (29.2)	1.0					
Maythavone	58/66 (87.9)	17.55	7.05-43.70	0.001	17.55	6.26-49.20	0.001
Daklakao	40/54 (74.1)	6.92	3.08-15.55	0.001	6.91	3.03-15.81	0.001
Dakyat	49/52 (94.2)	39.54	10.97-142.6	0.001	39.54	8.57-182.5	0.001
Nonghin	40/53 (75.5)	7.45	3.27-16.96	0.001	7.45	2.72-20.37	0.001
Hatnhiay	52/73 (71.2)	5.99	2.87-12.52	0.001	5.99	2.98-12.06	0.001
Senkeo	27/59 (45.8)	2.04	0.97-4.28	0.059	2.04	0.95-4.38	0.066
Bengvilay	47/67 (70.2)	5.69	2.69-12.02	0.001	5.69	2.73-11.84	0.001
Pagbo	25/59 (42.4)	1.78	0.85-3.74	0.128	1.78	0.90-3.51	0.096
Kampho	16/53 (30.2)	1.05	0.47-2.31	0.910	1.05	0.50-2.21	0.904
District							
Sanamxay	226/429 (52.7)	1.0					
Sansai	147/172 (85.5)	5.28	3.32-8.40	0.001	6.13	3.48-10.82	0.001
Water pump							
No	193/296 (65.2)	1.0					
Yes	180/305 (59.0)	0.77	0.55-1.07	0.118	0.80	0.48-1.35	0.402
Elevation a.s.l.	global category p-value 0.001						
70-120 m a.s.l.	167/311 (53.7)	1.0					
300-420 m a.s.l.	59/118 (50.0)	0.86	0.56-1.32	0.494	0.87	0.48-1.59	0.655
>1000 m a.s.l.	147/172 (85.5)	5.07	3.14-8.19	0.001	5.86	3.31-10.35	0.001

Abbreviations: biv. = bivariable, adj. = adjusted

With respect to occupational status, working as a farmer increased the probability of being helminth infected 1.9-fold (95% CI 1.27-2.91, p = 0.002) in comparison to children staying at home (Table 12). After adjusting the prevalence rate for the imbalance in the sampling fractions per village and the clustered nature of the data, the bivariable OR did not change and the CI did not widen (OR 1.93, 95% CI 1.30-2.88, p = 0.001).

Table 12: Occupation status associated with any helminth infection (bivariate analysis, n=601)

Any helminth infection present vs.	Infection rate n / total (% infected)	OR	95% CI	p-value	Biv. OR adj.	95% CI adj.	p-value adj.
Occupation							
Children-home							
No	304/466 (65.2)	1.0					
Yes	69/135 (51.1)	0.56	0.38-0.82	0.003	0.58	0.39-0.86	0.007
School children							
No	275/443 (62.1)	1.0					
Yes	98/158 (62.0)	1.0	0.69-1.45	0.991	0.88	0.59-1.33	0.542
Farmer							
No	174/303 (57.4)	1.0					
Yes	199/298 (66.8)	1.49	1.07-2.08	0.018	1.60	1.18-2.18	0.003
Off. employed							
No	368/596 (61.7)	1.0					
Yes	5/5 (100.0)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Adults-home							
No	371/596 (62.3)	1.0					
Yes	2/5 (40.0)	0.40	0.07-2.44	0.323	0.63	0.09-4.46	0.645
Occupation; 5 cat.	global category p-value 0.015						
Children-home	69/135 (51.1)	1.0					
School children	98/158 (62.0)	1.56	0.98-2.49	0.061	1.38	0.83-2.29	0.214
Farmer	199/298 (66.8)	1.92	1.27-2.91	0.002	1.93	1.30-2.88	0.001
Off. employed	5/5 (100.0)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Adults-home	2/5 (40.0)	0.64	0.10-3.94	0.628	0.96	0.13-7.12	0.971

Abbreviations: off. = officially, cat. = categories, n.a. = not applicable, home = staying at home, biv. = bivariable, adj. = adjusted

No statistically significant associations were found in bivariable analysis for the nutritional status indicators (Tables 13 and 14) except in the subgroup of 5-19 years of age, where BMI for age was negatively associated with being helminth infected in bivariable analysis (OR 0.34, 95% CI 0.17-0.65, p = 0.002).

Wasting, stunting and underweight according to W/A were not statistically significantly associated with the outcome helminth infection present in bivariable analysis (Table 13 and 14).

Table 13: Nutritional status indicators associated with any helminth infection in children 0- 5 years of age (bivariate analysis, n=113)

Any helminth infection present vs.	Infection rate n / total (% infected)	Biv. OR	95% CI	p-value	Biv. OR adj.	95% CI adj.	p-value adj.
Children 0-5 years; Total	65/113(57.5)						
Stunting							
No	28/48 (58.3)	1.0					
Yes	32/65 (49.2)	0.69	0.33-1.47	0.339	0.82	0.37-1.78	0.603
Wasting acc. MUAC							
No	47/86 (54.7)	1.0					
Yes	13/27 (48.2)	0.77	0.32-1.83	0.555	0.80	0.32-1.99	0.620
Wasting acc. W/H- W/L							
No	47/93 (50.5)	1.0					
Yes	13/20 (65.0)	1.82	0.67-4.96	0.244	1.48	0.58-3.80	0.411
Wasting combined							
No	38/74 (51.4)	1.0					
Yes	22/39 (56.4)	1.23	0.56-2.67	0.609	1.10	0.48-2.56	0.815
Underweight acc. W/A							
No	29/59 (49.2)	1.0					
Yes	31/54 (57.4)	1.39	0.66-2.93	0.380	1.39	0.60-3.20	0.434
Anemia acc. hb <=11g/dl							
No	52/86 (60.5)	1.0					
Yes	8/27 (29.6)	0.28	0.11-0.70	0.007	0.36	0.13-0.97	0.044

Abbreviations: acc. = according to, biv. = bivariable, adj. = adjusted, hb = hemoglobin

People having suffered from “any health problem” in the month prior to the survey were not significantly associated with being helminth infected (OR 1.25, 95% CI 0.83-1.87, p = 0.283). Furthermore, people suffering from abdominal problems (OR 1.25, 95% CI 0.63-2.46, p = 0.519) or from diarrhoea (OR 0.95, 95% CI 0.55-1.64, p = 0.840) were not statistically associated with being helminth infected in bivariable analysis (Table 14).

Anemia prevalence showed a statistically significant negative association with being helminth infected in the age group of 0 to 5 year old children (Table 13) and no statistically significant associations in the other age groups (Table 14).

Previous treatment against lymphatic filariasis and previous deworming history were not statistically associated with helminth infection risk (Table 14).

Table 14: Nutritional and health status associated with any helminth infection in different age groups (bivariate analysis)

Any helminth infection present vs.	Infection rate n / total (% infected)	Biv. OR	95% CI	p-value	Biv. OR adj.	95% CI adj.	p-value adj.
0-19 years:	207/**340** (60.9)						
Stunting							
No	76/133 (57.1)	1.0					
Yes	121/207 (58.5)	1.06	0.68-1.64	0.811	1.15	0.67-1.98	0.620
0-10 years:	101/**206** (49.0)						
Underweight acc. W/A							
No	58/105 (55.2)	1.0					
Yes	59/101 (58.4)	1.14	0.66-1.98	0.645	0.98	0.51-1.89	0.952
5-19 years:	49/**249** (19.7)						
Underweight acc. BMI							
No	130/200 (65.0)	1.0					
Yes	22/49 (44.9)	0.44	0.23-0.83	0.011	0.34	0.17-0.65	0.002
>19 years:	67/**261** (25.7)						
Underweight acc. BMI							
No	133/194 (68.6)	1.0					
Yes	43 / 67 (64.2)	0.82	0.46-1.47	0.510	0.92	0.52-1.61	0.762
Anemia							
No	152/226 (67.3)	1.0					
Yes	24/35 (68.6)	1.06	0.49-2.28	0.877	1.20	0.58-2.49	0.629
0-99 years:	107/**601** (17.8)						
Anemia							
No	311/494 (63.0)	1.0					
Yes	62/107 (57.9)	0.81	0.53-1.24	0.333	0.84	0.53-1.35	0.469
Health problems	385/**601** (64.1)						
Any health problem							
No	130/216 (60.2)	1.0					
Yes	243/385 (63.1)	1.13	0.80-1.59	0.477	1.25	0.83-1.87	0.283
Abdominal problems							
No	347/558 (62.2)	1.0					
Yes	26/43 (60.5)	0.93	0.49-1.75	0.823	1.25	0.63-2.46	0.519
Diarrhoea							
No	327/522 (62.6)	1.0					
Yes	46/79 (58.2)	0.83	0.51-1.34	0.451	0.95	0.55-1.64	0.840
Deworming history	53/**100** (53.0)	global category p-value: 0.730					
< 6 months ago	15/28 (53.6)	1.0					
6-12 months ago	2/4 (50.0)	0.87	0.11-7.05	0.894	1.29	0.09-18.14	0.846
>12months ago	11/17 (64.7)	1.59	0.46-5.50	0.465	2.22	0.54-9.13	0.262
never	25/51 (49.0)	0.83	0.33-2.10	0.699	0.85	0.30-2.45	0.765
LF treatment	129/**176** (73.3)	global category p-value: 0.311					
No	20/47 (42.6)	1.0					
Yes	66/129 (51.2)	1.41	0.72-2.77	0.313	1.22	0.61-2.42	0.569

Abbreviations: LF = lymphatic filariasis, acc. = according to, adj. = adjusted, biv. = bivariable

4. 3. 2. Multivariable analysis

The multivariable analysis of risk factors for intestinal helminth infections identified ethnicity and village as independent risk factors for helminth infections.

Ethnicity was significantly associated with being helminth infected. Belonging to the Niaheun ethnic minority group (OR 10.65, 95% CI 1.58-71.82, p = 0.015) and to the Lavaen ethnic minority group (OR 13.57, 95% CI 2.69-68.48, p = 0.002) increased the risk for being helminth infected when compared to the Lao Loum ethnic group (Table 15).

Villagers living in Maythavone were associated with a 28–fold increased risk for helminth infections (95% CI 9.76-82.09, p = 0.001) when compared to villagers living in Saydongkhong. People living in Daklakao showed a 10–fold increased risk (95% CI 3.91-27.38, p = 0.001) and villagers living in Dakyat had a 59.6–fold increased risk for being helminth infected (95% CI 14.83 – 239.5, p = 0.001) when compared to inhabitants of Saydongkhong (Table 15).

Gender (OR - female versus male: 0.85, 95% CI 0.57-1.26, p = 0.419) was not significantly associated with being helminth infected in multivariable analysis (Table 15).

Age was not an independent predictor for helminth infection when compared to the age group of 0-5 years old children (age group 6-15 years: OR 1.22, 95% CI 0.48- 3.13, p = 0.673; age group 16-30 years: OR 0.90, 95% CI 0.21- 3.87, p = 0.886; age group 31-55 years: OR 0.99, 95% CI 0.23- 4.28, p = 0.987; age group of 56 years and older: OR 1.14, 95% CI 0.21- 6.04, p = 0.880); (Table 15).

When compared to children staying at home as the reference group, occupational status was not significantly associated with being helminth infected in multivariable analysis (working as a farmer: OR 2.29, 95% CI 0.58-9.02, p = 0.238; school children: OR 1.31, 95% CI 0.52-3.30, p= 0.565); (Table 15).

Access to a safe water source did not lower the risk for helminth infections significantly in multivariable analysis (OR 0.56, 95% CI 0.09-3.68, p = 0.548); (Table 15).

Table 15: Multivariable analysis (n=596)

Any helminth infection present vs.	Infection rate n / total (% infected)	Biv. OR	Biv. 95% CI	Biv.p-value	Mult. OR	Mult. 95% CI	Mult. p-val.
Total	**373/601 (62.1)**						
Sex							
Male	185/288 (64.2)	1.0					
Female	188/313 (60.1)	0.84	0.60-1.17	0.293	0.85	0.57-1.26	0.419
Age-categories							
0-5 years	60/113 (53.1)	1.0					
6-15 years	115/193 (59.6)	1.30	0.82-2.08	0.296	1.22	0.48-3.13	0.673
16-30 years	76/117 (65.0)	1.64	0.96-2.78	0.068	0.90	0.21-3.87	0.886
31-55 years	93/137 (67.9)	1.87	1.12-3.12	0.017	0.99	0.23-4.28	0.987
> 55 years	29/41 (70.7)	2.13	0.99-4.60	0.053	1.14	0.21-6.04	0.880
Ethnicity							
Lao Loum	22/70 (31.4)	1.0					
Sou	101/184 (54.9)	2.65	1.48-4.75	0.001	1.41	0.31-6.41	0.653
Ta-Oi	48/75 (64.0)	3.88	1.94-7.74	0.001	0.18	0.01-2.82	0.224
Alak	2/6 (33.3)	1.09	0.19-6.41	0.923	0.88	0.76-10.12	0.918
Tariang	156/213 (73.2)	5.97	3.31-10.76	0.001	0.37	0.06-2.40	0.295
Niaheun	13/16 (81.3)	9.45	2.44-36.58	0.001	10.65	1.58-71.82	0.015
Lavaen	31/37 (83.8)	11.27	4.11-30.93	0.001	13.57	2.69-68.48	0.002
Villages							
Saydongkhong	19/65 (29.2)	1.0					
Maythavone	58/66 (87.9)	17.55	7.05-43.70	0.001	28.30	9.76-82.09	0.001
Daklakao	40/54 (74.1)	6.92	3.08-15.55	0.001	10.35	3.91-27.38	0.001
Dakyat	49/52 (94.2)	39.54	10.97-142.6	0.001	59.60	14.83-239.5	0.001
Hatnhiay	52/73 (71.2)	5.99	2.87-12.52	0.001	3.92	0.47-32.93	0.209
Senkeo	27/59 (45.8)	2.04	0.97-4.28	0.059	0.81	0.08-8.49	0.859
Bengvilay	47/67 (70.2)	5.69	2.69-12.02	0.001	27.05	1.53-479.58	0.025
Pagbo	25/59 (42.4)	1.78	0.85-3.74	0.128	1.33	0.17-10.24	0.783
Kampho	16/53 (30.2)	1.05	0.47-2.31	0.910	0.99	0.21-4.71	0.993
Water pump							
No	193/296 (65.2)	1.0					
Yes	180/305 (59.0)	0.77	0.55-1.07	0.118	0.56	0.09-3.68	0.548
Occupation							
Children-home	69/135 (51.1)	1.0					
School children	98/158 (62.0)	1.56	0.98-2.49	0.061	1.31	0.52-3.30	0.565
Farmer	199/298 (66.8)	1.92	1.27-2.91	0.002	2.29	0.58-9.02	0.238
Off. employed	5/5 (100.0)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Adults-home	2/5 (40.0)	0.64	0.10-3.94	0.628	0.60	0.04-8.66	0.709

Abbreviations:
Biv. OR = Odds Ratio (OR) from bivariable analysis
Biv. 95% CI = 95% confidence interval from bivariable analysis
Biv. p-value = p-value based on X^2 Pearson/Fisher's exact test from bivariable analysis
Mult. OR = Odds Ratio (OR) from multivariable logistic regression analysis
Mult. 95% CI = 95% confidence interval from multivariable logistic regression analysis
Mult. p-value = p-value based on the Likelihood ratio test from multivariable logistic regression analysis

5. Discussion

Malnutrition and poor living conditions are still of serious public health concern in Lao PDR. Neglected populations living in remote areas are especially susceptible to suffer from health problems including malnutrition, anemia and NTD such as intestinal helminth infections (Schratz et al., 2010). This baseline health survey conducted revealed that malnutrition, poor health status, anemia and intestinal helminth infections are still highly prevalent in the ten rural villages surveyed in Attapeu Province, Lao PDR. Living in the mountainous villages of the Sansai District and belonging to ethnic minority groups when compared to the majority Lao Loum ethnic group was shown to be a risk factor for helminth infections. In the following, the results of this baseline survey will be discussed in detail.

5. 1. Health status - malnutrition results

The results of this baseline health survey confirm high rates of malnutrition in the remote villages of Attapeu Province (Tables 6a/6b-10a/10b). 56.0 % of the children aged 0 to 5 years of the study population were stunted, 19.9% were wasted according to W/L and W/H, 22.0% were wasted according to MUAC for age and 48.8% were underweight according to W/A (Table 6a). These malnutrition rates exceed the countries average estimations (World Health Organization, 2012a).

Poverty is one of the main reasons for suffering from hunger which itself has multidimensional causes. The access to food, the availability of food, the time period over which food insecurity persists as well as the nutritional quality and the quantity of food consumed are among the key factors influencing the malnutrition prevalence. Lack of access to food is even more problematic than food availability (Food and Agriculture Organization of the United Nations, 2012).

Natural disasters occur regularly in Lao PDR. While floods are common between May and September, droughts prevail between November and March. After the flood and typhoon-Ketsana in 2008-2009 a survey funded by the United Nations International Children’s Emergency Fund (UNICEF) was conducted in nine affected provinces of Lao PDR. In Attapeu Province, 517 households with a total population of 3193 household members were assessed. This was the first nutritional assessment with an extensive sample size at the provincial level in Attapeu Province. According to the results of this survey, acute malnutrition rates were highest in Attapeu Province: Prevalence amounted to 18.9% of the children below the age of 5 being wasted (95% CI 14.5-23.2) of whom 2.9% (95% CI 1.4-

4.4) were severely wasted. Stunting rates were 51.6% for children below the age of 5 in Attapeu Province (Teshome, 2010). Similar rates have been detected in this study for stunting. With stunting rates of 59.5% for children and adolescents aged 0 to 19 years (Table 7a/7b), chronic malnutrition remains a critical problem in the rural villages of Attapeu Province. Stunting is related to chronic malnutrition, indicating poor environmental conditions and long-term restriction of adequate food supply for growth potential. WHO considers a stunting prevalence of 40% and more to be very high. Wasting represents acute malnutrition and rates higher than 15% are considered as critical for public health significance by international standards. Wasting is thereby related to acute food shortage or to inadequate uptake of food due to infectious diseases such as diarrhoea. Underweight according to W/A is a composite indicator as it refers to chronic and/or acute undernourishment. Its acuteness is therefore difficult to interpret. From a public health perspective, underweight prevalence of 30% and more is considered to be very high (World Health Organization, 2010a). The survey thus, showed worryingly high rates for stunting, wasting and underweight. Especially the acute malnutrition prevalence detected in this study is alarming. Wasting according to MUAC for age was as high as 22.0%, of which 3 children (2.0%) were severely wasted. Wasting according to W/H and W/L showed a prevalence of 19.9%, of which 2 children (2.2%) were severely wasted. The combined wasting prevalence according to MUAC, W/H and W/L, which amounted to 34.7%, was even higher (Table 6a).

Measurement and classification bias may in part be responsible for the differences in the wasting assessments according to MUAC for age, W/L and W/H. Age assessment may confound the MUAC for age classification to some extent but does not confound the W/L and W/H-assessments. None of the severely undernourished study participants developed oedema. Oedema increases the body weight which needs to be taken into account for the classification of malnutrition. Wasting prevalence higher than 30% has been shown in some villages in Lao PDR before. A recent study detected similarly high wasting rates in two villages of Khammouane Province, Lao PDR: Wasting prevalence in children below the age of 5 was as high as 37.8% of a total of 45 children (95% CI 22.5-53.1) in the village Nongboua; 24.0% of a total of 96 children below the age of 5 (95% CI 14.9-33.0) in the village Sop On were wasted (Nam Theun 2 Power Company, 2008).

Differences in malnutrition rates were observed between the surveyed villages. While wasting ranged from 10.0% in Nonghin to 58.3% in Pagbo, stunting differed between 41.7% in Pagbo and 85.7% in Bengvilay (Table 6b). Causes for these differences between villages are not entirely clear. In Bengvilay, 25.4% of the village population mentioned to lack rice 9 month per year (Table 16) which may explain the high prevalence of chronic malnutrition/stunting to some extent. In contrast, 59.7% of the villagers living in Bengvilay reported to consume protein-rich food such as meat, egg or fish daily, which was among the highest intake of protein-rich food reported in the region and does not fit well to the high stunting prevalence (Table 18). The comparatively low wasting rate reported for Nonghin (10%) may correspond to relatively few (1.9%) of its inhabitants lacking rice more than 5 months per year (Table 16). Pagbo showed a higher wasting rate (58.3%). Moreover, underweight of children belonging to the age group 0-5 years reached a prevalence of 75.0% in Pagbo (Table 6b). Contrarily, one of the highest food quality intake results was found for inhabitants of Pagbo who reported to consume protein-rich food daily (64.4%); (Tables 18). This finding does not correspond well to the high wasting and underweight rate. The small sample size by subgroups limits the interpretation of these results.

Further investigations are required to gain insight into the potential causes of the different malnutrition rates between the particular villages. Even though the survey sample design does not allow for statistical representation at the provincial level, the facts assessed exemplify the gravity of acute malnutrition detected in remote villages of Attapeu Province.

Due to the acuteness of the nutritional situation, the Ministry of Health (MoH) of Lao PDR developed an integrated management plan to combat acute malnutrition in southern Lao PDR in cooperation with several partners, for example UNICEF, WHO, World Food Programme (WFP) and other NGO partners. The plan follows a capacity building approach and aims to identify the acutely malnourished children in the community as well as to improve their access to proper referral and treatment of severe acute malnutrition using supplementary and therapeutic feeding programmes. Preventive measures focus on nutritional education. Monitoring and evaluation of the nutritional situation are also addressed (Ministry of Health Lao PDR, 2011).

A limitation of our survey results was the age assessment. 92.8% of the study population did not know their exact date of birth. Age was therefore recorded in years. We measured the nutrition-related indicators for children aged 0-5 years. Consequently, inexact age assessment might confound the results to some extent. It should however be mentioned that the exact age of participants taking part in cross-sectional surveys conducted in developing countries is often not known. The calculated SD-scores for L/A and H/A are more reliable than the SD-score for W/A because a child grows more slowly than it gains weight. W/L and W/H are in turn not affected by inexact age assessments (Schelp, 1998). The survey results for wasting (19.9%) according to W/L and W/H are thus, not confounded by age assessment.

Despite this limitation, the results of this survey highlight the need to improve the nutritional status of people living in Attapeu Province. Further investigations of the causes of undernourishment, particularly of acute food shortages, are required to sustainably improve the nutritional situation. The survey revealed that food security remains problematic in the sampled regions. Only 11.8% of the study population stated to have enough rice supply per year (Table 16). More than half of the study population (53.8%) mentioned to lack rice approximately 3 to 6 months per year (Table 16). The rice shortage may in part be explained by the severe flooding of the area following the typhoon Ketsana in September/October 2009. Associated crop loss may still have influenced the food availability results of this study.

Protein-rich food such as meat, eggs or fish were eaten to various extends per week. The villagers in the Sansai District eat the least protein-rich food per week (Table 18). Fishing is common in the riverside villages. Daily intake of protein-rich food was highest in Senkeo (69.5%), followed by Pagbo (64.4%), Bengvilay (59.7%), Hatnhiay (58.9%) and Kampho (52.8%). When compared to the surveyed villages in Sansai District, there was a higher frequency of protein intake for villagers located in Sanamxay District, which is partly explained by their opportunity to go fishing.

Even though the quality of the food that was consumed by the villagers was in general nutritionally unbalanced, the frequency of food intake was considered sufficient. The majority of the study population (87.9%) declared to eat three meals per day (Table 17).

In Attapeu Province, food habits have been shown to be often inadequate, such as feeding infants improperly with insecure food, e.g. chewed rice or a mixture of water and bananas (Meusch, 2003). Early introduction of complementary food is common in Lao PDR. Most infants are fed additional food such as rice soup or sticky rice from the first days of life on instead of being exclusively breastfed. This leads to a greater risk of illness such as acute respiratory infections or diarrhoea (Teshome, 2010).

Food intake is commonly restricted not only by its unavailability but also by cultural habits. The health status of lactating and pregnant women and their young children is for example endangered by food taboos such as not eating certain types of animal meat, vegetables and fruits. In the first weeks after birth, women tend to follow food restrictions rigorously. They commonly consume only rice with salt and may exceptionally eat some chicken or fish. Families who lost an infant were among those who were poorest and who restricted food intake most strictly (Meusch, 2003). High prevalence of traditional postpartum restricted diets and inadequate maternal nutrition have been found recently not only in rural but also in urban areas of Lao PDR (Barennes et al., 2009).

A recent study highlighted improved child care practices of care takers in Lao PDR when they were properly advised. The project counseled care givers on increasing the frequency and amount of feeding and on differences in food quality. The increased feeding of meat, fruits and vegetables to children was encouraged. The approach was carefully developed according to formative research. Exclusive breastfeeding in the first months of life was promoted. Interactive feeding practices motivate the child to eat more frequently instead of feeding the child only on his/her demand. Women were especially willing to try new recommendations and the behavior change was widely implemented when properly addressed. In turn, food taboos could be breached and child feeding practices were improved by low cost interventions such as by counseling care givers appropriately (Gillespie A. et al., 2004).

In future, questions related to food habits, eating behavior and breastfeeding practices should be included in the baseline survey questionnaires. Insufficient nutrition is known to be related to infections. Broad interventions are required to improve the nutritional status of the people and to reduce infections. Generally, the socio-economic situation and food availability are important aspects. More specifically, interventions targeting the improvement of villager's access to safe water and sanitation, immunization, treatment of infectious diseases such as diarrhoea, acute respiratory syndromes, regular deworming, health education and training of health care workers as well as financing the health care are essential (Schelp, 1998).

5. 2. Health status - anemia

Anemia rates detected in this survey were lower than expected. According to a recent nutritional assessment survey carried out in 2010, anemia was of severe public health concern in Attapeu Province with a prevalence of 54.7% in children below the age of 5 (Teshome, 2010). We used the same hemoglobin cut-off value of 11g/dl for defining anemia and detected only 17.8 % of the total survey population to be anemic. According to the age categories, anemia prevalence was 22.1 % for the 0-5 year old age group (Table 6a), 18.1% for the 0-19 year old age group (Table 7a) and 11.7% for adults (Tables 8a). WHO considers a prevalence of 5% to 19.9% of anemic people to be of mild public health concern. Anemia prevalence rates of 20% to 39.9% are regarded to be of moderate public health importance and prevalence rates of 40% and higher are rated to be of severe public health significance (World Health Organization, 2008). Interestingly, anemia rates of the study population were mild to moderate according to the above classification scheme.

In part, this may be explained by the universal hemoglobin cut-off value chosen for all study participants. Hemoglobin levels are known to vary between different age groups, gender, physiological state, e.g. in pregnant women, and altitude levels. For simplicity, we chose a cut-off value below 11 g/dl for all study participants and did not differentiate between men and women, age groups or elevation above sea-level. Living at an altitude of 1000 m a.s.l. may lead to 0.2 g/dl higher hemoglobin levels than hemoglobin values defined at sea level. In consequence, we may have underestimated the anemia prevalence to some extent, e.g. in men where anemia is defined by a hemoglobin cut-off value below 13 g/dl (World Health Organization, 2001).

Iron deficiency is the most common and widespread nutritional disorder worldwide. Iron deficiency is suspected to be the major cause of anemia in the surveyed regions, but could not be evaluated further. The body's iron requirements are directly related to growth velocity. Therefore, increased iron supply is especially necessary for pregnant and lactating women, during growth of children and during old age when people tend to consume insufficient amounts of iron. Iron deficiency develops in case of insufficient iron uptake and/or increased iron loss. Iron loss can for example result from infections or bleeding. Other genetic causes of anemia include thalassemia, sickle cell disease and glucose-6-phosphate dehydrogenase deficiency (World Health Organization, 2001). Further laboratory examinations are required to investigate the various possible causes of anemia, but such investigations were beyond the scope of this health survey.

5. 3. Health status – reported health problems

60.7% of the study population suffered from health problems. The most common self-reported health problem in the last month preceding the survey was fever with 32.2% (Table 4a). At the time of the survey, almost no thermometers were available in the study villages. The exact temperature could thus, not be measured by the survey participants.

Fever was highest in Senkeo with 76.3% of its inhabitants reported to have had fever in the month preceding the survey (Table 4b). At the time of the survey, there was no access to safe water in Senkeo. Drinking water was fetched from a muddy river at a 10 minutes walking distance where people washed clothes and cleaned themselves, too. Many dermatological problems and impaired wound healing were present in this village. Skin infections and malaria are suspected to be the main reasons for the high fever prevalence in Senkeo. Access to health care is particularly difficult in the most remote villages, which may only be reached by car approximately six months per year due to weather and road conditions. The government of Lao PDR has selected health volunteers in each village who receive e.g. malaria treatment kits and malaria rapid diagnosis tests but no thermometers. Currently, the *SFE* Community Health Development Project continues to train village health volunteers in basic health care such as malaria rapid diagnosis and treatment, management of diarrhoea and wound care and provides medical materials such as oral rehydration solutions, thermometers, bandages and plasters.

The second, most commonly mentioned health problem was cough (25.3%) and the third was subsumed under "general problems" (20.1%), which comprised mainly pain and exhaustion-related unspecific symptoms (body pain, waist pain, bone pain, back pain, fatigue and tiredness); (Table 4a). The surveyed villagers, whose subsistence is mainly based on farming and agriculture, are used to work physically every day. Their exhaustion and physical pain can be explained by their daily working conditions, which are mainly related to hard manual work at their rice fields. Especially the dry rice cultivation which is carried out in the villages Maythavone, Daklakao and Dakyat of the Sansai District and to some extent in the village Bengvilay of the Sanamxay District is manually demanding. This may partly explain the high prevalence of more than two thirds of the inhabitants of Maythavone, Daklakao and Dakyat (78.8%, 70.4% and 78.9%) and around half of the inhabitants of Bengvilay (49.3%) mentioning to have had at least one health problem in the last month prior to the survey (Table 4b). General pain syndromes and tiredness were reported most often in these villages and reached prevalence rates up to 30.8% in Dakyat (Table 4b).

Cough and cold are common symptoms reported by the villagers amounting to 25.3% and 14.6%, respectively (Table 4a). The survey took place during the cold season in which cold and cough are very frequent. Indoor smoke due to indoor cooking and a lack of warm clothes are presumably among the main causes of cough and cold in the mountainous villages of the Sansai District. Tuberculosis status was not known and could not be assessed during the survey due to the remoteness of the locations. If a clinical, severe suspicion of tuberculosis of a villager was detected, the survey-team provided transport to the next hospital. *Paragonimus* spp. infections were found in the Sansai District only (Maythavone 10.6 %, Daklakao 18.5% and Dakyat 11.5%). In endemic areas, *Paragonimus* spp. infections contribute to the respiratory symptoms such as cough with sometimes bloody expectorations. Little is known about *Paragonimus* transmissions in Lao PDR but there are concerns that it may be widespread. A study conducted 2004 in three villages belonging to the province of Vientiane revealed the significance of

Paragonimus spp. as an etiological cause in people with chronic cough (Odermatt et al., 2007). Due to logistic and financial constraints, sputum examination could not be conducted for the detection of *Paragonimus* spp. eggs during this survey. In future, inclusion of such tests may provide further insight into *Paragonimus* spp. infection-related respiratory problems.

In the riverside villages Hatnhiay and Senkeo, as well as in Pagbo and Nonghin, smoking was common among the village population. This may partly explain the prevalence of around one third of their inhabitants who reported to suffer from coughing (Table 4b).

Diarrhoea was reported by 12.0% of the study participants and abdominal problems were mentioned by only 7.0% of the study population (Table 4a). These rates seem surprisingly low when considering the prevailing low hygiene conditions in the villages. As the survey took place in the dry season, the low diarrhoea prevalence may be due to the weather conditions, since germs are suspected to spread more widely during the rainy season.

Future assessment of health behavior will be of great interest to determine associations with health status-related indicators and to adapt future project priorities on improving health related behavior.

5. 4. Helminthiasis results

Globally, one third of the infections by *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms occur in Southeast Asia (de Silva et al., 2003, Hotez and Ehrenberg, 2010). Progress towards helminth control differs between countries. The economically more developed countries Malaysia and Thailand have controlled helminth infections in their most accessible areas. High prevalence rates predominantly persist in their remote, poverty-stricken areas where access to safe water and sanitation remains poor. Contrarily, countries such as Vietnam, Cambodia and Lao PDR still suffer from a high burden of helminthic infections. For East Timor and Myanmar up-to-date helminth prevalence data is lacking. Only very few prevalence data is available for ethnic minority groups, refugee populations and geographically isolated communities in most countries (Jex et al., 2011).

In this study, nearly two thirds of the study population suffered from intestinal helminth infections. The adjusted prevalence of being infected with at least one helminth species was 60.3% in the remote surveyed villages of Attapeu Province (Table 5a). Helminth prevalence rates of the survey exceed the latest prevalence estimations for Attapeu Province. According to a recent nationwide survey on children going to primary school, the helminth infection prevalence was estimated to be 41.5% (340/819) for primary school children being infected with at least one species in Attapeu Province (Rim et al., 2003).

In this survey, the helminth prevalence increased with age but the association was not statistically significant. The lowest prevalence of intestinal helminth infections was found for the age category of 0 to 5 years old children (53.1%). The highest prevalence corresponded to the age category of more than 55 years old people (70.7%); (Table 5b). Helminth infections are known to increase by age. Different helminth species have different age priorities. In endemic areas, the highest infection intensities of *Ascaris lumbricoides* and *Trichuris trichiura* usually occur during childhood. Hookworms, on the other hand, generally show the maximum infection intensity in early adulthood. The reasons for the different age peaks of the various helminth species infection may be manifold; they may result from the different helminth fecundity and life span of different species, their transmission efficiency, changes in immunity and age-related changes in exposition to helminth infections (Anderson, 1986). *Ascaris lumbricoides* prevalence detected in this study was highest for the age group of 0 to 5 year old children (25.7%); (Table 5b). Similar results were obtained by a previous study where highest infection rate by *Ascaris lumbricoides* (39.7%) was identified for the same age group (Sayasone et al., 2011).

Opisthorchis viverrini infections peaked with 12.2% prevalence for the age group of adults older than 55 years (Table 5b). A previous study carried out in Champasack Province detected similar trends for increasing *Opisthorchis viverrini* infections with age, showing as high rates as 69.1% for the age group 16 to 30 years, 70.1% for the age group 31 to 55 years and 78.6% for the age group of persons older than 55 years (Sayasone et al., 2011).

In this study, a 24.7% prevalence of *Opisthorchis viverrini* infections was found in Hatnhiay, a fishing community located near a river (Table 5b). Lab Pa is a favorite Laotian dish, which among others consists of raw fish. The eating of raw or undercooked fish has been shown to increase the risk of *Opisthorchis* spp. infection (Sayasone et al., 2007). Raw or undercooked fish consumption is thought to be the main reason for the high prevalence rate of *Opisthorchis* spp. infection within the fishing community of Hatnhiay. Habits of consuming raw aquatic products were not explored in the survey, thereby limiting the assessment of food related exposures to *Opisthorchis* spp. infection. Adults may eat more raw fish than children which may lead to increased infections during adulthood. In contrast to the riverside villages, all villages which are located in a mountainous environment above 1000 m a.s.l. in the Sansai District did not show any *Opisthorchis viverrini* infection.

The Kato-Katz thick smear technique is widely used for diagnosing the helminth prevalence and intensity of helminth infections. The individual worm burden intensity is however, a more exact indicator of morbidity than prevalence rates (Guyatt and Bundy, 1991). A limitation of the study results is related to the stool examination: Due to logistic and financial restrictions, only one microscopic thick smear stool analysis was performed per person during the survey and the worm intensity measured in eggs per gram stool could not be assessed. A single Kato Katz thick smear examination is known to have a low sensitivity compared to repeated stool examinations or the combination of different diagnostic methods (Booth et al., 2003, Bergquist et al., 2009). Consequently, the intestinal helminth prevalence rates assessed in this survey may even be lower than the actual helminth prevalence in the region. Conducting helminth assessments in rural areas is particularly difficult due to poor infrastructure. Time delays for specimen transport from stool production, stool collection to examination in the laboratories may critically influence the sensitivity of the results. For hookworms, time delays of more than three hours from stool production to examination or preservation have been shown to decrease the sensitivity of the Kato Katz method by half (Dacombe et al., 2007). In this study, stool specimens were examined directly on-site in 8 of the 10 villages. The direct stool processing on-site and examination by an experienced parasitologist from the Attapeu Provincial hospital enabled the most accurate results possible given the remoteness of the areas and the technical equipment available. Financial and logistic constraints did not allow for preservation of stool specimens. Time from stool collection to examination was less than 2 hours but in case stool was produced some time before the stool collection, these possible time delays could have lowered the sensitivity of our prevalence results. In 2 of the 10 villages, stool was transported to hospital laboratories. Time from stool collection to hospital examination did not exceed 4 hours.

Helminth prevalence differed by location. *Ascaris lumbricoides* prevalence was highest in the mountainous villages of the Sansai District (Table 5b). Hookworm prevalence peaked in riverside village Hatnhiay with 49.3%.

The results are in line with a recent study that showed Ascaris lumbricoides prevalence to be highest in the mountainous areas of Bolikhamxay Province, Lao PDR, and hookworms to be associated with people living in the plains (Hohmann et al., 2001). Each helminth species may have different ecological settings in which they prevail. Little is known about the extent to which environmental conditions influence the transmission of STH.

Environmental conditions such as altitude and land surface temperature have been shown to influence helminth transmission. Hookworms tend to survive higher temperatures than *Ascaris lumbricoides* and *Trichuris trichiura* which may be partly because of the motility of its larval stages. In contrast, *Ascaris lumbricoides* and *Trichuris trichiura* ova are non-motile and are therefore unable to migrate to more suitable, moist soil layers. They are more prone to desiccation when exposed to warm temperatures than hookworms.

Life expectancy differs between species. Hookworm species have a longer life expectancy and may last 3 to 4 years, while the life expectancy of *Ascaris lumbricoides* and *Trichuris trichiura* is 1 to 2 years. Fecundity depends on the worm burden and on the particular species. Egg production is highest for *Ascaris lumbricoides* where a female worm produces 10,000 up to 200,000 eggs per day as compared to 2,000 to 20,000 eggs being produced daily by female worms belonging to *Trichuris trichiura* and hookworm species (Brooker et al., 2006).

Human tapeworms include the pork tapeworm *Taenia solium* and the beef tapeworm *Taenia saginata*. The three villages Daklakao, Dakyat and Maythavone located in Sansai District showed high prevalence rates of taeniasis with 25.9%, 26.9% and 39.4%, respectively (Table 5b). Little is known about the distribution of Taeniasis in Lao PDR. Taeniasis mainly affects farming communities in impoverished regions of Southeast Asia with poor water and sanitation as well as poor animal management. Neurocysticercosis is a serious long-term sequel of *Taenia solium* infection and can substantially impede the well-being of people (Willingham et al., 2010). The high infection rates in the Sansai District are alarming. *Taenia solium* and *Taenia saginata* could not be specified, as their eggs cannot be distinguished by light microscopy. Infections by *Taenia solium* are more dangerous than infections by *Taenia saginata* since *Taenia solium* cysts may lead to cysticercosis including neurocysticercosis. *Taenia solium* is suspected to be the most common cestode in the Sansai District since pig farming is very common. Pigs, which are the intermediate hosts of *Taenia solium*, are ubiquitously living in the surveyed villages of Sansai District moving freely around within the village compounds. Clinically, we did not observe any case of neurocysticercosis during the survey. *Taenia* spp. infections require treatment with praziquantel (Crompton and World Health Organization, 2006). Therefore the routine deworming programmes with benzimidazole drugs are not effective for people suffering from taeniasis. Antihelminthic treatment needs to be extended and sustained.

Infection prevalence of *Strongyloides stercoralis* and *Enterobius vermicularis* were not considered further in this survey, as they are more sensitively diagnosed by methods other than the Kato-Katz thick smear technique (Siddiqui and Berk, 2001, Jeandron et al., 2010).

Multiparasitism was identified in 12.5% of the study population (Table 5a). The actual prevalence rates of multiparasitism are expected to be even higher than assessed by a single stool examination only. The survey result for multiple intestinal helminth infections is lower when compared to the multiparasitism prevalence rates detected elsewhere. According to a recent study on three eco-epidemiological settings in Champasack Province, Lao PDR, multiparasitism was found to affect more 86.6% of the study population. The study population comprised of 669 people from three districts which represent three different settings with regard to socio-economic and eco-epidemiologic context and are thus, thought to be characteristic for other parts of Lao PDR as well. Prevalence rates assessed were 32.9% for persons harboring two different helminth species and 53.5% for people being infected with 3 to 6 different helminth species at the same time (Sayasone et al., 2011). Multiparasitism is considered to be of substantial public health concern especially when people are exposed to multiple parasites, as is common under socio-economically poor living conditions with lack of safe water and sanitation systems (Steinmann et al., 2010).

Since intestinal helminth infections contribute substantially to malnutrition and ill health, helminthic infections are related to underdevelopment and poverty. Resource-poor communities such as the surveyed villages of Attapeu Province are mostly affected and often they lack resources needed for disease control, e.g. deworming programmes. International partnerships with economically more developed countries are needed to support deworming programmes and to achieve morbidity control (Partners for Parasite Control. Meeting [3rd : 2004 : Geneva Switzerland] and World Health Organization. Strategy Development and Monitoring for Parasitic Diseases and Vector Control Team, 2005).

106.8 million preschool-aged children and 265.2 million school-aged children are estimated to require regular treatment of preventive chemotherapy to combat soil-transmitted helminthiasis in Southeast Asia. The World Health Assembly Resolution 54.19 from 2001 set the target for all countries, where soil-transmitted helminthes are endemic, to attain a minimum of 75% regular treatment coverage of all school-aged children by 2010 (World Health Organization, 2011). Public health actions against STH have recently been scaled up in Lao PDR. A nationwide deworming program with regular mebendazole administration was launched in September 2005 targeting school-aged children through the school system. A national overall coverage rate of 95.8% in enrolled and non-enrolled school-aged children was reached in April 2007 at the low cost of 0.124 USD per child per year for twice yearly deworming. Prevalence data declines already after one year of deworming (Phommasack et al., 2008). However, high prevalence of intestinal helminths persists in neglected populations like our study population. Further deworming efforts need to be extended and sustained especially in remote areas inhabited by marginalized populations.

5. 5. Risks for helminth infections

Multivariable logistic regression analysis results showed ethnicity and village location to be independently associated with being helminth infected using a manual model building strategy (Table 15).

Ethnic minority groups were associated with higher helminth infections than the Lao Loum reference group (Table 11 and 15). In multivariable analysis, ethnicity was significantly associated with the outcome for the Niaheun (OR 10.65, 95% CI 1.58-71.82, p = 0.015) and the Lavaen (OR 13.57, 95% CI 2.69-68.48, p = 0.002) ethnic minority groups (Table 15). These findings are likely to be due to differences in socio-economic status, food-related practices and hygiene behavior, which were not assessed in this survey and limit the interpretation. Nevertheless, people belonging to an ethnic minority group of Attapeu Province were associated with an increased risk of suffering from helminth infections when compared to the Lao Loum reference group. These findings underscore the importance of paying attention to marginalized ethnic groups and their state of health.

The lowest prevalence of helminth infections (29.2%) was recorded for people living in the village of Saydongkhong (Table 5b). Bivariable associations of living in the surveyed villages Maythavone, Daklakao, Dakyat, Nonghin, Hatnhiay and Bengvilay when compared to the village Saydongkhong as the reference village, were statistically significantly associated with the outcome “helminth infection present” (Table 11). The significant associations between village locations and people being helminth infected as shown in bivariable analysis were verified in multivariable analysis for the three villages in the Sansai District (Table 15). Living in Daklakao increased the risk of people being helminth infected 10-fold (95% CI 3.91-27.38, p = 0.01) and residing in Maythavone increased the probability of being helminth infected 28-fold (95% CI 9.76-82.09, p = 0.01)

when compared to people residing in Saydongkhong (Table 15). Living in Dakyat increased the probability of being helminth infected nearly 60-fold (95% CI 14.83-239.5, p = 0.01) when compared to people living in Saydongkhong.
Socio-economic differences are suspected to be among the main causes for these differences. The three villages of the Sansai District are among the most remote villages assessed. None of these villagers had electricity and toilets were unavailable at the time of the survey. None of the villagers possessed for example a motor-bike, which would be a proxy indicator for higher socio-economic status. Future studies may include a household assets approach to assess the socio-economic status of the communities and relate it to the health status of the villagers. It is however possible, that the variables village level and ethnicity were interacting to some extent.

Due to multicollinearity between villages, district and elevation above sea-level, the variables district and elevation a.s.l. were not included into the multivariable logistic model. The village-level was considered to be the most important variable for multivariable analysis from a public health perspective.
The variables district and elevation a.s.l. could only be assessed in bivariable analysis in this study:
The bivariable analysis revealed that people living in the Sansai District were associated with a 6.1-fold increased risk of being helminth infected as compared to people living in Sanamxay District (95% CI 3.48-10.82, p = 0.001); (Table 11). The three villages located in the Sansai District are situated in the remote, mountainous part of Attapeu Province at an altitude of more than 1000 m a.s.l. In contrast, the seven villages surveyed in the Sanamxay District are located at an altitude of less than 420 m a.s.l.

Elevation above sea-level increased the probability of being helminth infected according to bivariable analysis, but was not considered for multivariable analysis due to statistically collinearity with the district and village level. Elevation above sea-level could thus, not be assessed as an independent predictor for intestinal helminth infection in this survey. Elevation has been found to serve as an independent risk factor for helminth infection elsewhere (Hohmann et al., 2001, Steinmann et al., 2007). Ascariasis and taeniasis have been found to be significantly higher among the poorer and less educated people residing at altitude levels higher than 2150 m a.s.l. in China (Steinmann et al., 2007).
In our study, a 5.86-fold increase of being helminth infected was detected by bivariable analysis for people living in the Sansai District, which only includes villages located

above 1000 m a.s.l., when compared to the reference villages located at less than 120 m a.s.l. (95% CI 3.31-10.35, p-value 0.001); (Table 11). One possible explanation for the greater risk of helminth infections of people living in Sansai District may be the poorer economic status and adverse living conditions in the remote, mountainous areas as well as the lack of safe water and sanitation. At the time of the survey, none of the villages in the Sansai District had access to a safe water source such as a water pump and toilets were unavailable.

In future it may be interesting to assess the economic status and hygiene behavior of the village inhabitants and to associate hygiene behavioral aspects with helminthic infection prevalence. While poor hygiene behavior has been shown to be associated with *A. lumbricoides* and *T. trichiura* infections, no positive association was found for hookworm infections in Bolikhamxay Province, Lao PDR (Hohmann et al., 2001). Poor socio-economic status has been identified to increase the risk for being helminth infected in Champasack Province, Lao PDR (Sayasone et al., 2011).

In multivariable analysis, occupational status did not remain significantly associated with the outcome. Albeit not statistically significant in multivariable analysis, being a farmer was associated with a 2.3-fold higher probability of being helminth infected in comparison to children staying at home including a confidence interval pointing in the positive direction of the association (OR 2.29, 95% CI 0.58-9.02, p = 0.268). This finding is most likely due to a greater exposition to helminth transmissions when working on farmland.

In the multifaceted vicious circle between undernourishment, infections, anemia and poverty, the survey results detected no statistically significant association between malnutrition indicators and helminth infection. With respect to nutritional status indicators, bivariable analysis showed that the BMI for age for children and adolescents aged 5 to 19 years was the only variable that was statistically significantly associated with being helminth infected (Table 14). It was even negatively associated in bivariable analysis with the outcome helminth infection and did not stay significantly associated in multivariable analysis.

According to bivariable analysis, the availability of a water pump in the villages lowered the risk of being helminth infected by 20% as compared to villages which did not have access to a safe water source like a water pump (Table 11), but the association was not statistically significant (OR 0.80, 95% CI 0.48-1.35, p = 0.402). Moreover, multivariable analysis (Table 15) did not confirm the availability of a water pump to be an independent predictor for helminth infection (OR 0.56, 95% CI 0.09-3.68, $p = 0.548$). This may partly be explained by the short time period of the water pumps being installed in only some of the surveyed villages and the lack of safe sanitation at the time of the survey. Even if sanitation was poor at the time of the survey, people who had access to water pumps were potentially at lower risk to become helminth infected, although this association was not statistically significant. This finding emphasizes the importance of effective and safe water supply and improved sanitation as a long-term approach to combat soil-transmitted helminth infections as well as the need for improved hygiene behavior and healthy living conditions. In this study, the safety of the water source was recorded according to the availability of a water pump at the village level. Future studies should also focus on how many villagers exclusively use water from the water pump as drinking water within each village. In addition, all water sources used by the villagers should be assessed in future surveys.

Since 2010, the *SFE* Community Health Development Project has started building toilets together with the village populations and continuous efforts are made to improve the access to safe water sources in each village. In consequence, the sanitary conditions will continue to improve substantially. In less developed countries, interventions such as improving sanitation facilities and hygiene practices or access to safe drinking water have been proven to increase the health status of the population and to reduce diarrhoeal diseases effectively (Fewtrell et al., 2005). It will be interesting to compare the present findings with the results of nutritional, health status and helminthic prevalence in 2013, when a follow-up survey is planned.

5. 6. Infection prevalence and limitations of the survey

Prevalence rates and bivariable analysis results were adjusted according to the different sampling fractions in the villages and according to the clustering concerning households and villages. Overall, prevalence rates did not change much due to the adjustment and stayed within the 95% CI of the crude point-prevalence rates.

With respect to bivariable analysis, confidence intervals and standard errors mostly broadened after adjustment (Tables 11-15), which is a realistic situation according to the survey sampling design. The crude prevalence rates and confidence intervals do not take into account the inverse weights of the sampling fractions and the clustering by household and village. The sample size calculation was done for each village separately. Since the sample fractions differed by village the crude prevalence results were biased towards villages with fewer inhabitants. Adjustment of the data was important to exclude that the survey results of larger villages were extensively biased in comparison to smaller villages. When disregarding the clustering, crude prevalence rates show smaller standard errors and confidence intervals and may lead to a less valid description of the study population (Korn and Graubard, 1999).

The interpretation of the multivariable model in this study remains limited as the survey questionnaire was not explicitly developed to identify risk factors for intestinal helminth infections. It became apparent that only few variables were suitable for the multivariable model since few variables were significantly associated with the outcome in bivariable analysis. In addition, the cross-sectional baseline survey design was developed to gain an insight into the health status of the villagers which further serves as a baseline against which future project achievements will be compared. The questionnaire lacked important aspects of helminth infections such as questions related to hygiene behavior, e.g. assessment of hand washing after defecation or before eating, acceptance and use of the different water sources and socioeconomic status.

Water sources were assessed at the village level, but not every study participant was questioned if he or she actually used the water from the water pump if available in the village. In future, it may also be interesting to evaluate the acceptance of the villagers to use water from a water pump, as in some villages rumors were spread, that the water from the water pump does not taste well.

Financial and logistic constraints limited the effects of the survey. One should consider that the rather insensitive single Kato-Katz smear technique influenced the prevalence data. The true rates are expected to be even higher than the rates detected in a single stool sample.

The age assessments limited the results to some extent. Classification bias may have been present when anthropometric indicators such as H/A (stunting), W/A (underweight), BMI for age (underweight) and MUAC for age (wasting) were used. In situations where age assessment of children below the age of 5 is inexact, MUAC for height growth reference may be a valuable alternative to MUAC for age growth reference and may be a more practical screening tool under difficult field conditions (Mei et al., 1997).

Furthermore, a lot of missing data was associated with the deworming history and history of treatment against lymphatic filariasis and could therefore not be included in the multivariable model. In future it would be interesting to examine if an independent association of being helminth infected exists when previous deworming has taken place. Treatment against lymphatic filariasis was introduced in February 2010 by the Lao government. It includes albendazole treatment and is therefore effective against lymphatic filariasis and STH (Crompton and World Health Organization, 2006).

In endemic areas helminth reinfections occur rapidly after deworming. Changes in prevalence may be much smaller than changes in the individual worm burden intensity because the helminth numbers per person are highly aggregated. Few people harbor heavy helminth burdens and most people harbor only few helminths which implies that changes in the average intensity of infection may be large even if changes in prevalence still appear small. The maximum intensity of infection is determined by the parasite loss and acquisition since intestinal helminths do not multiply directly in the host. The transmission depends also on the life expectancy of the helminth species (Anderson, 1986).

6. Conclusion

The results of the *SFE* Community Health Survey are worrying when considering the health status of the neglected populations in the remote villages of Attapeu Province. The key study objectives assessed the villager's state of health including the nutritional status, anemia, reported health problems and helminth infections. Risk factors of the villagers for being helminth infected were assessed.

The high rates of malnutrition, which exceed the countries average, are alarming. For children aged 0 to 5 years, wasting reached as high rates as 34.7%, stunting was 56.0% and underweight according to W/A was 48.8%. Villagers self-reported to have suffered from various health problems. Nearly two thirds of the study population mentioned to have had at least one health problem in the month preceding the survey. Fever, cough, general pain problems, cold and diarrhea were among the most reported symptoms. Helminth infections were highly prevalent with 60.3% of the study population being infected with at least one helminth species. Taeniasis turned out to be a serious problem in the mountainous villages located in the Sansai District. Multivariable logistic regression analysis results showed ethnicity and village location to be independently associated with being helminth infected.

Main significances of the baseline survey results for the SFE project

There is a strong need to improve the health status of the village population and to improve their access to public health services. Since access to health care centers remains limited especially in the remote locations, village health volunteers are currently trained by the *SFE* team to treat general health problems directly on site. In this respect, improvements are particularly needed for the basic management of health problems such as wound care, syndrome management of cough, diarrhea and fever including oral rehydration and applying rapid tests for malaria and treatment of malaria.

Improvements of access to safe water and sanitation and of the nutritional status of the village population are fundamentally required for improving the general health status in the region.

Nutritional education and agricultural improvements are ongoing with the aim to diversify the food availability and to sustainably improve the nutritional situation in the villages.

There is an urgent need for extending and maintaining regular deworming programmes. Currently, the *SFE* Community Health Development Project continues to provide regular antihelminthic treatment with benzimidazole drugs in the surveyed villages. Praziquantel treatment was provided for people who were infected with *Taenia* spp., *Opisthorchis* spp. and *Paragonimus* spp.

Access to praziquantel for treatment against cestodes and trematodes is even more limited than access to benzimidazole treatment against nematodes. Further emphasize on these neglected tropical diseases and improved treatment is urgently required.

Main implications of the baseline survey results for Attapeu Province

Ethnicity was an independent risk factor for being helminth infected in this survey when compared to the Lao Loum reference population. This finding emphasizes the importance of paying attention to neglected populations in Attapeu Province who tend to suffer from NTD the most.

Interesting future aspects to explore may concern behavioral, socio-economic and environmental conditions leading to an increased prevalence of NTD. Socio-economic information such as household wealth has been shown to be a determinant of health. According to a recent study, people belonging to one of the least poor households have been shown to be significantly associated with a 39% lower infection rate of *Ascaris lumbricoides* infection when compared to people belonging to the poorest households. A household assets approach was used as a proxy indicator for socio-economic status (Kounnavong et al., 2011).

The results show that chronic and acute malnutrition are of critical public health concern in Attapeu Province, Lao PDR. The need for improvement of the health status of marginalized, neglected populations in Attapeu Province is evident. Commitment and activities to combat poverty-related diseases such as malnutrition and NTD still need to be strengthened and enlarged in the region. Continued efforts such as the work of the *SFE* Community Health Development Project are vitally needed and should be intensely supported. Future research is required in the region in order to investigate the extent of undernourishment and their causes in detail.

The magnitude of helminthic infection and its decline need to be surveyed in order to target continued project efforts effectively. In future studies, the individual worm burden should be measured in eggs per gram stool, which is a more sensitive marker for declining infection rates. The higher the intensity of worm burden, the more likely will people suffer from helminth related clinical illness. Helminth infection intensity is a marker for morbidity and is labor-intense to obtain. Due to deworming efforts, the individual worm burden intensity declines before a decline in prevalence becomes evident, since the relationship between intensity and prevalence is non-linear (Guyatt and Bundy, 1991). The prevalence rates assessed in this survey may underestimate the actual extent of helminth infections as only a single Kato Katz-stool examination was performed due to logistical and financial constraints.

Access to safe water and sanitation is a prerequisite for sustainably improving the hygiene conditions and the health status of the population in the long-term.

Future perspectives

In general, antihelminthic control strategies need to integrate the various aspects of the different regions within different countries such as climatic conditions, geographical location, environment, sanitation, political background as well as cultural and socio-economic circumstances. An integrated approach for preventive and control strategies is desirable including the assessment of drug failure rates, drug development, surveillance and monitoring of the epidemiological situation, standardized diagnostic tools as well as reporting forms (Jex et al., 2011). Up-dated prevalence data is urgently required. An international open-access project aims at collecting helminth infection prevalence data worldwide in order to monitor and to evaluate the progress of antihelminthic actions and to identify where data is missing or where deworming is most needed. The “Global Atlas of Helminth Infection” (GAHI) is a promising approach to monitor and target deworming efforts worldwide. Control programs against NTD are improved by up-to date mapping of NTD. Mapping highlights current estimations of the disease burden and the baseline situations. Programme impacts can be monitored effectively by comparing the intervention results with these baseline estimators. Mapping of NTD can be a helpful device for national control programs (Brooker et al., 2010).

In order to use scarce resources sustainably, estimating populations at risk is important in order to target those first who require interventions the most (Brooker, 2010). Technical tools such as remote sensing and geographical information systems represent promising opportunities for future disease control programmes and may be successfully used for large-scale, sustainable and cost-effective planning, monitoring and evaluating of disease control programmes (Brooker et al., 2006). Model based geo-statistics such as Bayesian geo-statistical models present challenging, flexible approaches to predict prevalence data for regions, where prevalence data is currently not available (Magalhaes et al., 2011).

Future research should also focus on antihelminthic drug development and possible drug resistance. Currently, there are only few antihelminthic drugs available. Since mass treatment with anthelminthic drugs is generally the treatment of choice in endemic areas, resistance to antihelminthic drugs is likely to develop. Therefore, particular emphasize should be placed on recognition of drug failure rates and on the development of new drug alternatives. Since helminth infections are a serious public health burden worldwide, future pharmaceutical research is needed. Continued improvement of drug availability and procurement as well as of drug quality assurance is still especially essential for people living in remote regions of developing countries (Keiser and Utzinger, 2010).

Satisfaction of basic needs such as access to safe water and sanitation are often taken for granted in most well-developed countries, but less developed and poor countries often lack such facilities. Worldwide, about 13 million deaths per year could be prevented by environmental improvements. Around one third of these deaths could be prevented by improving hygiene, water, sanitation, indoor and outdoor air quality. Improvement of water, sanitation and hygiene behavior as well as safer cooking facilities, thereby reducing indoor smoke, could diminish child mortality by more than one forth in 20 of the lowest income countries (Prüss-Üstün et al., 2008). NTD such as intestinal helminth infections and malnutrition prevalence can be reduced in the long-term by sustainable interventions to improve access to basic health care, adequate nutrition, safe water and sanitation. Improving access to safe water and sanitation has been shown to reduce the prevalence of helminthiasis and should therefore be prioritized in addition to health education and short-term preventive deworming strategies (Ziegelbauer et al., 2012)

The international community recognized the need to work closely together with various stakeholders in order to combat malnutrition, the poor health status including NTD and to improve access to health care services and education (United Nations, 2000a). Vulnerable populations strongly need international commitment, support and shared responsibilities between the various stakeholders in order to make progress towards achievement of the MDGs.

The author hopes to have contributed by this evaluation of the baseline health survey to disclosure of the neglected health situation of the marginalized populations in rural Attapeu Province, Lao PDR and that future prospects will continue to improve the situation of the villagers.

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8. Annexes

8. 1. Contributions to the project

The *SFE* Community Health Project manager and medical coordinator Ms. Esther Rauen designed the survey and conducted the survey with her team. The author was involved in all steps of the study, ranging from consultancy in the protocol development to field work, data entry, data management, analysis and reporting. The author was part of the survey team during the field work in Attapeu Province from 6 November 2010 until 12 January 2011. In detail, the author participated in the implementation of the survey in 5 of the 10 surveyed villages, namely in Maythavone, Dakyat, Daklakao, Hatnhiay and Senkeo. During the village surveys the author's task was to supervise and to implement hemoglobin level assessments, height and weight measurements and handling of stool samples (labeling, distribution and collection of stool containers). The author further participated in the village meetings and conducted and supervised medical treatments including drug distribution and drug procurement. Every study participant with helminth infection was treated with albendazole and/or praziquantel according to the particular infection. A Lao medical doctor was present during the whole survey who also served as an interpreter. The author double entered data from the survey questionnaires into EpiDATA and validated the entries, conducted the data analysis of all surveyed villages, interpreted the results and reported on them. This master thesis is regarded as a contribution to achieving the MDGs by gathering and evaluating information on the state of health of people living in remote areas of Lao PDR, which barely exists throughout the country. By communicating the obtained results of the survey, it is hoped to improve the villager's situation including better access to public health care and to make peoples voice heard who are otherwise hardly realized and neglected.

8. 2. Sample size calculated an attained

Table 1: Sample size for each village

Village	Total population (P)	Sample size (n)	Sample size attained (N)	Sampling fraction N/P
Dakyat	339	75	80	23.6
Daklakao	222	67	64	28.8
Maythavone	259	70	68	26.3
Saydongkhong	488	80	87	17.8
Nonghin	379	77	86	22.7
Hatnhiay	351	76	105	29.9
Senkeo	152	59	63	41.4
Bengvilay	347	75	77	22.2
Kampho	252	70	73	29.0
Pagbo	545	82	80	14.7
Total	**3334**	**731**	**783**	**23.5**

8. 3. Map of Attapeu Province, Lao PDR

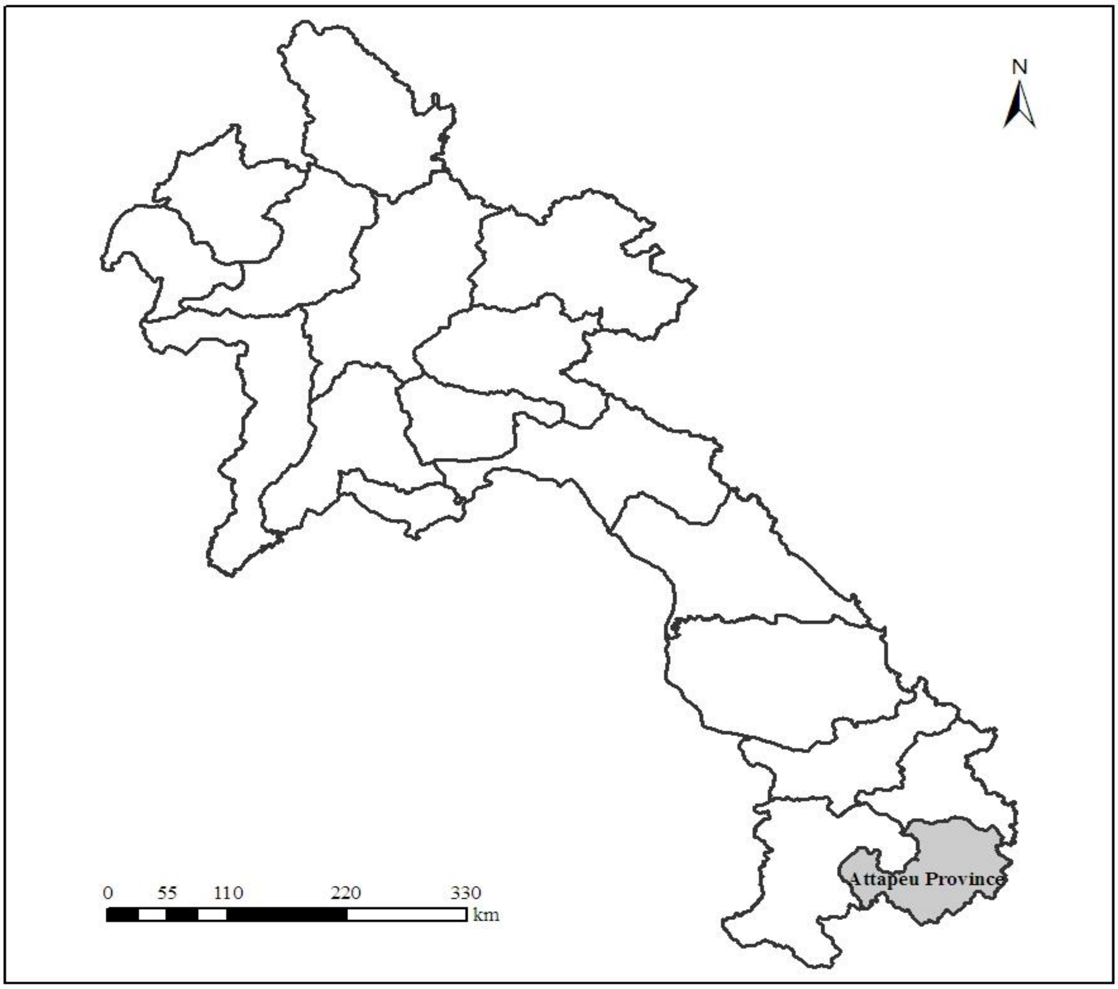

Figure 3: Map of Attapeu Province, Lao PDR

8. 4. Survey questionnaire – Lao version

ແບບສອບຖາມຂອງການກວດກາທາງດ້ານສຸຂະພາບ

ຂໍ້ມູນເບື້ອງຕົ້ນ ຊື່ຂອງບ້ານ	ວັນທີຂອງການລົງກວດກາ
ເມືອງ	ຜູ້ສໍາພາດ

ຂໍ້ມູນສ່ວນຕົວ	
ຊື່ຂອງຜູ້ໃນການເຂົ້າຮ່ວມ	
ເພດ	
ວັນ.ເດືອນ.ປີ ເກີດ	
ອາຍຸ	
ເຜົ່າຊົນ	
ອາຊີບ	
ການປະເມີນທາງດ້ານການແພດ	
ລວງສູງ	
ນໍ້າໜັກ	
ການກວດວິເຄາະອາໂຈມ	
ຜົນກວດHB	
ເຈົ້າມີບັນຫາທາງດ້ານສຸຂະພາບບໍ່ໃນຕອນນີ້?	
ຖ້າ ມີ, ແມ່ນເປັນພະຍາດຫຍັງ?ຫຼືເປັນແນວໃດ?	
ເຈົ້າໄດ້ເປັນພະຍາດຖອກທ້ອງບໍ່ໃນລະຫ່ວາງເດືອນທີ່ຜ່ານມານີ້?	
ຖ້າເປັນ,ແມ່ນເປັນດົນປານໃດ? ແລະມີອາຈົມອອກມາປະມານເທົ່າໃດຕໍ່ມື້?	
ເຈົ້າໄດ້ເປັນໄຂ້ບໍ່ໃນລະຫ່ວາງເດືອນທີ່ຜ່ານມານີ້?	
ຖ້າເປັນ, ຈົ່ງບອກວ່າ ຈັກອົງສາ? ເປັນຈັກມື້?	
ເຈົ້າໄດ້ເປັນໄອຫຼາຍກ່ວາ 2ອາທິດບໍ່?	
ເຈົ້າໄດ້ເປັນພະຍາຂີ້ໝາກເຫຼືອງໃນລະຫວ່າງເດືອນທີ່ຜ່ານມາຫຼືບໍ່?	
ຖ້າເປັນ, ຈົ່ງບອກເປັນຈັກມື້?ແລະມີອາການອື່ນໆແນວໃດ?	
ເຈົ້າໄດ້ຮັບການສັກຢາກັນພະຍາດຄົບຖ້ວນບໍ່?	
ຫຼາຍປານໃດ ທີ່ໄດ້ກິນປາ,ຊີ້ນ,ແລະໄຂ່?ໄດ້ກິນເລື້ອຍໆບໍ່?	
ໃນປີໜຶ່ງ ເຈົ້າບໍ່ມີເຂົ້າຫຼືຂາດເຂົ້າກິນມີຈັກເດືອນ?	
ກິນເຂົ້າຕໍ່ມືໜື່ງຈັກຄາບຫຼືຈັກເທື່ອ?	
ສໍາລັບເດັກທີ່5ປີລົງມາ	
MUAC (ເປັນ ມມ, ເດັກນ້ອຍ 5ປີລົງມາ)	
ເດັກຍັງໄດ້ກິນນົມແມ່ບໍ່?	
ຄັ້ງສຸດທ້າຍທີ່ເດັກກິນຢາຂ້າແມ່ທ້ອງແມ່ນຕອນໃດ?	
ໝາຍເຫດ	

8. 5. Survey questionnaire – English version

General Information Name of the village	Date of questionnaire
District	Interviewer
Personal information	
Name of participating person	
Gender	
Date of birth	
Age	
Ethnic group	
Occupation	
Medical assessment	
Height (in cm)	
Weight (in cm)	
Stool analysis	
HB result	
Do you have any health problem in the moment?	
If yes, what kind of problem?	
Did you have diarrhoea during the last month?	
If yes, describe how long, how many stools per day?	
Did you have fever during the last month?	
If yes, describe (degree C°? how many days?)	
Do you have cough since more than 2 weeks?	
Did you have jaundice during the last month?	
If yes, describe (how many days? other symptoms?)	
Are you fully vaccinated?	
How often do you eat fish, meat or egg in a week?	
How many months in a year do you lack rice?	
How many meals do you eat per day?	
For children < 5 yrs:	
MUAC (in mm, only for children < 5yrs)	
Is the child still breastfeeding?	
When was the child dewormed for the last time?	
Remarks:	

8. 6. Food-security, Tables 16 - 18

Table 16 shows the number of months people lack rice per year by location in the last year prior to the survey. Table 17 identifies the number of meals eaten per day by location in the last year prior to the survey. In Table 18 the average servings of protein-rich food per week by study location in the last year prior to the survey are listed.

Table 16: Number of months with lack of rice per year by study location in the last year prior to the survey (n=601)

Lack of rice per year (in months)	Total	Total adj.	Study location									
			Daklakao	Dakyat	Maytha-vone	Saydong-khong	Nonghin	Hatnhiay	Senkeo	Beng-vilay	Pagbo	Kampho
	n (%)	(%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
0	71(11.8)	(10.9)	21 (38.9)	0 (0)	6 (9.1)	4 (6.2)	1 (1.9)	4 (5.5)	0 (0)	17 (25.4)	5 (8.5)	13 (24.5)
1	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	87 (14.5)	(18.6)	0 (0)	0 (0)	7 (10.6)	1 (1.5)	33(62.3)	0 (0)	3(5.1)	5 (7.5)	30 (50.9)	8 (15.1)
3	56 (9.3)	(8.1)	8 (14.8)	3 (5.8)	13 (19.7)	0 (0)	3 (5.7)	9 (12.3)	9 (15.3)	6 (9.0)	5 (8.5)	0 (0)
4	62 (10.3)	(10.3)	0 (0)	10 (19.2)	23 (34.9)	7 (10.8)	0 (0)	5 (6.9)	5 (8.5)	0 (0)	9 (15.3)	3 (5.7)
5	106(17.6)	(17.3)	16 (29.6)	24 (46.2)	17 (25.8)	18 (27.7)	15 (28.3)	2 (2.7)	14 (23.7)	0 (0)	0 (0)	0 (0)
6	100(16.6)	(16.8)	9 (16.7)	11 (21.2)	0 (0)	26 (40.0)	1 (1.9)	22 (30.1)	11 (18.6)	11 (16.4)	3 (5.1)	6 (11.3)
7	39 (6.5)	(5.3)	0 (0)	0 (0)	0 (0)	8 (12.3)	0 (0)	13 (17.8)	14 (23.7)	0 (0)	0 (0)	4 (7.6)
8	22 (3.7)	(3.3)	0 (0)	4 (7.7)	0 (0)	0 (0)	0 (0)	1 (1.4)	3 (5.1)	11 (16.4)	0 (0)	3 (5.7)
9	58 (9.7)	(9.5)	0 (0)	0 (0)	0 (0)	1 (1.5)	0 (0)	17 (23.3)	0 (0)	17 (25.4)	7 (11.9)	16 (30.2)
Total	601(100)	(100.1)	54 (100)	52 (100.1)	66 (100.1)	65 (100)	53 (100.1)	73 (100)	59 (100)	67 (100.1)	59 (100.2)	53 (100.1)

Abbreviation: adj. = adjusted (taking into account the clustering at household- and village-level)

Table 17: Reported number of meals per day by study location in the last year prior to the survey (n=601)

Meals per day (n)	Total	Total adj.	Study location									
			Daklakao	Dakyat	Maytha-vone	Saydong-khong	Nonghin	Hatnhiay	Senkeo	Beng-vilay	Pagbo	Kampho
	n (%)	(%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
1	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1.5	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	59 (9.8)	(9.4)	11 (20.4)	9 (17.3)	12 (18.2)	13 (20.0)	1 (1.9)	11 (15.1)	2 (3.4)	0 (0)	0 (0)	0 (0)
2.5	8 (1.3)	(1.5)	0 (0)	4 (7.7)	2 (3.0)	2 (3.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	528 (87.9)	(88.1)	43 (79.6)	37 (71.2)	52 (78.8)	49 (75.4)	52 (98.1)	62 (84.9)	56 (94.9)	65 (97.0)	59 (100)	53 (100)
3.5	5 (0.8)	(0.9)	0 (0)	2 (3.9)	0 (0)	1 (1.5)	0 (0)	0 (0)	0 (0)	2 (3.0)	0 (0)	0 (0)
4	1 (0.2)	(0.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.7)	0 (0)	0 (0)	0 (0)
Total	601 (100)	(100)	54 (100)	52 (100.1)	66 (100)	65 (100)	53 (100)	73 (100)	59 (100)	67 (100)	59 (100)	53 (100)

Abbreviation: adj.= adjusted (taking into account the clustering at household- and village-level)

Table 18: Reported number of servings of protein-rich food (meat, egg or fish) per week by study location in the last year prior to the survey (n=601)

Protein-rich servings per week	Total	Total-adj.	Study location									
	n (%)	(%)	Daklakao n (%)	Dakyat n (%)	Maytha-vone n (%)	Saydong-khong n (%)	Nonghin n (%)	Hatnhiay n (%)	Senkeo n (%)	Bengvilay n (%)	Pagbo n (%)	Kampho n (%)
0	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1	73 (12.2)	(10.7)	11 (20.4)	11 (21.2)	40 (60.6)	11 (16.9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1.5	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	96 (16.0)	(15.5)	33 (61.1)	20 (38.5)	10 (15.2)	9 (13.9)	11 (20.8)	1 (1.4)	0 (0)	6 (9.0)	0 (0)	6 (11.3)
2.5	20 (3.3)	(4.2)	0 (0)	4 (7.7)	2 (3.0)	14 (21.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	75 (12.5)	(13.9)	6 (11.1)	14 (26.9)	8 (12.1)	9 (13.9)	4 (7.6)	16 (21.9)	0 (0)	0 (0)	13 (22.0)	5 (9.4)
3.5	12 (2.0)	(2.8)	0 (0)	3 (5.8)	0 (0)	0 (0)	5 (9.4)	0 (0)	0 (0)	0 (0)	4 (6.8)	0 (0)
4	7 (1.2)	(1.1)	4 (7.4)	0 (0)	0 (0)	0 (0)	3 (5.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4.5	40 (6.7)	(6.2)	0 (0)	0 (0)	6 (9.1)	4 (6.2)	8 (15.1)	0 (0)	6 (10.2)	8 (11.9)	0 (0)	8 (15.1)
5	47 (7.8)	(7.7)	0 (0)	0 (0)	0 (0)	9 (13.9)	3 (5.7)	2 (2.7)	10 (17.0)	13 (19.4)	4 (6.8)	6 (11.3)
5.5	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	20 (3.3)	(3.2)	0 (0)	0 (0)	0 (0)	0 (0)	7 (13.2)	11 (15.1)	2 (3.4)	0 (0)	0 (0)	0 (0)
6.5	0 (0)	(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	211 (35.1)	(34.7)	0 (0)	0 (0)	0 (0)	9 (13.9)	12 (22.6)	43 (58.9)	41 (69.5)	40 (59.7)	38 (64.4)	28 (52.8)
Total	601 (100.1)	(100)	54 (100)	52 (100.1)	66 (100)	65 (100.2)	53 (100.1)	73 (100)	59 (100.1)	67 (100)	59 (100)	53 (99.9)

Abbreviation: adj. = adjusted (taking into account the clustering at household- and village-level)

9. Declaration of originality of work

This thesis is the result of independent investigation. Where my work is based on the work of others, I have made appropriate acknowledgements.

I declare that this study has not already been accepted for any other degree nor is it currently being submitted in candidature for any other degree.

Fulda, 20th August 2012 ____

10. Acknowledgements

First of all, I would like to express my deep gratitude to my supervisor Dr. Peter Odermatt and to Ms. Esther Rauen. Their continuous support as well as profound advice and motivation supported me throughout the whole process of the thesis development.

Dr. Peter Odermatt is a specialist in epidemiology and public health with a focus on helminth infections with extensive working experience in Southeast Asia. His in-depth supervision and advice was always very exact, detailed and constructive. He always made time for my questions. I was enabled to learn a lot of his experience and I am very impressed by his extraordinary motivation and enthusiasm in working with students.

I am fascinated by the *SFE* Community Health Development Project Attapeu led by Ms. Esther Rauen who enabled me to be part of the survey team in 2010/2011. During this time, I got to know the people, life and work related to the project and learned a lot about Lao culture. I am still strongly motivated by my experience and the time that I spent in Attapeu. I would like to thank all participants of the baseline health survey for having taken part in the survey and for their trust in the project thus, making the data collection for the survey possible.

I thank my family and friends for their support, especially my sisters, my brother-in-law and my godmother.
My very special huge thank you is for my sister Christine, who was actively involved in double checking the data and proof reading the many drafts.

I dedicate this thesis to my friend Esther and her team.

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