2017

Landscape analysis for Taeniasis/Cysticercosis control

Nepal report

GALVmed

Protecting Livestock – Improving Human Lives

Table of Contents

Acronyms and Abbreviations

ADB	-	Asian Development Bank
AHD	-	Animal Health Directorate
CDC	-	Center for Disease Control
CDO	-	Chief District Officer
CNS	-	Central Nervous System
CT	-	Computerize Tomography
CVL	-	Central Veterinary Laboratory
DALY	-	Disability-adjusted life year
DHS	-	Department of Health Services
DLS	-	Department of Livestock Services
DLSO	-	District Livestock Service Office
DPH	-	District Public Health Office
EDCD	-	Epidemiology and Disease Control Division
EEG	-	Electroencephalogram
ELISA	-	Enzyme Linked Immunosorbent Assay
EITB	-	Enzyme-linked Immunosorbent Transfer Blot
EEG	-	Electroencephalogram
FAO	-	Food and Agricultural Organization
FBPZ	-	Food-borne Parasitic Zoonosis
GAP	-	Federation of Asian Parasitologist
HMG/N	-	His Majesty's Government of Nepal
ICP	-	Increased intracranial pressure
IFS	-	International Foundation for Science
IHA	-	Indirect Haemagglutination Assay
ILRI	-	International Livestock Research Institute
INGOs	-	International Non-Government Organisation
IWGE	-	Informal Working Group on Echinococcosis
KMC	-	Kathmandu Metropolitan City
LSTD	-	Livestock Services Training Directorate
MOAC	-	Ministry of Agriculture and Cooperatives
MOH	-	Ministry of Health
MOHP	-	Ministry of Health and Population

MOLD	-	Ministry of Livestock Development
MRI	-	Magnetic Resonance Imaging
NARC	-	National Agriculture Research Council
NCC	-	Neurocysticercosis
NGOs	-	Non-Government Organisation
NIPPON	-	National Industry of Pork Processing Nepal
NPHL	-	National Public Health Laboratory
NTD	-	Neglected Tropical Disease
NZFHRC	-	National Zoonosis and Food Hygiene Research Centre
OIE	-	World Organisation for Animal Health
OPD	-	Out Patient Department
PCR	-	Polymerize Chain Reaction
PHC	-	Primary Health Care
R/I	-	Radio-Imaging
RFLP	-	Restriction Fragment Length Polymorphism
SEAR	-	South East Asia Region
TLDP	-	Third Livestock Development Project
TLDP	-	Third Livestock Development Project
VDC	-	Village Development Committee
VEC	-	Veterinary Epidemiology Center
VPHO	-	Veterinary Public Health Office
WHO	-	World health Organization

Executive summary

Pig farming in Nepal has a long history associated with the aboriginal tribe Kirat and are reared by communities such as Tharu and Dalit in Terai region and by Janajati namely Rai and Magar in the northern hilly parts of the country. Although, acceptability of pork consumption is increasing in all communities, pig raising is common in the area where these communities are predominantly settled. In Nepal, distribution of pig per capita (pig/1000 human population) is 45, majority of them were concentrated in mountain (70 pigs/ 1000 people), followed by hills (70 pigs/ 1000 people) and Terai (32 pigs/ 1000 people) ecological zones.

Taeniasis/cysticercosis is at the top of the list of the six most prioritized zoonotic diseases of Nepal Research to-date found porcine cysticercosis in up to 32.5% of pigs (based on lingual inspection) (9), and a range of neurocysticercosis from 12.0% (8) up to 47.0% in epileptic patient of Nepal (10). With the increasing evidence of a growing number of epilepsy cases due to cysticercosis in Nepal, control of porcine cysticercosis has become paramount of importance to reduce the effects of Neurocysticercosis in human population. To highlight the situation of Taeniasis/cysticercosis/neurocysticercosis in pigs/humans of Nepal, and provide base for drawing future strategies for pilot and control pilot project, this landscape analysis was commissioned.

This landscape report includes desk review and a baseline survey. The desk review was conducted through the literature searched about *T. solium* infections in humans and pigs in various literature search engines: Web Science, Scopus and Google Scholar, and from the reports published by the Department of Livestock Services (DLS), Department of Health Service (DHS) Nepal, policy papers and University Dissertations. In addition, a base line survey was conducted through a standard questionnaire for 198 pig-raising farmers, 61 pig traders including butchers and 30 policy makers between April and June of 2017. The respondents were taken from 12 districts to cover a large geographic distribution from hills to Terai areas of Nepal.

KEY MESSAGES

a) Desk review

I. In Nepal, the systemic epidemiological studies on taeniasis/cysticercosis are still scanty. Most of the prevalence estimates came from slaughterhouse animals and may not be the true representation of prevalence in the total pig population. Other studies have given higher estimates indicating that the sample population selected were from a high prevalence area.

II. Available literature recorded mean prevalence of PC 12.77% (0.94-32.7%) from Necropsy, 14.54% (0.63-32.54%) from Lingual Palpation, 21.25% (19.00 -23.5%) from EITB and 24.35% (19.7-29.5%) from ELISA.

III. None of the studies has attempted to record the prevalence of T. solium in people of Nepal on an epidemiological basis. However, studies made at various locations in Nepal are high enough to draw concern. Various studies have shown the human taeniasis prevalence ranges between 0.6-39%.

Approximately 92% Psychiatry OPD patients had epileptic cases, majority of them being below 40 years of age (40). The Department of Health Service Nepal has reported growth of epilepsy cases by 6.6% per year with variation between regions from 0.93 % in Eastern Region to 9.04% in Western Region. Among the ecological regions, hill region has the highest epileptic prevalence. In addition, one population-based study found 50% of the epileptic cases were from neurocysticercosis (41), whereas, a hospital based study showed 10.2% epileptic cases due to neurocycticercosis. Overall, an average of 24.8% (10.2-61.0%) epileptic cases were found due to neurocysticercosis and has reported DALYs of 14,268 from 2000 to 2012 data of neurocysticercosis of Nepal (16). However, there is absence of community based neurocysticercosis and asymptomatic studies in Nepal.

Cysticercosis were also reported from skin biopsy of the hospital-admitted patients in Nepal who had nodules in different sites like skin (82%), oral mucosa and breast (19). The other study observed 21 soft tissue cysticercosis in patients, with the majority related to striated muscles (11/21), eye (6/21), tongue (1/21), breast (1/21), and other tissues (2/21) (20).

b) Baseline survey

I. Result from farmers' survey

1) Only 27.3% farmers confined pigs completely, whereas a large population of pigs are tethered or penned for part time of the day, and only 6.1% farmers kept on free-range system.

2) Majority farmers did not know about tapeworm infections (64%) and its symptoms (68%) and how *Taenia* infection was acquired (79%) by people.

3) Many of these farmers (87%) did not know what measles (cyst) are and how pigs are infected with porcine cysticercosis (93%), although they (83%) have habit of eating measly pork. In addition, 90% traders sell measly pork without any concern. According to surveyed farmers and traders, main source of information of the diseases is Village Health Service Providers and Village Veterinary Service Providers.

II. Result from Policy stakeholders' survey

The policy stakeholders stated that porcine cysticercosis is in the list of OIE notifiable disease but neither Neurocysticercosis is in the list of notifiable disease nor is there any *Taenia solium* control strategy in Nepal. In addition, there are also no mass drug administration programme and no specific health education for the control of taeniasis. In addition, they mentioned that there were no enforcement of "Slaughterhouse and Meat Inspection Act, 1999", "Slaughterhouse and Meat Inspection Regulation, 2010", and changes in hygienic practices in meat shops and slaughter places.

Key recommendations

a) A population based *T. solium* infection study should be conducted at regional or national level so that the actual burden of the disease in animals and humans across Nepal could be determined and fully understood, thereby helping in developing authentic and effective control mechanisms.

b) There is a need for a sensitive, robust and specific standardized diagnostic protocol for the detection of taeniasis and cysticercosis in both humans and pigs, so that the

research output could be equated nationally, across the regions, as well as internationally.

c) Proper housing for pigs should be enforced nationwide for creating better hygienic condition.

d) Efforts to educate the communities on disease transmission and prevention, pig management, personal cleanliness, meat hygiene and sanitation should be conducted through education such as conducting service-centre level training programme, disseminating information through paper and electronic media, including zoonotic diseases in the school curriculum from class 8th to class 10th in 'Health, population and environment' which is a compulsory subject.

e) Mass drug administration should be considered or programmes of administration of Oxfendazole along with vaccination against *T. solium* should be initiated and implemented in Nepal through government subsidy so that the lower income farmers would benefit and produce the cysticercosis free pork for the consumers.

f) The legislation such as development of practical and effective legislative frameworks to address meat inspection and biosecurity at local and national level should be considered for the development of a control plan for NCC and PC. In addition, One Health approach such as formation of one health institute should be considered to improve the holistic approach for management and control of the disease and the monitoring of the effectiveness of the measures implemented program (see Section 8.2.6.1 and 8.2.6.2).

1 Background

Taenia solium is a zoonotic helminth with a wide, global distribution and with the potential to cause an insidious neurological disorder, epilepsy, which occurs in people through the aberrant larval infection of the brain (1). *T. solium* causes taeniasis and neurocysticercosis in human, and cysticercosis in pigs (Figure 1). Neurocysticercosis is a major cause of epilepsy in people of many developing countries and is a cause of epilepsy in up to 30% cases (1, 2). Source of taeniasis/cysticercosis in people is through unhygienic measures and eating improperly cooked infected pork (1). The true prevalence are challenging to enumerate, particularly in developing countries, as many of neurocysticercosis cases go undiagnosed due to lacking diagnostic facilities in the region. Since the burden of *T. solium* infection on disability-adjusted life years (DALYs) and deaths are very high compared to other parasitic diseases (3, 4), various approaches have been adopted in other developing countries to prevent and control this disease, comprising mass drug administration, education, and vaccination in pigs (5).

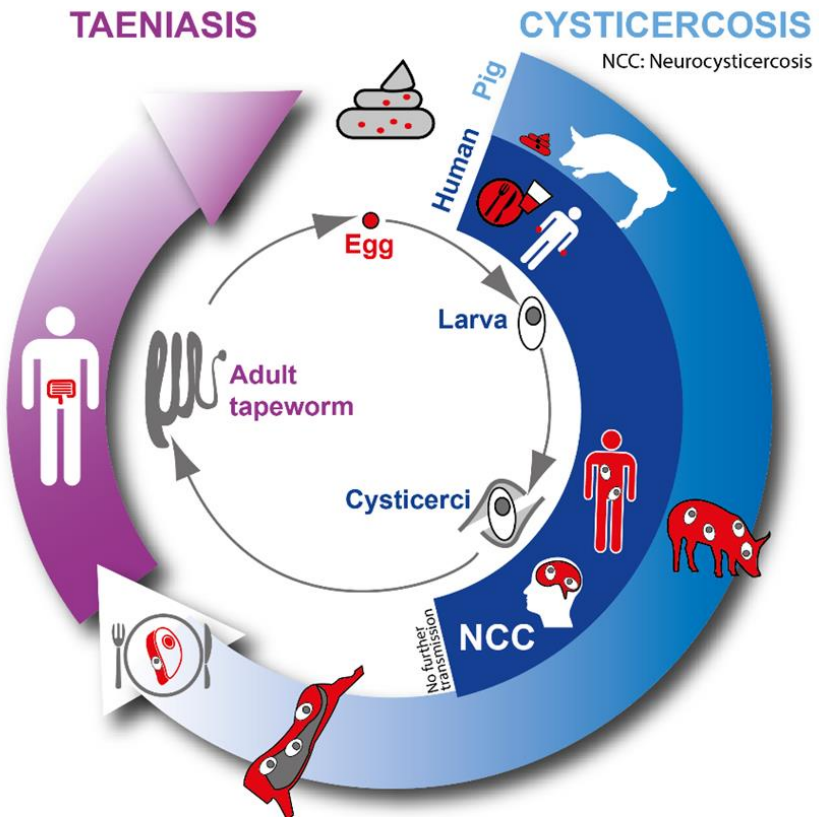

Figure 1: A diagrammatic representation of *T. solium* transmission and life cycle (Source: A. M. Labouche, WHO)

Nepal is a landlocked country with the area of 147,181 km^2 bordered by China (Tibet) in Northern part and by India in the remaining parts... The country is divided into five regions Eastern Region, Central Region, Western Region, Mid-Western Region, Far west Region) with 75 districts, and each district is further divided into local units of Village Development Committee (VDC) and Municipalities (Nagar Palika NP) depending density of human population. Recently, the development regions have been removed and replaced with seven provinces viz. provinces 1 to 7 (Figure 2).

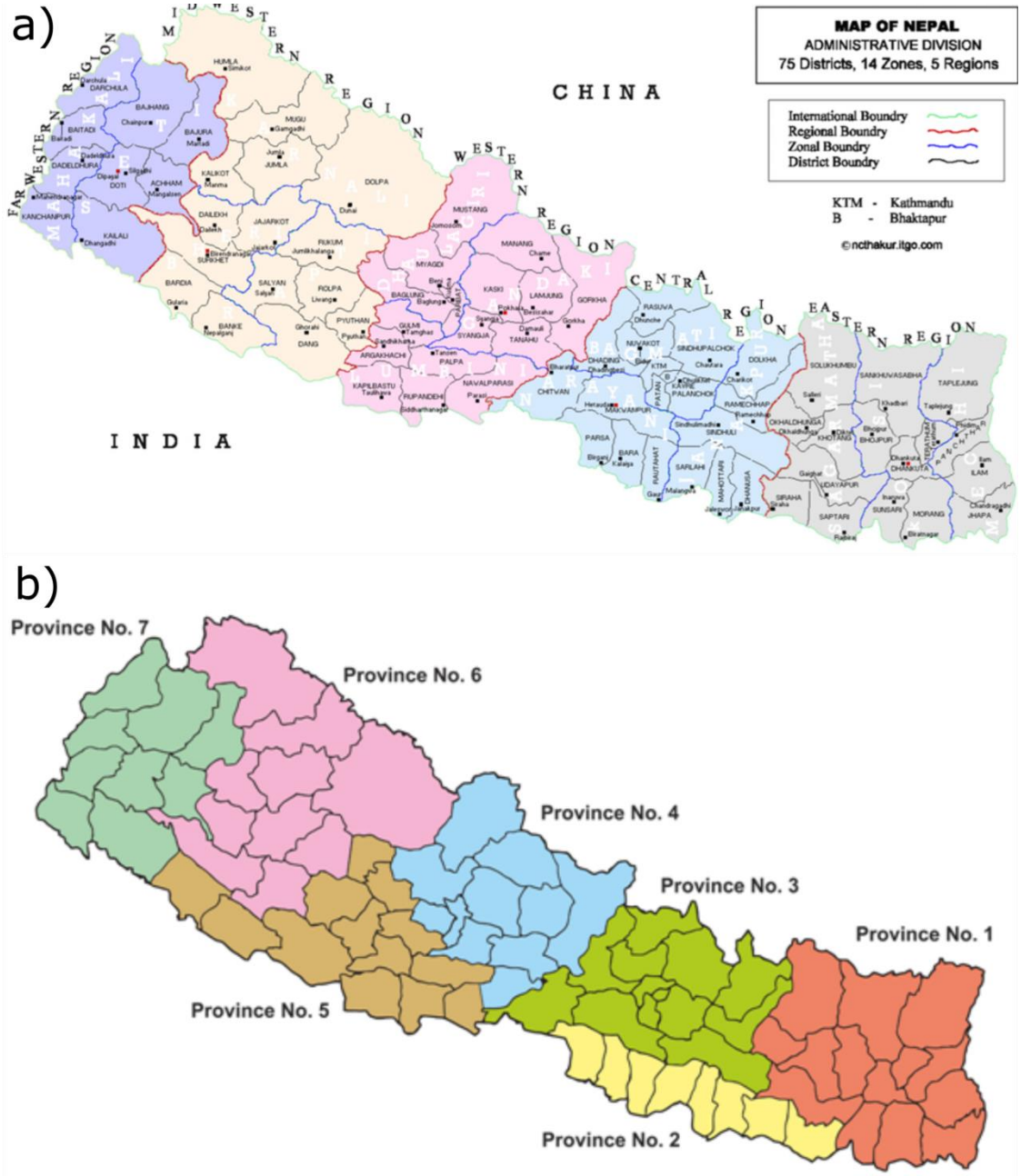

Figure 2: a) Administrative map of Nepal comprising five development regions, 14 zones and 75 districts.
b) Map showing seven Provinces with 75 districts of Nepal.

Nepal is geographically divided into three major topographical areas- Mountain, Hill and Terai with 12.52% of land in Himalayan region under perpetual snow cover. The country has 75 districts that are divided into three eco-zones and analysis in this report is based these administrative districts.

Table 1: List of districts in eco-zones with human and pig population

Eco-zones	Number of districts	% Area	Human Ppn.	Pig Ppn
Mountain	16	35.21	1781792(6.73)	125174 (10.54%)
Hills	39	41.68	11394007(43.00)	629821 (53.05%)
Terai	20	23.11	13318705(50.27)	432142 (36.40%)
Total	**75**	**100**	**264945049 (100)**	**1187137 (100)**

Source: CBS[1], NPC[2]

Of the three eco-zones; 1) Mountain; altitude of this region ranges from 2 000 m to 2 500 m and it lies below the permanent snow line with 32.21% land, 6.73% human population and 10.54% pig population of the country; 2) Hills has 41.68 % of total Land Mass between 300 to 2500m altitude with 43.01% human population and 53.05% pig population. 3) Terai is southernmost part of the country bordering India as the part of the extension of Indo-Gangetic plain and holds 23.11% of land mass with 50.27% human population and 36.04% pig population (Table 1 & Figure 3).

[1] Centre for Bereu of Statististic, Population Monograph of Nepal Vol I, pp. 22,2013

[2] National Plannig Commission, United nations Development Programme, Nepal Human Development Report " Beyond Geography, Unlocking Human Potential, 2014"

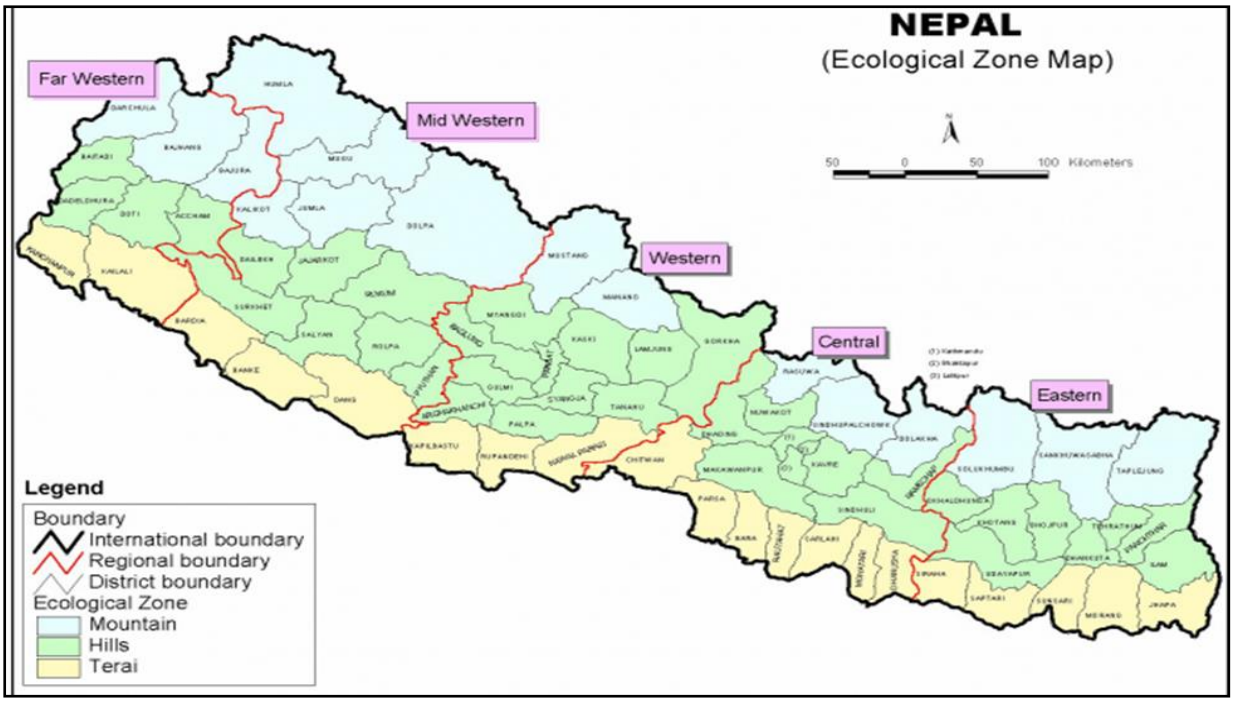

Figure 3: Three ecological zones-mountain, hills and Terai of Nepal

In Nepal, pig farming has a long history associated with the aboriginal tribe Kirat in subsistence level of production. Pigs are reared by Tharu, Janajati and Dalit, Khatik, Mahaut, Dom, Dushadh, and Mushahar communities in Terai region and by Janajati; Rai, Limbu, Magar Tamang and among the Dalit Blacksmith in the northern hilly parts of the country (6) (Figure 4)

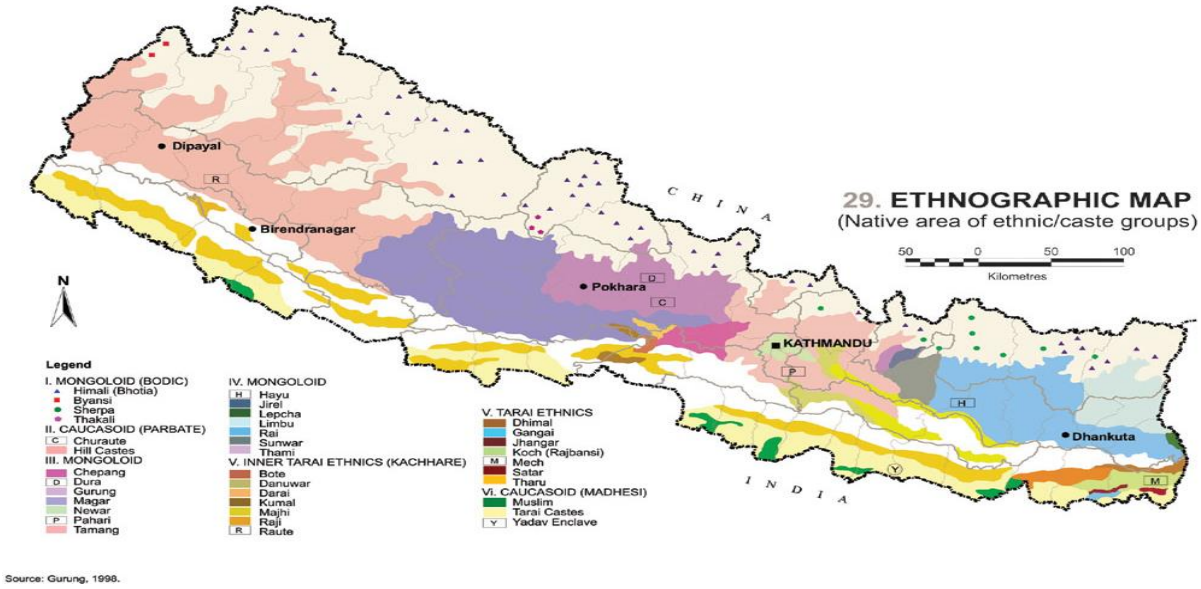

Figure 4: Ethnographic Map of Nepal (source: Gurung, Harka (Ed.). 2006. Nepal Atlas and Statistics. Kathmandu: Himal Books. ISBN 99933-43-72-2)

Native breeds of pigs like Hurra and Chwancheare quite popular among them and these breeds are distributed throughout the country (Figure 5). There is trend of modernisation of pig farming through advent of commercialised pig farms, thereby increasing the production and consumption of pork. The majority of commercial farms have adopted exotic breeds such as Hampshire, Duroc and Landrace and their crosses, which were first time imported to Nepal in 1957 (7). Pigs are usually reared by indigent farmers in pigsty constructed using brick, mud and roofs with paddy straw (Figure 6). Pigs are mostly fed on swill and wheat bran. Many farmers still let their pigs scavenge in rural areas, where only a handful of farmers have introduced commercial feed into their feeding regime. Sanitation and bio-security at farms are grossly neglected by the farmers due to the lack of awareness of zoonotic diseases, including lack of awareness regarding *T. solium* infections amongst the community.

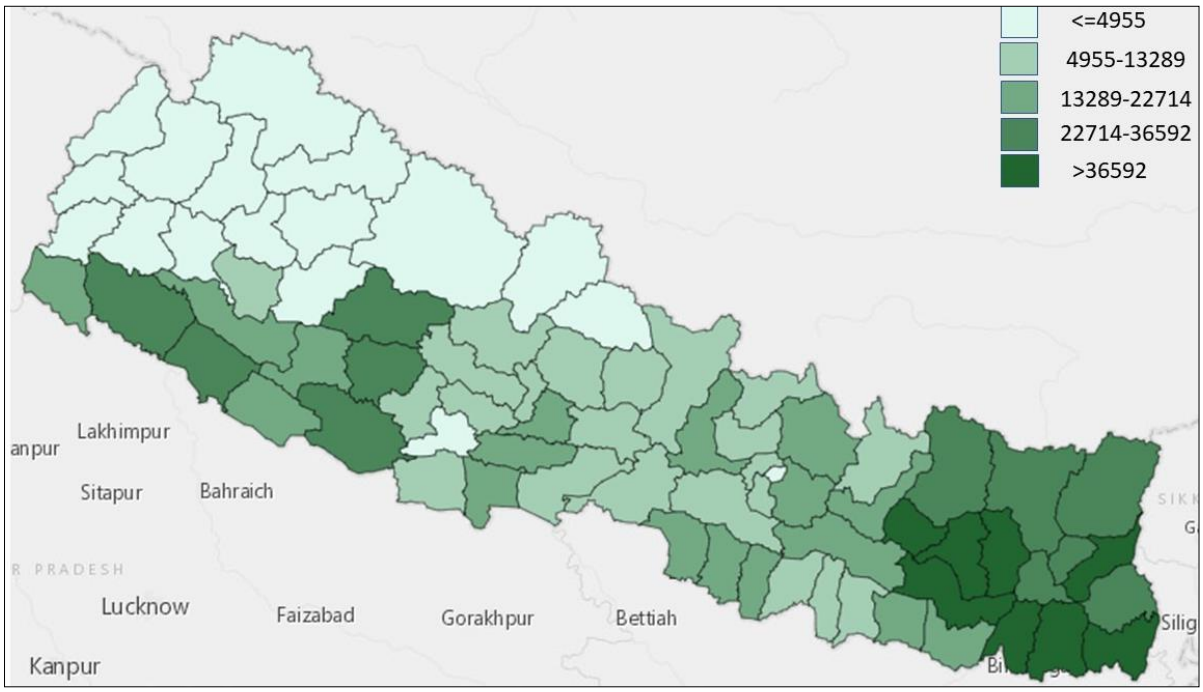

Figure 5: A heat map showing the pig population distribution in Nepal by districts (Source: Agriculture Atlas, ICIMOD Nepal).

In Nepal, Taeniasis/cysticercosis is at the top of the list of the six most prioritized zoonotic diseases. Research to-date found porcine cysticercosis in up to 32.5% of pigs (based on lingual inspection) (9), and a range of neurocysticercosis from 12.0% (8) up to 47.0% in epileptic patient of Nepal (10). Human cycticercosis were diagnosed either by the researcher or from clinical findings in hospital admitted cases. In addition, there is neither

a known true prevalence nor a control plan in action in Nepal. Global Alliance for Livestock Veterinary medicine (GALVmed[3]) with Professor Lightowlers[4] have worked with Indian Immunologicals Ltd (IIL) Hyderabad to come up with TSOL-18 vaccine (Cysvax™) for pigs for the first time in the world. Thereafter they joined forces with Heifer Project International Nepal (HPI/N)[5] to evaluate the efficacy of TSOL-18 vaccine (Cysvax™) and Oxfendazole to control porcine cysticercosis in free ranging pigs in VDCs of Banke districts. At the time of writing this report, this field study was in progress.

As zoonotic disease like *T. solium* infection involves multidisciplinary approach in its control, landscape analysis is necessary to explore the situation for proposing future control strategies. Porcine cysticercosis with its insidious nature has been affecting communities, but has failed to attract the attention from the communities since its harmful effect is not visual and often difficult to identify. In addition, the risk of the disease is more prevalent in poor farming communities, which may have extremely limited resources and means to tackle it.

Therefore, landscape analysis was commissioned to highlight the current disease situation with prevalence, knowledge, attitude and practices and control measured adopted, possibly helping in drawing future strategies for validation and developing control pilot project.

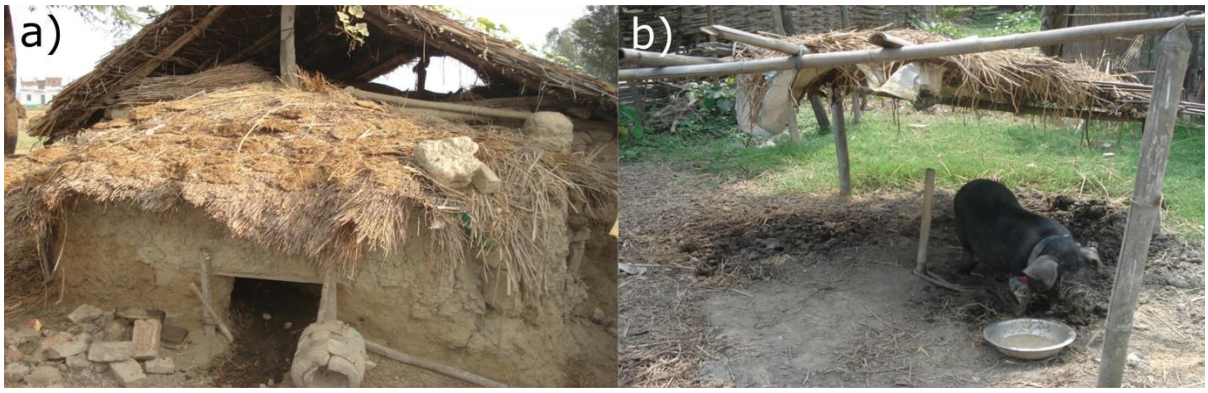

Figure 6: A Typical Pig house of Khatik – a marginal farmer in Banke District (a) and a tethered pig in Morang District of Nepal (b).

[3]GALVmed is a 'not-for-profit' livestock health product development and access partnership, which aims to create solutions for sustainable poverty alleviation by making animal health products available and accessible to livestock keepers in the developing world.

[4]Heifer Project International Nepal, a nonprofit organization working to eradicate poverty and hunger through sustainable values-based holistic community development.

[5]Professor Marshall Lightowlers is a pioneer in the field of parasitology and works in the University of Melbourne.

2 Objectives

With the increasing evidence of a growing number of epilepsy cases due to cysticercosis in Nepal, control of porcine cysticercosis has become paramount of importance to reduce the effects of Neurocysticercosis in human population. To draw the control strategy for this purpose, information regarding prevalence, transmission, diagnosis and control measures of *Taenia solium* infections in humans and pigs along with knowledge, attitude, and practices farmers need to be analyzed. Once the current situation is fully known, it should be viewed in the global context for identifying the gaps that need to be addressed in strategy development for the control of the disease. It is recommended that this information be utilized by several pig traders, producers, farmers and health policy makers to produce the road map for NTD control plan.

3 Methodology

This landscape analysis report is prepared using the critically analysed information collected during a desk review and a baseline survey. The desk review was conducted through the literature searched about *T. solium* infections in humans and pigs in various literature search engines: Web Science, Scupous and Google Scholar. A search was conducted for both national and international context to review and compare the results. As much information in Nepal was in hard copy and are available within the country, the other source of information collected were from the reports published by the Department of Livestock Services (DLS), Department of Health Service (DHS) Nepal and their ministries for policy papers and University Dissertations. The results of the desk review are presented in Appendix 5 and the summaries of the review are presented in Sections 4.2 to 4.6 and in Section 6.

The survey was conducted with a standard questionnaire completed through interviews of 200 pig farmers and 57 pig traders. The questionnaire was designed to capture elements illustrating the current situation of pig production and husbandry, knowledge, attitude, practices in relation to porcine cysticercosis/neurocysticercosis. The respondents were taken from 12 districts to cover a large geographic distribution from hills to Terai areas of Nepal (Figure 7 and Table 2). In addition, 30 policy makers from

central regions were interviewed and a meeting of experts was organised in order to understand and collect their views/suggestions towards the vision for control of taeniasis/cysticercosis in Nepal. The results for the survey are presented in Appendix 4 and summaries of the survey in Section 5 of this report.

Figure 7: An administrative map of Nepal showing provinces and districts of Nepal. The red dots are the areas where sampling was performed for this study.

Table 2: Number of respondents for survey from selected districts of Nepal

Districts	Sample Size			Total
	Farmers	Policy Makers	Traders	Sample Size
Surkhet	33	0	1	34
Palpa	60	0	0	60
Banke	26	0	10	36
Bardiya	31	0	1	32
Dang	21	0	5	26
Morang	21	9	3	33
Sunsari	5	3	9	17
Bhaktapur	0	10	5	15
Kathmandu	0	8	9	17
Lalitpur	0	0	7	7
Saptari	0	0	1	1
Rupandehi	0	0	2	2
Total	197	30	53	280

4 Taeniasis and cysticercosis

4.1 Brief introduction

Taeniasis/cysticercosis is a neglected zoonotic parasitic disease caused by the three species of tapeworm: *Taenia solium, T. saginata,* and *T. asiatica.* The impact of the latter two species have not been found to be significant on human health, therefore, this section refers *T. solium* infection for taeniasis/cysticercosis.

Taeniasis is an intestinal infection caused by adult tapeworms, and acquired by humans through the ingestion of cysticerci (larval cyst) of tapeworm in undercooked and infected pork (11). Infected humans may show mild clinical symptoms such as abdominal pain, nausea, diarrhoea, and rarely may cause gall bladder perforation, appendicitis and bowel obstruction (11, 12). The *T. solium* eggs or eggs bearing gravid proglottids are then excreted in stools (11). These eggs are infective to both humans and pigs, and may contaminate the environment, including water and agricultural produce (1, 11). If eggs or proglottids are ingested, the eggs develop into cysticerci (larvae) and migrate to various organs such as muscles, skin, eyes of the human and form cysts, causing disease "cysticercosis" (1, 11). If cysticerci enter the central nervous system, the infection is called "neurocysticercosis" (1, 11). In humans, neurocysticercosis may cause severe headache, blindness, hydrocephalus, meningitis, convulsions, and epileptic seizures and may lead to death; however, some people may remain asymptomatic for many years (1, 11). Some people may also develop solid lumps of 1-2 cm size under the skin, which may become painful and swollen after months or years.

Cysticerci infection in pigs is commonly referred to as "measly pork or pork measles". Usually pigs do not show any symptoms, but when the meat is inspected, cysticerci are found mainly in the heart, tongue, forearm, thigh and neck muscles (13). The diagrammatic presentation of *T. solium* infection is shown in Figure 1.

4.2 Burden of Taeniasis/Cysticercosis

Taeniasis/cysticercosis is distributed worldwide (Figure 8) and has the highest burden on people of developing countries, particularly affecting the health and livelihoods of farming communities and people that have compromised hygiene. A study in 2010 estimated

~503,000 (95% CI: 379,000–663,000) disability-adjusted life years (DALYs) lost and approx 28,000 deaths worldwide attributed to *T. solium* infection annually (3). The other estimate reported 2.8 million disability-adjusted life-years (DALYs) in 2015 (14). Also, 30% of epilepsy cases reported was primarily related to neurocysticercosis. Taeniasis/cysticercosis has been reported as a disease among the top six major zoonotic diseases in Nepal (15). This disease received medical priorities when epilepsy cases were increasingly reported in pig farmers and pork consuming communities. It was found that factors like poor hygienic and sanitation practices, unregulated pig husbandry and pork production attributing the disease incidence. To date, only one study has reported DALYs of 14,268 for 2000 and 2012 from neurocysticercosis in Nepal (16), although taeniasis/cysticercosis reports are still scanty in Nepal.

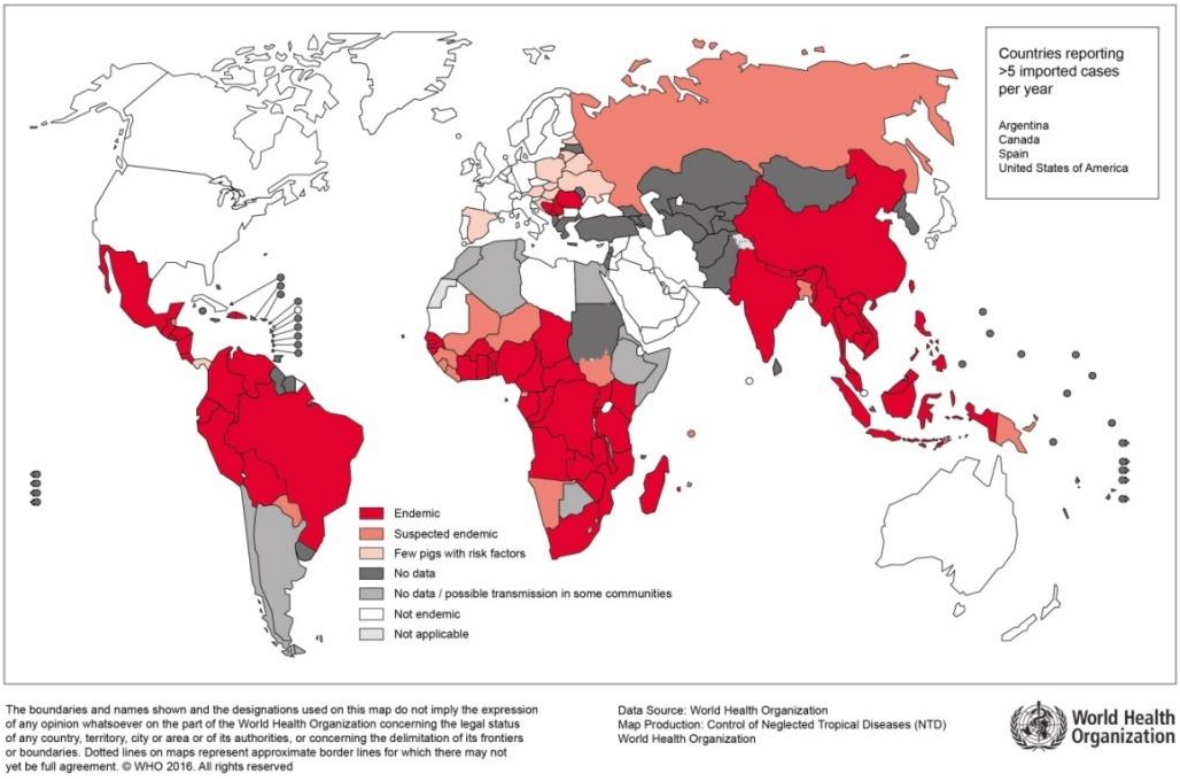

Figure 8: Spatial distribution of *T. solium* infection in the world. Red colour indicates the endemicity of *T. solium* infection in humans (Source: WHO)

4.3 Porcine cysticercosis (PC)

Many countries have reported a wide range for the prevalence of porcine cysticercosis (PC) such as 0.6-39% in West Africa from meat inspection, 0.03-56.6% in South Africa from post-mortem and 1.0-35% in Latin America from ELISA in population based study (17). In Nepal, the systemic epidemiological studies on taeniasis/cysticercosis are still

scanty. There are only a handful of studies (*n=26*) that reported PC in Nepal (Table 1 of Appendix 1), with the majority localised in Eastern and Central regions. These studies are not epidemiologically based and are not comparable. However, these studies have either used necropsy, lingual palpation, EITB and ELISA test in pigs and they reported mean prevalence of 12.77% (0.94-32.7%), 14.54% (0.63-32.54%), 21.25% (19.00 -23.5%), and 24.35% (19.7-29.5%), respectively (Section 5.1 of Appendix 5). In one PC study using lingual examination, the prevalence was found to be significantly higher ($p < 0.001$) in the pigs above 6-months old (35.1%) than the pigs below 6-months old (29.3%) (10). However, findings of cysticerci in both age groups were high, indicating that both piglets and adult pigs are potential sources of infection. Although these studies have taken samples from high risk areas of porcine cysticercosis and many have not used gold standard method for confirmatory diagnosis, the results are alarming and indicate the potential for neurocysticercosis in humans.

4.4 Human Taeniasis/Cysticercosis/Neurocysticercosis

Human taeniasis/cysticercosis/neurocysticercosis have been reported worldwide and in developing countries are endemic to the diseases. A taeniasis prevalence study conducted in 21,901 individuals from various countries using different diagnostic techniques reported the prevalence of 0-17.25% (18). Such population based studies have not been conducted in Nepal, however, there are few published work (n=42) on prevalence of taeniasis/neurocysticercosis/epilepsy in people of Nepal (Appendix 2). These studies showed occurrences of *T. solium* eggs in stools samples from various districts, ranging from 6-68% (Table 1-3 in Appendix 2).

The ethnic based stool survey also showed *T. solium* eggs in 31-50% samples. The ethnicity includes Magars, Sarkies, Damai and Bote, who were consuming pork since a long time. Interestingly, this study has also reported higher incidence in Brahmin/Chhetri who are living with these ethnic groups (Appendix 2). Culturally, the Brahmin/Chhetri group is prohibited to consume pork, and this disease may be attributed to vegetable consumption indicating contaminated environments with *T. solium* eggs. The higher occurrences were also found in communities based study than the hospital based study. These studies are not epidemiologically comparable as sampling size, population, and

detection method varies, and may over- or under- represented the occurrences of taeniasis in humans.

Community-based estimation of the prevalence of NCC is difficult as it requires neuroimaging in large groups of healthy people which may incur large cost of MRI or CT scan. Also this is possibly not easily accessible and available, particularly in rural areas. Hence, the prevalence of human cysticercosis in communities has been commonly assessed through sero-prevalence. A recent meta-analysis conducted on community based prevalence studies between 1989 and 2014 in Africa, Latin America and Asia showed 7.30% (4.23–12.31), 4.08% [2.77–5.95] and 3.98% [2.81–5.61] for circulating *T. solium* antigens; and 17.37% [3.33–56.20], 13.03% [9.95–16.88] and 15.68% [10.25–23.24] for antibody, respectively (18).

In Nepal, no community based neurocysticercosis studies have been conducted. Rather, many neurocysticercosis studies were retrospective studies of epilepsy cases admitted in the hospital... Overall, an average of 24.8% (10.2-61.0%) epileptic cases were due to neurocysticercosis (Appendix 5). Furthermore, cysticercosis were also reported from skin biopsy of the hospital-admitted patients in Nepal who had nodules in different sites (like skin, oral mucosa and breast, with values of 82%, 10% and 8%, respectively) (19). The other study observed 21 soft tissue cysticercosis in patients, with the majority related to striated muscles (11/21), eye (6/21), tongue (1/21), breast (1/21), and other tissues (2/21) (20). In addition, there is a lack of evidence of asymptomatic neurocysticercosis in pig farmers and others, thereby indicating e possible environmental contamination and taeniasis/cysticercosis in a healthy population through such population.

4.5 Diagnosis

Taenia solium infections have been diagnosed through microscopy, serological tests, and other radiological imaging tools in human, whereas serological tests, tongue palpation, and post-mortem are used commonly in the pigs. The common laboratory diagnosis methods used for taeniasis/cysticercosis in humans and pigs is given in Table 1 of Appendix 3. Among these assays, microscopy, Ag-ELISA and EITB are commonly used for taeniasis and cysticercosis diagnosis.

Tongue inspection for the diagnosis of porcine cysticercosis is the most commonly used method, as it does not require the sophisticated laboratory establishment. When both

palpation and visual inspection are applied, the specificity could reach 100% (21, 22). However, the sensitivity of this technique depends upon the degree of infection, and in heavy infection, detection rate could go up to 70%, but it declines with light infection. Studies have shown that none of the animals could be detected by tongue inspection, if infected pigs have less than 100 cysts (21; 23). The relationship between sero-prevalence and tongue inspection has been established and found to be ~3:1 in ratio. Therefore, researchers suggested that detection of cysts in the tongue of pigs by more than 10% could indicate the area to be at high risk of cysticercosis for both humans and pigs (24). In Nepal, tongue inspection and all other diagnostic methods have been used to detect porcine cysticercosis. However, these tests are not comparable to results from other part of the world. This indicates a need for development of a standard protocol to be adopted by all researchers.

In Nepal, there is no community-based study for taeniasis and the faecal microscopy assay could be expensive for the community testing. In the context of neurocysticercosis, it is suspected only if the hospitalised epilepsy cases did not show improvement through its basic line of treatment. The radiological imaging is inaccessible and unaffordable to all the infected people. Many people are based in rural areas, are from poor economic backgrounds, and not even all hospitals are equipped with adequate diagnostic facilities such as MRI and CT-scanning. Those studies that have identified neurocysticercosis and taeniasis are also not comparable due to the use of different diagnostic tools, and the fact that their sensitivity and specificity were not assessed (Table 2 of Appendix 3). In addition, people with epilepsy are often subjected to stigmatization and discrimination because of misconceptions and negative attitudes surrounding the disease. Some common misconceptions are: “possession by evil spirits”, “epilepsy is contagious” or its equivalence to “madness”. This stigmatization not only leads to human rights violations and societal exclusion, but the real scenario and burden of epileptic and associated neurocysticercosis cases are not reported accurately.

4.6 Treatment and Control of *T. Solium* infections

The FAO/UNEP/WHO started a sustained control strategies plan of *T. solium* four decades ago, and established the International Task Force on Disease Eradication (ITFDE) for *T. solium*. This task force identified that the disease is potentially eradicable in humans or pigs because the life cycle requires humans as its definitive host; infected

humans are the only source of infection for pigs (intermediate host), the domestic pigs can be managed and no significant wildlife reservoir exists, and practical intervention is available in the form of chemotherapy for both human taeniasis and porcine cysticercosis (25). Therefore, anthelmintic treatments in humans and pigs have been widely recommended/suggested. The Epidemiology and Disease Control Division (EDCD) of Nepal has also suggested using either praziquantel or niclosomide for treatment of taeniasis; and for neurocysticercosis, either praziquantel for 15 days or albendazole for 15-21 days has recommended. Mass drug administration and health education in humans were suggested to be effective where the disease is endemic, but such a programme has not yet been implemented in Nepal.

Simultaneously, improvement in pig husbandry, sanitation, meat inspection, administration of anthelmintic drugs, and vaccination in pigs are needed to reduce the taeniasis and cysticercosis. Currently, anthelmintic and vaccination combination strategies have been widely used for prevention and control of the disease in pigs in some parts of the world. For anthelmintic, Oxfendazole and niclosamide have been suggested for pigs, but these drugs have not been used in pig practice in Nepal.

Four types of vaccine have been developed based on:

i) crude antigen extracts from meta cestodes of infected pigs (26);

ii) recombinant onchosphere antigen TSOL16 or TSOL18 (27);

iii) synthetic peptide antigen derived from *T. crassiceps* named S3Pvac (28, 29)

iv) DNA vaccines immunized with DNA constructs expressing antigen B of *T. solium* (30).

Among them, TSOL18 was found to have better efficacy. Recently, TSOL18 vaccine was developed by Indian Immunological Limited (IIL), based on technology from Professor Marshall Lightowlers at the University of Melbourne. It has been registered as Cysvax™ has been licensed in India and available in the market since November 2016 (1). It is recommended to be administered twice initially, a month apart, along with an anthelmintic treatment to develop the immunity. Vaccine needs to be repeated in six months, and thereafter annual vaccination is needed for effective control of the

taeniasis/cysticercosis. Nepal has no experience in PC vaccination, but recently, vaccination with Cysvax™ have been done in a field trial supported by GALVmed and implemented by Heifer International Nepal.

Another control strategy suggested is community education on the cause, mode of transmission, economic and social impact for prevention of *T. solium* infections in endemic areas (31-33). This approach is suggested to be used alone where other control strategies are not available, or to be coupled with other strategies such as the treatment of human tapeworm carriers.

There is no formal control plan strategies have been formulated to date in Nepal. However, a pre and post knowledge, attitude and practice (KAP) study on zoonotic diseases demonstrated a statistically significant difference in KAP after two years intervention from educational programme (34), which could be possibly implemented along with other control strategies in controlling *T. solium* too.

5 Knowledge, attitude, perceptions and practices

Taeniasis/cysticercosis was reported in Nepal a few decades ago, and high prevalence of the disease have been found, particularly in certain ethnic groups and areas (10). These reports do not provide information about the actual knowledge, attitudes and practices of the disease among those who raise/trades/consume/distribute the pigs or the policy makers. For developing any control strategies of disease, it is important to understand the disease situation and understanding of the disease by producers and consumers. One of the best and easiest methods is to collect such information from the targeted respondents. Therefore, a baseline survey was conducted among pig farmers, policy makers, and live pig traders in 12 districts, representing 5 provinces namely province number 1, 3, 4, 5, and 6 of Nepal (Figure 7 and Table 2). Although no statistical framework was prepared, 198 farmers, 61 traders and 30 policy makers and traders were targeted for the survey conducted between April and June of 2017. Details of the survey results are found in Appendix 4.

In summary, the survey showed that only 27.3% farmers fully confined pigs, whereas a large population of pigs are tethered or penned for part of the day, and only 6.1% farmers

kept on free range system. In addition majority farmers did not know about tapeworm infections (64%), its sign and symptoms (68%), and how Taenia infection was acquired (79%) in people (Table 3). Also, many of these farmers (87%) did not know what measles (cyst) are and how pigs are infected with porcine cysticercosis (93%), although they (83%) have habit of consuming measly pork. In addition, 90% traders sell measly pork without any concern (Table 3). Glimpses of eating and selling practice of pork meat is shown in Figure 9.

The baseline survey conducted among sampled population (farmers and traders) showed that more than half of them were male, between the ages of 20-50 years who are considered economically active, and whose income depended on livestock and crop production, and pig trading for a living. Eating and selling practice of measly pork appeared very high which can be a big public health concern. However, this practice is found to be influenced by the education in both male and female members in the household. Although pig traders have received various information about a cysticercosis from GOs or NGOs extension authorities, yet many of them did not have knowledge of disease transmission cycle between humans and pigs. Only a few respondents (<10%) have tertiary education and others although literate, practiced negligible hygienic measures.

Table 3: A summary of baseline survey conducted with farmers and pig traders.

Knowledge
• Many farmers (57.0%) had observed measles in pork, but only 7.6% knew that it was tapeworm and 92% did not know about tapeworm. • 64.7% farmers were not aware of about tapeworm infection in humans • 66.7% of farmers did not complain of tapeworm infection in the villages • Many farmers (93.43%) did not know that it is transmissible to human and also 79.29% did not know that pig can transmit it to human • However, many respondents reported of seeing epilepsy cases (38.9%), chronic headache (37.4%) and skin nodules (0.51%) in villages.
Attitude
• 83.8% of respondents eat pork that had measles without any concern of its health hazards • 89.90% did not mind selling the measly pork
Practice
• Majority of the farmers consume pork (95.0%) and slaughter pigs at home (91.4%). • 83.8% stated that they eat measles containing pork without any concern. • 62.3% of traders sell pork with measles and 60.1% of them even eat it! • 78.28% used toilet, 16.16% used it sometimes, and 5.56 % did not use toilet at all. • 66.67% of pigs were tethered/ penned for part of the day, 27.3 % were in complete confinement, and the remaining 6.1 % were in free range.

Figure 9: a) Pork barbecue preparation at Banke district and Pork sale at weekly market in Morang district of Nepal.

When survey results were compared between formal or no formal education group, significant difference occurred in toilet use, awareness of porcine cysticercosis, knowledge on transmission to pigs, knowledge on measles in pork, disease transmission to pigs, sale of pork with measles, except similarity was found in observation of measles and eating measled pork (Table 4). This indicates that education could change the unwanted behaviours in the transmission of cysticercosis. These evidences and a pre and post KAP intervention study on zoonotic disease suggest the need for educational intervention to address the knowledge gap on porcine cysticercosis, neurocysticercosis or epilepsy cases among farmers and traders to mitigate the attitude and practices of eating/selling measles pork and trading them. The ssignificant difference not seen in eating measles must have some influence of social behaviour. However, it should be noted that the number of respondents in three variables was less than five in some cells and, that also may influence the result.

Among stakeholders, there were not much differences between sex of the respondents in responding to the majority questions in Yes/No/Don't know (Figure 10).

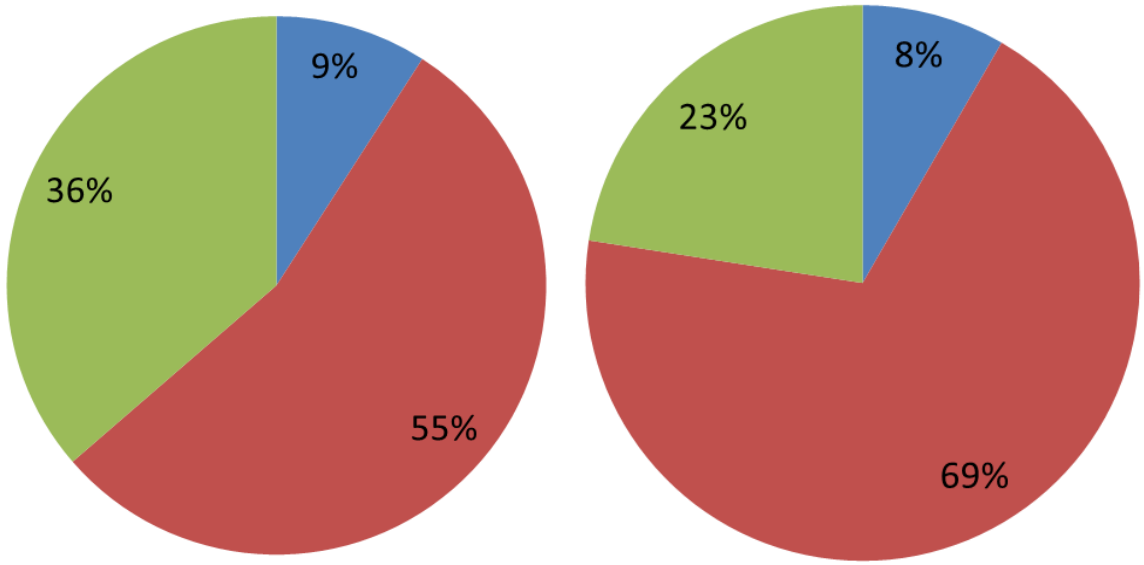

Figure 10: Pie charts representing overall female (left) and male (right) stakeholders' responses to 11 questions (Q. 9-14 & 16-20). The red colour represents "No", green for "Yes" and Blue to "Don't Know" to the responds of the questions.

Table 4: Behaviour variations between formal education and no-education group of respondents (farmers)

Variables	Formal education (n=120)		No formal education (n=78)		Total	Chi-square value*	P-value
	No.	%	No.	%			
Toilet in households							
Presence	107	89%	48	62%	155	20.32	0.0000 38***
Presence but sometimes used	8	7%	24	31%	32		
Absence	5	4%	6	8%	11		
Awareness of porcine cysticercosis							
Yes	47	39%	18	23%	65	4.84	0.0277 1**
No	73	61%	60	77%	133		
Knowledge on PC transmission to human							
Eating infected meat	35	29%	6	8%	41	12.01	0.0005 3***
Unknown	85	71%	72	92%	157		
Observation measles in pig meat?							
Yes	74	62%	39	50%	113	2.17	0.1405
No	46	38%	39	50%	85		
Knowledge on measles in pig meat?							
Yes	14	12%	1	1%	15	5.87	0.0153 7**
No	106	88%	77	99%	183		
Knowledge on cysticercosis transmission in pig							
Yes	12	10%	1	1%	13	4.52	0.0334 6**
No	108	90%	77	99%	185		
Eating measles containing meat							
Yes	97	81%	69	88%	166	1.51	0.2197
No	23	19%	9	12%	32		
Sell measles containing meat							
Yes	103	86%	75	96%	178	4.18	0.0410 3**
No	17	14%	3	4%	20		

* Yates' Chi-square corrected value
**Significant as is less than 0.05
***Highly significant as is less than 0.01

6 National Control Policy

Nepal h both human and animal health policy to reduce the important communicable and non-communicable diseases in Nepal.

6.1 Human health policy

Policy of the health system of Nepal has been guided by Health Policy 1991, and Nepal Health Sector Strategy Implementation Plan, 1975 (NHSP-IP) for the period 2004-2009 and Nepal Health Sector Strategy Implementation Plan, 1991 (NHSP –IP II) for the period of 2010-2017 acts for the implementation. Recently, a new health policy 2014 has been in place with Nepal Health Sector strategy implementation Plan 2017, whose prime concern is to strengthen the partnership of public and private stakeholders for uplifting public health. In addition, there are other supporting acts: Nepal Health Service Act, (1997), Infectious Disease Control Act, (1964), Mental Health (Treatment and Protection) Act, 2006 and Food Act, 1967. Currently, there are 104 public hospitals and 303 private hospitals in service in Nepal. In addition, these hospitals and institutes are supported by 291 public and 1237 private laboratories for supporting disease diagnosis (Appendix 7).

Epidemiology and Disease Control Division (EDCD) is responsible for planning, implementation, monitoring and evaluation of surveillance, prevention and control activities of diseases, and also for mobilizing the Rapid Response Team (RRT) for the outbreak control. Within itself, the EDCD has a Zoonotic Disease Sub-section, which has the mandate for prevention and control of the zoonotic diseases. About 60 zoonotic diseases have been recognized in Nepal, but only six diseases; Taeniosis/cysticercosis/neurocysticercosis, leptospirosis, hydatidosis, brucellosis; toxoplasmosis and Avian Influenza are on the list of priorities. Taeniosis/cysticercosis/neurocysticercosis is yet to be in the 'control list' to establish a country-wide surveillance system because the human health policy states that those human diseases listed in the control programme are only to be supported with epidemiological surveillance, control measures with laboratory back up, early detection, and monitoring system. However, the health policy is open to establish coordination and collaboration with multilateral, bilateral and national stakeholders to establish functional

participation in managing and controlling of zoonotic diseases and other diseases. In addition, the formation of a joint medical and veterinary coordination committee from the health and veterinary service to the direct zoonotic diseases policy and control programme is in the process of being established.

6.2 Animal health policy

In Nepal, Animal health policy consists of various veterinary legislations: i) Animal Health and Livestock Services Act, 1998, Animal Health and Livestock Services Regulation, 2000, ii) Animal Slaughterhouse and Meat Inspection Act, 1999, Slaughterhouse and Meat Inspection Regulation, 2000, and iii) Nepal Veterinary Council Act, 1999 and Nepal Veterinary Council Regulation, 2000. However, these acts exist for functional purposes only and policy documents still need to be finalised, including the development of veterinary legislative framework with international harmonization standards.

The available acts mainly focus on controlling livestock diseases and are drawn towards the most economical production diseases and Transboundary diseases such as PPR, FMD, Ranikhet, Classical Swine Fever and HS/ BQ Control Program. Currently, a strategy for the control of PPR and FMD has been drawn.

Animal Health Directorate under Ministry of Livestock Development (MOLD) through its Veterinary Public Health Office (VPHO) takes responsibilities for control and management of zoonotic diseases. VPHO is currently preparing a national surveillance plan for zoonotic diseases. One of the successful disease control program implemented in Nepal is for Avian Influenza. The project was supported by the World Bank, implemented by Department of Health (DOH) and Department of Animal Health (DOAH) to strengthen the technical capacities in surveillance, diagnostics, bio-security, quarantine, response (containment among animals and human case management), and communication, thereby creating a great atmosphere for “One Health Approach”. In addition, a pilot project under One Health Asia Program (OHAP) was also run for two years in the three districts (Chitwan, Rupandehi, Banke) for awareness and capacity building of six identified zoonoses.

6.3 Survey and meeting with policy stakeholders

Overall 30 policy makers were surveyed, of whom the majority were male (25/30) and were aged between 40 and 70. According to them, neurocysticercosis is not a notifiable disease and there are no control strategies available for neurocysticercosis or porcine cysticercosis in Nepal, although porcine cysticercosis is listed in the OIE notifiable disease list. Most of the control or treatment programme is based on clinical diagnosis in humans or pigs. Although the slaughterhouse and meat inspection act is present in Nepal, it has not been implemented. However, there were few changes in hygienic practices observed in some meat shops in cities in the last few years.

6.3.1 Outcome of technical advisor committee meeting

In April 2017, a national technical advisory committee meeting was held on 20th April 2017 in Kathmandu, Nepal (Appendix 6). The participants were from varied backgrounds- human and animal pathologists, professors, government policy makers, epidemiologists, public health experts and medical practitioners. At the meeting, pig production scenario, neurocysticercosis, economic burden of the disease and the need for landscape analysis, and ongoing vaccination trial were presented. The participants acknowledged that landscape analysis study is useful to control cysticercosis in Nepal and appreciated the effort of Heifer International Nepal and GALVmed for their contribution on this project. In addition, they also highlighted the-

- Lack of population-based cysticercosis and epilepsy prevalence studies in both, human and pigs;
- Need of standard diagnostic tests validation;
- Need to use the University publications such as dissertations and the Government reports, and
- Need of using one health approach for developing control strategies.

7 Conclusion

T. solium infection is known as a preventable poor-man's disease. This report describes the current status of cysticercosis in Nepal and it identified: 1) the increasing trend of pig

production and 2) a higher prevalence rate of taeniasis/neurocysticercosis in both, humans and pigs. Following the surveys and meetings with farmers, pig traders, policy stakeholders, and scientific advisors, it became apparent that both humans and animal sectors are vulnerable to *T. solium* infection, and there is a need to formulate various control plans, including drug administration and vaccination. However, significant gaps were found in various areas *T. solium* infection such as deficiency in- population based disease estimation, diagnostic protocols, hygienic pig husbandry practices, and control policy (Table 3). These gap areas should be taken into consideration for the effective control of taeniasis/cysticercosis/neurocysticercosis in people of Nepal.

8 Gaps and Key recommendations

This report identified significant gaps in diagnosing, understanding and controlling *T. solium* infections in Nepal and thereby proposed the specific recommendations. Table 4 shows lists of gaps and recommendations identified in context of Nepal.

Table 4: Lists of gaps and their remedy to control *T. solium* infections in Nepal

S. no.	Gaps	Recommendations
1	Actual disease burden is unknown	• Population based study required
2	Research methodology varies from researcher to researcher in diagnosis of *T. solium* infections in animals and humans	• Development of standard protocol at national level • Identify meat inspection sensitivity to diagnose the disease in Nepal
3	Poor hygienic condition in pig husbandry practices	• Create awareness about the disease to farmers • Enforce proper housing and sanitation system for pigs
4	Knowledge gap on *T. solium* infections leading to consumption of measly pork, treatment and prevention is unknown	• Create mass awareness programme through education on transmission, safe cooking and toilet use • Mass administration of drug e.g. Oxfendazole and administration of vaccine e.g. CYSVAX

5	Lack of *T. solium* infection control policy and mechanism	• Active implementation of meat inspection policy • Formation of One Health Institution • Formation of steering committees

8.1 Gaps

8.1.1 Deficiency in population based disease estimation

There are gaps in the study of true prevalence of *T. solium* infection in both humans and animals because population-based epidemiological studies have not been conducted yet.

8.1.2 Deficiency in research/diagnostic protocols

Although there are more than 25 papers on taeniasis/cysticercosis in humans and pigs, these studies did not follow a standard and robust research methodology or a diagnostic protocol, thereby indicating a lacking of standard protocol at national level in both human and animal sectors. In addition, there is a lack of pork meat inspections, that could also diagnose the *T. solium* though this diagnostic method in pork meat has low sensitivity.

8.1.3 Deficiency in Knowledge of T. solium infection

In spite of the fact that many participants in the survey were able to read and write, there is a lack of knowledge on *T. solium* infection leading to selling and consuming measly pork.

8.1.4 Deficiency in hygienic pig husbandry and cysticercosis prevention practices

Good pig husbandry practices are also lacking in Nepal as many farmers/traders are from low-income families and they lack proper pigsty, have little knowledge about hygienic practices. In addition, there is a lack of knowledge about anthelminthic drugs or vaccines for treatment/prevention of cysticercosis. The availability of appropriate anthelmintic is an issue while PC vaccine is yet to be registered in the country.

8.1.5 Deficiency in T. solium infection control policy and mechanism

There are no legislations and regulations for efficiently controlling cysticercosis in pigs, but only a presence of limited regulations for human neurocysticercosis in Nepal

8.2 Key recommendations

Having reviewed the taeniasis/cysticercosis status in pigs and humans of Nepal, and the available diagnosis, treatment and prevention strategies in Nepal, the strategies have been identified and recommended to address the deficiencies and improve control of the disease, and ultimately improving animal and human health.

8.2.1 Research study design

A population based *T. solium* infection study should be conducted at regional and/or national level so that the actual burden of the disease in animals and humans across Nepal could be determined and fully understood, thereby helping in developing actual and effective control mechanisms.

8.2.2 Detection of the disease

There is a need for a sensitive, robust and specific standardized diagnostic protocol for the detection of taeniasis and cysticercosis in both humans and pigs, so that the research output could be equated nationally, across the regions, as well as internationally. Furthermore, this would help to identify the actual disease burden and economic impact of the disease in the country for formulating a better public health policies and management.

8.2.3 Pigs husbandry

Proper housing for pigs should be enforced nationwide for creating better hygienic condition. The housing should be affordable, with ample sanitation, dry floor, dry bedding, and good ventilation so that the hygiene conditions would be improved. District Livestock Service Office (DLSO) in its extension program has been supporting farmers to build improved housing conditions for pigs through subsidies, but not sufficiently and adequately.

8.2.4 Awareness programme through Education

Efforts to educate the communities on disease transmission and prevention, pig management, personal cleanliness, meat hygiene and sanitation through the education have been reported as fairly successful, especially in terms of the increased knowledge areas in other countries (32-34). In addition, health education plays an important role in helping to change eating habits (boiling meat, washing vegetables), promote self-diagnosis of infection, improve sanitation (e.g. Use of closed latrines or toilets), personal hygiene (hand washing) and husbandry systems (confinement of pigs) (35) . These behavioural changes through education could be achieved in Nepal through:

- Conducting service-centre level training programme by the Department Livestock Service and Primary Health Care Outreach Clinic (PHCORC) sites.
- Dissemination of information implemented through paper and electronic media such as leaflets, pamphlets, TV, radio and local F.M radio etc. at national level.
- Creating more awareness in the population, effort could be made to include important zoonoses in the school curriculum from class 8th to class 10th in the subject of health, population and environment, which is a compulsory subject.
- Providing information on the effectiveness of the education programme through epidemiological studies that are based on the incidence of epilepsy and porcine cysticercosis. Such studies are scanty from Nepal to draw strategy and validation. The National Agricultural Research Council (NARC) could develop a long-term research protocol. The Epidemiology and Disease Control Division (EDCD) and Veterinary Public Health Office could build resources to conduct such research through Medical and Veterinary College or other country's research organisations.

8.2.5 Treatment and Prevention measures

Mass drug administration should be considered for implementation in both, humans and pigs in areas where porcine cysticercosis is detected/identified. In pigs drug such as Oxfendazole is commonly used as antiparasite drug. However, its efficacy alone for *T. solium* infections is rather less effective than the use of drugs and vaccine combination. Therefore, programmes of administration of Oxfendazole along with vaccination against *T. solium* should be initiated and implemented in Nepal through government

subsidy/programme so that the lower income farmers would benefit and produce the cysticercosis free pork for the consumers. For vaccination, GALVmed along with others has produced the CYSVAX™ (TSOL18) vaccine to be used in pigs. This vaccine is in the trial phase in Nepal and expected to be used in future for controlling cysticercosis in pigs. The use of Oxfendazole alongside vaccine in the initial stages of control would ensure that pigs with existing infections are cleared of infection. Controlling the disease in pigs alone would take some time to reduce the taeniasis carrier numbers in the human population and, therefore, treatment of the human population would provide a further break of the transmission cycle. The exact strategies to be applied would need further assessment in terms of cost-benefit analysis, which is recommended.

8.2.6 Policy formulation and implementation

Nepal has some policies formulated for zoonotic diseases, like Avian Influenza. Such legislation should be considered for the development of a control plan for NCC and PC. Among others, development of practical and effective legislative frameworks to address meat inspection and biosecurity at local and national level should be given priority. One Health approach should be considered to improve management and control of the disease. Monitoring of the effectiveness of the measures implemented program (see Section 8.2.6.1 and 8.2.6.2) is also recommended.

8.2.6.1 Meat Inspection

Although sensitivity of meat inspection for diagnosis is very low (22%), especially for light cysticercosis infections (21), according to the Slaughter House and Meat Inspection Act 1999, the national legislation for pork inspection should be reviewed and enforced with special reference to porcine cysticercosis at regional and national levels immediately.

8.2.6.2 One Health institution formation

A “One Health” approach should be implemented to control and eliminate the *T. solium* taeniasis-cysticercosis because simultaneous multiple interventions of human, animal and ecosystem health is possible by appropriate health education tools (36, 37). It is based on a *T. solium* transmission model (38) and a combined approach utilising the

treatment of human taeniasis cases (through mass drug administration or selective chemotherapy) combined with the vaccination (CYSVAX™) and treatment of the porcine host. This core approach should be supplemented by supporting measures such as 1) improved meat inspection, 2) improved husbandry and 3) improved sanitation (35). In addition, it is essential to form a health institution in order to achieve a successful and sustainable control of this complex and socially determined zoonotic disease (39). Therefore, a possible framework for the institution is proposed as shown in Figure 11. The inputs to support the proposed framework are listed in Appendix 9.

8.2.6.3 Steering committee for controlling the disease

It is recommended that steering committee is formed comprising researchers, educators, medical and veterinary practitioners and legal authorities to formulate all the legislation and to develop the institution as suggested in above points.

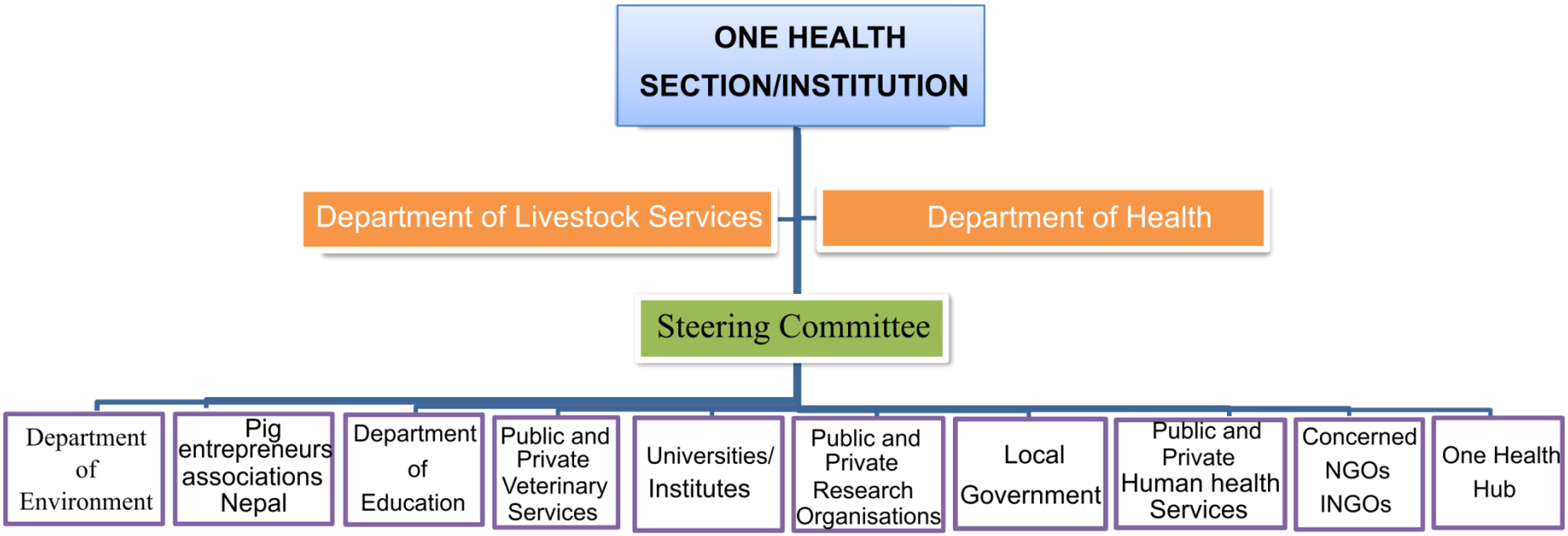

Figure 11: A diagrammatic representation of proposed conceptual framework for One Health Section/Institutions in Nepal.

9 Acknowledgements

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10 Appendices

The various appendices including their references were given in the following page.

10.1 Appendix 1

Table.1: Prevalence of porcine cysticercosis from various studies in Nepal

SN	Age group of Pig	No. of samples	% of positive cases of PC	Recorded Year	Place	Type of Test	Reference
1	Finisher	196	14.3	1997-98	Kathmandu	Post mortem	(1)
2	" "	54	11	1997-98	Dharan	" "'	" "'
3	All age	419	32.5	2000-02	Syangja	Lingual	(2, 3)
4	All age	204	24	2000-01	Syangja	EITB	(2, 3)
5	All age	200	10.5	2004-05	Kathmandu	Lingual	(4)
6	" "'	" "'	22.5	2004-05	Kathmandu	ELISA	(4)
7	" "'	" "'	20.5	2004-05	Kathmandu	Necropsy	(4)
8	All age	320	0.63	2006	Kathmandu/ Chitwan	Lingual	(5)
9	All age	320	0.94	2006	Kathmandu/ Chitwan	Necropsy	(5)
	All Age	30	6.66	2005	Chitwan	Necropsy	(6)
10	All age	100	19	2010	Sunsari/Ktm	EITB	(7)
11	All age	320	7.2	2010	Sunsari/Ktm	Necropsy	(7)
12	All age	297	29	2011	Katmandu Valley	Ag-ELISA	(8)
13	All age	742	19.7	2007-2010	Katmandu	Ag-ELISA	(9)
14	All age	97	25.77	2013- 014	Multiple location	Ag-ELISA	(10)
15	All age	400	2.74	2013-2015	Kathmandu + 4 dist.	Necropsy	(11)
16	All age	110	32.7	2015	Banke	Necropsy	(12)

10.2 Appendix 2

Table 1: Taeniasis infection identified from microscopic examination in various districts in Nepal.

Districts	Mean Positive (%)	Range (%)	References
Syangja (Tindobate VDC)	43.0	28-68	(13)
Tanahun (Vyas Municipality)	18.4	6-37	(14)

Table 2: Taeniasis infection reported among different ethnic groups by stool examination.

Ethnic groups	Total samples	No. of positive samples	% of infection
Magars	122	61	50
Sarkies	58	16	28
Darai	90	9	10
Bote	62	19	31
Total	**332**	**105**	**31.4 (Average)**

Table 3: Prevalence of Taeniasis in Vyash Municipality of Tanahun District and household that has toilet.

Places	Total stool samples	No. of positive Samples (%)	Household with toilet (%)
Baireni	27	6 (22)	10 (6.57)
Bote Tar	35	13 370	0 (0.0)
Atreuli	43	6 (14)	16 (10.53)
Dumsi	47	3 (6)	72 (47.37)
Total	**152**	**28 (18)**	**98 (64.5)**

Table 4: Prevalence of taeniasis at various locations in Nepal

Location	Sample size	% Positive	Reference
Birgunj teaching Hospital	2221	2.6	(15)
Schools in Dharan	935	5.5%	(16)
Teaching Hospital, Nepal Medical college	2423	3.8%	(17)
Biratnagar	2423	0.6%	(18)

Table 5: Age distribution of patients visiting the Psychiatry OPD at teaching hospital of TU.

Age-groups (In years)	Females (N=108)		Males (N=179)		Total (N=287)	
	N	%	N	%	N	%
1-10	12	11.11	22	12.29	34	11.85
11-20	44	40.74	62	34.64	106	36.93
21-30	28	25.93	57	31.84	85	29.61
31-40	12	11.11	27	15.08	39	13.59
41-50	4	3.7	8	4.47	12	4.18
51-60	6	5.56	2	1.12	8	2.79
61-70	1	0.93	1	0.56	2	0.7
>70	1	0.93	0	0	1	0.35

Table 6: Annual growth of epilepsy and Pig population in different regions

Regions	Epilepsy Annual Growth	Pig Population Growth
Eastern Region	0.93	1.66
Central Region	4.79	4.56
Western Region	9.04	2.72
Mid Western Region	1.84	-4.78
Far Western Region	3.44	1.76

Table 7: Percentage of Neurocysticercosis found in total admitted patients with or without epileptic episodes between 2002-2006 years at different hospital in Kathmandu

SN	Type of patients	Hospitals					Total
		Teaching	Bir	Patan	Norvic	NMC	
1	Total admission episodes	85895	50033	94870	8727	28252	267777
2	Total epileptic admission episodes	560	49	321	210	124	1264
3	% 0f epileptic episode	0.652	0.098	0.338	2.406	0.439	0.472
4	Total NC episodes	28	16	25	46	14	129
5	% of NC in epileptic cases	5.0	32.7	7.8	21.9	11.29	10.2
6	% of NC in total admission	0.033	0.032	0.026	0.527	0.050	0.048

10.3 Appendix 3

Table 1: Various common laboratories diagnosis techniques used in human and pigs for *T. solium* infections

Diagnostic assay	Technique	Reference
Assays for human cysticercosis		
Ag-ELISA	HP10 (lateral flow format being tested)	19
	B158/B60 (commercialized by ApDia)	20
Ab-ELISA	oncospheral peptides	21
	crude Ag extract (commercialized by NovaTec)	22
LLGP-EITB	glycoproteins (commercialized by several companies)	23
EITB	rT24H (recombinant Ag) (lateral flow format being tested)	24, 25
Assays for human taeniasis		
Microscopy	Kato Katz, formol ether concentration techniques	Several
Copro-AgELISA		26
Copro - PCR	Nested PCR	27
	Multiplex PCR	28
	RT-PCR	29
EITB	rES33	30
Assays for porcine cysticercosis		
Meat inspection	local legislation Tongue check	19
Ag-ELISA	HP10 (lateral flow format being tested)	19
	B60/158 (commercialized by ApDia)	20
Ab-ELISA		31
LLGP-EITB		23

Table 2: Recorded cases of epilepsy and various diagnostic methods used to determine neurocysticercosis in Nepal.

SN	Age group of patients	No. of epileptic cases	% of NC	Recorded Year	Place	Type of Test	Reference
1	All ages	724	61	2000-01	Kathmandu	EITB	(32)
2	"	233	17	2000-01	Banepa	EITB	(32)
3	Adult	300	47	2000	Kathmandu	EEG, MRI	(33)
4	All ages	112	13.4	2006-07	THK,NMC	CT Scan	(34)
5	All ages	1264	10.26	2002-06	5 hospital, Kathmandu	EITB, CT Scan, MRI	(35)
6	Children 2.5-16 yrs.	678	16	2004-09	MTH, Pokhara	CT Scan	(36)
7	All ages	100	44.00	2007-10	TUTH, Ktm.	CT Scan ELISA	(37)
8	All ages	217	22.58	2005-13	Pokhara	CT Scan	(38)
9	1/2 to 15 years	551	12	2007-011	MTH, Pokhara	CT Scan, MRI	(39)
10	2-5 Children	133	17.3	2010-11	GMC. Pokhara	CT Scan	(40)
11	Adult, >16 Yr.	91	15	2008-09	BPKIHS	Ag ELISA	(41)
12	16 above	445	36.85	2014-015	MTH, Pokhara	CT Scan,	(42)
13	All age	131	16	2012-14	Bir Hospital	CT Scan, MRI	(43)
14	All age	250	32	2013-14	TUTH, Ktm.	CT Scan, MRI	(44)
15	Children (3-12 Yr.)	321	12.1	2009-2014	BPKIHS	CT	(45)
	Avg of total	4929	24.83				

10.4 Appendix 4

Various policy and other stakeholders that could be useful for the proposed One Health Institution are:

Policy

1. Ministry of Health, Kathmandu, Nepal (+977) 01 4262543, 4262802, 4262696, 4267376 Email; info@mohp.gov.np
2. Department of Health Services Teku, Kathmandu, Telephone: 977-1- 4262063, (Management Division) Fax: 977-1- 4251173
3. Ministry of Livestock Development; Singha Durbar, Kathmandu, Nepal. Phone: Secretary: 01-4211706, Fax: 01-4211480; E-mail: info@mold.gov.np, pasupanchibakas@gmail.com; Website: www.mold.gov.np
4. Department of Livestock Services; Hariharbhawan, Lalitpur, Nepal. Phone : 01-5522056 /5521610 / 5525478, Toll free number: 1660-0167890. Fax : 01-5542915; Email: dgdls@ntc.net.np, www.dls.gov.np

Research

1. Nepal Health Research Council, Ramshah Path,P.O.Box 7626,Kathmandu, Nepal Telephone 977-1-4254220 / 4227460 Fax 977-1-4262469 / 4268284 Email Address: nhrc@nhrc.org.np
2. Health Research Division, National Animal Science Research Institute (NASRI) Nepal Agricultural Research Council (NARC) Khumaltar, Lalitpur, Nepal Tel.: +977 1 5551855,5551292 E-mail: Website: http://www.narc.gov.np
3. Central Department of Biotechnology Institute of Science and Technology Tribhuvan University Kirtipur, Kathmandu, Nepal Phone: +977-01-4336221 Email: info@biotechtu.edu.np; biotechtu.edu.np@gmail.com
4. Centre for Molecular Dynamics (CMDN) Email: s.dixit@intrepidnepal.com Tel: 01-4251590

5. Annapurna Neurological Institute and Allied Science, Kathmandu, Nepal Phone: 4256656 Mobile: 9851021975 Email: bpant@wlink.com.np
6. Four Veterinary Colleges affiliated with three universities (Two of them are private)
7. Currently, about 20 Medical Colleges are operating in Nepal (both governmental and private colleges). Most of the colleges are affiliated to two main Universities of Nepal i.e. Kathmandu University (KU) and Tribhuvan University/IOM (TU).

INGO/NGO

1. Heifer International Nepal, Hattiban, Lalitpur, P.O. Box.: 6043, 977-1-5250554, 5250841, heifer.nepal@heifer.org.
2. NZFHRC, Jeevan Smriti Marg Chagal, Kathmandu, Nepal, email: hello@nzfhrc.org.np , Tel:+97714274928,

Farmers' Associations

1. Pig Entrepreneur Association Nepal-PEAN/ Email; pean.pignepal@gmail.com Mobile: 985-1183891
2. Pig farmers Groups; Several Producer Groups organized in each districts by the District Livestock Service Office
3. Butcher shops; Most of the shops of the district are registered by the concern District Livestock Office.

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