

Cysticercosis in Nepal: A Review

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ABSTRACT

Cysticercosis is the infection caused by larvae of Taenia solium, which is one of the major zoonotic diseases in Nepal. Infection of larvae in the central nervous system is neurocysticercosis and infection of adult tapeworm is taeniasis. Cysticercosis is associated with the social, cultural, and economic aspects of the country and is endemic in many developing countries like Nepal. Detection of neurocysticercosis among eight Gurkhas in Hong Kong (1987) shows its existence in Nepal since many decades ago. The occurrence of cysticercosis/neurocysticercosis is higher in males and young people are more susceptible. Lack of awareness about disease and seizure, unhygienic behaviours, free-roaming pigs, and lack of surveillance are major factors contributing to the transmission of this diseases from pigs to humans and among humans. Cysticercosis is endemic in Nepal and a large number of cases are reported in hospitals. The Social, public health and economic impact of the disease is yet to be evaluated. Increased survey and surveillance to understand the burden of cysticercosis throughout the country along with public awareness is urgently needed. The collaboration of multi-stakeholders including human and animal health, pig farmers, and policymakers using the concept of “One Health” is needed to reduce the burden of cysticercosis/neurocysticercosis in Nepal.

Keywords: Cysticercosis; Nepal; Neurocysticercosis; Taeniasis

INTRODUCTION

Cysticercosis is the infection caused by larva of *Taenia solium* (pork tapeworm) which belongs to Cestoda class of phylum Platyhelminthes (Gripper and Welburn, 2017). Neurocysticercosis; cysticercosis of central nervous system, is an ancient, commonest helminthic disease of the (Del and Sotelo, 1988). Taeniasis is the infection caused by adult tapeworm and cysticercosis is used for infection due to larval or metacestode (cysticercus) stage of *Taenia solium* (Carpio, 2002; Gripper and Welburn, 2017). Cysticercus develop as neurocysticercosis after infecting the nervous system (José et al., 2018). This disease is related to social, cultural, and economic factors of any place or country and is endemic in developing countries like Nepal (Del Brutto et al., 1988). The occurrence of Taeniasis in society is considered a biological indicator of social and economic development (Pal et al., 2000). Headache, seizure, and focal deficits are major neurological symptoms (Fogang et al., 2014), but has a different range of pleomorphic clinical manifestation depending on the number and size of larvae, stage of development, and localization within the brain (Gripper and Welburn, 2017). Clinical history, neuroimaging, immunological evidence in combination with epidemiological factors can lead to a diagnosis of the disease (Del Brutto et al.,

2001; Gripper and Welburn, 2017). Pleomorphic and heterogenicity of the clinical appearance of disease not only affects diagnosis but also makes it difficult to treat (Gripper and Welburn, 2017). Improve sanitation, education, and awareness, corralling pigs to prevent contact human feces and development of a vaccine for pigs helps in the prevention and control of the disease (Gripper and Welburn, 2017; Pawlowski, 2016).

Taenia solium is one of the major medical issues in Nepal and causes the highest burden among parasitic infections (Devleesschauwer et al., 2014). Nepal is an agricultural developing country, with majority population living in rural areas which is gradually changing. From 1992 to 2015 rural population of Nepal decreased from 97.1% to 59.51% (Rimal et al., 2017). There are limited toilet facilities in rural areas due to which people often defecates in an open area. In 2015, around 1.1 billion population across the world practiced open defecation (McMichael, 2018). In a study in the rural village of Nepal, 60 % of people had no toilet facilities (Karn et al., 2012), which are the primary barrier of fecal-oral disease transmission (McMichael, 2018). Human feces are the source of contamination of food and water with *Taenia solium* eggs (Gripper and Welburn, 2017). Infection with *Taenia solium* is not only due to uncooked pork meat but also caused by contaminated, unhygienic vegetables (Adhikari and Bagale, 2019). In Nepal, epilepsy cases are increasing up to 7.3/1000 population and around 50% of cases are due to neurocysticercoses (Joshi et al., 2007). Sanitary habits, low economic status, open pig rearing system, food preparation, and consuming habits, and open defecation are the risk factors associated with NCC (Joshi et al., 2007). Neurocysticercosis is one of the prioritized zoonotic diseases in Nepal by the Zoonotic Control Project (ZCP) of World Bank and Epidemiology and Disease Control Division, Department of Health Services, Nepal Government (Acharya et al., 2019). Although cysticercosis including is endemic and widespread in Nepal, very few studies have been made and approach of one health has not emphasized yet. The main aim of this article is to review different articles and literatures and propose present situation of porcine and human cysticercosis in Nepal and also to address prevention and control measures.

Etiology

Taenia solium belongs to phylum, Platyhelminthes, family, Taeniidae, order, Cyclophyllidea and subclass, Eucestoda (Pawlowski, 2016; Del Brutto et al., 2001). The adult tapeworm is two to four meter in length which consist of a scolex and a strobila and lives in the intestine of human beings (Carpio, 2002). Scolex consists of four suckers and a rostellum with 22-32 hooks and strobila (elongated segmented tape-like body) which consist of 700-1000 segments known as proglottids (Carpio, 2002; Pawlowski, 2016). Each proglottid consists of about 40,000 eggs and *Taenia solium* sheds up to 300,000 eggs per day (Carpio, 2002). An egg consists of an oncosphere with six hooklets and is covered by an embryophore (Pawlowski, 2016). The egg can act as a source of infection of people after shedding in feces. Mature oncosphere is a globular larva, 30µm in diameter and consist of six characteristic embryonic hooklets (hexacanth embryo) and a pair of penetration gland for migration (Carpio, 2002). Development of oncosphere into metacestode i.e. cysticercus occurs in the intermediate host (pig). The oncosphere quickly changes from a solid larva into a bladder form filled with fluid and has groups of cells that differentiate into invaginated scolex (Pawlowski, 2016). Cysticercus is an ovoid bladder stage filled with an opalescent fluid and contains an invaginated scolex. From behind of scolex of cysticercus, adult tapeworm develops (Carpio, 2002).

Life Cycle and Pathogenesis

The life cycle of *Taenia solium* consists of two hosts and an environment. Human beings act as the final host; consist of adult tapeworm while pigs act as intermediate hosts; which ingest egg that develop into cysticercus. Human beings acquire the infection after consumption of cysticerci in meat, which develop into an adult tapeworm in the intestine which produces eggs (CDC, 2013) (Figure 1). Human beings can also be infected by eggs via external and internal autoinfection (Gemmell and Johnstone, 1976; Lawson and Gemmell, 1983). Fecal-oral infection with *T. solium* eggs in an individual with intestinal taeniasis is external autoinfection and infection with eggs through reverse peristalsis is internal autoinfection. Internal autoinfection is unlikely to happen because eggs have to pass through a brief period of peptic digestion, which is necessary for dissolving of embryophore before they can invade human tissue (Carpio, 2002; Pawlowski, 2016). Heteroinfection occurs when eggs are ingested in contaminated food, as occurs in areas where water for drinking and irrigation carries feces or when taenia carriers handle food (Carpio, 2002). Eggs and gravid proglottids are present in human feces which is ingested by intermediate host i.e. pig. The egg develops into the oncosphere which hatches and penetrates muscles and develops into cysticercus (Figure 1). Cysticercus can affect both humans beings and pigs and develop as neurocysticercosis after infecting the nervous system (José et al., 2018).

Neglected Tropical Disease

There are 17 neglected tropical diseases (NTDs) prioritized by the World Health Organization (WHO), taeniasis/cysticercosis is one of them. It is one of the NTDs due to its public health impact on socioeconomically disadvantaged people (Ito et al., 2014). A large number of cases of taeniasis/cysticercosis are unreported because people do not realize they are infected, thus can infect the other peoples too. Identification of *T. solium* eggs without laboratories and advance molecular tests are impossible and eggs are found in feces, which may go unnoticed. So, human cysticercosis is underreported in endemic areas (Praet et al., 2009). Absence of clinical symptoms in affected pigs and poor meat inspection service in endemic regions aids in the under-recognition of porcine cysticercosis (Praet et al., 2009).

Signs and Symptoms

Clinical manifestation of infection with cysticercosis in humans is pleomorphic and heterogeneous (Gripper and Welburn, 2017). The clinical appearance of cysticercosis depends on the site of the cyst and the burden of the cyst (Hawk et al., 2005; Kraft, 2007). The cyst can settle in the brain, spinal column, skeletal muscle, subcutaneous tissue, and eye (Kraft, 2007; Rath et al., 2010). Cyst in the brain (most common site) and eye (least common site) cause the most morbidity (Hawk et al., 2005). Parenchymal neurocysticercosis is the common cause of focal and generalized seizures and heavy cyst burden in neural tissue can cause, headache, nausea and vomiting, encephalopathy with fever, altered mental status, and seizures (Kraft, 2007). Cysts when occurring in the subarachnoid or ventricular spaces can cause, meningeal signs and symptoms, obstructive hydrocephalus, or cranial nerve palsies caused by nerve entrapment (García et al., 2003). A cyst can lodge in the extraocular muscle of the eyes, and affect eye movement which mimics cranial

nerve paralysis (García et al., 2003; Mohan et al., 2005). The presence of a cyst in skeletal muscle and subcutaneous tissue can cause nodule formation and pain (García et al., 2003; Kraft, 2007).

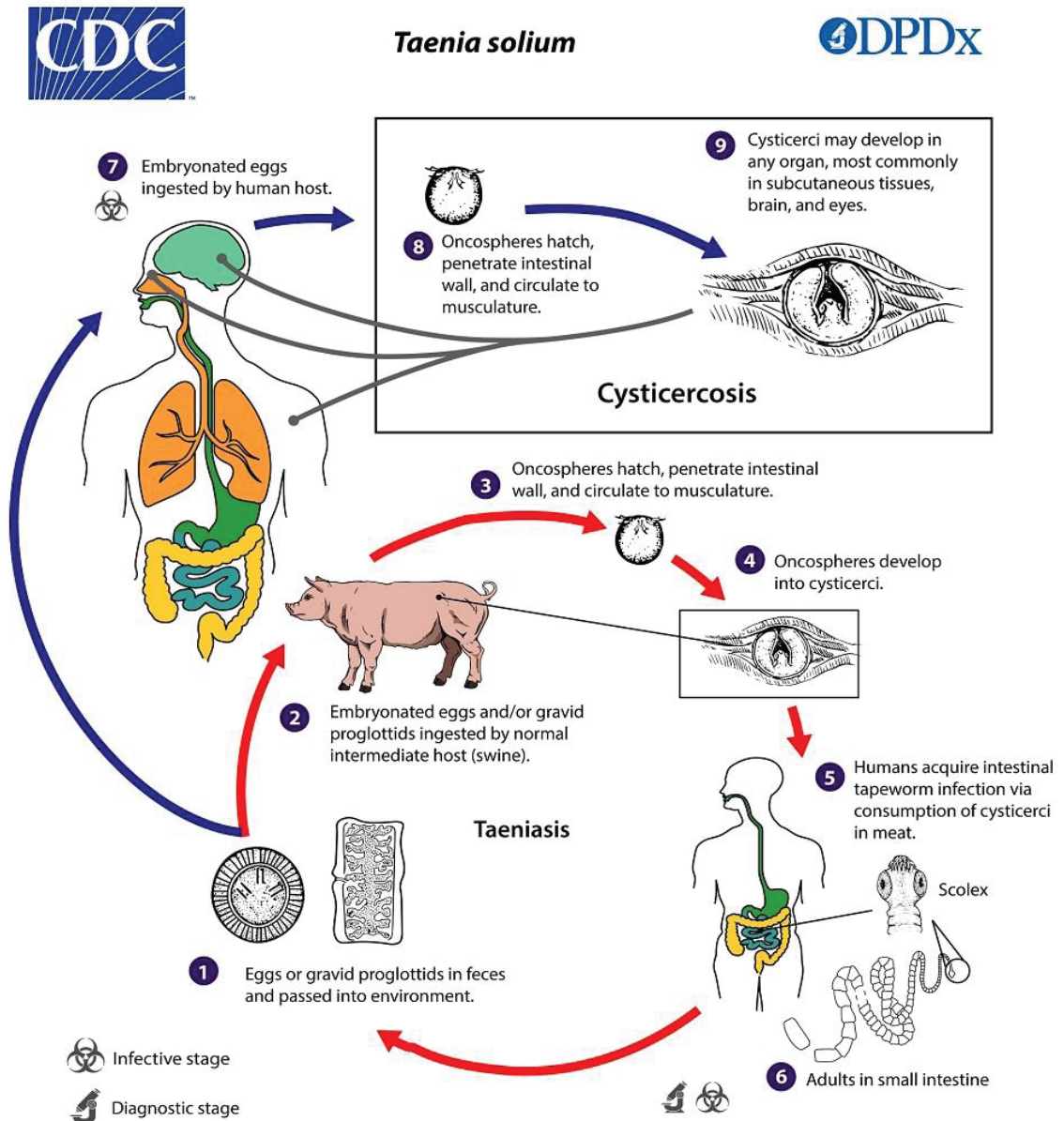


Figure 1: Life Cycle of *Taenia solium*

Diagnosis, Treatment, and Prognosis

The ultimate diagnosis of porcine cysticercosis is necropsy; detection of cysts which are usually present in strained muscle and brain (Gauci et al., 2019). Sign and symptoms of NCC in humans are not specific, neuroimaging findings may not be pathognomic, the serological test usually has low sensitivity and specificity (Carpio, 2002), because this combination of the different diagnostic tool helps in accurate diagnosis of NCC. The diagnosis of neurocysticercosis can be done accurately by clinical symptoms in combination with a history of the disease, x-ray of dependent parts, CT-scan or Magnetic Resonance Imaging (MRI), serological tests, and laboratory examination (Joshi et al., 2004). ELISA (enzyme-linked immunosorbent assay) is a serological diagnostic tool for demonstrating anticysticercal antibodies. Pathological confirmation via biopsy or autopsy is the only true reliable gold stander (Carpio et al., 1998). MRI and CT scan are major tools in the diagnosis of NCC and can be taken as gold stander (Carpio, 2002; Carpio et al., 1998). Complement Fixation Test (CFT), indirect haemagglutination, ELISA, and Enzyme-linked Immuno-electrotransfer Blot (EITB) are some immunological diagnostic tools of NCC (Carpio, 2002).

Treatment of cysticercosis and neurocysticercosis is complex and vary among different individual. Antiepileptic drugs for seizures are widely used in NCC. Mannitol or oral glycerol is used if high intracranial pressure and corticosteroids are commonly used in inflammation and edema around dying parenchymal cysts. There are controversies for the use of anthelmintic drugs like albendazole and praziquantel in the treatment of NCC, because this drug may lead to arachnoiditis, arteritis, and hydrocephalus when cysts are usually present in subarachnoid space (Carpio, 2002; Pal et al., 2000).

Cysticercosis and neurocysticercosis usually have a good prognosis in parenchymal form but the prognosis for the extra parenchymal form is not favorable when patients have arachnoiditis, arteritis, and hydrocephalus. The majority of patients had a good prognosis after treatment among different cases of different hospitals in Nepal (Basu et al., 2007; Khanal and Shrestha, 2019).

SITUATION IN NEPAL

Porcine Taeniasis and Cysticercosis

Very few studies have been made about porcine cysticercosis in Nepal. Between 1997 and 1998, 250 pigs from Kathmandu and Dharan were slaughtered, among them 13.6% were found positive for cysticercosis (Joshi et al., 2007). The study by Joshi et al. (2007) showed that 23.50% (204 pig sera) seroprevalence by ELISA and 32.50% (419 pig tongue) prevalence by lingual palpation (Joshi et al., 2007). In a study conducted by Joshi and Willingham in 2005, the prevalence of porcine cysticercosis was 10.5% (21/200) by lingual examination, seroprevalence was 22.5% (45/200) by ELISA method, and prevalence of *T. solium* cysticercus was 20.5% (41/200) in the post-mortem carcass organs examined (Joshi et al., 2007). Diagnosis with lingual palpation and post-mortem examination seems to be less accurate than ELISA, which may be due to human error and neglect. In a study in 2006, 320 pigs in Chitwan and Kathmandu Valley, the prevalence of cysticercosis was 0.63%, 0.94% for lingual and carcass examination respectively (Joshi et al., 2008). Out of the 250 pigs examined, 34 (14%) were positive for porcine cysticercosis in Kathmandu Metropolitan City and Dharan Municipality (Joshi et al., 2004). Seroprevalence of *T.*

solum cysticercosis was 13.8% among 742 pigs sampled from 2007 to 2010 from Kathmandu Valley (Devleeschauwer et al., 2013). From 2004 to 2005, the prevalence for cysticercosis was 0.99% (5 positives) of the 504 porcine carcasses inspected in Kathmandu Valley, Nepal (Sapkota, 2008). In 2014, 384 pig serum samples were analysed by Ag-ELISA test, 33 pigs were found positive for cysticercosis infection where apparent seroprevalence was 8.59% and the true seroprevalence was 7.9% (Chaulagain et al., 2017).

In Udaypur, Hirminiya and Betahani Village Development Committee (VDC) of the Banke district, 32 of the 110 animals were found positive for *T. solium* cysticerci (29%), of which 30 (27%) were found to have viable cysticerci (93% of the infected animals) (Sah et al., 2017). This is among the highest prevalence of porcine cysticercosis described for any region in the world (Sah et al., 2017). Most of the studies of porcine cysticercosis was carried out in limited districts like Kathmandu and Chitwan (Table 1), this may be due to the high numbers of veterinarians and animal health workers in these districts and due to availabilities of laboratory or easiness of conducting research. Very limited research and study are done in a remote place of the country, where the prevalence of cysticercosis might be high as in the study of Banke district. People of rural area are more susceptible to the neurocysticercosis because of social and economic status and few studies in the pig population of this area shows how vulnerable people are. Without study or research in pigs, human cysticercosis cannot be controlled, so, programs should be launched to reduce the burden of disease in pigs, which can eventually decrease the number of human cases.

Table 1. Prevalence of Procine Cysticercosis in Nepal

S. N	Year	District/Place	Detection Method	Prevalence % (Total Sample Size)	Reference
1.	1997-1998	Kathmandu Metropolitan City and Dharan Municipality	Post-mortem Carcass Evaluation	13.60% (250) 14.28% (196) 11.11% (54) Kathmandu Dharan	(Joshi et al., 2007)
2.	2001	Nepal	ELISA	23.50% (204)	(Joshi et al., 2007)
			Lingual Palpation	32.50 % (419)	
3.	2003-2004	Kathmandu Metropolitan City and Dharan Municipality	Post-mortem Carcass Evaluation	14% (250)	(Joshi et al., 2004)
4.	2004-2005	Kathmandu Valley	Post-mortem Carcass Evaluation	0.99% (504)	(Sapkota, 2008)
5.	2005	Nepal	ELISA	22.50% (200)	(Joshi et al., 2007)
			Lingual Palpation	10.51% (200)	
			Post-mortem	20.50% (200)	

			Carcass Evaluation		
6.	2006	Chitwan District and Kathmandu Valley	Lingual Palpation	0.63% (320)	(Joshi et al., 2008)
			Post-mortem Carcass Evaluation	0.94% (320)	
7.	2007-2010	Kathmandu Valley	ELISA	13.80 (742)	(Devleesschauwer et al., 2013)
8.	2014	Kathmandu Valley	ELISA	8.59% (384) Apparent 7.90% (384) True	(Chaulagain et al., 2017)
9.	2016-2017	Banke District Udayapur, Harminiya and Betahani VDC	Post-mortem Carcass Evaluation	29% (110)	(Sah et al., 2017)

Human Cysticercosis

Neurocysticercosis (NCC) is endemic in Nepal and there is a practice of visiting traditional healers before presenting to the hospital by many seizure patients (Ojha et al., 2015). There are very few published materials on cysticercosis/ neurocysticercosis and only hospital-based data are available. In the investigation in 1987, seven of eight epileptic Gurkha soldiers (Nepalese) in Hong Kong were diagnosed with Neurocysticercosis (Heap, 1990).

Cysticercosis was prevalent for many decades ago and people often used to visit traditional healers after epileptic signs and symptoms. Lack of hospitals, neurological departments, and lack of awareness and knowledge about diseases forced people to visit them (KC and Kaphle, 2019). Very few people were aware of the disease and some patients from Nepal used to pursue neurological treatment outside the country, especially in India (Rajshekhar, 2004). In 2014, there were only six neurosurgeons and six CAT (Computed Axial Tomography) scanners active in Nepal, all of which, except for one CAT scanner in Dharan, were located in Kathmandu (Joshi et al., 2004). According to the Nepalese Society of Neurosurgeons, there were 63 neurosurgeons in Nepal in 2017. At the present days, those numbers might be increased, but are limited in big cities like Kathmandu, Pokhara, Bharatpur, Butwal, Dharan, etc. After the 2000s, many people were aware of the disease, awareness programs on radio, and the establishment of health posts and clinics in the village made people visit hospitals. After then, many cases started to report in hospitals and neurological departments (Table 2).

Table 2. Cases of Human Cysticercosis in Nepal

S. N	Years	Number of Confirmed Cases	Disease Confirmation Place/Hospital	Infection and Diagnosis	Comments	Reference
1.	1987	Seven out of eight epileptic patients	Hong Kong among Gurkhas soldiers	NCC by CT Scan	Gurkhas acquire NCC in Nepal.	(Heap, 1990)
2.	1993 - 1998	62 out of 23,402 biopsies	Patan Hospital (Approximate 60 hospital and clinics of Nepal)	Cysticercosis by Histopathology	38-Female 24-Males	(Joshi et al., 2004; Rajshekhar, 2004; Amatya and Kimula, 1999)
3.	1995 - 1997	Four out of 25,033 cases	Bir Hospitals	Cysticercosis by Histopathology		(Joshi et al., 2004; Rajshekhar, 2004)
4.	1995 - 1997	11	Kanti Children's Hospital	Cysticercosis by Histopathology	Only children hospital in Nepal	(Joshi et al., 2004; Rajshekhar, 2004)
5.	2000 - 2004	124 Children	Western Nepal	NCC by CT Scan	Susceptibility is high among children	(Joshi et al., 2004; Rajshekhar, 2004; Basu et al., 2007)
6.	2003 - 2015	299 out of 1355 seizure cases	Department of Paediatrics Manipal Teaching Hospital	NCC by CT Scan	99- 6 to 10 years old 91- 11 0 15 years old	(Rao et al., 2017)
7.	2006 - 2007	15 out of 112 seizure cases among 14,118 indoor patients	Nepalgunj Medical College	NCC by CT Scan	80%- Males 20%- Females Mean age: 21 years old	(Piryani et al., 2007)
8.	2016	54 out of 142 seizures cases	COMS-TH	NCC by CT Scan	29-Male 25-Female All patients were related with	(Khanal and Shrestha, 2019)

					agriculture and farming	
9.	2017	6.25% (5) Seroprevalence out of 80 patients	Neurological Department, Tribhuvan University, Teaching Hospital	Seroprevalence of NCC using Ag-ELISA	8.1%-Male 4.6%-Female Age group of 10-30 years	(Poudel and Maharjan, 2018)
10.	2017 - 2018	29 out of 103 seizures cases	B and C Medical College	NCC by CT Scan	21-Male 8-Females	(Thapa et al., 2020)
11.	2019	22-year old man	Kathmandu	Ocular Cysticercosis	Disseminated neurocysticercosis with bilateral papilledema	(Shrestha and Shrestha, 2019)

Sixty-two of 23,402 biopsy cases were detected as cysticercosis which was examined from July 1993 to February 1998 in Patan Hospital, which was collected from approximately 60 hospitals and clinics of Nepal (Amatya and Kimula, 1999). Among them, forty cases were from Kathmandu valley, and the rest from outside, and the mean age was 21 ± 11 years (Amatya and Kimula, 1999). Easily available pork meat in Kathmandu valley and crossing the religion barrier by young age people might contribute to a high number of cases in young people in Kathmandu. Also, young aged people are more vulnerable to eggs of *T. solium*. Between 1995 and 1997, four (0.01%) out of 25,033 pathological specimens examined at Bir Hospital, Kathmandu, were diagnosed as cysticercosis (Amatya and Kimula, 1999; Joshi et al., 2004; Rajshekhar, 2004) and 11 confirmed cases were reported in Kanti's Children Hospital in the same time (Joshi et al., 2004; Rajshekhar, 2004).

In western Nepal, 124 children cases of NCC were diagnosed from 2000 to 2004, the majority of age group affected was 10-12 years and youngest patient was of 11 months (Basu et al., 2007; Joshi et al., 2004; Rajshekhar, 2004). The partial seizure was the most common clinical manifestation and patients were treated with albendazole for 28 days along with antiedema and anticonvulsant drugs with a follow-up period of 1-3 years (Basu et al., 2007). After 1 year, 98 patients were successfully treated and 87 had complete disappearance of the lesion in CT scan. The recurrent seizure appeared in 6 patients and they have a calcified lesion in CT scan (Basu et al., 2007). Vulnerability and susceptibility of cysticercosis/neurocysticercosis are high among children and young people because of frequent exposure to soil, raw vegetables, also they play on bare feet and eat soil. Out of 131 patients admitted to the Neurology Department, Bir Hospital, Kathmandu, Nepal from April 2012 to February 2014, 21 (16%) were diagnosed with NCC (Ojha et al., 2015). Seven patients (33.33%) initially visited traditional visitors before presented to the hospital and eight patients (38.1%) were treated with antiepileptics drugs in local health posts without neurological studies (Ojha et al., 2015). This is not a very old incident, although many hospitals with the neurological department are established, people initially visit traditional healers and small health post due to unawareness of the disease and weak socioeconomic condition. Many educated people of the city area also believe in “*Phukauney*”; a way of traditional healing and

farmers in the village have conservative life and still believe and depend on “*Dhami*” and “*Jhankri*”; traditional healers (Ito et al., 2014).

1,355 cases of seizure disorders were admitted to the Department of Pediatrics, Manipal Teaching Hospital, Pokhara, Nepal from 2003 to 2015, out of which 229 (16.90%) were diagnosed as NCC (Rao et al., 2017). There were 99 (43.23%) and 91(41.09%) patients in the age group 6 to 10 years and 11 to 15 years respectively (Rao et al., 2017). From 2006-207, out of 14,118 indoor patients admitted in Nepalgunj Medical College, Teaching Hospital, Kohalpur, Nepal, 112 had a seizure and 15 were diagnosed with Neurocysticercosis (Piryani et al., 2007). The mean age of patients was 21 years, among them 80% were male and 20% were female (Piryani et al., 2007). Male is more prone to infection with NCC than female because of their working nature (pig farmer, butcher, field worker) and personal hygiene. Female is more likely to be hygienic than male, this may be a cause of less prevalence of NCC in most of the cases in Nepal.

For 2016, 142 patients with seizures were admitted to the College of Medical Sciences, and Teaching Hospital (COMS-TH), Nepal, 54 (38%) were CT scan confirmed Neurocysticercosis cases (Khanal and Shrestha, 2019). Among NCC cases, 29 (54%) were male, and 25 (46%) were female, and 17 (31.5%) patients were 10-20 years old. All patients were related to agriculture and farming and 10 (18.5%) patients were vegetarian (Khanal and Shrestha, 2019). Personal hygiene and sanitation of farmers is an equally important risk factor as pork consuming behavior of a person. People involved in agriculture and farming have a high chance of exposure to cyst present in fields, vegetables, water, and pig and are at high risk of infection of NCC. From September 2017 to August 2018, 103 patients were admitted to the B&C Medical College Teaching Hospital, Birtamode, Jhapa, with clinical features of seizure disorder, 29(28%) patients were diagnosed with Neurocysticercosis, among them 21(72.41%) were males and 8(27.59%) were females (Thapa et al., 2020). 80 patients visited in the neurology department of Tribhuvan University Teaching hospital were screened using the Ag-ELISA method, where 6.25% seroprevalence of neurocysticercosis was found among symptomatic and non-symptomatic neurological patients (Poudel and Maharjan, 2018). Cysticercosis is one of the most encountered diseases in the neurology department of many hospitals in Nepal. Also, in 2019, ocular cysticercosis with multiple disseminated subcutaneous nodules and papilledema in both eyes was reported in a 22-year-old man in Nepal (Shrestha and Shrestha, 2019). Hospitals with the well-equipped neurological department are only located in major cities and beliefs of “*Phukauney*” (Traditional Healing) during epileptic disorder is still practiced in the country. Still, most of the epileptic patients initially visit traditional healers (“*Dhami*” and “*Jhankri*”) and then visit the hospital after unsuccessful treatment. Delay in reporting in hospital, increase the number and burden of the cyst, and make them a worse condition of the disease.

One Health practice is rudimentary in Nepal and only applied in a few diseases like Highly Pathogenic Avian Influenza and rabies. Improvement in pig rearing system, awareness about food hygiene and epilepsy, increased number of health workers and hospitals, improved communication and internet facilities and other factors are helping in the control of cysticercosis but still highly prevalent in the country. The collaborative effort of animal workers, veterinarians, public health officer, human doctors, and stakeholders related to sanitation and the environment can help in mitigation of the disease.

PREVENTION AND CONTROL

High cost and complexity in diagnosis and treatment of NCC are major demerits in developing countries like Nepal where NCC is endemic. Many people cannot afford the cost of diagnosis which drives them towards traditional healers. Prevention and control are the better way to reduce the number of cases and health care and economic burden of NCC.

1. Awareness and Education

Exposure to different risk factors of the disease can be minimized through awareness and educating the pig farmers, butcher, pig meat consumers, and communities which practice open pig rearing system. Knowledge sharing programs and training related to personal hygiene, hand washing, use of toilets, environmental sanitation, and pig rearing system should be provided to high-risk peoples. Efforts should be made to raise awareness about the seizure and its causes; to stop the flow of seizure patients toward traditional healers. Public health authorities should convince high-risk peoples that, their habits and way of living are major risk factors so that they can improve personal hygiene and sanitation. In a country like Nepal where infection with *T. solium* is endemic, awareness and education are basic yet most important tools for the prevention of disease. So, all stakeholders related to human health, pig farming, animal health, the Nepal government, and different organizations should work together to raise awareness and provide education to those people who are at risk with infection of *T. solium*.

2. Personal Hygiene and Environment Sanitation

Personal hygiene and environment are the mediators for the continuation of *T. solium* life cycle in pigs and human beings. In Nepal pig rearing communities generally have low economic status and they do not much care about their hygiene, food hygiene, and environmental sanitation. Washing hands with soap water after defecation and working in the field, wearing boots/slippers while working in field/farm, freezing and cooking meats and vegetables, and use of toilet can decrease the risk of infection with *T. solium*. Cleaning of pig barn and proper disposal of feces of pigs can help in the prevention of the disease. The establishment of pig farms in a different area than human settlement and prevention of pigs from free-roaming can decrease the risk of infection among humans.

3. Slaughter House and Meat Inspection

Proper management of slaughterhouse and meat inspection before selling can play a significant role in breaking the life cycle of the parasite and thus help in the prevention of disease. Slaughter of pigs in the open area must be prohibited and the establishment of a hygienic slaughterhouse is urgently needed.

4. Vaccination

Vaccination against the infection of *T. solium* is not immunologically and logistically appropriate because of the oculate nature of infection and minor effects during intestinal infection. Vaccination of pigs is possible and can break the life cycle of the parasite. Vaccination of pigs using a combination of recombinant antigens, TSOL16 and TSOL18 has the potential to stop transmission in pigs and infection in humans (Jayashi et al., 2012).

5. Epidemiological Investigation and Surveillance

Time to time surveillance of the disease is important to know the disease status in any region and prevention of the disease. Surveillance among pig farmers, pig meat consumers, butchers, and communities with a free pig rearing system can help in the prevention of disease and to make programs, control strategy and policies for the infection with *T. solium*. Fecal examination, analysis of hospital-based data, personal interview to know signs and symptoms are some tools for the investigation of infection with *T. solium* in humans. Serological surveillance in pigs can help in the mitigation of disease in humans. Risk-based surveillance programs in animals as well as in humans can help in the mitigation of disease (Alban et al., 2020).

CONCLUSION

The present situation of cysticercosis and neurocysticercosis is alarming in Nepal. High numbers of cases in hospitals indicate that people are unaware and lack knowledge about the disease. Awareness programs along with other control strategies are urgently needed. Efforts should be made to improve self sanitization, food hygiene, and environmental cleanliness to reduce transmission among humans and from pigs. Identification of risk areas and people and launching different programs can reduce the social and economic burden of the disease.

Conflict of Interest: None.

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