2017

Integrated One Health porcine cysticercosis landscape analysis

India report

GALVmed
Protecting Livestock – Improving Human Lives

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Abbreviations and acronyms

ADIR	ANIMAL DISEASE INFORMATION REPORT
CBHI	CENTRAL BUREAU OF HEALTH INTELLIGENCE
CSF	CLASSICAL SWINE FEVER
DADF	DEPAERTMENT OF ANIMAL HUSBANDRY DAIRYING AND FISHERIES
DALY	DISABILITY ADJUSTED LIFE YEARS
FSSAI	FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA
GHSA	GLOBAL HEALTH SECURITY AGENDA
ICAR	INDIAN COUNCIL OF AGRICULTURAL RESEARCH
IDSP	INTEGRATED DISEASE SURVEILLANCE PROGRAMME.
IHHL	INDIVIDUAL HOUSEHOLD LATRINES
IHR	INTERNATIONAL HEALTH REGULATION
IVRI	INDIAN VETERINARY RESEARCH INSTITUTE
KAP	KNOWLEDGE ATTITUDE PRACTICE
ML	MEGHALAYA
NADRS	NATIONAL ANIMAL DISEASE REPORTING SYSTEM
NCC	NEUROCYSTICERCOSIS
NCDC	NATIONAL CENTRE FOR DISEASE CONTROL
NEIDA	THE NORTH-EAST INITIATIVE DEVELOPMENT AGENCY
NIVEDI	NATIONAL INSTITUTE OF VETERINARY EPIDEMIOLOGY AND DISEASE INFORMATICS
NL	NAGALAND
NTD	NEGLECTED TROPICAL DISEASES
ODF	OPEN DEFECATION FREE
OND	OTHER NEUROLOGICAL DISORDER
RRT	RAPID RESPONSE TEAM
STH	SOIL TRANSMITTED HELMINTHS
UP	UTTAR PRADESH
WHO	WORLD HEALTH ORGANIZATION

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1 INR = USD 0.016 USD

Preface

Taeniasis / cysticercosis caused by pork tapeworm *Taenia solium* is considered as one of the major neglected tropical disease (NTD) by WHO and is a leading cause of epilepsy in human. Consumption of undercooked pork obtained from pigs reared in unhygienic, free roaming conditions is a key risk factor for transmission of the parasite to human. Scientifically, the parasite can only be controlled through focused 'One Heath' actions involving interventions directed at prevention and treatment of the disease both in human and pigs, meat inspection etc. besides essentially ensuring personal hygiene and environmental cleanliness more particularly prevention of open defecation.

In recent years, GALVmed is implementing activities regarding the field testing of a vaccine (TSOL18) in pigs co-administered with oxfendazole (OFZ) as a control strategy for *Taenia solium* or pork tapeworm. The TSOL18 vaccine, was developed by University of Melbourne and in collaboration with Indian Immunologicals (IIL), developed commercially as Cysvax™ with support from GALVmed, and has recently been launched in India. The life cycle of the pork tapeworm is dependent on the link between humans and pigs. Treatment and vaccination of pigs can break the parasite's life cycle and thus enable removing the

source of infection for humans. However, it is anticipated that significant public advocacy, partnership and funding will be needed to take forward the implementation of taeniasis /cysticercosis control program with a 'One Health' approach involving partners from multiple specialization.

During May 2017, GALVmed commissioned this study to evaluate how *Taenia solium* control in pigs will integrate within the framework of India's agricultural, medical, food safety and public health frameworks.

The report of the study covers in detail a review of literature on prevalence, social and monitory cost, control strategy and related aspects. Based on key informant interviews conducted across seven states under study, vis-à-vis Assam, Bihar, Jharkhand, Meghalaya, Mizoram, Nagaland and Uttar Pradesh, the report elaborates the landscape for future 'One Health' taeniasis /cysticercosis control in India. It highlights the general policy environment, institutional set up for animal disease reporting and control, initiatives for intersectoral collaboration, the framework for disease control, surveillance, meat inspection besides effect on trade in pork and pork products. Considering the importance of environmental cleanliness in the control of disease, it also briefly reviews the landscape of sanitation and wastewater use in India. The learning on the landscape is likely to help stakeholders to take a holistic approach and collaborate for a One Health national taeniasis / cysticercosis control program.

Considering the linkage of taeniasis / cysticercosis with epilepsy in human, the reports highlights the problem of epilepsy in India and explores for possible correlation between incidence of reported cases of epilepsy (recorded under the broad heading 'other neurological disorder') and pig population using population based datasets available with the government. It also explores if the available datasets can be used to identify hotspot areas for taeniasis / cysticercosis control.

The report also highlights the findings of a rapid situational analysis and a survey of knowledge, attitude practices covering smallholder pig farmers, traders besides professionals, officials and social workers at the grassroots level. The findings are likely to strengthen the understanding of ground realities, essential for designing a targeted control program focusing on communities in areas known for backyard, free roaming pig population.

The report finally explores synergy and partnership for any future taeniasis / cysticercosis control program in India lead by public funded agencies and recommends suggestions for central agencies, state government, research institutions and private sector stakeholders.

Executive Summary

The review of literature established high rate of prevalence of Cysticercosis caused by *Taenia solium* (Pork tapeworm) both in human and pig in India. This along with recorded societal cost associated with the disease, justifies government interest to control the disease in India. The review also indicated the global commitment for control of NTDs like Cysticercosis and the established one health approach for Cysticercosis control with tested interventions focused at human health, animal health and environment.

The review however, indicated critical gap in evidences. The available prevalence studies are localized in nature. The cost studies too are based on limited geographical areas. The country level evidence on extent

of linkages of neurocysticercosis or epilepsy in human to pork or raw vegetable consumption is not available. There is also scope of detail molecular level studies to identify species of the parasite involved.

The control or eradication of any infectious disorder requires an assessment not only of the prevalence of infection in the community but also of knowledge about, attitudes towards and practices (KAP) regarding the disorder among members of the community. Such assessments are however, rare for cysticercosis specifically amongst pig farming community in India.

Robust evidence on prevalence, risk mapping vis-à-vis estimate on burden is needed for prioritization and focused policy-linked investment to control zoonotic diseases like cysticercosis. Generation of such robust evidence covering the entire country and risk mapping (identification of hotspots) is not possible without proper public-funded strong surveillance, reporting system that takes an integrated approach linking human surveillance with animal health surveillance. The current study conducted one to one interviews with experts both at national and state level to explore in detail the ongoing investment of Government of India to develop integrated disease surveillance system and mechanism to ensure intersectoral collaborations. The current study recorded that, both human and animal disease surveillance system in the country can help in collecting more robust evidences of incidence of neurocysticercosis and porcine cysticercosis. The discussion on the policy, institutional and legal landscape indicated that, any public investment on control of Cysticercosis with one health approach can be positively linked to countries demonstrated ability and effort towards controlling other neglected tropical disease. It can also be linked to specific public funded programs such as the flagship program of clean India mission, National deworming program and future planned initiative like National Epilepsy control program.

India has shown its commitment to food safety with series of investment on reform and in developing legal and institutional framework. The specific framework required to ensure safety of locally produced pork is available in India. However, much investment is needed for law enforcement, creation of slaughter related infrastructure and capacity building at ground level for awareness and meat inspection. The current study discussed legal provisions, available standards and initiatives aimed at popularization of community slaughterhouses.

The study also recorded the opinion of organized piggery sector representatives and highlighted the fact that future investment by India to control cysticercosis can help in boosting local pork demand and in building trade related capacity of the sector.

Considering the gap in evidences indicated above, the current study used available population based government data to highlight the magnitude and spread of epilepsy problem. It also reviewed district level data from three states in India and showed the correlation between reported cases of epilepsy (recorded under broad heading of other neurological disorder) and the pig population. The study also showed the potential of using available multiple population based government data such as reported cases of other neurological disorder, census data on pig population and Individual household latrine coverage data to target future control program.

To bridge the gap in understanding related to Knowledge Attitude and Practices (KAP) amongst pig rearing communities' specific to cysticercosis, the study conducted detail situational analysis in three identified villages of Bihar and Jharkhand state and a detail primary survey covering seven sample states vis-à-vis Assam, Bihar, Jharkhand, Meghalaya, Mizoram, Nagaland and Uttar Pradesh. The primary survey covered

675 pig farmers, 188 small-scale pig traders and 150 field level policy implementers such as local government officials, veterinarians, human doctors, teachers and social workers. The KAP finding concluded high prevalence of risky husbandry practices, risky food habits, poor awareness about cysticercosis but high awareness of epilepsy related symptoms, predominant open (household level) slaughter and lack of access to slaughter houses and official meat inspection.

Achieving partnership is essential to take forward the agenda of developing a national cysticercosis control program aligning it suitably with other synergistic initiatives. The current study highlighted key stakeholders such as Ministry of health's nodal focal point – the National Centre for Disease Control (NCDC) and its sub offices related to zoonotic disease and soil helminth control, Clean India Mission of Ministry of drinking water and sanitation and CDC-India supported zoonotic disease action package under Global Health Security Agenda (GHSA) etc. The report also highlighted the potential of partnership opportunities with piggery related development programs implemented under tribal sub plan provision and with few development organizations like Tata Trust active in piggery sector in India. To bridge the gap in evidence, specific contribution can also be expected from partners like ICAR National Research Centre on Pig, IVRI's outreach program on Zoonosis and technical associations like Indian Epilepsy Society (IES).

A designed 'one health' cysticercosis control program assumes immense importance in the context of government agenda of preventive health focus and achievement of SDG goal target 3.3 related to Neglected Tropical Disease (NTDs). Since the disease largely affects poor and excluded communities, such a program conforms to government core governance mantra: *Sabka Saath Sabka Vikas* (collective efforts, inclusive growth). The report provides specific recommendations for both central and state government agencies besides public and private research institutions, technical associations and NGOs. For central government agencies, the report suggests a road map for creating much needed evidences and cysticercosis related risk map of the country using the available data sets and methodology shown in the report. It recommends that central department like DADF should focus on strengthening its animal disease reporting system where as FSSAI can circulate a model instruction to local bodies in-charge of pig slaughterhouses specifying the procedure of meat inspection in pig and policy to be followed for condemning carcasses. The recommendation targeted at state governments include strengthening of framework for joint actions, promotion of community level slaughter house, training of community animal health workers capable of supporting authorities in meat inspection, amendment of the allocation of business rule (where required) for larger role of state veterinary departments in matters related to public health, mandatory vaccination of inter-state imported pigs at source, awareness creation of civil servants as facilitator of intersectoral collaboration etc. The reports also recommend specific contribution from public and private research institutions, technical associations and NGOs. For GALVmed and its private partners, the study recommends initiatives towards demonstration of benefits of ring strategy as a control intervention essentially using tools for use in pigs such as vaccines and anthelmintics.

Background

GALVmed's aim is to create solutions that address sustainable poverty alleviation by making available and accessible animal health products (vaccines, medicines and diagnostics) to livestock keepers in the developing world. As part of the programme "Protecting livestock, improving human life" funded by the Bill & Melinda Gates Foundation and UK Department for International Development (DFID), GALVmed is implementing activities regarding the field testing of a vaccine (TSOL18) against porcine cysticercosis (PC) co-administered with oxfendazole (OFZ) as a control strategy for *Taenia solium* or pork tapeworm. The specific purpose of the field testing is to evaluate the use of TSOL18/OFZ in free ranging pigs in rural areas to reduce the prevalence of porcine cysticercosis and ultimately lead to a reduction in the prevalence of human taeniasis and neurocysticercosis- a leading cause of epilepsy. In effect, these are proof of concept of control of porcine cysticercosis on a large-scale. The output of these trials will provide evidence to inform national and international policy guidelines and to attract investment in future development of the products. It is anticipated that the benefits are predominantly accrued in human health, the funding and development is anticipated to be through the medical and public health sectors.

In the above backdrop, there is a need to evaluate opportunities to integrate pig control with other controls e.g. mass drug administration, education and sanitation and the national and state policy framework for implementation. These other controls are likely to be delivered by other sectors within public health/ medical/ food safety sectors. Therefore, there is a need to identify key stakeholder communities with an interest in controlling taeniasis / cysticercosis. To ensure that the evidence generated from the trials is fit for purpose, it is necessary to evaluate how porcine cysticercosis control will integrate within the framework of India's agricultural, medical, food safety and public health frameworks.

The TSOL18 vaccine was developed by University of Melbourne and, in collaboration with the Indian Immunologicals (ILL) developed commercially as Cysvax™ with support from GALVmed, has recently been launched in India. However, it is anticipated that significant public advocacy, partnership and funding will be needed to take forward the implementation of taeniasis / cysticercosis control program.

Awareness about taeniasis/ cysticercosis is low amongst the various stakeholder communities and risk factors for disease are high in India. Pig keepers in India are among the poorest in India and free ranging pigs are a fast growing, low input source of protein for poor rural communities. It is likely that there is little understanding of the risk factors for cysticercosis or knowledge about the prevalence of porcine and human disease in the key pig rearing areas of India.

About the disease and its economic importance

Infection with the intestinal parasite called *Taenia solium* (pork tapeworm) can result into two distinct conditions in humans: taeniasis and cysticercosis. Adult tapeworm in the human intestine or taeniasis does not have major health impacts but the larval form caused by eating undercooked infected pork can cause cysticercosis, a serious parasitic disease where the larvae of the tapeworm get into tissues such as muscle and brain, and form cysts there (these are called cysticerci). The cysticerci may develop in any human organ, being more common in subcutaneous (under the skin) tissues as well as in the brain and eyes. When cysts are found in the brain, the condition is called neurocysticercosis (NCC). This is the most severe

form of cysticercosis with seizures (epilepsy), headaches and hydrocephalus as most common manifestations often leading to death.

The disease spreads via the fecal-oral route through contaminated food and water, and is primarily a food borne disease. *Taenia solium* is different from other species in the genus Taenia, in that it can use its definitive host (human) as an intermediate host. The oncosphere[1] larva can infect a human host through external autoinfection, where eggs expelled through fecal matter are ingested orally. Internal autoinfection (refer fig-1), where a larva can infect the host without being expelled through fecal matter, is yet to be observed. However, researchers are open to the possibility of its occurrence. Considering this, according to some literatures one common route or transmission pathway can be through eating raw vegetables, which have been grown in fields irrigated with untreated sewage water. Other potential sources of feco-oral contamination are a mixture of sewage water with drinking water in pipelines, and through houseflies and cockroaches.

Eating undercooked pork can result in intestinal tapeworm if the pork contains larval cysts. Pigs suffer from porcine cysticercosis. They usually get infected by food or roaming in areas contaminated by human feces (which can come from sewage water or direct pollution). Occasionally in-utero contamination[2] occurs. Porcine cysticercosis normally causes few symptoms in pigs but make pork unsafe for human consumption leading to reduced value of pig and pork. It is a major constraint of smallholder pig production and marketing.

[1] Taenia solium has six stages in its life cycle: preadult tapeworm, adult tapeworm, egg, oncosphere, postoncospheral form and cysticercus.

[2] within the womb

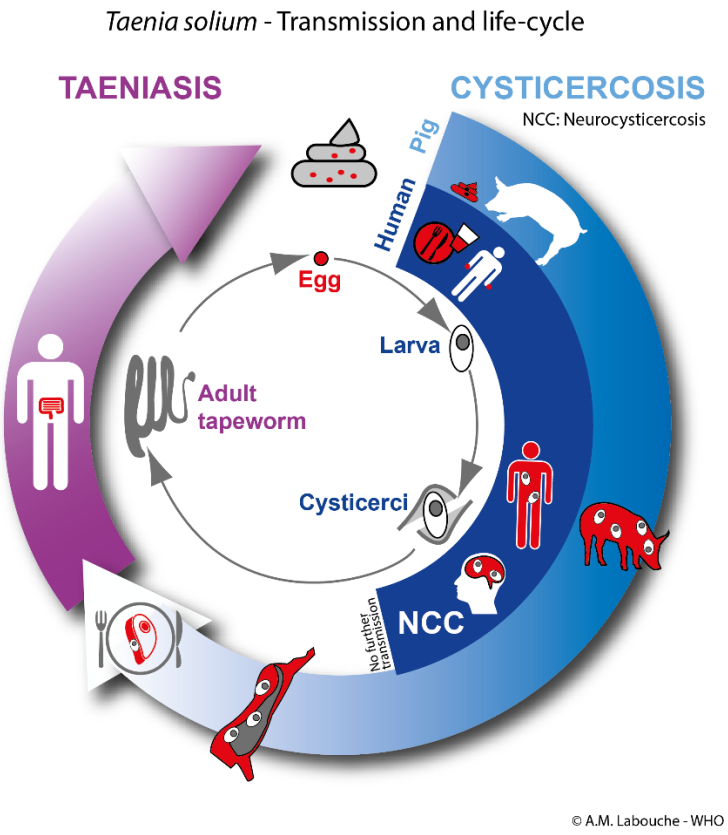


Figure 1: Taenia solium transmission and life cycle

The life cycle of the pork tapeworm explained in the above fig-1. is dependent on the link between humans and pigs. Treatment and vaccination of pigs can break the parasite's life cycle and thus enable removing the source of infection for humans.

The economic importance and endemicity in global context

Taeniasis / cysticercosis is one of the 18 WHO listed Neglected Tropical / Infectious Disease. Neglected Tropical Diseases (NTDs) are known for their impact on the lives of the poorest and most marginalized populations. UN Sustainable Development Goal-3 (SDG 3): 'Ensure healthy lives and promote wellbeing for all at all ages', has nine targets, one of which extends the Millennium Development Goals (MDGs) beyond HIV, TB and malaria to 'end the epidemic' of NTDs by 2030 (Refer target 3.3). The fact that NTDs have now been accorded a specific target reflects their importance in terms of global prevalence and their social, economic and developmental consequences. (Bangert, Molyneux, Lindsay, Fitzpatrick, & Engels, 2017) Made a detail analysis of how interventions related to NTDs are linked to all the 17 Sustainable Development Goals.

According to a report (FAO -WHO, 2014), "Multi-criteria based ranking for risk management of food-borne parasites", *Taenia solium* ranks first amongst top 10 parasites with greatest global impact. In the year 2015, the WHO Foodborne Disease Burden Epidemiology Reference Group identified cysticercosis caused by *Taenia Solium* as a leading cause of deaths from food-borne diseases, resulting in a considerable total of 2.8 million (Uncertainty Interval: 2.1 to 3.6 million) disability-adjusted life-years

(DALYs)[3]. According to the same report, the total number of people suffering from neurocysticercosis, including symptomatic and asymptomatic cases, is estimated to be between 2.56–8.30 million, based on the range of epilepsy prevalence data available. Various systematic reviews have confirmed long-held beliefs that approximately 30% of people living with epilepsy in countries endemic for cysticercosis show neurocysticercosis (NCC) lesions in their brain. The Disability Adjusted Life years (DALYs) estimate in this case excludes NCC-associated sequelae other than epilepsy.

Taenia solium infection in pigs affects the livelihood of many communities as pigs lose their market value. The cysticercosis disease could enter any country through importation of infected pigs, meat or material contaminated by human faeces. Humans can also introduce it into a country. The domestic pork and pork product industry of a country endemic for porcine cysticercosis suffer from international trade restrictions.

Reliable epidemiological data on geographical distribution of *Taenia solium* taeniasis/cysticercosis in people and pigs is still scarce. The figure-2 published by WHO (Endemicity of Taenia solium, 2015) indicates endemicity of *Taenia solium* around the globe. The disease is endemic in South and South-East Asia and is emerging in parts of sub Saharan Africa, particularly in rural areas where animal husbandry practices allow pigs to come into contact with human feces. According to WHO, the disease occurs in countries where families engage in community farming practices and raise free roaming pigs. It is also common in areas where animals are slaughtered outside approved abattoirs and in the absence of meat inspection.

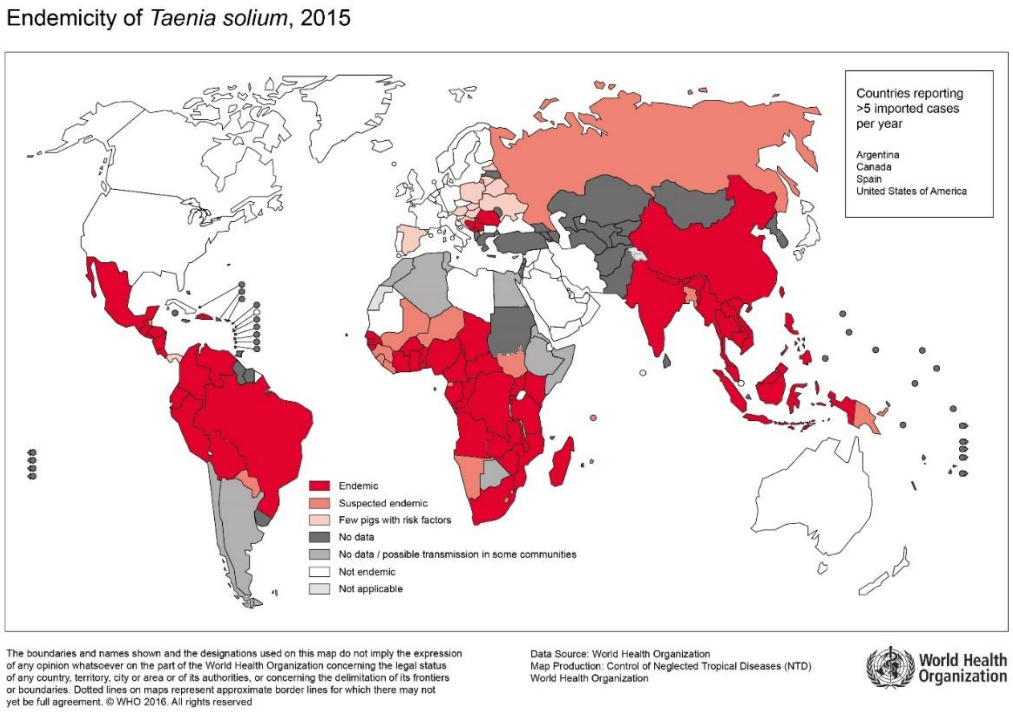


Figure 2: Endemicity of Taenia solium, 2015

[3] Represents the disease-related loss of one year of full health because of premature death or disability. It provides a summary measure of the burden of disease but does not reflect economic burden. e.g. cost of illness, losses in agricultural and food sectors, trade impacts

Objective, study area, timeline and methodology

The study aims at evaluating how porcine cysticercosis (cysticercosis in pig) control in India will integrate within the framework of India's agricultural, medical, food safety and public health frameworks. The specific objective of the study is to:

1. To conduct a review of the prevalence of porcine cysticercosis and human taeniasis/ cysticercosis in India and the environment for implementation of its control in India.
2. To provide a detailed report on the policy landscape for taeniasis/ cysticercosis control in India.
3. To suggest a roadmap for stakeholders for a national One Health taeniasis / cysticercosis control program ensuring adoption and further dissemination of the porcine cysticercosis control tools.

Study Area

A published (Prasad K. N., 2008) paper that indicated the geographical distribution of human cysticercosis in India highlighted Uttar Pradesh, Maharashtra, Andhra Pradesh and Sikkim as highly endemic area. The same paper indicated all Northeastern states, West Bengal, Karnataka and Pondicherry as moderately endemic area. However, the paper failed to indicate the details of data set used to develop the geographical distribution map.

As per census data (2012), in terms of percentage share, states having more than 5% share of total population of Pig includes: Assam (15.89%), Uttar Pradesh (12.96%), Jharkhand (9.35%), Bihar (6.31%), West Bengal (6.30%) and Meghalaya (5.28%).

Similarly, in terms of density per 100 human population, states with 10 or more pigs per 100 humans includes: Arunachal Pradesh (25.77), Nagaland (25.43), Mizoram (22.48), Meghalaya (18.33), Manipur (10.19). (Refer fig 3)

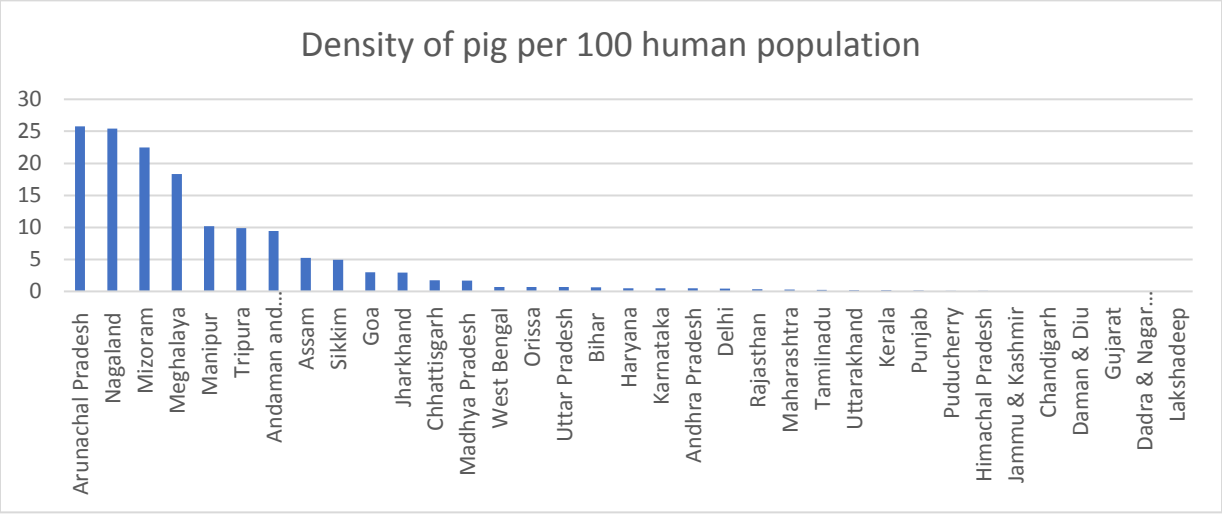


Figure 3: Density of pig per 100 population state wise (India) Source: Livestock census 2012

As per (USDA, 2016) report, the pork consumption in India is mainly concentrated in northeastern states including Assam, Nagaland, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim, and Tripura. Other Indian states with high pork consumption include Bihar, Jharkhand, West Bengal, Goa and Kerala.

Based on the above information, available study budget and review of logistics seven states vis-à-vis Uttar Pradesh (UP), Assam (AS), Nagaland (NL), Jharkhand (JH), Meghalaya (ML), Bihar (BR) and Mizoram (MZ) of India were considered for the study. (Refer fig 4). All the seven states together share 57.06% of total pig population of India.

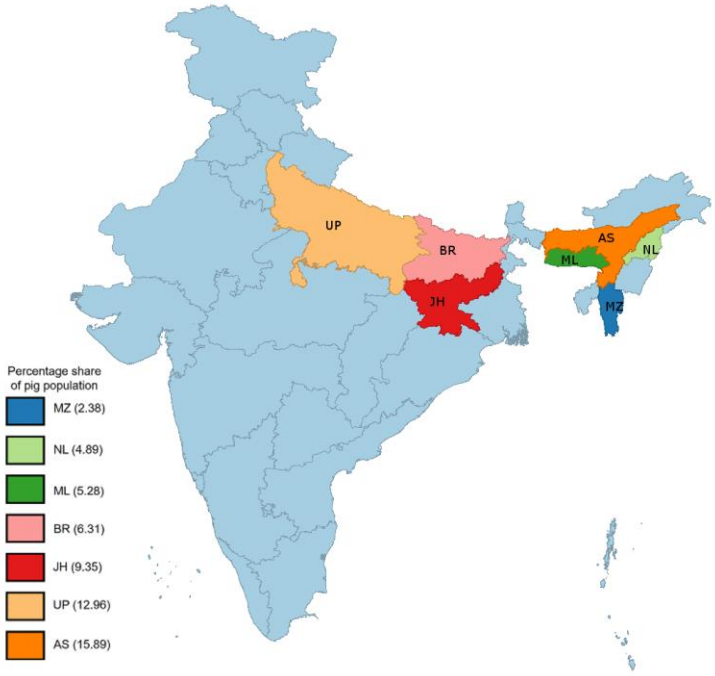


Figure 4: Study area with percent share of pig population out of total pig population of India *(Data source: Livestock census 2012)*

Further to selection of states, for field survey and district level interviews probability proportional to size sampling was administered to select the districts within the study states with a pre-determined size of three districts per study state (Refer annexure-I). 19th Livestock census data of pig population per 1000 household as available at government open data portal[4] was used for sampling of districts.

The field team attempted to cover a minimum of two districts out of the sampled three districts based on logistic convenience.

As per rule 9.2 of Model Municipal Solid Waste (Management & Handling), Cleanliness and Sanitation rules and byelaws (Swachh Bharat Mission, Ministry of Urban Development, Government of India, 2016) free roaming of animals are not allowed in municipality areas. Since, detail information on pattern of urban

[4] https://data.gov.in/

livestock keeping within Indian cities are rare, it was decided that field data collection from farmers and traders should exclude urban slums.

Timeline

The study was conducted from 8th May to 8th September 2017 (5 months).

Methodology

The study methodology includes:

- Desk review of papers related to prevalence, societal monetary cost, control strategies, gap in evidence and policy environment.
- Review of available secondary population based government surveillance data to highlight disease problem, explore ways to bridge the gap in evidence and identify disease hotspots within India.
- Key informant interview and focus group meetings on the opportunities, constraints, contested issues and possible innovations thereof: Snowball interviewing method was adopted to identify key informants beyond an initial list of resourceful contacts obtained from secondary sources.
- Rapid situational analysis (refer picture-1 and picture-2) of three identified villages drawn from sampled districts based on logistic convenience and reference of district level veterinary officer.
- Detail survey of pig farmers, traders and field level policy implementers / social workers to record the knowledge attitude and practice (KAP).

Tools

Two study guides were developed for key informant interviews and district level focused group meetings. Similarly, for organized private pig sector stakeholders an online questionnaire was designed. Refer annexure-II for list of study tools.

Three survey schedules for documenting KAP were adapted to Indian situation based on similar schedules developed elsewhere by GALVmed team for un-organized pig farmers, traders and mid or low-level policy implementers / social workers.

Documentation of field visit by team leader

Detail reports of each of visit of the team leader to state capitals and districts besides one to one interview with key informants were prepared to capture learning.

Administration of Key Informant Interviews and field surveys

Key informant interviews of leading officials and policy initiators were conducted at New Delhi (capital of India) and state capitals of all the study states. Refer annexure V for list of people interviewed.

Resource points at each state capital were identified, contacted and interviewed to collect government surveillance data on reported epilepsy cases in human, tapeworm / porcine cysticercosis cases in pigs.

A few focus group meetings were organized in presence of district collectors / magistrates to understand the 'One Health' implementation hurdles and opportunities at district level.

An online survey was administered through email and using tools provided by survey monkey[5]. Link or URL of the survey page was marketed through social media like Facebook, Twitter and WhatsApp (Paid post promotion to reach targeted audience in case of Facebook). Telephonic contacts were also made to collect responses.

The detailed methodology adopted for KAP survey of un-organized pig farmers, traders and district level policy implementers / social workers are included in annexure-III

Picture 1: Rapid Situational Analysis, at Tengarmari village of Kishanganj (Bihar) district

Picture 2: Community meeting at Govindpur village, Pakur district (Jharkhand) for situation analysis.

[5] https://www.surveymonkey.com/

Literature review

Cysticercosis prevalence in India

(Prasad K. N., 2008) did a comprehensive literature review with special emphasis on Indian studies to create awareness about the disease in India. The review was supported financially by the University Grant Commission, New Delhi and Council for Scientific and Industrial Research, New Delhi respectively. Box-1 from his literature review indicates prevalence of the disease in pigs.

> Cysticercosis also appears to be widespread among swine in India. In and around Chandigarh, 8-10% of the pigs slaughtered had cysticerci in their muscles and around 0.5% of the pigs reared in government farms were found to be infected (Mahajan et al 1982). Another survey in slaughterhouses of Kolkata (West Bengal) revealed cysticercosis in muscles of 7% of the slaughtered pigs (Ratnam et al 1983). Prasad et al (2002) reported a high frequency of cysticercosis (26%) in swine from Mohanlalganj block of Lucknow district in the state of Uttar Pradesh and 40% of them had cysticerci in the brain.

Box 1: 2008 Literature review by Prasad K N indicating prevalence of cysticercosis in Pigs within India

The same review indicates high prevalence in humans. Box 2 is an excerpt of his literature review.

> There are wide variations in the frequency of cysticercosis in India. Before the era of CT scan and magnetic resonance imaging (MRI), the National Institute of Mental Health and Neuro Sciences (NIMHANS), Bangalore reported diagnosis of NCC in 2% of an unselected series of epileptics (Mani et al 1974). At a tertiary referral centre in New Delhi, NCC constituted 2.5% of all intracranial space-occupying lesions (Wani et al 1981). With the availability of CT and MRI, the proportion of NCC in seizure disorders dramatically increased. Sawhney et al (1996) reported cerebral cysticercosis in 31% of patients in whom CT was done. In a community survey of 50,617 individuals from South India, the prevalence of active epilepsy was 3.83 per 1000 and NCC was detected in 28.4% of them by CT (Rajshekhar et al 2006). In a study of 156 histologically proven cases of cysticercosis from Patiala, Punjab, 88% patients presented with solitary lesion. (Saigal et al 1984). In a sero-prevalence study in and around Chandigarh, anti-cysticercus antibodies was found to be 17.3% with highest prevalence (24%) reported from slum areas; (Khurana et al 2006; Saigal et al 1984). Cysticercosis sero-prevalence among the healthy blood donors from Pondicherry was 6.5% using both antigen and antibody detection methods (Parija et al 2005). The prevalence of taeniasis ranged from 0.5-2% in hospitalized patients in northern India, 12–15% in labour colonies where pigs are raised (Mahajan et al 1982).

Box 2: Excerpts from 2008 literature review by Prasad K N indicating prevalence of cysticercosis in human

(Juyal, 2008) also conducted a similar review of cysticercosis. Box-3 and 4 are excerpts of his review.

> Out of 4,858 pigs slaughtered at a bacon factory in Uttar Pradesh, 123 (2.53%) were found positive for the parasite (Varma and Ahluwalia, 1981). In northern India, the prevalence of metacestodes and *Cysticercus cellulosae* was 20.8% in pigs (Deka et al., 1985). *C. cellulosae* was detected in 477 (4.24%) of 11,237 pigs of various ages examined at the Tangra (Calcutta) pig abattoir (Pramanik et al., 1985). Prevalence of *C. cellulosae* (*T. solium)* in Chitoor, Krishna, West Godavari and Guntur districts of Andhra Pradesh were 8.66, 8, 6 and 43.3 percent, respectively (D'Souza, 1998). Prevalence was found to be 5.36% a bacon factory in Gannavaram. The prevalence of *C. cellulosae* was investigated in 279 pigs slaughtered at different abattoirs in Greater Guwahati, (Assam) which was found to be 3.22 percent Sharma et al. (2004). The prevalence rate

Box 3: Excerpts of the 2008 review by P D Juyal indicating prevalence of T. solium in Pig in India

of 1.70 and 6.35 percent was reported in Ludhiana city of Punjab state on post-mortem examination (Avapal et al., 2003; Sharma et al., 2004).

Human neurocysticercosis is regarded as the second most common intracranial space occupying lesions following tuberculosis in India (Mahajan, 1982) and the most common cause of epilepsy (Sawhney et al., 1996). 5.47 % of children with subacute and chronic meningitis have revealed the presence of anti cysticercal antibody in cerebrospinal fluid (Chandermukhi and Nayak, 1990).

Box 4: Excerpts of the 2008 review by P D Juyal about Neurocysticercosis

More location specific studies were conducted across India to record the prevalence of cysticercosis. A study by (Borkataki, 2012) conducted in the year 2002-2003 covering three districts of Assam state vis-à-vis Nagaon, Morigaon and Karbi Anglong) reported a prevalence of 9.5% amongst the sampled pigs on slaughter. District wise, the highest (13.70%) prevalence was found in Karbi Anglong and the lowest (7.55%) in Nagaon district. Interestingly, the study recorded that prevalence is more in cross breed (12.53%) than in local breed (7.49%). Not much information is available in the paper regarding the farming system of sampled crossbred pigs.

(Rajshekhar, 2006) reported that NCC is associated with approximately one-third of all cases presented with active epilepsy in either urban or rural regions of Vellore district of Tamil Nadu, India.

Mohanlalganj block of Lucknow district of Uttar Pradesh where (Prasad K. N., 2002) reported porcine cysticercosis in 26% of sample pigs, was selected for another study to record taeniasis within the pig rearing community in the block by the same researcher in 2007. A paper (Prasad, et al., 2009) was published based on the second study, which used the WHO-suggested cluster sampling approach. The study recorded the prevalence of taeniasis at 18.6%. The two important key factors associated with taeniasis were identified as undercooked pork consumption and poor hand hygiene. In the same community, active epilepsy was identified and clinically confirmed in 5.8% of the populations during door-to-door survey and 48.3% of them fulfilled either definitive or probable diagnostic criteria of NCC.

(Singh & Sappal, 2012) of Ludhiana wrote an article titled Neurocysticercosis: the Indian scenario that was published in 2012 medicine update of The Association of Physicians of India. In their discussion on epidemiology, the authors mentioned all studies covered in the 2008 review by K N Prasad. They additionally mentioned a study (Wadia, Makhale, Kelkar, & Grant, 1987) where authors observed that 26% and 50% of all Indian patients presenting with partial seizures are diagnosed with a Solitary cerebral cysticercus granuloma (SCG) on the CT scan.

(Fahrion, et al., 2013) reported a study conducted in 2009 that assessed the food-safety hazards in the pork chain of Nagaland state of India. The paper reported that 8.8% live pig samples were found positive for cysticercosis on lingual palpation. However, on post-mortem of carcasses, 2.2% samples showed cyst in meat. A consumer survey was conducted as a part of the above study and 57% of consumers reported sighting of white, rice grain like cysts in the pork they purchased. It is a common practice in Nagaland to consume smoked pork products (indicated by 43%of consumers) which may remain undercooked.

A study (Saravanan, et al., 2014) funded by and conducted at the Indian Veterinary Research Institute aimed at recording the prevalence of cysticercosis in pigs in Bareilly district of Uttar Pradesh from August

2012 to July 2013. The study revealed that the overall prevalence of porcine cysticercosis within the district was 5.14%. Similar to the study by (Borkataki, 2012) referred to above, which was conducted in three districts of Assam, this study too revealed that the prevalence of porcine cysticercosis was relatively higher in crossbred pigs (5.88%,) than in the non-descript local breed of pigs (4.11%).

A study (Chawhan & Singh, 2015) covering urban slums of Punjab recorded prevalence of 4.23% (95% CI 2.8–6.3%, 22/519). The proportion of positive carcasses was found to be significantly higher[6] in 192 scavenging pigs (10.41%) than in 327 farm pigs (0.61%).

The 2015, WHO map showing the endemicity of *Taenia solium*, included India under endemic countries category. The countries grouped under this category display strong evidence that the full cycle of disease transmission is present. A WHO endemicity map updated by (Donadeu, 2016) can be referred to for more detailed understanding of the methodology adopted for preparing the endemicity map.

A recent paper published by the National Institute of Mental Health and Neurosciences, Bangalore, Karnataka, titled Epilepsy in India: Epidemiology and public health published at Annals of Indian Academy of Neurology (Amudhan & Gopalkrishna , 2015) reviewed a number of Indian studies. It indicated that prevalence of active epilepsy related to NCC varies from 1.3 to 4.5 per 1,000 population. The same study reported that in a farming community, prevalence is 6.6% for epilepsy and 18.6% for *Taenia solium* infection.

A recent published paper (Pappala, et al., 2016) based on a study partially supported by the Indian Council of Medical Research covered three districts of Andhra Pradesh vis-à-vis Visakhapatnam, Vizianagaram, and Srikakulam. NCC was diagnosed in 44 of 160 (27.5%) seizure cases based on imaging characteristics and a positive serum antibody ELISA.

Tables 1 and 2 summarizes prevalence of porcine cysticercosis and neurocysticercosis in India.

Author / Source	Year of study	Area of study	Prevalence of Porcine cysticercosis
(Juyal, 2008) reviewing work of Varma and Ahluwalia.	1981	A bacon factory in Uttar Pradesh	2.53%
(Prasad K. N., 2008) reviewing work of Mahajan et al)	1982	Chandigarh	8 to 10% (0.5% in government farm)
(Prasad K. N., 2008) reviewing work of Ratnam et al)	1983	Kolkata	7%
(Juyal, 2008) reviewing work of Pathak et al.	1984	Uttar Pradesh	9.3%
(Juyal, 2008) reviewing work of Deka et al.	1985	Northern India	20.8%

[6] chi square = 28.65, p = 0.0001, d.f. = 1

(Juyal, 2008) reviewing work of Pramanik et al	1985	Pig abattoir in Kolkata	4.24%
(Juyal, 2008) reviewing the work of D'Souza	1998	Chittor, Krishna, West Godavari and Guntur district of Andhra Pradesh	8.66, 8.00, 6.00 and 43.3% respectively. Bacon factory in Krishna dist. (Gannavaram: 5.36%)
(Prasad K. N., 2008) reviewing work of Prasad et al.	2002	Lucknow (Mohanlalganj block)	26%
(Borkataki, 2012)	2002	Nagoan, Morigaon and Karbi Anglong (KA) district of Assam state.	9.5% (Highest KA dist. 13.70%)
(Juyal, 2008) reviewing the work of Avapal et al	2003	Ludhiana, Punjab	1.7 and 6.35% in two groups.
(Juyal, 2008) reviewing work of Sharma et al.	2004	Guwahati (Assam)	3.22%
(Fahrion, et al., 2013)	2009	Kohima district, Nagaland	8.8% in live and 2.2% cyst in meat.
(Saravanan, et al., 2014)	2012	Bareilly district, UP	5.14%
(Chawhan & Singh, 2015)	2014	Urban slums of Punjab	4.23%

Table 1: Summary of Prevalence of Porcine cysticercosis in India

Author / Source	Year of study	Area of study	Prevalence of Neurocysticercosis
(Prasad K. N., 2008) reviewing work of Mani et al)	1974	NIMHANS, Bangalore	2% of an unselected series of epileptics.
(Prasad K. N., 2008) reviewing work of Wani et al)	1981	A tertiary referral centre at New Delhi	2.5% of all intracranial space occupying lesions.
(Juyal, 2008) reviewing work of Chandermukhi and Nayak	1990	NA	5.47% of children with meningitis showing anti cysticercal antibody in cerebrospinal fluid.
(Prasad K. N., 2008) reviewing work of Sawhney et al.	1996	NA	31% of epilepsy patient with whom CT scan was done.
(Prasad K. N., 2008) reviewing work of Parija et al	2005	Pondicherry	6.5% (Sero-prevalence)

(Prasad K. N., 2008) reviewing work of Khurana et al	2006	Chandigarh	17.3% (Sero-prevalence)
(Rajshekhar, 2006)	2006	Vellore district	Approximately 1/3 (33%) of all cases presented with active epilepsy.
(Prasad, et al., 2009)	2007	Lucknow, UP	48.3% of diagnosed epilepsy cases in pig farming community.
(Amudhan & Gopalkrishna , 2015)	NA	NA	1.3 to 4.5 per 1,000 population based on review of various studies.
(Pappala, et al., 2016)	2011-2014	A tertiary hospital in Andhra Pradesh	27.5% of seizure cases

Table 2: Summary of Prevalence of Neurocysticercosis

Societal monetary cost of cysticercosis in India

According to first WHO report on neglected tropical diseases (WHO, 2010), the estimated societal monetary cost of *Taenia solium* cysticercosis is US$ 15.27 million (95% CI US$ 51.6–299 million) in India.

With financial support from the School of Public Health and Zoonoses, Guru Angad Dev Veterinary & Animal Sciences University, Ludhiana, Punjab, India, (Singh, Khatkar, Gill, & Dhand, 2017) estimated the health and economic impacts due to NCC-associated active epilepsy in India based on the data for the year 2011. The year 2011 was selected as the latest studies on disease epidemiology were carried out in 2011. As per the estimate, in the year 2011, human NCC-associated active epilepsy caused an annual median loss of Rupees 12.03 billion (US $ 185.14 million). Out of the, Rs.9.78 billion ($150.56 million) loss is from North India and Rs.2.22 billion ($34.14 million) from the South. The disease resulted in a total of 2.10 million DALYs (Disability-adjusted life years: One DALY can be thought of as one lost year of "healthy" life) per annum without age weighting and time discounting with 1.81 million DALYs from the North and 0.28 million from the South. The health burden per thousand persons per year was 1.73 DALYs.

Review of literature on control strategies

Twenty-four years ago, the International Task Force for Disease Eradication (CDC, 1993) declared that *Taenia solium* infection is potentially eradicable. Recently, WHO commissioned a study to review global evidence related to *Taenia solium* control. The report of the study “Landscape analysis: control of *Taenia solium*” was published in the year 2015. The report identified all the evidence for *T. solium* control available in the literature published in English.

The report recorded that empirical data was available for preventative chemotherapy, health education, anthelmintic treatment of pigs and vaccination of pigs and some combinations thereof.

Due to the paucity of data available, the above-mentioned report could not make definitive recommendations on control strategies to be used. However, extrapolation from the evidence available along with modelled projections and the various recommendations of experts available in the literature, it

indicated that a combined approach utilizing the treatment of human taeniasis cases (through mass drug administration or selective chemotherapy) combined with the vaccination and treatment of the porcine host would be the 'best-bet' for rapid reduction of infection pressure. These core approaches should be supplemented where possible by longer-term sustainable measures such as health education, focusing on the need for improvements in sanitation, pig husbandry and meat inspection.

WHO fact sheet (WHO, 2017) updated until March'2017 indicates the following eight interventions for the control of *Taenia Solium.*

1. Mass drug administration for taeniasis.
2. Identification and treatment of taeniasis cases.
3. Health education, including hygiene and food safety;
4. Improved sanitation;
5. Improved pig husbandry;
6. Anthelmintic treatment of pigs (Oxfendazole at doses of 30 mg/kg – commercially produced and registered for the treatment of cysticercosis in pigs)
7. vaccination of pigs (TSOL18 vaccine – commercially available)
8. Improved meat inspection and processing of meat products.

This can be used in different combinations designed based on the context in the countries and as integrated 'one health' control strategy.

Relevance of Knowledge Attitude Practice Survey

The control or eradication of any infectious disorder requires an assessment not only of the prevalence of infection in the community but also of knowledge about, attitudes towards and practices regarding (KAP) the disorder among members of the community. Control can be effectively implemented when the attitude of the community is scientifically appropriate and community members are supportive of the measures taken towards control or eradication. Study to capture KAP linked to *Taenia solium* cysticercosis in India is scarce. (Sankhyan, 2015) reported a study to record KAP of people attending the adult epilepsy clinic of Dayanand Medical College, Ludhiana, India between 1st January 2007 and 30th June 2007. 17% of the sample taken for the study had the evidence of neurocysticercosis on their imaging studies. The study recorded that, regardless of presumed etiology of their epilepsy, 12.1% respondents believed that a worm was responsible for their epilepsy. 52% respondents were aware that worms might be responsible for epilepsy. The majority (82%) were however unsure about the name or nature of the worm (i.e. tapeworm). Interestingly 89% believed that the worm was found in cabbages and therefore could be acquired by eating raw cabbages. Only 8% of respondents held the view that the tapeworm could be acquired by consuming pork. The study concluded that there is high level of awareness of the relationship between helminths and epilepsy. However, there are misconceptions regarding the transmission and treatment of the disorder.

The current review, could not find reference of porcine cysticercosis related Knowledge Attitude and Practice (KAP) studies conducted exclusively for pig farmers and traders. Similarly, KAP of field level functionaries is also not available.

The gap in evidence and conclusion

The literature review indicated that there are evidences on prevalence of *Taenia solium* infection in India both in human and pig. There is also evidence of high incidence of taeniasis and neurocysticercosis amongst pig farming communities consuming pork. However, country level evidence on extent of linkages between neurocysticercosis to pork or raw vegetable consumption is not available. There is also scope of detail molecular level studies to identify species of the parasite involved. Many news reports (Times of India City, Bangalore , 2003) and published general interest articles in India indicate that eating raw vegetables, which have been grown, in fields irrigated with untreated sewage water is a common route of transmission of *Taenia solium* in India. In this context, it is important to note that there is inadequate amount of research that has been conducted about *Taenia solium* eggs in the external environment e.g. vegetable garden etc. With current knowledge, it is difficult to assess the type of habitat the eggs favor. Temperature is known to effect egg survival. If the habitat is colder than 10 degrees Celsius or above room temperature, the eggs are likely to perish. A more detailed study is required to establish common transmission pathways in Indian context. A review paper by (Lam, 2015) that documented evidence for Public Health Risks of Wastewater and Excreta Management Practices in Southeast Asia mentioned only one case control study (Tran, 2007) that linked such practices to epilepsy.

All the evidences of prevalence related studies discussed in the review are location specific. India is a vast country and there are great disparities within India in geography, ethnicity, religious rituals, income, food habits, personal hygiene, level of education and standards of living, which are likely to influence the disease burden. The review also indicated two reports that quantified the economic burden of cysticercosis in India. A question (Lok Sabha, 2010) about the 2010 WHO report was raised in the Indian parliament. In reply to the question, the Minister of the government indicated that the cost estimation by WHO report might not be reliable as estimates are based on small studies in limited geographical areas.

Robust evidence on prevalence, risk mapping vis-à-vis estimate on burden is needed for prioritization and focused policy-linked investment to control zoonotic diseases like cysticercosis. Generation of such robust evidence covering the entire country and risk mapping (identification of hotspots) is not possible without proper public-funded strong surveillance reporting system that takes an integrated approach linking human surveillance with animal health surveillance.

Conclusion

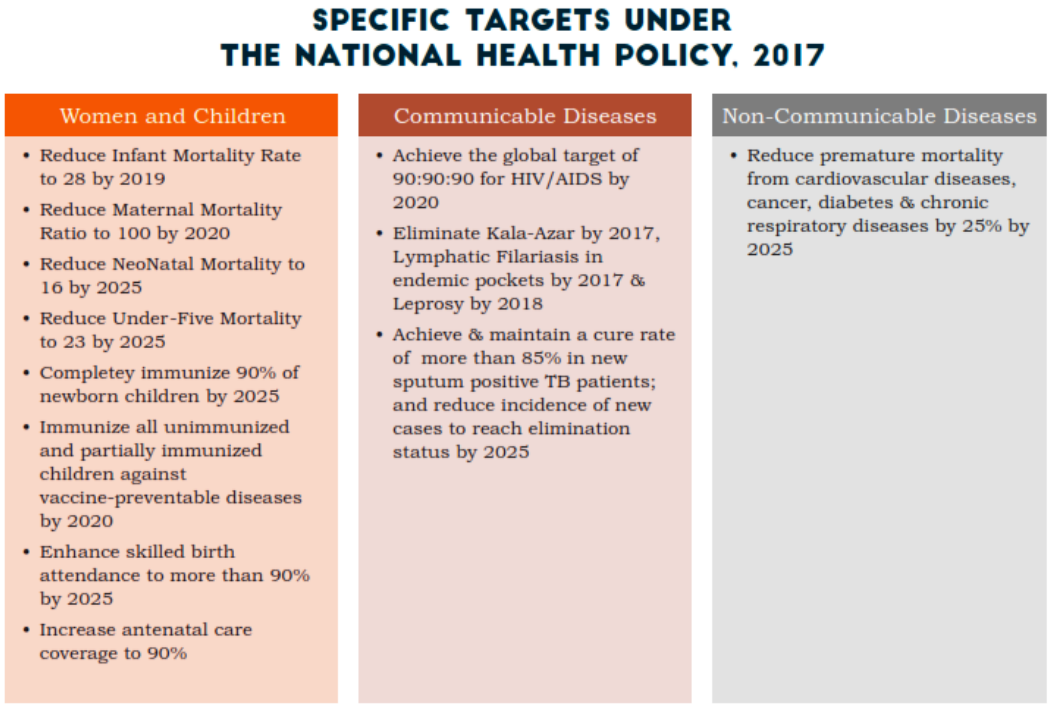
The review discussed not only prevalence and the economic burden of *Taenia solium* cysticercosis but also the gaps in population based evidence required for risk mapping. There is limited understanding on KAP (Knowledge Attitude Practice) of farmers, traders and grassroots workers. The current study therefore aims at bridging these gaps except the gap related to required population based evidence on common transmission pathway, which is beyond the scope of the study. The review highlighted internationally accepted required integrated control measures that cover health, veterinary, agriculture and environmental domains. The current study further aims at improving the understanding on the policy, institutional and legal landscape required to evaluate how porcine cysticercosis (cysticercosis in pig) control in India will integrate within the framework of India's agricultural, medical, food safety and public health frameworks.

Review of One Health landscape

Many one to one interviews and focus group discussions were organized across seven study states and capital city of New Delhi (Refer annexure -V for persons interviewed). The following review is based on discussions clubbed with analysis of referred secondary data and collected evidences.

Learning on general policy environment

The year 2017 is an eventful year for the Indian health sector: the government approved the (National Health Policy 2017) after having deferred it twice before. The last health policy was issued 15 years ago in 2002. Aiming to provide healthcare in an "assured manner" to all, the policy aims to address current and emerging challenges arising from the ever-changing socio-economic, technological and epidemiological scenarios. Though there is no target year for achievement, it also proposes raising public health expenditure to 2.5 per cent of the GDP in a time-bound manner.



Source 1: Voluntary National Review Report on implementation of SDG, United Nations High Level Political Forum (July 2017)

The policy target addresses SDG target 3.3 in terms of HIV, TB and select Neglected Tropical Diseases (NTDs). India's policy emphasis and program implementation related to NTDs is impressive. The country has achieved the target for eliminating visceral leishmaniasis (kala azar), a neglected tropical disease (NTD), in 82 percent sub-districts, according to the fourth World Health Organization (WHO) report on NTDs released on April 19, 2017. Another significant achievement by India was the elimination of Yaws, a chronic skin disease that mostly affects poor children. In 2015, WHO recognized India as the first member state to achieve this important milestone. India has also progressed in treating lymphatic filariasis (elephantiasis), and has stopped mass drug administration in 72 endemic districts after successful evaluations. The experience gained by India in control of NTDs is likely to make the country receptive to any program related

other NTDs like cysticercosis. The National Health Policy 2017 does not have any specific mention of facilitation of intersectoral collaboration for control of zoonotic diseases. However, the three-year Action Agenda 2017-18 to 2019-20, of NITI[7] Aayog (NITI Aayog) - the Government of India policy think tank indicated following para on strengthening inter-sector collaboration. This indicates clear intent on the part of the present government to invest on public and preventive health initiative.

> The most important step for prioritizing intersectoral public health will be the creation of a designated focal agency within the Union Health Ministry. The functions carried out by this entity should include disease surveillance, monitoring of health status, educating the public, providing evidence for the public health action and enforcing public health regulations. A suggested focal point is the pre-existing National Center for Disease Control, which could be provided greater authority and resources to perform this role. An official equivalent to the Director General Health Services should lead the institution. An autonomous counterpart to the focal point in the Union Health Ministry should be considered for establishment at the state level for coordinating with different agencies for public and preventive health initiatives. This state -level body should be adequately empowered to take decisions, which are of cross-sectoral nature since public and preventive health span action across many departments.
>
> Excerpts from Three-year Action Agenda 2017-18 to 2019-20 of Government of India (Refer 21.8), Published by NITI Aayog

On 2nd October 2014, the Government of India initiated an ambitious *Swachh Bharat Abhiyan* (English: Clean India Movement). The objectives of *Swachh Bharat Abhiyan* are to reduce or eliminate open defecation through the construction of individual, cluster and community toilets. The *Swachh Bharat* mission will also make an initiative of establishing an accountable mechanism of monitoring latrine use. The government is aiming to achieve an Open-Defecation Free (ODF) India by 2 October 2019, the 150th anniversary of the birth of Mahatma Gandhi, by constructing 12 million toilets in rural India, at a projected cost of ₹1.96 lakh crore (US$30 billion) (Wikipedia). This campaign, if targeted at risky communities, can immensely contribute to cysticercosis control.

In general, the policy environment is conducive for a national effort towards control and eradication of cysticercosis.

The Institutional set up for animal disease reporting and control in India

The protection of animal health is a state subject in India. Government of India through Department of Animal Husbandry, Dairying and Fisheries (DADF) is responsible for coordination and control of animal diseases at national level, while Indian Council of Agricultural Research (ICAR) through Animal Science Division is responsible for animal diseases research, diagnosis and their control.

National Animal Disease Reporting System (NADRS) supported by DADF is a system of animal disease reporting that links each block, district and State headquarters to Central Disease Reporting and Monitoring Unit at New Delhi. The success of the system is mixed in India. Besides entering input to the system, state veterinary departments collates information collected from districts and sends it in the form standard Animal Disease Information Report (ADIR) by email to corresponding authorities at DADF.

[7] National Institution for Transforming India

Indian Council of Agricultural Research (ICAR) has established three institutes to look after animal disease monitoring and surveillance in the country. The institute, Project Directorate on Foot and Mouth Disease (PD-FMD) carries out epidemiological studies on Foot and Mouth Disease (FMD), while National Institute for Veterinary Epidemiology and Disease Informatics (NIVEDI) (Formerly PDADMAS) looks after the major economically important livestock diseases in the country. Exotic disease surveillance is carried out by the National Institute of High Security Animal Disease (NIHSAD), Bhopal, which has a BSL-4 facility.

ICAR through NIVEDI maintains at National Animal Disease Referral Expert System (NADRES) to forecast livestock disease. The system was the outcome of National Agriculture Technology Program Funded Mission Mode Sub Project on "Weather Based Animal Disease Forecasting" and "Animal Health Information System through Disease Monitoring and Surveillance".

NIVEDI has recently developed a climate-parasitic disease relationship model for timely control measures for parasitic diseases of livestock in India (NIVEDI, 2017) However, porcine cysitcercosis was not considered for the model.

Major public infrastructure for animal disease control in India includes state of art referral diagnostic laboratories. There are one central (CDDL) and five Regional Disease Diagnostic Laboratories (RDDL) The Centre for Animal Disease Research and Diagnosis (CADRAD) of Indian Veterinary Research Institute (IVRI), Izatnagar, UP is working as the Central Disease Diagnostic Laboratory. The Regional Laboratories are located at Kolkata (Eastern), Pune (Western), Jallandhar (Northern), Bengaluru (Southern) and Guwahati (North-eastern).

India has one of the finest institutional structures for human resource development needed for animal disease control. Indian Veterinary Research Institute (IVRI) is conducting a countrywide outreach programme on Zoonotic Diseases with 17 coordinating partner organization. The IVRI outreach program covers 20 zoonotic diseases, which includes cysticercosis. Besides the outreach program, number of ICAR institutes across India are mandated with conducting basic, applied and translational research on zoonotic infections.

Intersectoral collaboration for control of zoonotic diseases

Government of India has initiated programs for strengthening of intersectoral coordination for prevention and control of zoonotic diseases during the last 12th plan (2012-2017) period itself. There are disease specific programs too such as National Rabies Control Programme and Programme for the prevention and control of Leptospirosis. The Zoonosis Division of NCDC (National Center for Disease Control) – the India focal point of International Health Regulations (IHR), located at New Delhi act as Nodal Coordinating Centre for intersectoral collaboration. A standing committee on zoonoses advises on various facets of strengthening of intersectoral coordination mechanism within the country. The premier research organization such as Indian Council of Medical Research (ICMR) and Indian Council of Agricultural Research (ICAR) have both constituted joint task Forces on Zoonoses.

The Government of India has further strengthened the Integrated Disease Surveillance Program (IDSP) launched in the year 2004 with the Word Bank assistance. The program under National Health Mission currently has its presence in 670 districts of India with a district level surveillance unit. Many districts have constituted rapid response team (RRT) to quickly manage any outbreak of a disease. Veterinarians as

deputed from parent line departments are part of these RRTs for handling zoonotic diseases. To augment surveillance activities and response mechanisms, a wide network of epidemiologists, microbiologists and entomologists has been made available in all district and state headquarters under the IDSP. IDSP in many states now have veterinary consultants under their pay roll to facilitate coordination with line veterinary departments and related agencies. The organization has published a specific training manual for Veterinary Consultants for control of zoonotic diseases (NCDC, 2015). In recent years, there are documented stories of joint outbreak investigation of zoonotic disease like anthrax (Nayak, 2015). The interactions at various district headquarters indicated efficient functioning of RRTs in the context of intersectoral collaboration. States like Mizoram have issued formal notifications[8] constituting joint technical working group on zoonosis. Department of Animal Husbandry, Dairying and Fisheries (DADF) too issued request vide a letter (DADF, 2017) dated 26th May 2017 to states for ensuring intersectoral collaboration and to create post of public health veterinarian in state health departments. IDSP have established Information technology connectivity with all states, districts and medical colleges for the rapid transfer of data. There is ongoing initiative for Integration of IDSP surveillance system with National Animal Disease Reporting System (NADRS) maintained by Department of Animal Husbandry, Dairying and Fisheries (DADF) and National Animal Disease Referral Expert System (NADRES) maintained by ICAR.

As a part of strengthening of intersectoral collaboration, the government is taking initiative for preparing inventory of laboratories in health and animal sector. Identification of referral and diagnostic laboratories is being undertaken to ensure networking and sharing of laboratory facilities. Countrywide training is being organized on laboratory diagnostic techniques and capacity building of district level rapid response team (RRTs) members. Joint IEC[9] materials are being made available to create awareness and ensure involvement of communities. Steps include development of a roster of experts both from medical and veterinary specialization.

Amongst the non-government initiatives related to intersectoral collaboration for control of zoonotic diseases, the initiatives of Public Health Foundation of India are notable. They have been implementing a program titled “Roadmap to combat Zoonosis in India (RCZI)”. The program is a national-level multidisciplinary endeavor on research, capacity building and advocacy/ health promotion. The organization in the year 2013 organized a National One Health Symposium in collaboration with Massey University, New Zealand.

Many organizations in India are promoting intersectoral -One Health research and education in India. This includes educational institutions and alliances such as One Health Alliance of South Asia (OHASA).

All districts covered during the study indicated the presence of a district health action plan but cysticercosis control is not a priority. There is no instance of public demand for such program as awareness is very low. Facility of imaging technology-based diagnosis of neurocysticercosis is by enlarge available at district level public hospitals.

The discussion conducted at the district level indicated the important leadership role of district magistrate in ensuring the intersectoral coordination. Many respondents indicated that such coordination is not tough to achieve as senior officials within a district normally keeps good relationship with each other. Inter-

[8] No.J11011/62/2007-HFW/15 dated 20th Nov 2015

[9] Information, Education, and Communication

departmental meetings are a regular event at the office of district magistrate to ensure and supervise convergence of work of various development schemes.

The legal framework for disease control with special reference to taeniasis / cysticercosis control

Many states in India used to invoke various provisions of the Epidemic Diseases Act of 1897 to force disease control measures. The Act requires medical practitioners to notify the public health authority about anybody with a communicable disease and disclose the identity of the person. This is a very old Act and many states formulated their own public health laws and many amended the provisions of their epidemic disease Acts.

In 1955 and 1987, the Central government developed a Model Public Health Act, but failed to persuade the states to adopt this. The draft National Health Bill 2009 attempts to ensure a legal framework for providing essential public health services and powers for an adequate response to public health emergencies through effective collaboration between the Centre and the states. This bill is still pending.

The factories act (Act No. 63 of 1948) as amended by the Factories (Amendment) Act, 1987 mentions a list of 31 notifiable diseases. The only zoonotic disease mentioned in this list is Anthrax.

A review of notifiable disease list state wise also shows that cysticercosis in human is not notifiable.

For control of diseases in animals, the corresponding Act is prevention and control of infectious and contagious diseases in animals Act 2009. Porcine cysticercosis is a scheduled or notifiable disease in India under this Act. The list of other pig disease notifiable under the act in India are: African Swine Fever, Classical Swine Fever, Nipah Virus encephalitis, Porcine reproductive and respiratory syndrome, Swine vesicular disease and Transmissible gastroenteritis.

A legal provision related to control of animal movement can be of relevance for cysticercosis control. The study recorded an instance where a state government has specific law to ensure that animals are reared in confinement. Mizoram Animal (Control & Taxation) Act, 2014[10] ensures rearing of pigs in confinement. The law extends to the whole of the state of Mizoram except the areas within the jurisdiction of Municipalities and of Chakma, Mara and Lai Autonomous District Councils in Lawngtlai District and Saiha District.

As per rule 9.2 of Model Municipal Solid Waste (Management & Handling), Cleanliness and Sanitation Rules and bye-laws (Swachh Bharat Mission, Ministry of Urban Development, Government of India, 2016), free roaming of animals are not allowed in municipality areas.

A legal provision for preventing use of untreated wastewater in agriculture is of relevance too in the context of cysticercosis control. In India, there are Acts such as The Water (Prevention and Control of Pollution) Act of 1974 and the Environment (Protection) Act of 1986. The Central Pollution Control Board (CPCB) has developed General Discharge Standards that apply to all discharges. Discharge standards have been developed in India for 33 parameters under four categories including a category on irrigation (Banerjee).

[10] It's a new act after repealing the old one i.e. Mizoram Animal (Control & Taxation) Act, 1980 (Act No. 4 of 1980)

Framework for disease surveillance and zoonotic diseases

Integrated Disease Surveillance Program (IDSP) of Government of India follows a syndromic surveillance system. For data collection, the system uses three forms vis-à-vis Form S (Suspect Cases, collected by Health Workers at Sub Centers); Form P (Probable Cases, collected by Doctors at Primary Health Centers, Community Health Centers and Hospitals and Form L (Lab Confirmed Cases, collected from or reported by Laboratories).

The CBHI collects data on communicable and non-communicable diseases using two forms vis-à-vis Form 2-A (for communicable diseases) and Form 3-A (for non-communicable diseases). CBHI also records cases of death due to any reportable disease.

The main method of collecting information on livestock diseases is through a passive disease reporting system. A public veterinarian reports the cases only when owner or farmer contacts him. The information is not collected about all the cases and population at risk is not recorded.

There are number of zoonotic disease of public health importance in India (Refer Box 5)

Endemic: *Rabies, Anthrax, Brucellosis, Toxoplasmosis, Cysticercosis and Echinococcosis*

Re-emerging: *JE, Plague, Leptospirosis, Scrub Typhus, KFD (Kyasanur Forest disease)*

Emerging: *Avian Influenza, Nipah, Trypanosomiasis, Zika and CCHF (Crimean-Congo haemorrhagic fever)*

Box 5: Important zoonotic disease of public health importance in India

The major zoonotic diseases under national surveillance system of IDSP and CBHI includes Rabies, Leptospirosis and Anthrax. Cysticercosis is not included for IDSP or CBHI surveillance. Surveillance is also done under the category Acute Encephalitis Syndrome and Acute Respiratory Infection (Influenza like illness).

The NADRS has provision for recording number of zoonotic diseases such as Anthrax, Echinococcosis, Leptospirosis and Rabies and porcine cysticercosis.

The format used for sending Animal Disease Information Report (ADIR) categorizes diseases as digestive disorders, respiratory diseases, deficiency diseases, skin diseases, protozoal diseases, parasitic diseases, Gynecological disorders etc. It also records information on infectious disease outbreaks and vaccinations, conducted laboratory test and extension services.

A review few ADIR formats indicates that these reports collect data on species-wise tapeworm (cestodiasis) infections.

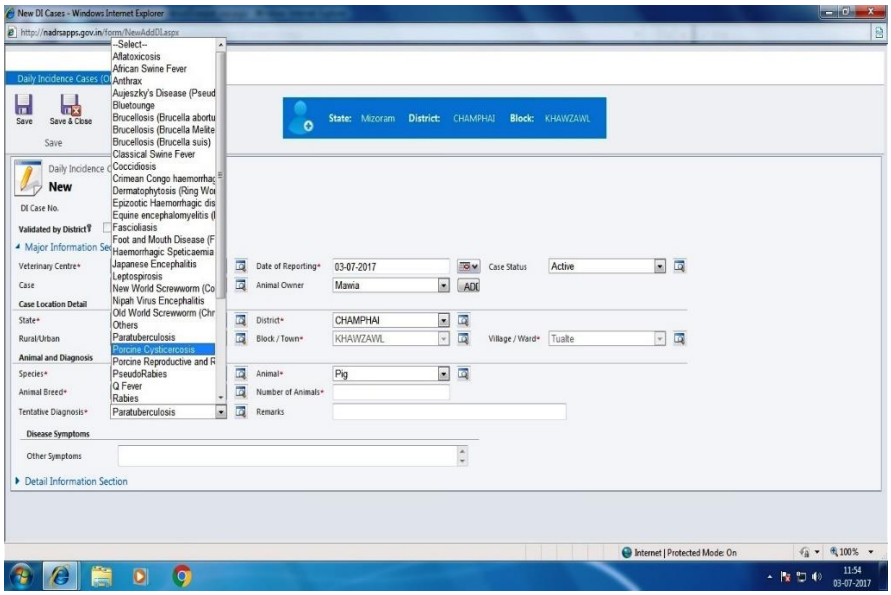


Figure 5: NADRS Interface showing provision for collecting data on porcine cysticercosis

Interviews conducted in study states indicated that, NADRS system performance is not up to the mark and it does not generate warning or permit data analysis at state level. There are limited efforts on the part of states to analyze collected hard data on their own. Investigations do not always follow based on generated data. A review of recent monthly ADIR in Jharkhand and Meghalaya indicated reporting of cases under the heading 'tapeworm in pig'. The current study could not collect time series data in any of the study states to evaluate reported cases of tapeworm infection in pig or porcine cysticercosis.

Amongst the parasitic disease, ICAR's National Animal Disease Referral Expert System (NADRES) focuses on: Trypanosomiasis, Fasciolosis, Anaplasmosis, theileriosis and Babesiosis. Porcine cysticercosis is not a priority disease in the context of targeted analysis expected from the NADRES. Amongst the zoonotic diseases, the web interface currently gives forecasting only for Rabies and Anthrax.

IDSP empowers states to take decision on collection of data on maximum five state specific diseases besides a common list for the country as such. This is primarily because health is a state subject in India. In future, for any project state, it is possible to initiate collection of specific data on cases of neurocysticercosis to generate more specific evidences (district wise) and to monitor success of any control program of taeniasis / cysticercosis.

The respondents interviewed indicated that private sector participation in reporting of disease can go a long way in strengthening surveillance system thus ensuring true estimation of disease burden in near future. Private sector involvement cannot be achieved only through regulations e.g. mandatory notification of disease. Respondents feel that there are still inadequate interactions with private sector. The lack of trust is evident in most of the circumstances. It is to be noted that the current data generated by IDSP is only representative of a trend in disease incidence rather than the true estimate of disease burden. There are likely to be vast difference between finding of specific studies and what is reported in IDSP.

In India, there are examples of state level implementation / testing of innovative surveillance programs (using electronic tools) that gives due importance to reporting by private sector including reporting by citizen scientist (John, Samuel, & V Balraj, 1998).

Country evaluation in terms of IHR Zoonotic disease indicator

As indicated earlier, India is currently implementing two national control programs for Rabies and Leptospirosis. The quick evaluation based on International Health Regulation (IHR) indicators related Zoonotic disease (Refer Fig 6) indicated that India can be grouped as a country in level three with developed capacity. The country is fast moving to level four identified as level with demonstrated capacity. This will require India to consider developing zoonotic surveillance system for minimum of five zoonotic diseases of public health importance. Surveillance and targeted control program for cysticercosis in specific regions may be a possibility in near future.

Score**	Indicators – Zoonotic Diseases*		
	P.4.1 Surveillance systems in place for priority zoonotic diseases/pathogens	**P.4.2 Veterinary or Animal Health Workforce**	**P.4.3 Mechanism for responding to infectious zoonoses and potential zoonoses are established and functional**
No Capacity – 1	No zoonotic surveillance systems exist.	Country has no animal health workforce capable of conducting *one* health activities.	No mechanism in place.
Limited Capacity – 2	Country has determined zoonotic diseases of greatest national public health concern but does not have animal zoonotic surveillance systems in place.	Country has animal health workforce capacity within the national public health system.	National policy, strategy or plan for the response to zoonotic events is in place.
Developed Capacity – 3	Zoonotic surveillance systems are in place for 1-4 zoonotic diseases/pathogens of greatest public health concern.	Animal health workforce capacity within the national public health system and less than half of the sub-national levels.	A mechanism for coordinated response to outbreaks of zoonotic diseases by human, animal and wildlife sectors is established.
Demonstrated Capacity – 4	Zoonotic surveillance systems in place for five or more zoonotic diseases/pathogens of greatest public health concern	Animal health workforce capacity within the national public health system and more than half of sub-national levels.	Timely and systematic information exchange between animal/wildlife surveillance units, human health surveillance units and other relevant sectors in response to potential zoonotic risks and urgent zoonotic events.
Sustainable Capacity – 5	Zoonotic surveillance systems in place for five or more zoonotic diseases/pathogens of greatest public health concern with systems in place for continuous improvement	Animal health workforce capacity within the national public health system and at all subnational levels. This includes a plan for animal health workforce continuing education.	Timely (as defined by national standards) response to more than 80% of zoonotic events of potential national and international concern.

* Refers to zoonotic infections shared by animals and humans

** For full scores, capabilities should be separately evaluated both in the human and animal (livestock, companion animal and wildlife) sectors and mechanisms for regular comparison and joint policy-development in a One-Health fashion should be in place. For final scores, the average should be taken.

Figure 6: IHR 2005, Indicator for Zoonotic disease

Framework for meat inspection and provision related to cysticercosis

Schedule 4, Part IV under regulation No.2.1.2 (1) (5) of Food Safety and Standards Regulations, 2011 implemented by Food Safety Regulatory Authority of India (FSSAI) covers in detail about Specific Hygienic and Sanitary Practices to be followed by Food Business Operators in India engaged in manufacture, processing, storing and selling of Meat and Meat Products. Though there is no specific reference of meat inspection procedure in case of pigs, the regulation clearly mentions that the post-mortem inspection must be conducted in accordance with the general rules laid down for such inspection in public slaughter houses under the control of local bodies besides special instructions that may be issued from time to time by the

licensing authority. The rules are however, silent on policy for condemning a pig carcass infected with cysticerci. Codex Alimentarius (Alinorm 93/16 A) prescribes that carcasses and viscera affected with 'heavy infestations' be totally condemned, the designation of 'heavy infestation' to be prescribed by the controlling authority. Cases of moderate or light infestation or small number of dead / degenerated cysticerci are to be subjected to freezing or heat treatment. United States regulations state that lightly affected pig carcasses may be passed for cooking but those heavily infested must be condemned.

As per recent (Bureau of Indian Standards (BIS) code of practice IS 1982: 2015) -Risk based PM inspection program, special measures like opening of heart and deep incision on septum should be carried out in pigs derived from areas where there is a risk of *Cysticercus cellulosae*. However, the standard is silent on antemortem measures such as tongue examination and verification of record of vaccination.

India has attended the Forty-Seventh Session of Joint FAO /WHO Food Standards Program -Codex Committee on Food Hygiene for preparation of proposed draft guideline on the application of general principles of food hygiene to the control of food borne parasites held during Nov.2015. However, there is no India specific guideline under FSSAI on card to reduce food borne parasite hazard in India.

The food safety regulation indicates that only healthy animals in good condition shall be transported unless they are meant for emergency slaughter. These animals should be certified by a qualified veterinary inspector for freedom from infectious diseases and ectoparasitic diseases and their fitness to undertake the journey. When animals are to be transported from endemic areas of a disease to non-endemic areas, the animals should be given protective vaccination and kept in quarantine for 30 days, before transportation. This regulation is particularly, relevant in the context of reported large inter-state movement of pigs in India for slaughter. Unconfirmed reports indicate that though inter-state imports are taking place through registered farms, the traders often engage in risky practices of procuring pigs reared in free range in urban slum areas through small traders. (Jimomi, 2014)

In majority of study states and districts visited, government line departments are not clear about the mandate for meat inspection and mechanism to ensure this. The study recorded an instance in Mizoram state where (Government of Mizoram (Allocation of Business) Rules, 2014) clearly specify mandate on the part of the veterinary department to undertake public health functions, meat inspection and slaughter house related affairs. The state also has a specific Act vis-à-vis (The Mizoram Animal Slaughter Act, 2013 (Act No. 6 of 2013)) and the rules thereof (The Mizoram (Animal Slaughter Houses) Rules, 2016) notified dated 7 June 2017 to ensure scientific meat inspection.

Licensing of meat shops and slaughterhouses in most cases is controlled by health department. In some places, town municipalities conduct limited inspection with support from deputed veterinarians from government line department. The interviews conducted at the district level highlighted the need for coordination with health department and district authorities for developing a standard system for meat inspection. Amongst the constraints identified during discussions for implementing scientific meat inspection include: lack of registered slaughter house, preference for community, village market and road side slaughter and sale, too many and scattered licensed and unlicensed meat shop, shortage of departmental man-power and likely conflict situation that may arise with influential meat trader lobby following any negative action on the part of officer conducting the meat inspection.

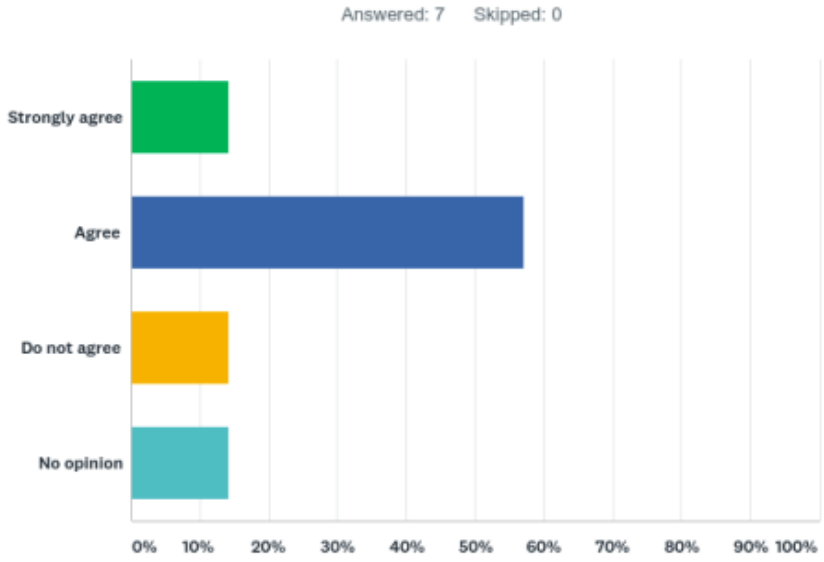
In majority of discussions conducted in UP, Bihar and Jharkhand, informants indicated that formal shops selling pork is limited. Slaughter and sale is seen mostly in fixed pockets and takes place at community level or at the level of household. In contrast to this, shops selling pork is common in states of North East India. However, in northeastern states too pig slaughter is mostly at community level or at household level. Modern slaughter houses -where available are catering to only urban areas.

The study could record initiatives at ICAR National Research Centre Pig related to promotion of community level low cost scientific slaughterhouses for Pigs in Northeast India.

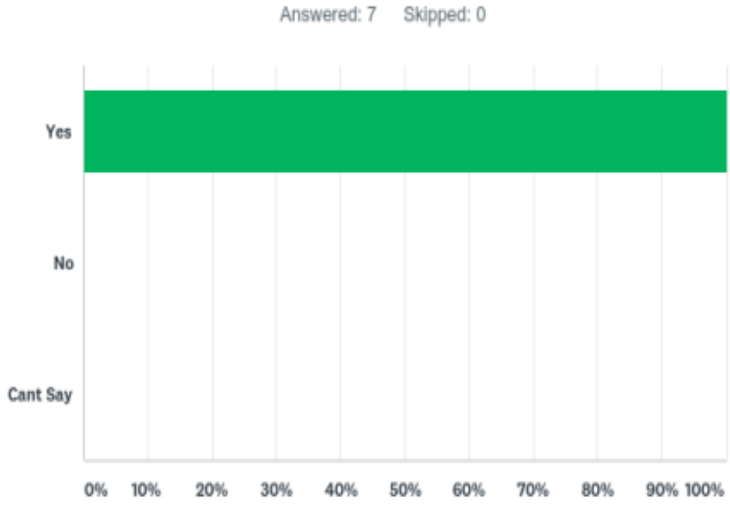
Cysticercosis and trade on pork and pork products

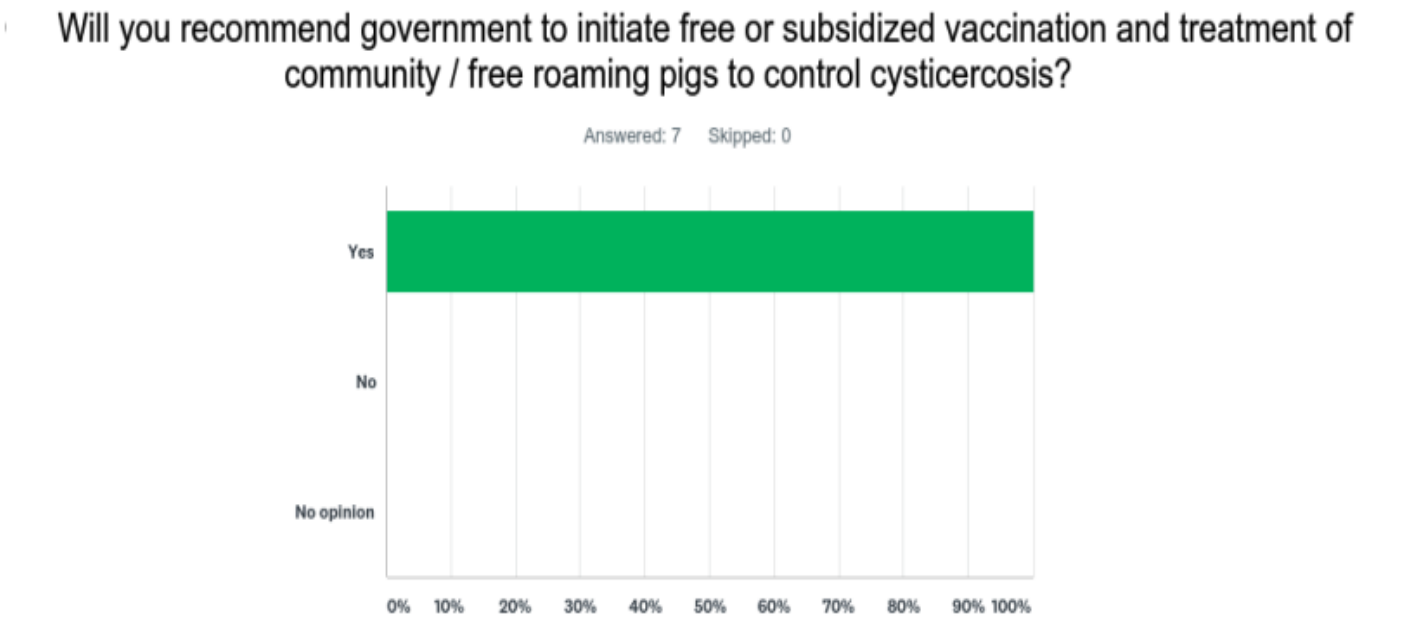
According to (USDA, 2016) report, pork production in India is estimated at 464 thousand metric tons in FY 2014-15 (April-March), which contributes approximately eight percent of the country's animal protein sources. There is growing demand for pork in many urban areas of India. India's pork importation was 527 metric tons in 2015, which increased at an annual growth rate of 11 percent from 2010 to 2015. The demand for imported pork is mainly in hotel, restaurant and institutional and high-end retail sector. Large number of organized farms are emerging in states like Punjab, Maharashtra, UP etc. besides few in northeastern states. Due to scientific husbandry practice, the incidence of cysticercosis in these organized farms is likely to be negligible. However, since country is endemic for *Taenia solium* cysticercosis as per WHO, the disease is likely to affect the trade capacity of domestic organized farms in the context of competition from imported pork. As a part of the study, a list of up to 50 major organized operation in India was prepared and an attempt was made to collect opinions through an online survey promoted through social media. With only seven responses, the participation in the online survey was significantly low. Majority felt that consumer perception in India regarding likely tapeworm infection from pork is restricting the demand for locally produced pork. All the respondents indicated that any national program to control cysticercosis will improve brand image of pork produced in India in the long run. They also approved the need of a public funded cysticercosis control program to assist farmers in unorganized sector to use the available vaccine and specific anthelmintic drugs. Following figures visually presents the survey analysis of responses from organized pig farms.

Do you agree with the statement that “consumer perception in India regarding likely tapeworm infection from pork is restricting the demand of locally produced pork in general”?



Do you think that a national program for human cysticercosis control with component related to vaccination and anthelmintic treatment of community pigs will also help in improving the brand image of pork produced in India?





Landscape of sanitation and waste water use in India

The investment made under clean India mission started in the year 2014, resulted into declaration of five states and 196 districts as open defecation free as on September 2017. This achievement is impressive considering only five ODF districts in 2015. The snapshot of Clean India Mission (Refer fig 7) indicates progress made between 2014 and 2017. Household toilet coverage, which was 38.7% in 2014, is now 68.05%.

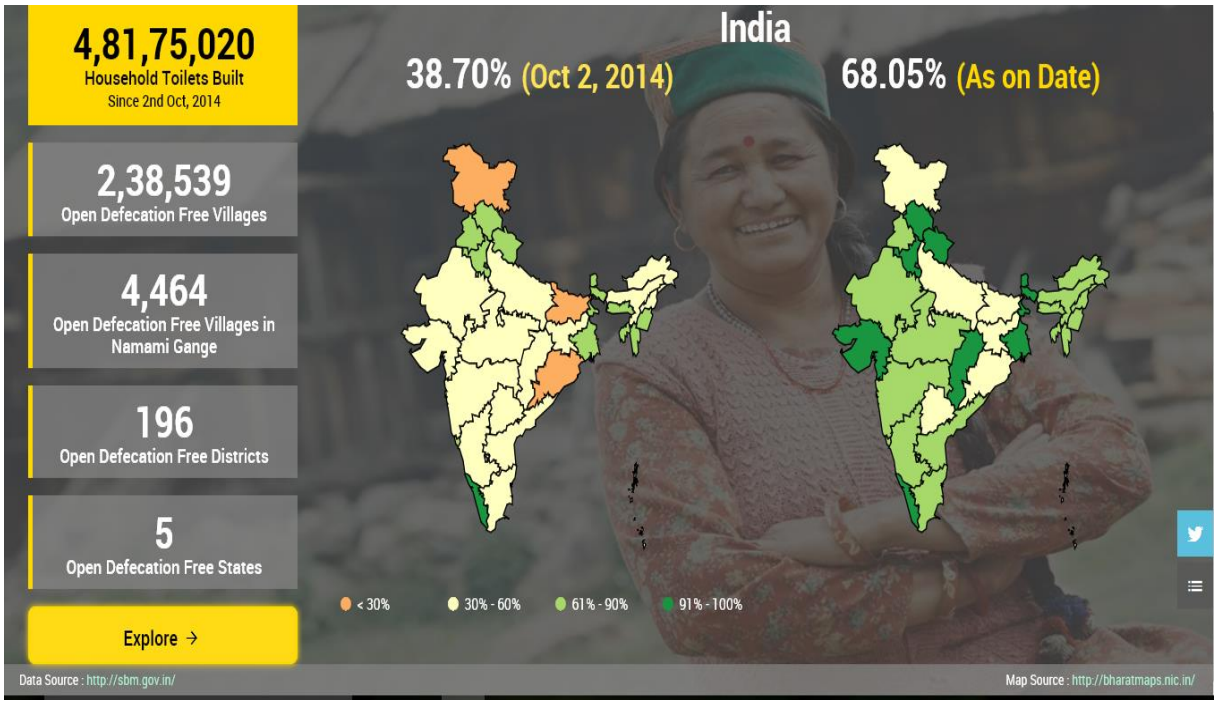


Figure 7: Infographic of progress made under Clean Indian Mission. Source: Snapshot of mission website as accessed on 15 September 2017

The performance of Clean India Mission will greatly enhance India's chance to reduce incidence or to eliminate cysticercosis from India. Government of India vide a letter (MDWS, GOI, 2016) have directed states to map villages based on a defined 'village cleanliness index' and SLWM (Solid Liquid West Management) Index. The availability of such village data related to cleanliness can further help in targeting areas for cysticercosis control program.

According to real time government data (MDWS, GOI, 2017) the cumulative Open Defecation Free status of each of the seven study states are shown in table -3

State Name	ODF Status (1%)
Assam	19.12
Bihar	6.08
Jharkhand	26.13
Meghalaya	72.48
Mizoram	49.64
Nagaland	46.30
Uttar Pradesh	10.37

Table 3: Open Defecation Free status of study states as on September 2017

Amongst the study states Bihar, Uttar Pradesh and Jharkhand is showing low Individual Household Latrine (IHHL) coverage, which is 32.3%, 50.97% and 59.94% respectively. All the other study states this percentage is much higher with Meghalaya, Mizoram and Nagaland achieving more than 85%.

Since access of pigs to human excrement is directly related to cysticercosis prevalence, the study reviewed available state-wise statistics (as per 2011 census) on number of latrines accessed by animals.

Fig 8 shows a visual presentation of the data on number of latrine accessible by animals (State wise) per 1000 household.

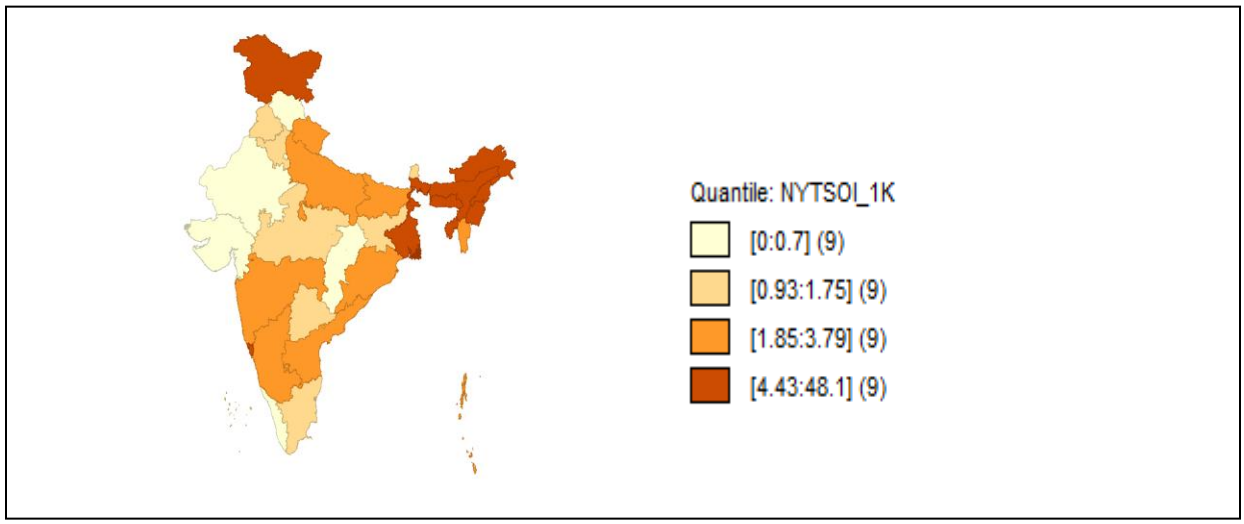


Figure 8: Number of latrine accessible by animals per 1000 household in India (Data source: Census 2011)

The visual indicates presence of such toilet is high in all the northeastern states. Arunachal Pradesh and Goa stands at the top with every 48 per 1000 Households having latrine accessible by animals. Every 3 - 6 Households per 1000 Households are having latrine accessible by animals in the entire north east excluding Mizoram, which is 2.5 number of such latrine per 1000 household. Latrines accessible by animals are much less in Kerala and Himachal Pradesh e.g. 0.2 to 0.3 household per 1000 household.

The use of latrine accessible by animals may have declined in recent years. There is however, ample scope to conduct fresh survey in sample populations within northeastern states to explore the need of any communication strategy aimed at augmenting removal of such latrines as a part of any future 'One Health' cysticercosis control program. The survey of Knowledge Attitude and Practice (KAP) conducted as a part of current study has failed to capture the situation.

Without proper management, wastewater use poses serious risks to human health and the environment. The Hyderabad Declaration on Wastewater Use in Agriculture (IWMI/IDRC, 2002) have urged policy makers to confront the realities of wastewater use in agriculture. It says that, to enhance the positive outcomes while minimizing the risks of wastewater use, there exist feasible and sound measures that need to be applied. Vegetables irrigated with wastewater can act as potential source of gastrointestinal parasitic infections. However, as indicated earlier[11] there is limited evidence that use of human feces to fertilize domestic vegetable gardens leads to incidence of neurocysticercosis or epilepsy.

According to a report (Banerjee), in most peri-urban areas of India, untreated rather than treated sewage is used for irrigation because either adequate sewage treatment capacity is non-existent, or the farms in question are not located close to the outflow of the sewage treatment plant. A variety of crops are grown

[11] Refer section in this report on gap in evidence

through sewage-fed farming in peri-urban areas, the most prevalent being vegetables for the local urban market. In many places, the practice of using sewage for agriculture has been going on for decades and has acquired some degree of formalization. As per a report (Central Pollution Control Board, New Delhi, 2010) in India, the estimated sewage generation from Class I cities and Class II towns (representing 72% of urban population) is 38,524 million litres/day (MLD), of which there exists treatment capacity of only 11,787 MLD (about 30%).

Cysticercosis control as solution to India's epilepsy problem

The literature review conducted under the current study highlighted the prevalence of neurocysticercosis in India. Most recent review (Amudhan & Gopalkrishna , 2015) of various Indian studies indicated that prevalence of active epilepsy related to neurocysticercosis varies from 1.3 to 4.5 per 1,000 population.

Any 'One Health' program aimed at control of cysticercosis can positively support success of any future National Epilepsy Control Program.

The following analysis of epilepsy problem in India justifies investment in cysticercosis control program as it can contribute synergistically to epilepsy control.

The magnitude of epilepsy problem

In a reply to a parliament question (Unstarred question number 3280 Lok Sabha, answered on 01.08.2014) on epilepsy, the Government of India stated that the data on people suffering from epilepsy, seizure and related neurological impairments in the country is not collected centrally. The reply also mentioned that as per government estimate, there were about 8 million people living with epilepsy in India in 2013. The same reply quoting a study by (Devi, 2003) mentioned that about 50% of people living with epilepsy and related neurological impairments in India do not receive medical treatment and the gap is found to be higher in rural settings as compared to the urban settings.

According to (Amudhan & Gopalkrishna , 2015), the overall prevalence of epilepsy in India is 3.0-11.9 per 1,000 population and incidence is 0.2-0.6 per 1,000 population per year.

The current study, however, could find presence of population based data on reported cases under the heading 'other neurological disorders' collected by Central Bureau of Health Intelligence, Government of India. The data collection format (CBHI) Form 3A -Sl.No.2.3 describes other neurological disorders as cases of epilepsy and Parkinson's disease. During 2016, India reported a total 534952 number cases under 'Other Neurological Disorder- a percentage increase of 37% from the reported cases of 2015 i.e. 389592 (Data source: CBHI). According to experts interviewed, the reporting can be grossly inadequate. The extent or efficiency of reporting also varies from state to state. However, analysis of state wise data of reported cases can be informative. Fig-9 represents a percentile map that shows the states in India as they contribute to overall case load. As high as 90-99% of the cases in 2016 are reported from Uttar Pradesh, Madhya Pradesh, Odisha and Andhra Pradesh.

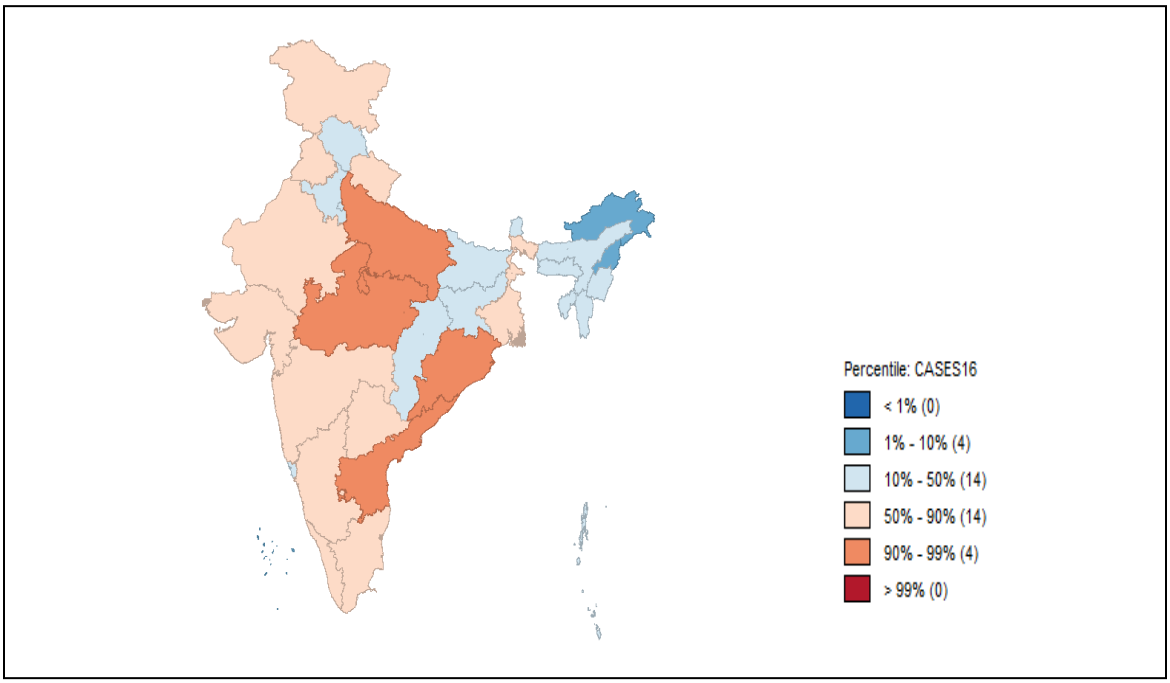


Figure 9: Map showing states in India as they contribute to overall case reported in 2016 under 'Other neurological disorder e.g. epilepsy / Parkinson's disease etc.

The above data indicates the extent of the problem of epilepsy in India. It is feasible to trace back origin of reported cases and conduct further research on actual diagnosis (e.g. whether reported neurological disorder is epilepsy due to neurocysticercosis) and food habit of patients. The analysis of such population based data on reported cases of neurological disorders along with other data sets e.g. Pig population, status of sanitation etc. can go a long way in identifying the hotspot areas for 'One Health' intervention related to taeniasis / cysticercosis control. The following section explores the usability of available data sets for identifying taeniasis / cysticercosis hot spots.

The linkage of epilepsy cases with pig population

The available evidences of prevalence of porcine cysticercosis and human neurocysticercosis in India are based on localized studies. There is a gap in evidence related to linkage between incidence of epilepsy and pork consumption. As per objective, in the current study, an attempt was made to explore available population based government data for three study states vis-à-vis Uttar Pradesh, Meghalaya and Nagaland to see the correlation between pig population and cases reported under the heading 'Other neurological disorder(OND) e.g. epilepsy, Parkinson's disease etc.'. This was done as detail data on pork consumption is not available.

The analysis assumed that reported OND cases are proportional to manifestation of neurocysticercosis (NCC), i.e., a fraction of the total OND cases are due to NCC.

Data set

The primary dataset used in this analysis comprised of district level annual reporting of OND cases available with CBHI. The data used includes annual OND reporting data for the years 2015 and 2016 for 51 districts

spread in three states vis-à-vis Meghalaya, Nagaland and Uttar Pradesh. Out of these 51 districts, seven belonged to Meghalaya (ML), seven from Nagaland (NL) and the other 37 were from Uttar Pradesh (UP). Since the human population data used in this analysis was from the Census of India 2011 and the pig population data used was from the 19th Livestock Census 2012, the 51 districts and the corresponding OND reporting were aggregated to match the districts as par Census of India 2011. The geo-political distribution of the districts considered in this study is shown in Fig 10. Population and numbers of households for each district was obtained from the Census of India 2011 data available in the public domain. Similarly, the number of pigs per district (in terms of number of pigs per 1000 household) was obtained from the 19th Livestock Census 2012. The CBHI OND data was obtained from the corresponding state governments. Using the above-mentioned datasets calculation was done for average annual number of OND cases per 1000 people and number of pigs per 1000 people, for the 51 districts considered in this study.

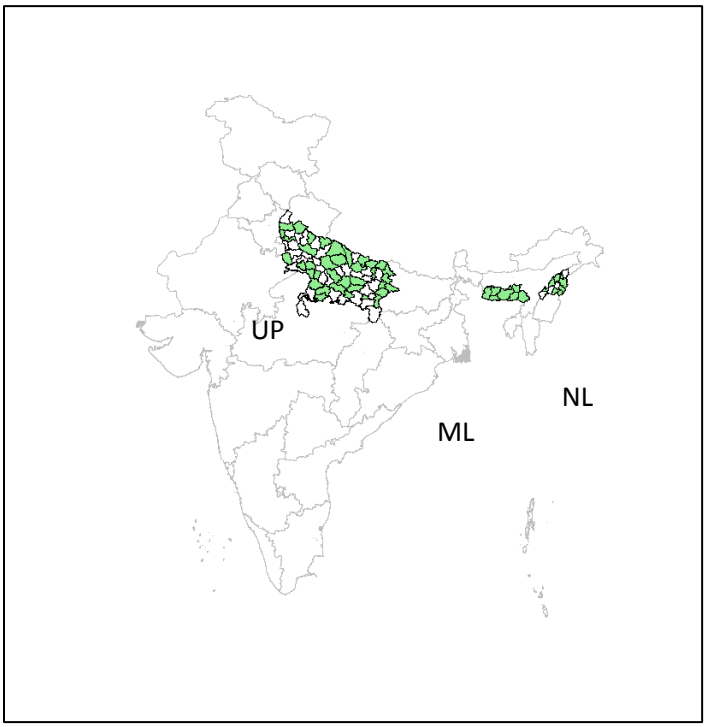


Figure 10: The distribution of the districts used in this analysis over the political map of India.

NB: The CBHI data on OND of the districts used in this study are shaded in green in this figure. Districts shaded in white were the districts with either insufficient data or data not available. Out of total 51 districts - 37 belonged to the North Indian state of Uttar Pradesh (UP), and seven each from the North-East Indian states of Meghalaya (ML) and Nagaland (NL) as par Census of India 2011.

Descriptive statistics

The districts considered in this study were very heterogeneous in terms of human population- ranging between minimum population of 50,484 (Longleng, NL) and maximum population of 4,474,446 (Sitapur, UP), with mean human population 1,849,141 per district. Whereas in terms of number of pigs West Garo Hills, ML had the maximum number of pigs (138,592), and Sant Kabir Nagar, UP had the minimum number of pigs (2467), the average number of pigs was found to be 30,234 pigs per district. The distributions of population, human as well as pig, were found to be significantly different from normal distribution (p<<

0.05, Shapiro-Wilk normality test). The average number of CBHI OND cases reported ranged between 0 (10 districts, all belonged to UP) and 1.406 cases (Ballia district, UP) with mean 0.192 cases per 1000 people. The distribution of OND cases was also found to be significantly different from being a normal distribution (p<< 0.05, Shapiro-Wilk normality test).

State wise, the average annual number of OND cases (between 2015 and 2016) were 0.419, 0.065 and 0.17 per 1000 human population for ML, NL and UP respectively. The average numbers of pigs per 1000 human population at state level were 190, 302 and 9 pigs for ML, NL and UP respectively. (Refer Table 4)

	Meghalaya (ML)			Nagaland (NL)			Uttar Pradesh (UP)			Combined		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Human population in districts	1,42,334	8,25,922	4,23,841	50,484	3,78,811	1,74,897	7,08,447	44,74,446	24,35,542	50,484	44,74,446	18,49,141
Number of pigs per 1000 people	72	294	190	184	592	302	1	34	9	1	592	74
Annual OND cases per 1000 people	0.014	0.984	0.419	0.008	0.213	0.065	0	1.406	0.173	0	1.406	0.192

Table 4: Summary of the data used in analysis

Correlation between number of pigs and OND cases

Both the distributions of number of pigs and annual OND cases (per 1000 people) were found to significantly different from normal distribution (p<< 0.05, Shapiro-Wilk normality test). Therefore, we opted for non-parametric Spearman rank correlation coefficient. The analyses at the level of states and three states combined are summarized in Table 5, Fig 12 and Fig 13.

From the analysis, the number of pigs per 1000 people and the average annual number of OND cases were significantly correlated for both UP and Meghalaya with a correlation coefficient 0.46 and 0.786 respectively with a p-value of 0.004 (<< 0.05) and 0.036 (<0.05) respectively. A correlation between the

number of pigs per 1000 people and average annual number of OND cases could not be inferred with sufficient confidence for Nagaland.

On the other hand, for the combined data of all the three states, number of pigs per 1000 people and number of OND cases per 1000 people were found to be significantly correlated with Spearman's rank correlation coefficient 0.43 and p-value of 0.0018 (<< 0.05). (Refer Fig 13)

State	Spearman rho	P Value
Meghalaya	0.786	0.036 (< 0.05)
Nagaland	-0.036	0.94 (>> 0.05)
Uttar Pradesh	0.46	0.004 (<< 0.05)

Table 5: Summary of state wise Spearman's rank correlation between number of pigs per 1000 people and average annual number OND cases per 1000 people in three states of India

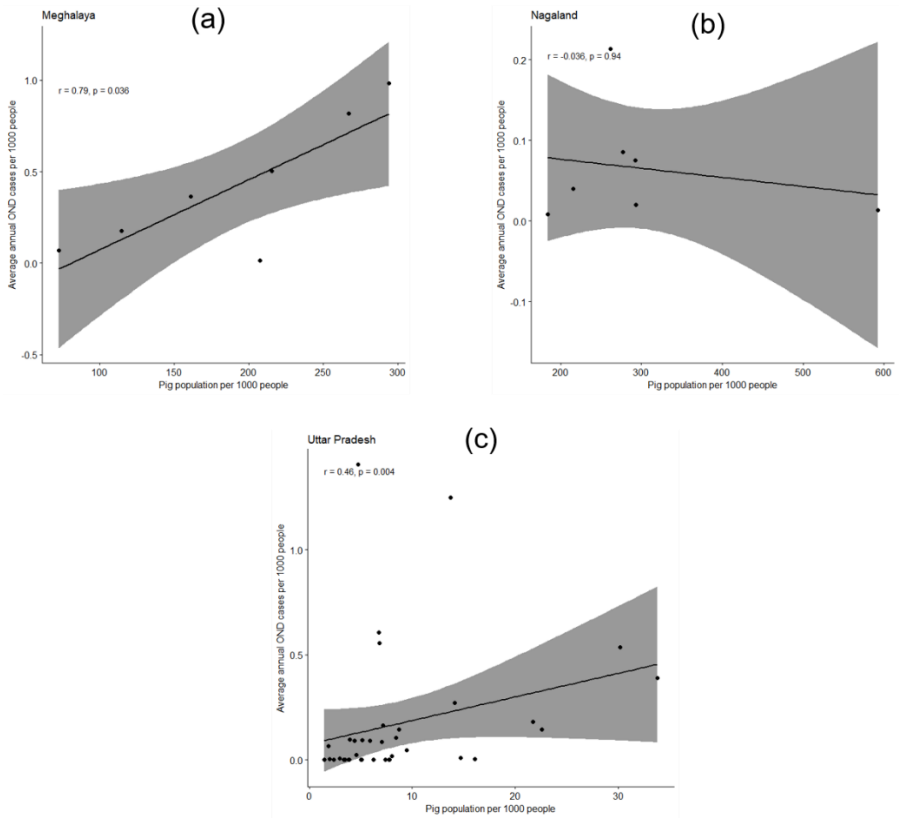


Figure 11: Estimation of Spearman's rank correlation and the confidence interval for the state level number of pigs per 1000 people and number of OND cases per 1000 people - (a) Meghalaya, (b) Nagaland and (c) Uttar Pradesh

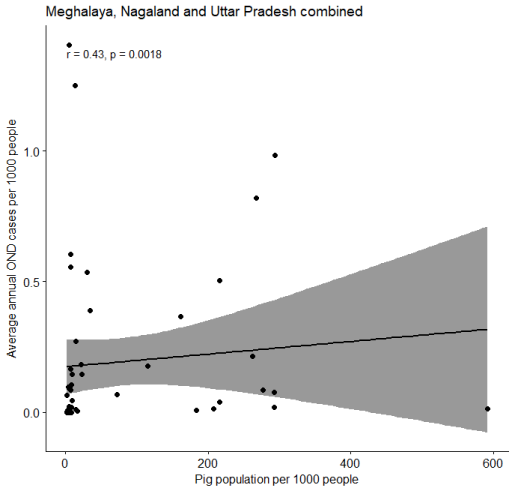


Figure 12: Estimation of Spearman's rank correlation and the confidence interval for number of pigs per 1000 people and number of OND cases per 1000 people - for the combined data from ML, NL and UP.

Identifying target areas for cysticercosis control in India

Analyses of the available datasets may lead to identification of the hot spots, enabling targeted interventions at district levels. The Swachh Bharat Mission maintains cleanliness ranking of the districts (IHHL coverage, ODF and a few other factors). The pig population data across India are available from the livestock census. Using human census data along with the livestock census data, one may easily calculate the pig density across the districts of India (say, number of pigs per 1000 people, a variable used in the analysis presented in this report) and CBHI maintains a record of OND cases at the district level. Intersection of the top percentile districts from each dataset might be used in identifying the target districts (Fig.14). The following example tries to identify the hotspot districts using the four sets of data mentioned above for 51 districts used in analyses before. The intersection of top 50% of the categories – the top 50% dirtiest districts: lowest cleanliness rankings (from SBM), top 50% high pig density districts: number of pigs per 1000 people (using Livestock census 2012 and Census of India 2011), and the top 50% of the districts in reported OND cases (CBHI data) leads to 7 districts, vis-à-vis., Mathura, Hardoi, Rae Bareli, Mahoba, Hamirpur, Unnao and Fatehpur (all from UP) (Fig.14) as targets for a district level targeted intervention program.

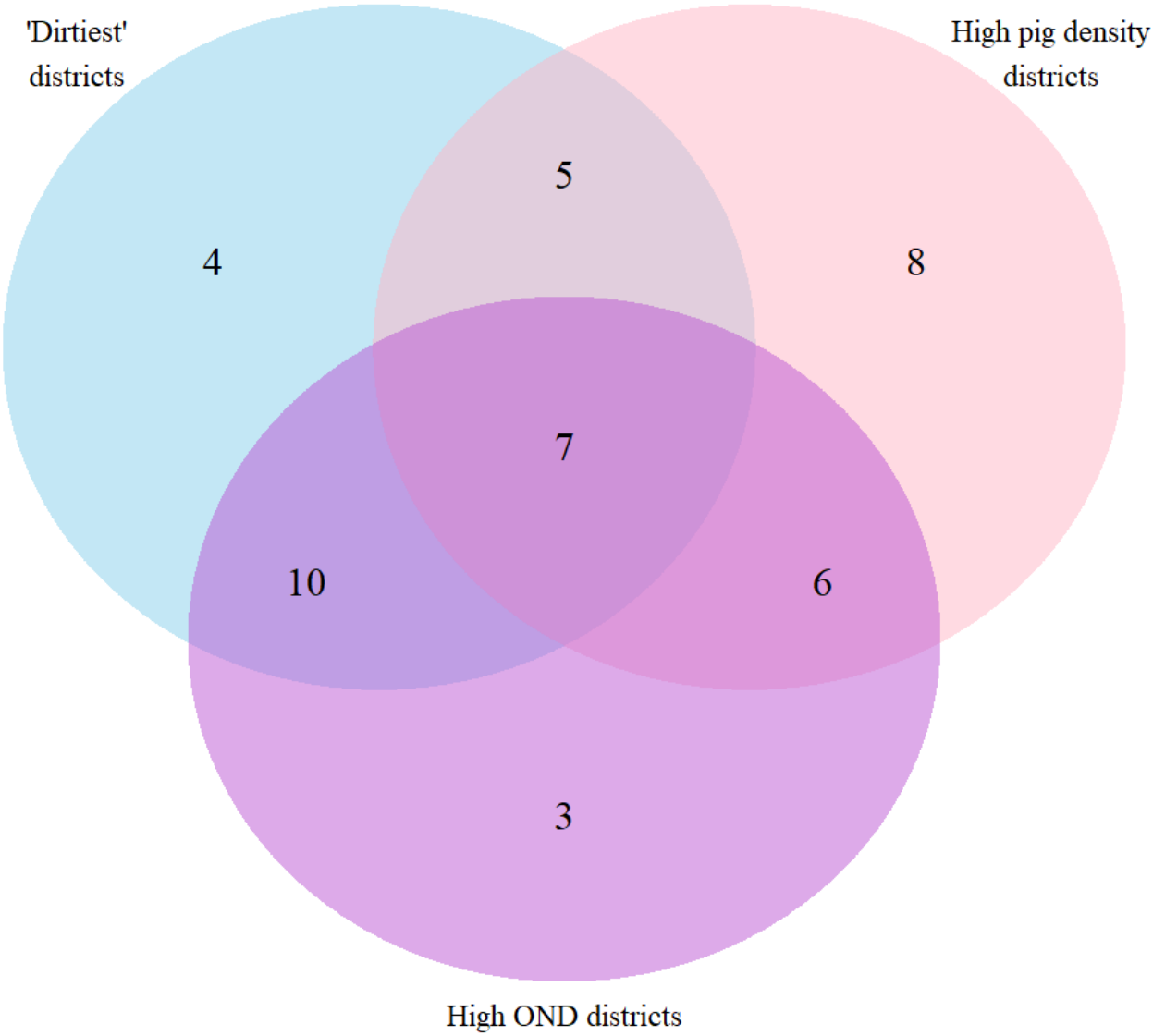


Figure 13: The concept of using the intersection of the top 50% of the 51 districts in different datasets to decide targets for an intervention program.

NB: In the above figure (Figure-13), the intersection between different datasets shows the number of districts to be targeted, based on the data sets considered.

The same can be represented on a geo-political map of India, showing the districts (Fig.15)

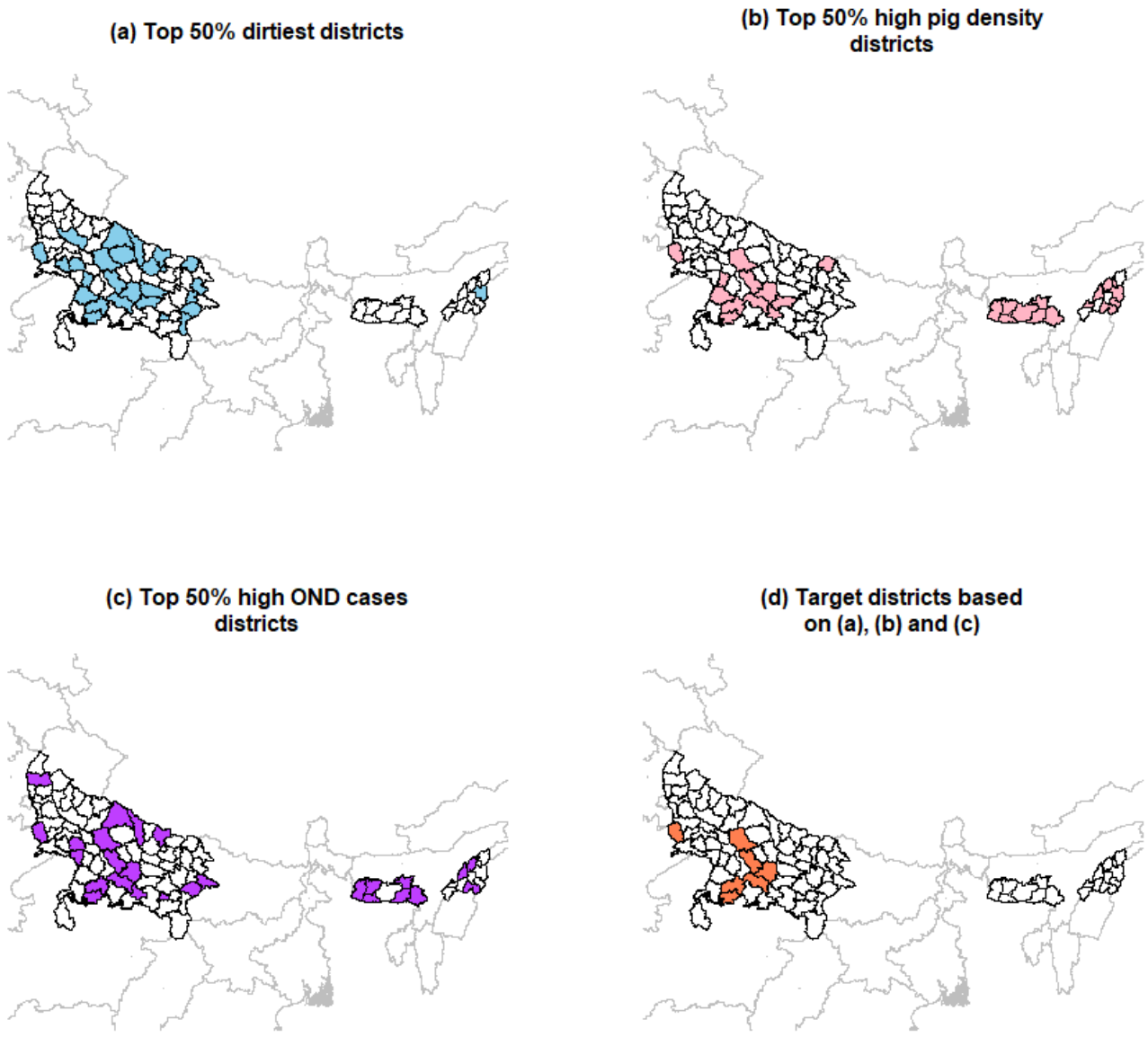


Figure 14: The top 50% of the 51 districts from each dataset and their intersection, shown over a map of India.

NB: (a) The top 50% of the dirtiest districts – districts with lowest SBM cleanliness index, (b) top 50% of the districts with highest number of pigs per 1000 people, (c) top 50% of the districts with highest average annual OND cases reported, and (d) the intersection of the top 50% from the three datasets (a), (b) and (c) - hotspots and targets.

The above analysis could not use data from NADRS or from Animal Disease Information Reports (ADIRs) available with DADF, Government of India. As mentioned earlier, NADRS /ADIR reports from states have provision for recording of tapeworm infection in Pig.

Future generated data from Government of India's ongoing initiative related to development of village cleanliness index (Refer section on landscape on sanitation) vis-à-vis village level free range pig population (derived from ongoing 20th Livestock Census) and Primary Health Centre record of epilepsy cases (if decided to be recorded by IDSP in real time) can be used for village level targeting after the districts are being selected with above conceptual model.

Targeting of areas can be made more robust by commissioning of available mobile / GIS based "One Health" surveillance system with provision of reporting by citizen stringers and farmers. Annexure-IV describes an application based "One Health" surveillance tool being tested by an Indian private organization in one of the study states vis-à-vis Assam. The tool has successfully capture data pertaining to confirmed cases of neurocysticercosis vis-à-vis pig population within the focused geographical area.

Finding of rapid situational analysis of select villages rearing pigs

Three villages of mostly tribal communities known for rearing of pigs were selected for rapid situational analysis. The objective was to explore the ground reality of village level implementation for any future taeniasis /cysticercosis control program using available tools e.g. Anthelmintic treatment and vaccination of pig for porcine cysticercosis. The selected villages are: Tengramari (Dist. Kishanganj Block or Tehsil: Kishanganj Cansus-2011 code: 222918), Govindpur (Dist. Pakur, Block or Tehsil: Pakaur Census-2011 Code: 360379) and Gokulpur (Dist: Pakur Block or Tehsil: Pakaur, 2011 Census-2011 code: 360349)

The key learning of the situational analysis includes:

1. The observed poverty in all the villages is a result of political, economic and social exclusion. Poverty is both a cause and a consequence of poor health.
2. Local pigs under free range /scavenging system is a common sight in all the villages. Many farmers however, buy farm waste to feed their pigs. The fact that they are investing on feeding of their pigs is a good sign and therefore there is scope to develop a sustainable chain of supply of drugs for deworming of pigs. However, this will require building of trust, community based awareness development and above all clear demonstration of benefits.
3. Pigs act as insurance against adversity for many families. Many farmers are forced to sell pigs at a young age to meet their immediate need.
4. Pork is an important and probably most common source of protein for poor families. The consumption is increasing with more disposable income.
5. Livelihood options are limited to crop and livestock, majority work as agricultural labor or periodic industrial labors (family labor) under contractor. (as observed in Tengramari)
6. They generally try to sell all free roaming pigs before cultivation season to prevent damage of crops by pigs.
7. Most of the people interacted with are not even aware of nearby veterinary facility, they believe on traditional practices. Making people adopt practices like deworming or vaccination will be a real

challenge. All the villages (which are relatively close to district headquarter) do reported occasional visits of trained para-vets.

8. Regular outbreaks of Classical Swine Fever (CSF) is forcing farmers to seriously limit herd size or go for early sale of stock. Vaccine for CSF is not available even in district headquarters. CSF is the priority disease for most of the pig farmers. Support for CSF control will be pre-requisite in many cases to build confidence / trust and promote use of porcine cysticercosis vaccine.
9. Open defecation is also common with very poor drainage, sanitation and water supply system. Farmers in majority of cases informed that because of poverty, problems related to land ownership, social exclusion due to caste system and poor leadership at community level they are unable to access benefit of ongoing government schemes aimed at development of infrastructures.
10. No community facility exists for slaughter of pigs. Meat inspection is a distant reality.
11. Many people slaughter their pigs at home and sell only remaining pork to people within the immediate community or to people living in nearby village.
12. Live sale of pigs is rare. Traders of live pigs visit villages only occasionally. They aggregate pigs after purchase and then transports to various destinations.
13. Awareness regarding cysticercosis, as disease is limited but majority farmers have encountered 'measly pork'. The local name of 'measly pork' encountered in these villages includes: 'Bangur' (village in Kishanganj) and Bajra (village in Jharkhand). Trimming of affected part is the only loss they are encountering. However, in many instances poor people are also buying such trimmed part at a lesser price.
14. Health awareness regarding tapeworm infection in human and the risk of consuming under-cooked infected pork is very limited. Few informed that consumption of under-cooked pork along with alcohol is a possibility at local restaurants.
15. Epilepsy is a common problem is all the three villages visited. However, no attempt was made to count numbers of families with such reported cases. Many believe that, there is no treatment for epilepsy. It is obvious that many patients hardly visit or report to hospitals.

The situational analysis was conducted coinciding with pilot study for a detailed Knowledge, Attitude and Practice Survey.

Analysis of Knowledge Attitude and Practice Survey

A primary survey to document Knowledge, Attitude and Practices related to cysticercosis amongst pig farmers, traders and field level policy implementers were conducted between 04/07/2017 to 30/07/2017. The procedure of conducting the survey was discussed in detail under methodology section and in Annexure-III. Following is the analysis of survey data at country level. The analysis is vary considerably between individual states and amongst districts.

It is a recognized fact that most parts of the livestock value chain in India are highly informal. The various categories of actors are not always well defined. There are individuals engaged in multiple functions or dealing with different products. Traders are also highly mobile and unlikely to respond to direct queries related to their business. Being an informal market, supply flows are likely to be non-linear and dynamic,

changing from day to day. It is difficult to derive representative budget information considering the non-linear supply system and inadequate records.

Analysis of survey of pig farmers

Data from pig farmers were collected from 675 respondents belonging to 154 villages from **seven** states of the country.

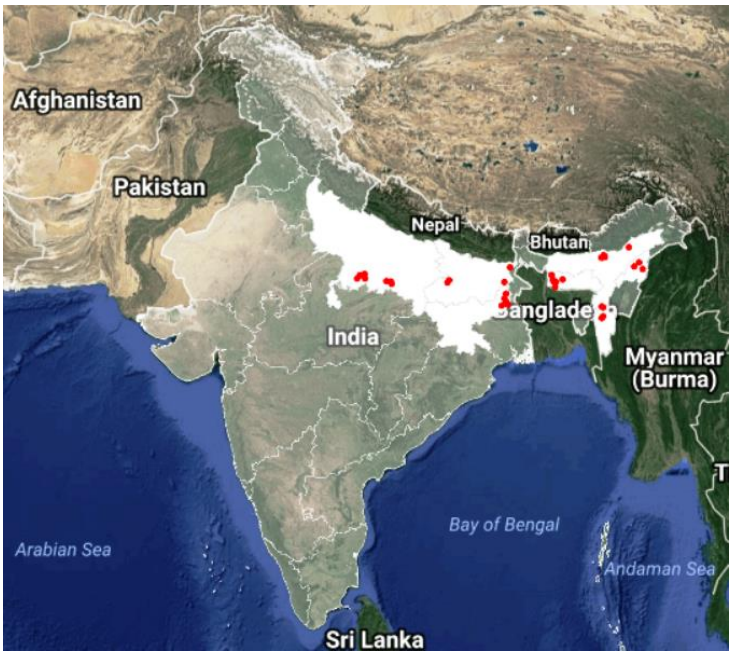


Figure 15: Spatial distribution of survey location

In 59% cases, the mobile number of respondent could be collected for easy tracing back of any missing data. The ratio of male and female respondent is 531:144. Around 48% respondents are below 40 years of age. In 79.1% cases, the respondent is a head of the households out of which 12.5% respondents were female. A good percentage of respondent (66%) have formal education with 12% having college level education. For 33% respondents' livestock and crops together are their main activity though 12% respondents reported government service too. Around 48% of respondents indicated selling of farm produce is one of the main income source. However equally 47.7% indicated salary or wage as main income source. Interestingly, for 37% of respondents for whom both livestock and crop is main activity income source is also wage. Majority of respondents can be categorized as small farmers as 63% of them rear not more than five numbers of local pigs. It is important to note that out of the 675 farmers interviewed only 27% farmers are rearing crossbred pigs.

The respondent profile in all the seven states are shown in table-6.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Number of farmer respondents.	100	100	100	76	100	100	99
Number of villages	22	7	46	28	13	18	20
Percent respondent sharing mobile numbers.	77	12	19	75	99	97	35
Ratio of male and female	75:25	93:7	79:21	31:45	77:23	80:20	96:3
Percent of young Respondents < 40 years	56	54	63	51	21	49	41
Percent respondent as head of household	65	100	93	45	86	60	97
Percent female amongst responding head of household.	16	7	23	20	14	6	3
Percent respondent with formal education.	90	22	47	88	89	100	30
Percent respondent with college level education.	11	0	3	21	5	41	3
Percent respondent with livestock and crop together as main activity	58	35	91	39	6	2	1
Respondents in government service	4	0	0	21	27	33	0
Percent respondent with selling of farm produce as one of the main income source	96	4	77	82	25	25	32
Percent respondents indicating salary or wage as main income source	23	97	20	36	43	47	66
Percent respondents whose main activity is crop and livestock but income source is also wage.	38	100	19	30	0	0	0

Percent small farmers < 5 animals	63	75	78	87	4	98	42
Percent farmers rearing crossbred pigs	49	0	1	41	98	1	3

Table 6: Farmer respondent profile across study states

Review of respondent profile in various states can support following assumptions:

- Access to mobile phones amongst pig farmers are relatively good in case of Northeastern states than in Bihar, Jharkhand and UP.
- Female farmers are more empowered in case of northeastern states.
- In majority cases, young people are showing interest in pig farming for states like Jharkhand, Assam, Bihar and Meghalaya.
- More female farmers are playing the role of head of household in case of Jharkhand, Meghalaya and Assam.
- Educational level of pig farmers is relatively poor for states like Bihar, UP and Jharkhand.
- A good number of pig farmers in Northeastern states are also government servant.
- In Bihar and UP majority pig farmers are also wage laborers.
- The herd size per family is bigger in case of Mizoram and UP.
- Crossbred pig is gaining popularity in Mizoram, Assam and Meghalaya.

Country level analysis indicates that in 45% cases, the pig husbandry system is predominantly free ranging (refer Fig 16). The variations across the state are shown in Fig 17.

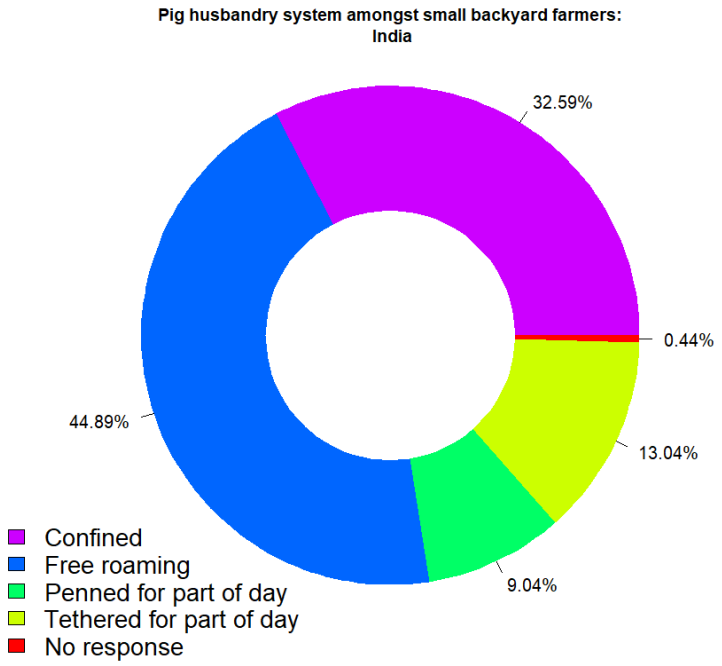
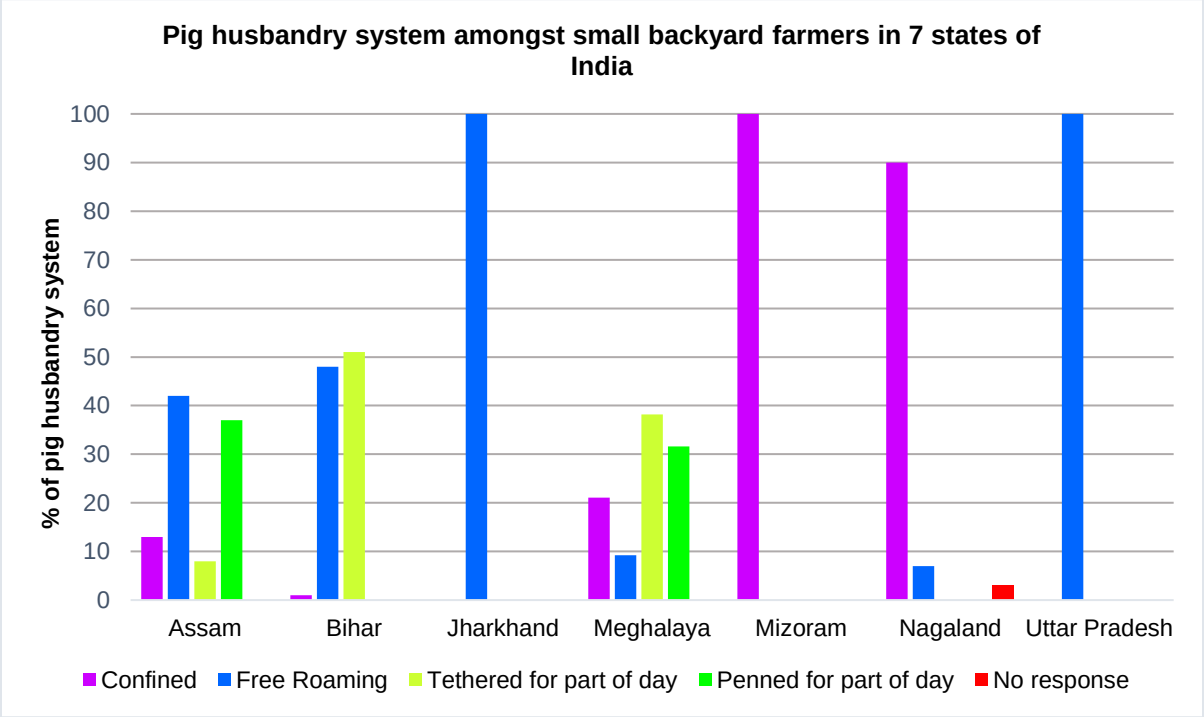


Figure 16: Husbandry system amongst backyard pig farmers (India)



The above analysis supports assumption that pigs are reared mostly under confinement in case of Mizoram and Nagaland and is largely free ranging in case of Jharkhand and UP.

As per country level analysis, as high as 94% of respondent's feeds household scraps and 40% of respondents allow scavenging. Farmers do not exclusively aim for breeding or sale of piglet. However, 27% respondents admitted selling piglets. This may be due to their need to maintain optimum herd size. Refer table 7 for state wise comparison.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Percent farmer feeding household scraps	83	100	100	91	98	92	96
Percent farmer allowing scavenging	49	27	93	3	0	0	99
Percent farmers selling piglet	65	25	2	5	31	54	0

Table 7: Feeding and breeding practices across seven states.

The feeding of household scrap is common across states. Farmers in Jharkhand and UP mostly raise pig under scavenging system. High percent selling of piglet is observed in Assam and Bihar. This may be due to increase demand for piglet from new farms trying to tap the opportunity of high demand for pork in these states.

The country level average price of finished live local pigs can be calculated at Rs.159.27 per kg body weight. In the majority cases, pigs are being sold at the body weight of 50 kg. As per literature, the local pig in India attains this weight at around 10 months (Khargharia, 2014). Table 8 indicates the variations across the study states.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Average price (Rs.) of finished live local pig per kg body weight.	177.94	148.62	131.87	68.62	215.86	180	126.3
Average body weight at sale (kg)	50	60	20	40	90	100	70

Table 8: Price and average body weight at sale across seven study states.

The high price observed in case of northeastern states like Assam, Mizoram and Nagaland is likely to be due to demand and supply gap. The price observed in case of Meghalaya needs further verification as the state is known for its demand for pork.

As expected from smallholder farmers, 47% respondents across all states informed that they also rear pigs for home consumption. As high as 68% of the respondents informed that they slaughter pigs at home while 97% respondents indicated that everyone in their family consumed pork. This indicates the importance of educating farmers on some basics of meat inspection besides setting up and popularization of community level small slaughtering facilities for pork safety. Only 3% of the respondent farmers indicated any instance of meat inspection by officials. The table 9 indicates state level variations.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Percent respondents rearing pig for home consumption	32	68	9	71	1	61	93

Percent respondent indicating slaughtering pigs at home	39	100	98	59	2	79	99
Percent household with everyone in the family consuming pork.	94	100	98	96	97	97	99
Percent instances of meat inspection by officials	0	0	0	0	0	17	0

Table 9: Practices regrading consumption, slaughtering and instance of meat inspection

The rearing of pig for home consumption is relatively much less in Mizoram. This may be due to the commercial nature of farming with majority rearing crossbred pigs.

Interestingly at national level, 9% of the sampled farmers were found to be engaged in contract farming. Contract farming in the study context was defined as farming on behalf of others and as such not necessarily indicate corporate contract farming. In UP as high as 40% respondent farmer are engaged with contract farming. This is 22% for Bihar and 0% for all the other 5 study states.

At the national level, only 16% farmers indicated worms as the main problem encountered and only 1% indicated cysticercosis as a problem. This may be due to low level of awareness about the disease. Large-scale adoption of practice of regular deworming of pig may require linking it to weight gain in near future.

Regarding the percentage of loss in price due to 'measly pork', only 1% respondent reported 50 to 75% loss. Majority of farmers are unable to estimate loss due to consumer rejection or voluntary throwing away of infected part of pork. It may be due to poor awareness or inability on the part of the interviewer to explain the indirect loss. Table -10 summarizes responses across the states.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Percent respondents indicating worm as problem	52	18	12	24	0	11	0

Percent respondent indicating fever as problem	25	89	67	0	0	0	94
Percent respondent indicating cysticercosis as a problem	8	0	0	1	0	0	0
Percent loss of price due to measly pork Up to 50%	0	0	0	0	0	0	0
Percent loss of price due to measly pork Up to 50-75%	5	0	0	0	0	0	0
Percent loss of price due to measly pork Up to 75 -100%	2	0	0	0	0	0	0

Table 10: Farmer response on problem of porcine cysticercosis across study states

Respondents indicating worm as a problem is much high in Assam comparison to other states. Humid climatic conditions of the state are very conducive for parasitic infestations. Previous research in Lakhimpur district of Assam (Deka, S.Choudhury, & Chakraborty, 1995) , which is a study district indicated metacestodes *cysticercus cellulosae* in Pig as very common. Very high reporting of fever in UP, Bihar and Jharkhand may be linked to Classical Swine Fever outbreak as regular vaccination against the disease is rare in these states in comparison to states in northeast of India. Except in Assam and Meghalaya, no sampled farmers in other states recognizes porcine cysticercosis as problem. This may be however, due to low awareness and the fact that disease is not leading to rejection of pork in absence of meat inspection.

Country level analysis indicates that up to 54% respondent farmers sell pork in local markets. While 67% have reported seeing 'measly pork', only 3% farmers know what measles is. Similarly, very few (3%) of the respondents could inform as to how pigs get cysticercosis or 'measly pork'. However, 50% farmers eat measly pork and 56% sell infected pork. Table 11 indicates findings across various study states.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Percent respondents selling pork in market	9	99	100	68	2	3	98
Percent respondent reported seeing measly pork.	50	99	100	54	6	55	99
Percent respondent who know what measly pork is.	3	0	2	0	0	16	0

Percent respondent who could inform how pigs get measly pork.	12	0	3	0	0	6	0
Percent respondent eating measly pork	44	92	71	64	0	0	84
Percent respondent selling infected pork	48	99	100	64	0	0	85

Table 11: Farmer responses on measly pork across study states

The table (Table 11) indicates that very low percentage of farmers sell pork in local market in states like Mizoram, Nagaland and Assam. This is because trading and retailing of pork is more developed and common in these states. Percentage of respondents who reported seeing measly pork is much higher in states like Jharkhand, UP and Bihar than the states of northeast India. Similarly, very high percentage of farmers in Jharkhand, Bihar and UP are engaged in risky practices of eating and selling of measly pork. This is primarily because of very low level of knowledge pertaining to the disease in these states.

Clean, open defecation free environment and prevention of fecal contamination of drinking water is essential for control of taeniasis /cysticercosis. The country level analysis revealed that 60% respondent households do not have latrines. Drinking water supply in 48% cases is borehole where as only 7% indicated hand pump. Table-12 indicates the findings across study states.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Percent respondents not having latrine	47	97	83	4	0	90	85
Percent respondent with drinking water supply from borehole.	56	99	99	28	0	1	51
Percent respondent with drinking water supply through hand pump.	45	0	0	0	0	0	0
Percent respondent with tap water supply	0	1	0	8	23	26	49

Table 12: Access to latrine and clean drinking water across study states

The above table (Table -12) indicates that open defecation is very common in Bihar, Jharkhand and UP in comparison to states in northeast except for Nagaland. The result of Nagaland is surprising as secondary government data (MDWS, GOI, 2017) indicates that 46.3% of the state is open defecation free and

Individual House Hold Latrine (IHHL) coverage within the state as on September 2017 is 85.32%. Table-3 in previous sections indicates open defecation free status of all study states. Borehole or hand pump as water source, which is relatively safe is not recorded in hill states like Mizoram and Nagaland. The people in these states normally uses spring water and water supplied through tap. The fact that open defecation is less and pigs are being reared in confinement are two main factors reducing the risk of cysticercosis in state like Mizoram.

As far as awareness regarding tapeworm infection in human is concerned, at country level, 25% respondent informed that they know about it but only 3% respondents had heard of or met someone within their village having tapeworm infection. The depth of awareness can be judged by the fact that 4% of the respondents reported presence of tapeworm in stool as the best way for one to know his or her infection. Eating infected meat as source of tapeworm infection was reported by 3% of the respondents. Interestingly amongst those who are aware of tapeworm, 94% feels that one should go to hospital and rest 5% would prefer traditional medicine against tapeworm. The analysis indicates that awareness program will be required for farmers to accept adult deworming programs to fight taeniasis.

Cases of epilepsy seems to be common as up to 52% respondents informed that they have heard people saying or complaining about epilepsy within their village. Interestingly, 4% respondents are aware of cases of worm in eye and 9% reported people complaining about skin nodules. It was not the scope of the study to find out individual cases within the villages, verify and to investigate further to quantify prevalence of epilepsy originating from neurocysticercosis.

To understand the best way to convey the disease information or to create awareness, respondents were asked to inform about their source of information as far as their current knowledge is concerned. While many avoided answering the specific question on source of information, only 9% indicated veterinarian and para-veterinarian as source of information for the disease. Table-13 indicates findings across study states.

	Assam	Bihar	Jharkhand	Meghalaya	Mizoram	Nagaland	UP
Percent respondents who know about tapeworm infection in human.	62	0	0	7	2	100	0
Percent respondent who have heard or met someone within their village having tapeworm infection.	16	0	0	3	1	0	0

Percent respondent who indicated tapeworm in stool as best way for knowing presence of infection.	19	0	0	5	0	1	0
Percent respondent indicating eating of infected pork as source of tapeworm infection.	18	0	0	5	0	0	0
Percent respondent who are aware of tapeworm and indicated one should go to hospital	84	0	0	100	100	100	0
Percent respondent who are aware of tapeworm and prefer traditional medicine.	15	0	0	0	0	0	0
Percent respondent indicating presence of epilepsy within their village.	58	98	97	12	0	0	89
Percent respondents indicating incidence of worm in eye within their village	25	0	0	0	0	0	0
Percent respondents indicating incidence of skin nodules within their village.	5	0	0	75	0	0	0
Percent respondents indicating veterinarian and paraveterinarian as source of information.	32	0	0	0	1	2	0

Table 13: Knowledge of farmer about and Incidence of human diseases linked to Taenia solium infection

The above table (Table 13) indicates very high variation as far as knowledge of tapeworm infection is concerned. The knowledge level is relatively good in case of Assam. A very interesting observation is responses of average 95% of sampled farmers of Bihar, Jharkhand and UP indicating presence of epilepsy cases in their villages. The reach of veterinary service personnel as knowledge provider is also limited across the states.

Analysis of survey of pig traders

The responses for this survey was collected from 188 small-scale pig traders belonging to seven states and 87 villages. The trading activity was defined as aggregation and / or both sale of live pigs / piglets and sale of pork. Considering the small sample size, state level analysis was avoided in majority of cases.
In 57% cases, mobile numbers could be collected from the respondents for easy tracing back of any missing data. The ratio of male and female respondent is 172:16. Majority (67%) of the respondents are young (< 40 years). In 81% cases, the respondent is a head of the household with 4% female trader as head of her household. The literacy level of the traders was found to be high as only 27% have no formal education. Only 6.3% of the respondents' indicated livestock farming and trading together as main activity. In 89% cases the trader is not a livestock farmer but involved in agricultural cultivation. Some (14%) respondents reported business (other than pig trading business) as also their livelihood activity. It can be assumed that trading is not common for pig farmers.

Up to 16% of the respondents indicated selling of farm produce as also their main income source. A good number (35%) of traders also gain income through sale of pork. Generally, for small-scale pig traders, trading is often a subsidiary activity to crop and livestock farming and they do both trading of live animals and sale of pork after slaughter.

From the health knowledge point of view, the country level analysis indicates that only (2/188) traders are aware of tapeworm infection in humans. However, 98/188 (52%) of traders have heard of people in their village saying or complaining about epilepsy. Traders who reported about people complaining other symptoms include- chronic headache (17/188), madness (2/188), skin nodules (19/188).

As high as 69% of traders interviewed have seen measles in pig meat but only 2.7% traders know what measles is. Similarly, only 2% traders could explain as how pigs acquire this infection. As high as 51%, reported that they eat measly pork and 55%, reported that they sell such pork. While many avoided answering the specific question on source of information, only traders (9.6%) indicated veterinarian and para-veterinarian as source of information.

As high as 97%, of the traders buy pigs from backyard farmers and 56%, (105/188) of them pay based on live weight and the rest pay on pork obtained. From the collected data, in majority of cases pigs are sold at the body weight of 40 kg for backyard local pig and 100 kg for crossbred pig. The average price of finished live local pig and crossbred pig is Rs.142.53 and Rs.191.24 per kg body weight, respectively.

A huge majority of traders (162/188) traders (162 / 188) sell pork through their own shops. Some traders (3/188) indicated selling live pigs to other meat shop owners. There are categories of traders such as big and small, in the current study 4%, (8/188) traders indicated that they sell live animals to big traders. None

of the local traders was found to aggregate purchased live pigs and then transport it to outside the area. Similarly, there is no procurement form established processors. Presence of organized procurement from processors or local aggregating traders in any locality is important, as they can be good contact point for market linked capacity building to streamline production as per market requirement and safety standards. Some traders (32%) indicated direct sell to consumers. It may be such that produce is consumed within the village itself. The analysis indicates presence of traders (8/188) who procures from other traders, growth of such traders is likely to increase with increase in urban demand. Since reaching out to all traders will be costly, identifying and communicating to such relatively big traders regarding the disease can be more feasible. It will also have more impact down in the chain e.g. producers.

Though 19% of traders indicated presence of local slaughterhouse, the study failed to capture the kind of slaughterhouses they are referring to. It is a known fact that public slaughterhouse for pigs is very rare in India. Up to 22% traders slaughter pigs in their shop only. A good number of traders (37%) are aware of porcine cysticercosis (from their local name). Only 8.5% traders think that the disease can be identified in live pigs too. A good number of traders (34.6%) indicated that they reject all pork when they find it is infected. However, this seems unlikely considering the awareness level indicated above and the cost implication. A good number of traders (38%) indicated that they sell 'measly pork' after trimming the affected part. Few traders (3/188) who said they reject all pork also indicated that they reduce price too. Either this may be due to wrong understanding of the question or they look for opportunity of selling the meat at a reduced price instead of rejecting all of it. It is interesting to note that, some traders (15.4%) know local meat inspector as in India meat inspection is not usually enforced in rural areas from where data was collected.

Based on the data generated from 188 traders interviewed, the probability of a purchased pig to show measly pork on slaughter is 2%. This however, varies from state to state. Fig 17 indicates the state level variations.

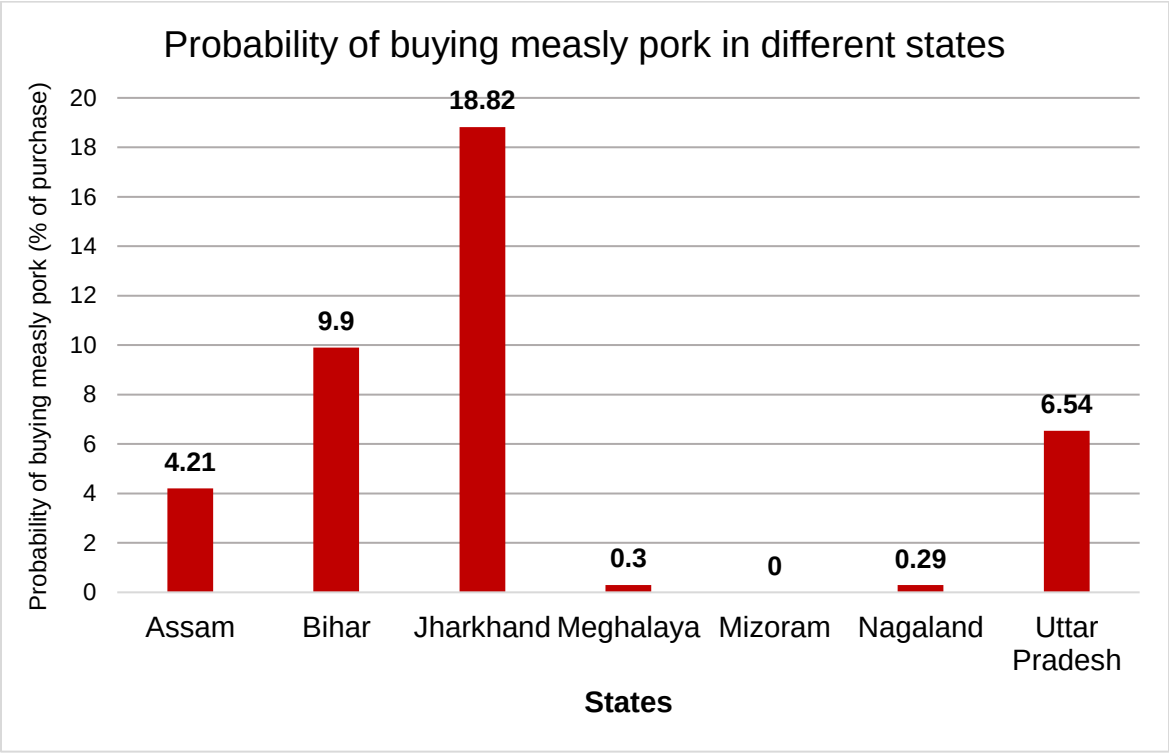


Figure 17: Probability of a trader buying measly pork in different states

Analysis of survey of policy implementers

The survey covered 150 respondents, who are field level policy implementers such as- teacher (30), municipal member (26), human doctor (21), veterinarian (17), NGO and social worker (15), technical staff (6), administrative officer (6), nurse (5), health worker (5), animal health worker (4), researcher (3), public health engineering official (3), pharmacist (2), administrative officer (2), veterinary college teacher (1), public distribution system worker (1), journalist (1), ex-serviceman (1), designation not specified (1).

A good number (10/21) of medical doctors reported that there is no ongoing government program to control *Taenia solium*. The secondary data too confirms this. While 8 /21 doctors reported that taeniasis and neurocysticercosis are not notifiable, 10 doctor(s) out of 21, with 1-30 years' experience range reported that both diseases in human are notifiable. As per available information, none of the diseases is notifiable by law in India. Detail of procedure of health data gathering in India is explained in earlier sections. All the 21 respondent doctors reported that there are mass drugs administration (MDA) program of government to fight worms and 12 amongst them think that MDA will not address taeniasis. As per secondary information, government of India conducts mass deworming program primarily to fight round worms amongst schoolchildren. Detail of this was discussed in sections. None of the doctors could mention the name of the MDA program of government they are referring to. According to 7 out of 21 responding doctors, a government doctor is not required to engage in active identification and treatment of taeniasis. The secondary data indicates that active identification and treatment of taeniasis is not mandatory. Only 12 out of the 21 doctors interviewed remembers specific health education program that talked about tapeworm and link of the disease to eating of undercooked pork. The have varying degree of knowledge and opinion of 'one health' intervention.

The majority of (11/17) veterinarians reported that they need to enforce or undertake meat inspection and a good number of (7/17) them follow the procedure of incision of heart muscle, masseter muscle and tongue for cyst. Some (4/17) of veterinarian respondents informed that in the last 10 years they have observed improvement in meat inspection and quality control service. While 15 of them could not mention specified improvement, one indicated increased number of meat inspectors, one indicated more training option for butchers, and one indicated setting up abattoirs. None of the veterinarian respondents was aware of vaccination of pig for control of porcine cysticercosis. All of them have indicated that they prescribe anthelmintic to pigs for control of porcine cysticercosis and mentioned drugs like - albendazole.

A huge majority of (94.6%) respondents are happy with the ongoing government program related to Swachh Bharat (Clean India Mission) or program aimed at making a village free from open defecation. Majority of (79%) respondents feel that clean (Free from fecal contamination) drinking water is available for villagers. Only 17% respondents could indicate that there is specific program of government to ensure clean water to villages out of this only three of the respondents could rightly mention piped water scheme of public health engineering department. A good number of (55%) respondents recognized the need for working together. Some (19%) respondents highlighted the need of awareness development amongst both farmers and consumers.

Synergy and partnership for taeniasis / cysticercosis control program in India

As indicated earlier (Refer section on general policy environment), the experience gained by India in control of a few known NTDs is also likely to encourage the government to undertake a national control program related to cysticercosis. Targeting more NTDs than the existing will improve India's ranking in terms of IHR zoonosis related indicator discussed earlier. Any cysticercosis control program in the current context can be synergistically linked to ongoing efforts – the most important of which is the flagship 'Clean India Mission' implemented by Ministry of Drinking Water and Sanitation, Government of India. It is possible, that convergence of available resources under mission can be made in areas to be targeted for cysticercosis control.

India is a leading partner under Global Health Security Agenda (GHSA). As per GHSA action packages are concerned, India is taking lead in packages related Anti-Microbial Resistance (AMR) and Immunization. CDC India under GHSA Zoonotic Disease Action Package is working with NCDC to prevent zoonotic diseases by strengthening intersectoral coordination. GHSA linked 'One Health' projects of CDC in India relate to Anthrax, Brucellosis and Antimicrobial Resistance (AMR). CDC-India's is currently collaborating with ICAR-NIVEDI for a project titled 'Countrywide surveillance for Anthrax in livestock and Mastitis in cattle for protecting and improving health. Globally: Building and Strengthening Public Health Impact, System, Capacity'. The experience of CDC in intersectoral collaboration and in implementing the GHSA action package on zoonotic disease in India can be great asset in designing future One Health taeniasis / cysticercosis control program.

The Soil Transmitted Helminths (STH) unit of NCDC under its Parasitology division provides technical support to mass deworming program implemented in India. Since 1963, NCDC has been conducting STH (round worms) surveys in different parts of the country and supporting state health departments and other

partners for countrywide de-worming programs in schools. India's deworming program - supported by partners like Children's Investment Fund Foundation, GlaxoSmithKline, Evidence Action etc. - is the world's largest ever school-based deworming programme. STH division as partner can provide valuable inputs including those related to private sector and donor engagement for mass deworming of human suffering from taeniasis under any future one health' program to control parasitic NTDs like cysticercosis cause by helminth too e.g. tapeworm.

Documented research in India (Jain, et al., 2015) indicate that presence of epilepsy is similar among tribal and non-tribal. However low socioeconomic status, low income, and less education of majority of tribal communities can be regarded as risk factors for epilepsy (Amudhan & Gopalkrishna , 2015). The risk factor for neurocysticercosis is likely to be high in tribal communities because of their preference for pork obtained from pig reared under free-range system. More detail study can further confirm this assumption. A taeniasis / cysticercosis control program can be a synergistic effort in the context of achieving health outcome in tribal dominated areas. Government of India is earmarking separate allocations under Scheduled Caste Sub Plan (SCSP) and Tribal Sub-Plan (STSP) as an instrument of inclusive growth since 2011. A scheme of local taeniasis / cysticercosis control program can be supported under this plan. States with sufficient tribal populations have developed independent institutional mechanism e.g. Jharkhand Tribal Development Society (JTDS) under social welfare department to implement schemes under such plans. These institutions can be viable partner at field level for a national taeniasis / cysticercosis control program. ICAR maintains a Tribal Sub Plan (TSP) cell at its head quarter to oversee implementation of the internal scheme meant for benefit of tribal communities. The study recorded that ICAR-NRC on Pig, Rani, and Guwahati is promoting number of schemes under the plan that ranges from piglet distribution to promotion of small-scale hygienic pig slaughterhouse (up to 5 pigs a day). Here the scheme of promotion of small-scale hygienic pig slaughterhouse can be linked to taeniasis / cysticercosis control.

Government of India in recent years have established a center of excellence for Epilepsy[12] at All Indian Institute of Medical Sciences (AIIMS), New Delhi under a DBT (Department of Biotechnology), and GOI funded program. Government is also considering launching of a National program for epilepsy control. A review of a paper related to the proposed program (Tripathi, et al., 2012) indicated that the program is not considering steps needed to prevent neurocysticercosis – a major cause of epilepsy. Any future taeniasis / cysticercosis control program can align its technical backstopping and field activities with that of work of the centre of excellence and future national epilepsy control program respectively. In the context of technical backstopping to future cysticercosis program, the Centre of Excellence on Epilepsy can be assigned by government to undertake hospital record based study for further evidence creation on linkage between epilepsy and pork consumption in India.

Future taeniasis / cysticercosis control program can also engage with ICAR National Research Centre on Pig and IVRI's outreach program on Zoonosis for more detail study on epidemiology of cysticercosis / taeniasis affectively bridging the gap in knowledge in local context and required evidences. (Refer section on gap in evidences, page 22).

A partnership with leading technical associations like Indian Epilepsy Society (IES) can be helpful to ensure enhanced reporting of epilepsy cases originating from neurocysticercosis.

[12] http://coeepilepsy.in/home.php

The Tata trust and its promoted organizations like Collectives for Integrated Livelihood Initiatives (CInI) in central India and The North-East Initiative Development Agency (NEIDA) in North East India have been working actively for piggery sector development in India. They have collaborated with International organizations like International Livestock Research Institute (ILRI) to find solutions to issues pertaining to health service delivery, value chain improvement and pork safety. The paper by (Fahrion, et al., 2013) referred in the section on literature review, which was supported by the trust helped in creating the evidence of cysticercosis prevalence within Nagaland. NEIDA is also working closely with ministry of drinking water and sanitation. A national taeniasis / cysticercosis control program can effectively build upon the work done by these organizations.

Recommendations

The success and experiences gained by India in the control of a few select Neglected Tropical Diseases (NTDs) in recent years should energize all stakeholders to work for control and potential elimination of taeniasis /cysticercosis from India. The time for action is appropriate as the country is already implementing the flagship 'Clean India Mission'. A designed 'One Health' cysticercosis control program assumes immense importance in the context of government agenda of preventive health focus and achievement of SDG goal target 3.3 related to Neglected Tropical Disease (NTDs). Since the disease largely affects poor and excluded communities, such a program conforms to government core governance mantra: *Sabka Saath Sabka Vikas* (collective efforts, inclusive growth).

Based on the learning, the study recommends the following:

For Central government departments and agencies

Institution: NCDC

NCDC should commission a study for detail analysis of data available with DADF, ICAR, CBHI and Ministry of Drinking Water and Sanitation to declare target areas for taeniasis / cysticercosis control in India using the methodology shown in the report. Once such areas are identified, steps should be taken to generate further evidences (focusing on the areas identified) in the context of extent of linkage of epilepsy (neurocysticercosis) to pork consumption (Study based on detail follow up of patients sampled from tertiary level hospital records). Any innovative mobile based surveillance system that engages citizens and stringer network of pig farmers / traders can further assist in generating local level evidence (beyond government data) on taeniasis / cysticercosis prevalence both in human and animals for the targeted districts. The report discussed one such system. IDSP units from such areas may be instructed to include epilepsy / neurocysticercosis under surveillance (Refer category on state specific disease).

Subject to satisfied evidences, NCDC should proposed to the appropriate authority within the government to initiate work for a designed one health control program preferably linking it to any future National Epilepsy control program.

NCDC may seek partnership under GHSA agenda to mobilize resources and to develop the road map of taeniasis / cysticercosis control program implementation in India.

Institution: DADF / ICAR

DADF and ICAR should undertake programs for upgradation and optimum use of existing animal disease reporting and forecasting system respectively. ADIR reports from states available with DADF can also be used for targeting hotspot areas mentioned above. Investment should be made for targeted orientation programs for field officers and to explore integration of reporting systems with surveillance system of IDSP.

Institution: FSSAI

To support any future 'One Health' taeniasis /cysticercosis control program, FSSAI can circulate a model instruction to local bodies in-charge of pig slaughterhouses specifying the procedure of meat inspection in pig and policy to be followed for condemning carcasses. FSSAI can also suggest slaughter houses receiving pig that are not from local area to mandatorily look for certificate of porcine cysticercosis vaccination issued at the point of origin.

For state government agencies

Line departments related to human, animal health and rural development

In states where there is no framework for joint actions as far as zoonotic disease control are concerned, government should notify constitution of joint technical group and earmark resources for its functioning. The study recorded an example in the state of Mizoram.

Veterinary Department in association with rural development department should focus on demand based commissioning of low cost community slaughterhouses (managed and operated by community level institution) as it is more feasible in Indian context. Selected people from community or animal health workers at community level should be trained on basic aspects of meat hygiene and inspection. This can make meat inspection efficient and thus help in control of taeniasis / cysticercosis. The model for such slaughterhouses is already available with premier research organization like National Research Center on Pig at Rani (Guwahati), Assam.

Where necessary, specific measures should be initiated to clarify mandate on the part of the veterinary department to undertake public health functions, meat inspection and slaughter house related affairs. This can be done by amending the allocation of business rule under corresponding state level Acts. This will facilitate the veterinary department to undertake focus initiatives related to public health.

The veterinary department of those states where research attributes incidence of measly pork to inter-state import of pig, can explore possibility of using provisions under Prevention and control of Infectious and Contagious Diseases in Animals Act,2009 to notify for mandatory vaccination of imported pigs at source. They can also request authorities at center government / animal trading, transport agencies or corresponding authorities in other states to promote vaccination of pigs for porcine cysticercosis before they are transported from endemic areas of north India to high consuming areas of North East India. This also corresponds to FSSAI regulation mentioned in this report.

Department of general administration

Civil administrators like Deputy Commissioners or District Magistrates can play the crucial leadership role to promote intersectoral coordination for disease control. State governments should explore opportunity to create awareness amongst local farmers and pork consumers and ensure involvement of civil servants in creating appropriate one health structures, operational framework at the district level essentially involving private organizations and citizens (for reporting of diseases). Office of district magistrate can ensure convergence of developmental schemes related health care, sanitation and water supply etc. in taeniasis / cysticercosis hotspot villages within a district.

Public and private research institutions

Literature review conducted as a part of current study indicated limited availability of publications from independent researchers / research institutions in eastern states like Jharkhand and Bihar besides states in North East India. Research or risk analysis aimed at exploring prevalence of cysticercosis / 'measly pork' can help stakeholders in these states to prioritize the cysticercosis control related interventions.
Research should also focus to prove the hypothesis that untreated wastewater irrigation is predominantly responsible for neurocysticercosis cases in India.

Research institutions and centre of excellences involved in supporting government for designing of future National Epilepsy Control Program should assist in aligning such program with any future 'One Health' taeniasis /cysticercosis control program.

Public health and other technical associations

The associations should endeavor to create the much-needed awareness amongst professionals and other stakeholders regarding importance of neglected tropical disease like taeniasis /cysticercosis. As a think tank, association can also guide government agencies for focus investments. They can also promote need based research work amongst their members.

Technical associations like Indian Epilepsy Society (IES) can support any hospital record based study to create further evidence of prevalence of neurocysticercosis and its linkage with food habits of patients. They can also suggest their members to ensure reporting of cases to government agencies.

Private sector / NGOs

Any future taeniasis / cysticercosis control programs should integrate private sector involvement. In India, private sector including NGOs were integrated successfully during implementation of National Polio and Tuberculosis control program.

Private sector tertiary hospitals are likely to record maximum number of cases of neurocysticercosis / epilepsy, which is often not reported to CBHI database. Their partnership can improve disease reporting. Role of private sector companies who makes it feasible the delivery of disease control tools (e.g. Drugs for control of taeniasis, vaccine for pig etc.) is crucial for success of the future control program.

Similarly, large number of national and international agencies, pig farmers associations, contract-farming companies who are involved in piggery sector development should be encouraged to collaborate with 'One Health' cysticercosis control program.

For Indian Immunological Ltd and other donor agencies

The current study indicates that in majority cases, pigs are being sold at the body weight of 50 kg. As per literature, the local pig in India attains this weight at around 10 months (Khargharia, 2014). It is to be noted that the literature of porcine cysticercosis vaccine as available in India indicates revaccination at 6 months of age after primary vaccination at 2 months of age and booster at 4 weeks of primary vaccination. There is no mention of withdrawal period of the vaccine. This indicates need for designing of an appropriate plan of vaccination keeping in mind the average age of finished pig ready for sale, the operational issues of vaccinating the same animal on many occasions and the cost implications thereof.

Donor agencies and Indian Immunological Ltd should jointly undertake few pilots in select areas of India to document and share the benefit of 'One Health' cysticercosis control using ring strategy and available tools.

"Ring-strategy" is a control intervention that targets treatment of humans and pigs among clusters of households (rings) that surround pigs heavily infected with cysticerci. These pigs are typically identified by examining the animal's tongue for cysts. In areas where ring strategy is implemented, health education campaign and cleanliness / sanitation drive should be taken up simultaneously. Additionally, focus should be made for drawing benchmarks for improved husbandry practices and meat inspection in local retail markets by trained village level persons. The evidence from such pilot programs can be collated through both efficient data generation and diagnostic services. The learning from the pilots can greatly assist in designing of a National Control program in near future.

Annexure

Annexure-I (Sampling of districts)

For field survey and district level interviews probability proportional to size sampling was administered to select the districts within the study states with a pre-determined size of three districts per study state. 19th Livestock census data of pig population per 1000 household as available at government open data portal was used for sampling of districts. The field team covered a minimum of two districts out of the sampled 3 districts per state based on logistic convenience.

S.No	Name of the district	State	Probability of Inclusion
1	Kaushambi	Uttar Pradesh	0.1660
2	Hamirpur	Uttar Pradesh	0.06666
3	Firozabad	Uttar Pradesh	0.0367
4	Bhojpur	Bihar	0.6953

5	Jehanabad	Bihar	0.1804
6	Kishanganj	Bihar	0.0730
7	Dima Hasao	Assam	0.3722
8	Lakhimpur	Assam	0.2315
9	Sonitpur	Assam	0.1451
10	Pakur	Jharkhand	0.3298
11	Dumka	Jharkhand	0.2410
12	Ramgarh	Jharkhand	0.1079
13	South garo hills	Meghalaya	0.6841
14	East garo hills	Meghalaya	0.5100
15	West garo hills	Meghalaya	0.4117
16	Champhai	Mizoram	0.4858
17	Kolasib	Mizoram	0.4570
18	Aizawl	Mizoram	0.3464
19	Kiphire	Nagaland	0.5801
20	Tuensang	Nagaland	0.3323
21	Mokokchung	Nagaland	0.2395

Annexure-II (Study Tools)

Integrated One Health porcine cysticercosis Landscape Analysis

(Key Informant Interview Guide)

We are conducting this study to evaluate how porcine cysticercosis control will integrate within the framework of India's agricultural, medical, food safety and public health frameworks.

Who can be called as Key Informant?

For the study, the following will be considered as key informant:

Snowball interviewing method will be used to identify key informants beyond an initial list of resourceful contacts obtained from secondary sources:

A. Any officials / veterinary consultant (National and at state level) associated with Government of India's Integrated disease surveillance program. (IDSP)
B. Relevant officials at Central and state governments (Both veterinary, health and agriculture department)

C. Key livestock health related contact points at DAHD, GoI
D. Key contacts within Food Safety and Standards Authority of India (FSSAI)
E. Officials at thinks tanks (Public / Private).
F. Key experts at potential partner organization for cysticercosis control.
G. Known experts in the field of public health & Community Medicine (Veterinary and Human)
H. Experts in the field of health reforms.
I. Officials at slaughter house /municipality for meat inspection.

Choice of question from amongst the suggested one for a key informant will depend on judgement of the interviewer. Interviewer needs to use his own ingenuity and internalize required information and engage in informal talks with the key informant, sequencing questions best suited to the flow of conversation.

Guide questions for Interviewer

(For Health / public health professionals)

1. UN Sustainable Development Goal -3 (SDG 3): 'Ensure healthy lives and promote wellbeing for all at all ages', has nine targets, one of which extends the Millennium Development Goals (MDGs) beyond HIV, TB and malaria to 'end the epidemic' of Neglected Tropical Diseases (NTDs) by 2030 (Refer target 3.3). Out of 18 NTDs, what do you think are priority or relevant NTDs for India to target? How will you rank them in India's or your state's context?
2. Can you elaborate on government of India's initiatives to address control of NTDs?
3. In your informed opinion, what is the incidence of cysticercosis in your state / India? *(Discuss some of the literature review to facilitate)*
4. Do you think current data on incidence and economic burden related to cysticercosis in India is sufficient to initiate priory and focus action by government? What are the gaps? How to generate better and reliable evidences? Any initiative to bridge the gap?
5. Can you elaborate any initiative under Integrated Disease Surveillance Program (IDSP) or any other program that is targeting cysticercosis in India?
6. Considering ongoing government mission like Clean India, FSSAI regulations, emerging market for quality pork and opportunity thereof for increasing the demand of local pork etc. it seems it is the best time for India to invest on a National targeted cysticercosis control program? What is your opinion? Any other things that can indicate that it is the best time for India to make focused investment on cysticercosis?
7. Can you help us identify missions / schemes / program of government or private donors that can converse with any future National cysticercosis control program?
8. Individuals with no history of pork consumption or travel to endemic areas can also develop neurocysticercosis. In India, too we have case histories that indicate no linkage to pork consumption. How strong is the linkage between raw vegetable consumption and taeniasis / cysticercosis in human in Indian context?
9. Vaccination and anthelmintic treatment of pigs with molecule like oxfendazole is one of the recommended strategy of WHO for integrated control of cysticercosis (India has already licensed production and use of vaccine). However, adoption of a strategy depends on country context:

How relevant will it be for India to invest on popularization of vaccine use and anthelmintic treatment with specific suggested molecule?

Where and how should we target use of such vaccines? Health being a state subject and considering ongoing further decentralization, what local partnership will work for last mile delivery (e.g. implementation of ring strategy!) for greater impact on targeted communities?

How best can we club delivery of pig vaccines / anthelmintic along with health department programs such as mass drug administration for taeniasis, identification and treatment of taeniasis cases, education and support for improved sanitation?

For food safety professionals

As per recent BIS code of practice IS 1982: 2015 (Risk based PM inspection program) special measures like opening of heart and deep incision on septum should be carried out in pigs derived from areas where there is a risk of Cysticercus cellulosae.

Do you know any initiative to share information on cysticercosis risk to stakeholders more particularly slaughter houses?

The standard is silent on antemortem measures such as tongue examination, record of vaccination and treatment of pigs for P. cysticercosis etc. How can we incorporate such guideline in future revision of standards?

India has attended the Forty-Seventh Session of Joint FAO /WHO Food Standards Program -Codex Committee on Food Hygiene for preparation of proposed draft guideline on the application of general principles of food hygiene to the control of food borne parasites held during Nov.2015

Is there any specific country specific guideline under FSSAI on card to reduce food borne parasite hazard in India?

Integrated One Health porcine cysticercosis Landscape Analysis

(Guide for interviewee for district focus group consultation)

We are conducting this consultation to evaluate how resources can be mobilized within a targeted district for cysticercosis control with One Health Approach.

Communication Strategy:

We have selected your district based on review of census data on pig population per 1000 households. We want to explore if any targeted pilot program can be designed for cysticercosis control in your district with one health approach. We also want to understand how such program can integrate with other ongoing programs such as clean India mission.

All attempts will be made to either meet one to one or where possible organize focused group consultation involving the following:

Deputy Commissioner (District Magistrate) and other junior civil servant, District Representative of National Rural Health Mission, District veterinary officer, any public health expert, District disease surveillance officer, representative of public health engineering department, representative from KVK and any other member from district health society etc.)

Guide Questions

Things to collect: District Health Action Plan and Status report of District Health Society

Ask for any initiative for participatory district health planning.

Initiation:

"Ring-strategy" is a control intervention that targets treatment of humans and pigs among clusters of households (rings) that surround pigs heavily infected with cysticerci. These pigs are typically identified by examining the animal's tongue for cysts. In areas where ring strategy will be implemented, we can take health education campaign and cleanliness / sanitation drive simultaneously. Animal Husbandry department can additionally focus on drawing benchmarks for improved husbandry practices and meat inspection in local retail markets by trained panchayat persons. The evidence from such pilot programs can be collected both through efficient data generation and diagnostic services.

1. Is there any mention of cysticercosis in District Health Action Plan?
2. Is there any instance where farmer / public representative is raising cysticercosis related health issues and their control during district or village development plan meetings?
3. How can we better generate further evidence of incidence of cysticercosis in human within your district? This is required to justify investment and general donor interest. (Feedback from District surveillance officer)
4. What facilities do you have for diagnosing cysticercosis?
5. What are your opinions in general on feasibility of such a program within your district?
6. Will there be any issue related to accessibility and public acceptance of such program?
7. Can such programs be organized and funded by districts through convergence of schemes?
8. Who can be designated as nodal contact responsible for coordination between the departments?

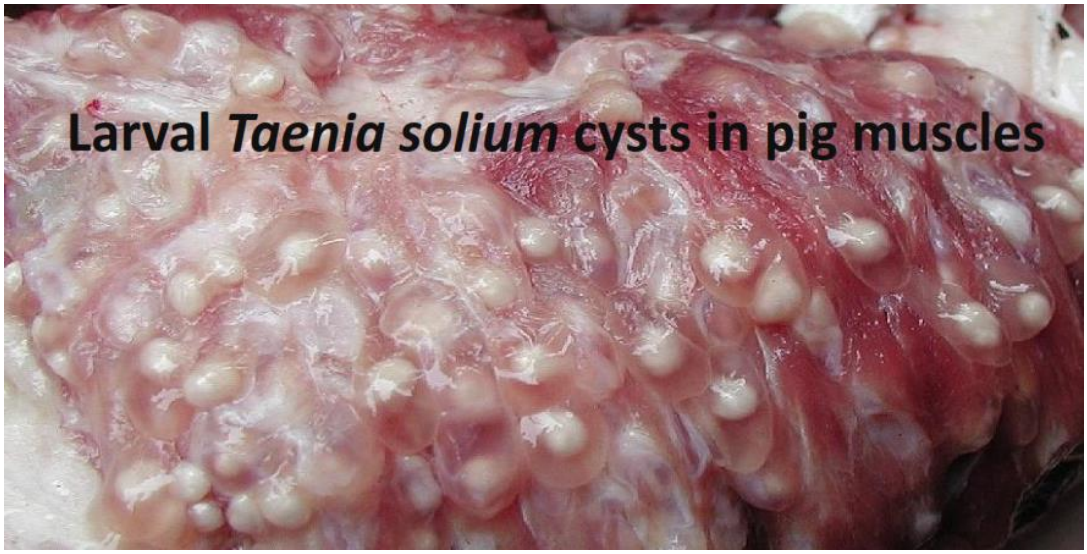
Integrated One Health porcine cysticercosis Landscape Analysis

(Online survey of organized pig sector stakeholder: Promoted through social media)

June-2017

Porcine cysticercosis is a parasitic tissue infection caused by larval cysts of *Taenia solium* (pork tapeworm) that makes pork measly causing major economic loss among pig farmers. The cyst also causes a human disease called neurocysticercosis, which is one of the major causes of seizures or epilepsy in most low-income countries including India.

According to World Health Organization (WHO), cysticercosis disease occurs in countries where families engage in community farming practices and raise free roaming pigs. It is also common in areas where animals are slaughtered outside approved abattoirs and in the absence of meat inspection.



Measly Pork (छोटा सुअर का मांस- फ़ीता कृमि से संक्रमित)

We are conducting this survey to understand incidence in organized sector and whether any future government supported cysticercosis control program with component related vaccination of free roaming pigs at community level can be of benefit to Indian Pig farming sector in general.

Q.1 Do you agree with the statement that "consumer perception in India regarding likely tapeworm infection from pork is restricting the demand of locally produced pork in general"?

- ☐ Strongly agree.
- ☐ Agree.
- ☐ Do not agree.
- ☐ No opinion.

Q.2 Will you recommend government to initiate free or subsidized vaccination and treatment of community / free roaming pigs to control cysticercosis?

- ☐ Yes

☐ No

☐ No opinion

Q.3 Do you think that a national program for human cysticercosis control with component related to vaccination and anthelmintic treatment of community pigs will also help in improving the brand image of pork produced in India?

☐ Yes

☐ No

☐ Can't Say

Your detail contact address will help us in developing a databased of organized piggery sector stakeholders in India. Please help in our endeavor.

Name of the respondent:

Organization:

Designation:

Contact (E-mail / Mobile):

Detail address:

Annexure-III (Detail methodology for KAP survey)

The following detailed methodology was adopted for KAP survey of un-organized pig farmers, traders and district level policy implementers and social workers.

1. Official communication was made to Veterinary and Animal Husbandry authorities at state capitals seeking direction to districts for facilitation of data collection from smallholder pig farmers and traders.
2. Similar communications were sent to District Collectors or Magistrates informing about the data collection from pig farmers, traders and officials / social workers.
3. Visits of study team leader to selected sampled districts / key areas were organized to mobilize resources for field data collection and to train appointed data collectors. All the data collectors appointed were graduates with experience of implementing research projects. Refer annexure VI for research team members.
4. Where possible, data collectors were introduced to district level government officers for indirect supervision.

5. Field level practical training of data collectors and pilot for survey were organized at the organizational headquarter and in 3 identified villages on the sideline of rapid situational analysis.
6. Small focus group meetings were organized at district headquarters to identify administrative blocks (sub districts) known for un-organized small holder pig farming / trading. Block / sub-district level pig population data (where available with district authorities) was reviewed during such meetings.
7. Further small focus group discussions were organized with officials at sub-district level to identify non-slum localities / villages / livestock markets known for population of households keeping backyard pigs or trade of pigs. Informal inputs from small local traders, pork retailers and local para-vets / animal health workers were considered for selection of villages and localities.
8. Data collectors were empowered during training to review census website[13] for correct spelling of sub district or block name, village, panchayat name etc. Similarly, they are also trained to verify postal codes through internet[14]. This was done to primarily ensure accuracy of addresses entered and accountability thereof.
9. Each data collectors were trained on symptoms of epilepsy and provided with photographs of measly pork / people with skin nodules etc. to ensure appropriate communication with respondents. Data collectors in few tribal areas were permitted to use interpreters.
10. A uniform maximum sample size of 75 respondents (50 farmers + 15 Traders and 10 Policy implementers / Social worker) was arbitrarily decided for each of the 14 districts (2 districts each from 7 states). The total sample size targeted was 700 farmers 210 traders and 140 policy implementers / social workers.
11. The sample to be collected from each identified village / locality was kept at the discretion of data collector who are empowered during the training to take decision considering the need for making samples representative of population.
12. Each filled in schedules were reviewed by assigned consultant through one to one meetings with appointed data collectors.
13. Filled in schedules were entered in to designed PDF forms for analysis and future reference.

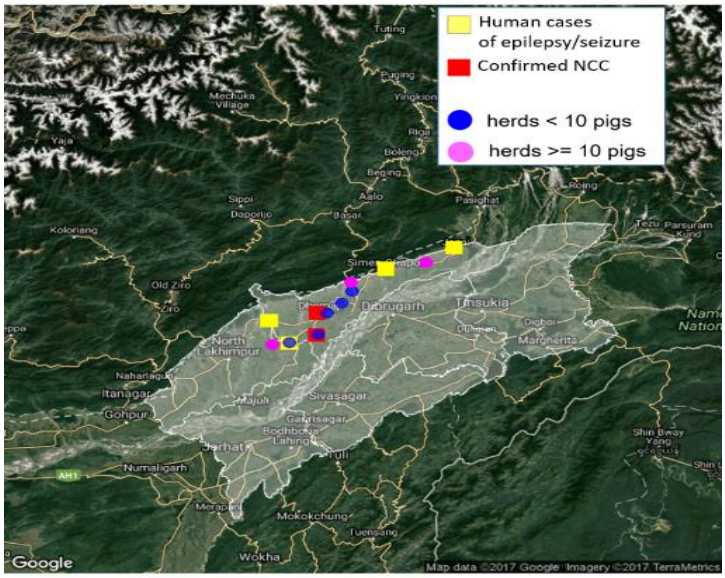
Annexure: IV (Example of Indian App based 'One Health' surveillance system)

The app based surveillance system named, Samārogyam, derived from 'Integrated Health' in Sanskrit, envisions an integrated health surveillance system with the One Health approach. It is designed to overcome the hurdles of data collection, verification and sharing by building and strengthening intersectoral, inter-disciplinary networking through near real time participatory health event reporting. It harnesses the power of Citizen Scientists – the primary contributors/ data sources. Anybody, irrespective of professional affiliations, having a supported mobile device and an active data-connection can become a Citizen Scientist of the Samārogyam system. Citizen Scientists participating in the Samārogyam system may report any geo-tagged human, animal, and environmental health related event they come across using the App in real time. The information /report contributed by the Citizen Scientists are securely stored and analyzed. Analysis of this data produces deliverables in disease surveillance, prevention and intervention; environmental agent detection and response; identification of at risk populations – monitoring

[13] http://censusindia.gov.in/2011census/Listofvillagesandtowns.aspx
[14] http://1min.in/indiapost/pincode (To check when code is available) https://pincode.net.in/ (When place name is available)

outcomes of interventions, treatments; improving public awareness of diseases and prevention; curricula for professional education and training; providing data resources for basic and translational research; and making informed decision for public policy and regulations.

The Samārogyam system is at the stage of field trials. Some of the data recorded by the system during its ongoing trials, which might be relevant to the study presented in this report (Samārogyam had no prior knowledge of this study), are shown in this demonstrative example. The data shown here is a part of a bigger dataset obtained during a 15-day trial. Given the potential of the Samārogyam system, it may be of good use in future One Health studies.



Example of spatial plot using data collected by the Samārogyam App. Here only two attributes of each of the two variables, which might be interest to the present study in this report are shown. They are- cases of epilepsy/seizure [attributes- (a) observed a case of epilepsy and (b) epilepsy cases known to be confirmed NCC through diagnosis] and domestic pig herd around [attributes- (a) herd size smaller than 10 pigs and (b) herd size of at least of 10 pigs]. The system also has the capacity of grouping the human cases in terms age and gender, which is not used in this plot.

Annexure: V (List of people interviewed / Contacted)

Serial No.	Name	Organization
New Delhi		
1	Bambal Rajendra	Department of Animal Husbandry Dairying & Fisheries (DADF)
2	Borah Hiranya	Ministry of Drinking Water and Sanitation
3	Chakraborty Amitav	Department of Animal Husbandry Dairying & Fisheries (DADF)
4	Chhabra Mala	National Centre for Disease Control
5	Jain Sudhir Kumar	National Centre for Disease Control
6	Kumar Ashok	Indian Council for Agricultural Research (ICAR)

7	Mehndiratta Man Mohan	Indian Epilepsy Society
8		
9	Mishra C Anil	Food Safety & Standards Authority of India (FSSAI)
10	Muniyellappa H K	Department of Animal Husbandry Dairying & Fisheries (DADF)
11	Nataraju S M	National Centre for Disease Control
12	Papanna Mohan	Global Disease Detection Regional Centre, CDC-India
13	Raikwar Madhu	Central Bureau of Health Intelligence (CBHI)
14	Sikdar Dilip	Department of Animal Husbandry Dairying & Fisheries (DADF)
Assam		
15	Bhagabati C Bhabesh	Directorate of Health Services, Government of Assam
16	Hazarika Arindom	Arohan Foods Private Limited
17	Laskar S A	Integrated Disease Surveillance Program (IDSP), Assam
18	Rajkhowa Swaraj	National Research Centre on Pig (NRC-Pig)
19	Sarma Dilip Kumar	National Research Centre on Pig (NRC-Pig)
20	Sharma Paresh	North East Regional Disease Diagnostic Laboratory (NERDDL)
21	Thomas Rajendran	National Research Centre on Pig (NRC-Pig)
Bihar		
22	Ahmed Md Rizwan	Integrated Disease Surveillance Program (IDSP), Bihar
23	Dubey Monuj	Integrated Disease Surveillance Program (IDSP), Bihar
24	Kumar Niranjan	Animal and Fisheries Resources Department
25	Kumar Sanjay	Animal and Fisheries Resources Department
26	Mishra Ragini	Integrated Disease Surveillance Program (IDSP), Bihar
27	Prasad Parshu Ram	Health Department, Government of Bihar
28	Singh Aloke Kumar	Mata Gujari Memorial Medical College, Kishanganj
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