REPORTING SYSTEMS AND DIAGNOSTIC CAPACITIES FOR *TAENIA SOLIUM* CYSICERCOSIS/TAENIOSIS: THE CURRENT STATUS IN SELECTED REGIONS OF TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFIMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN EPIDEMIOLOGY OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

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EXTENDED ABSTRACT

Porcine cysticercosis and human neurocysticercosis/taeniosis are two forms of a zoonotic disease caused by *Taenia solium* tapeworm. There is a perceived inefficient diagnosis and reporting of both forms of this parasitic disease in Tanzania. The aim of this study was to identify the challenges associated with diagnosis and reporting of both forms of the parasitic disease in medical and veterinary sectors. A cross-sectional study was conducted in Babati, Mbulu, Kongwa, Mbinga and Nyasa districts located in three regions namely Manyara, Dodoma and Ruvuma using qualitative and quantitative research approaches. The districts were purposively chosen basing on the porcine cysticercosis (PC) prevalence equal or more than 12.0% obtained through tongue palpation. In depth interview was used to collect qualitative data involving medical and veterinary officers from district to national level. Officers in charge of Zonal Veterinary Investigation Center and Tanzania Veterinary Laboratory Agency found in Iringa and Arusha regions were included in qualitative data collection to capture their perceptions and the role the investigation centers and laboratories were playing in the reporting and diagnosis of porcine cysticercosis. The quantitative data were collected by administering structured questionnaire to 154 medical officers in primary health facilities and 110 meat inspectors. Taeniosis diagnosis capacity was assessed for availability of functioning laboratories and qualified laboratory technicians and clinicians in primary health facilities with ability to test and diagnose helminthosis including taeniosis. Respondents' awareness and knowledge about *T. solium* tapeworm and *T. solium* cysticerci were assessed for their correct descriptions of the two forms of the tapeworm, tapeworm hosts and mode of human infection by the larval stage of the tapeworm. In addition, questions about pig slaughter slabs, transport facilitation to meat inspectors, qualification and number of meat inspectors were asked to meat inspectors. Information about availability of taeniosis and neurocysticercosis/epilepsy diagnostic facilities and challenges for PC diagnosis was also enquired from 33 medical and veterinary respondents. *T.*

solium taeniosis, neurocysticercosis and PC reporting was assessed for availability of reporting data of both forms of the disease in medical and veterinary reporting systems. Disease reporting was assessed for the availability of reporting format, specific disease reported, report completeness, timeliness in report submission, means of sending the report and presence of reporting feedback.

Quantitative data were analysed for proportions and Chi-square statistical test using Statistical Package for Social Science (SPSS). Content analysis for qualitative data was undertaken using ATLAS.ti software. Qualitative results based on ATLAS.ti revealed inadequate diagnostic facilities, laboratory personnel and clinicians to diagnose taeniosis in primary health facilities and inadequate CT scanners, MRI machines and physicians to diagnose neurocysticercosis/epileptic cases in secondary and tertiary health facilities. On the other hand, *T. solium* taeniosis and neurocysticercosis were not reportable diseases in the current medical disease surveillance and reporting system although the system was adequately facilitated. Inadequate facilitation of the general animal disease surveillance system particularly in the primary data collection hindered efficient PC reporting. The reports lacked completeness, always lately submitted and sometimes not submitted at all. Porcine cysticercosis diagnosis was challenged by availability of inadequate qualified meat inspectors, inadequate slaughter slabs and inadequate facilitation of routine meat inspection activities. Quantitative data revealed that only 33.8% of the visited primary health facilities had laboratories with capacity to diagnose helminthosis, 46.5% of respondents relied on patients' history to diagnose taeniosis. Majority of meat inspectors (71.5%) scored above average in *T. solium* cysticerci standard description compared to 57.9% medical personnel who scored below average. On contrary, 61.2% of medical personnel scored above average in *T. solium* tapeworm description while 57.4% of meat inspectors scored below average. Officers in charge with clinical medical health profession correctly described *T. solium* cysticerci than those with other medical health professions ($P<0.019$) whereas officers in charge with less working experience were much more aware about *T. solium* cysticerci than those with more working experience ($P<0.046$). Large

proportion of meat inspectors with professional background other than animal health were aware about *T. solium* tapeworm compared to those with animal health professional background (P<0.009). Medical disease surveillance and reporting system was adequately facilitated in terms of report preparation and submissions with 83.8% of respondents being able to submit reports timely and 43.8% capable of physically submitting the reports. Nevertheless, meat inspectors were inadequately facilitated in report preparation and submission, with 91.8% lacking abattoir disease surveillance forms and 41.8% unable to submit reports on time. It is concluded that *T. solium* cysticercorsis/taeniosis diagnosis and reporting is a challenge in both medical and veterinary sectors. In addition to that, both forms of the disease are not listed under the reportable diseases of the MoHCDGEC. Porcine cysticercosis was inadequately reported possibly due to inadequate facilitation to enable timely disease reporting as reflected by the general lack of the abattoir surveillance forms.

A One Health approach is needed to bring together medical practitioners and veterinarians and both should be equipped with common understanding regarding the tapeworm biology including medical and social economic importance of the parasite. Common strategies should be put in place to enhance efficient surveillance and reporting of both forms of the disease in medical and veterinary sectors.

DECLARATION

I, Fredy Odo Mlowe, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution for a degree award.

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(Supervisor)

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DEDICATION

This work is dedicated to my mother, Bestha Kinyunyu, who has always been my source of inspiration.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABREVIATIONS AND ACRONYMS

AHP	Animal Health Profession
ARDS	Agriculture Routine Data System
COVID 19	Corona Virus Disease 2019
CT	Computerised Tomography
DAICO	District Agricultural Irrigation and Cooperative Officer
DH	District Hospital
DLFO	District Livestock and Fisheries Officer
DLO	District Livestock Officer
DMO	District Medical Officer
DVO	District Veterinary Officer
ELISA	Enzyme Linked Immunosobent Assay
FAO	Food and Agriculture Organization of the United Nations
HMIS	Health Management Information System
IgG	Gamma Immunoglobulin
MHP	Medical Health Profession
MoLF	Ministry of Livestok and Fisheries
MoHCDEC	Ministry of Health, Community Development, Gender, Elderly and Children
MRI	Magnetic Resonance Image
NA	Not Applicable
NCC	Neurocysticercosis
ns	not significant
OIE	Wolrd Organization for Animal Health
OP	Other Profession
PCR	Polymerase Chain Reaction
RAS	Regional Administrative Secretariat
RH	Regional Hospital
RRH	Regional Referal Hospital
SPSS	Statistical Package for Social Science
TSCT	Taenia Solium Cysticercosis/Taeniosis
TVLA	Tanzania Veterinary Laboratory Agency
ZVC	Zonal Veterinary investigation Centre
WEO	Ward Executive Officer
WHO	Wolrd Health Organisation
AHP	Animal Health Profession

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COVID 19	Corona Virus Disease 2019
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ZVC	Zonal Veterinary investigation Centre

CHAPTER ONE

1.0 General Introduction

Porcine cysticercosis is an infection caused by the larval stage of the zoonotic tapeworm *Taenia solium*, transmitted among humans and between humans and pigs (Parkhouse and Harrison, 2014). The parasite has an indirect life cycle, involving human beings who are the definitive host and pigs which are principal intermediate hosts (Parkhouse and Harrison, 2014). Humans are infected by *T. solium* cysticerci through ingestion of food or water contaminated with infective *T. solium* eggs. Human infection by *T. solium* taeniosis is through consumption of improperly cooked pork infected by *T. solium* cysticerci (Weka *et al.*, 2019). Pigs get infected by *T. solium* cysticerci through scavenging on human faeces, feeds or water contaminated with infective *T. solium* eggs (Weka *et al.*, 2019). The prevalence of 17.4% has been estimated from community-based studies in pigs on the disease in northern highland district of Mbulu based on lingual examination method (Ngowi *et al*., 2004). Recent study in the southern highland districts of Mbeya rural and Mbozi reported a prevalence of 9.2% in pigs, estimated through total carcass dissection (Kabululu *et al.*, 2020). An abattoir-based prevalence varying from 0.0 to 18.2% has been reported in pigs (Ngowi *et al.*, 2019). In Tanzania, human taeniosis prevalence of 2.3% and 5.2%, estimated through Kato-Katz and copro antigen enzyme linked immunosorbent assay method, has been reported, respectively (Ngowi *et al*., 2019). Porcine cysticercosis prevalence of 16.0 to 17.0% has been estimated based on antigen ELISA and IgG western bloat (Ngowi *et al.*, 2019). The parasite life cycle maintenance is attributed to poor sanitation, unhygienic practices in food preparation, improper handling of cysticerci infected pig carcasses and poor pig husbandry practices (Kungu *et al.*, 2015). Taeniosis in human is characterised by non specific signs including abdominal discomfort and diarrhoea (Craig and Ito, 2007). The cystic form of the parasite in the central nervous tissues causes neurocysticercosis in human which is characterized by chronic headache and epileptic seizures whose intensity and frequency depends on the size and location of the cysticerci in the brain

(Delgado-garcía *et al.*, 2018). It is estimated that neurocysticercosis accounts for 30% of all epileptic cases globally (Bruno *et al*., 2013). A total of 2.6 to 8.3 million people are estimated to suffer from *T. solium* neurocysticercosis worldwide (WHO, 2019). In Tanzania, studies have shown that *T. solium* neurocysticercosis has significant contribution to epilepsy (Ngowi *et al.*, 2019).

For effective *T. solium* taeniosis, porcine cysticercosis and neurocysticercosis control and eradication, a reliable and well-coordinated disease diagnosis and reporting system is needed (WHO, 2015). Tongue palpation which is used for screening *T. solium* cysticercosis in pigs has high specificity but low sensitivity in detecting *T. solium* cysticerci, especially in lightly infected pigs (Secka *et al.*, 2010). Serological techniques have high sensitivity but have low specificity and are unable to differentiate antibodies and antigens of different cestodes (Dermauw *et al.*, 2017). The reliable method for diagnosing *T. solium* taeniosis is stool analysis, targeting identification of *T. solium* scolex with two double crowns of hooks as opposed to *T. saginata* which has single row of crowns of hooks (García *et al*, 2011). The World Health Organization (WHO), Food and Agricultural Organization (FAO) of the United Nations and the World Organisation for Animal Health (OIE) have jointly developed guidlines for diagnosis of *T. solium* neurocysticercosis that require the use of one absolute criterion to have a definitive diagnosis and a combination of either one major and two minor criteria, one major, one minor and one epidemiological criteria or three minor and one epidemiological criterion to have a probable diagnosis (Dorny*et al.*, 2005). The parasite diagnostic challenges have recently been addressed by the use of polymerase chain reaction (PCR) technique which is highly sensitive and specific for the diagnosis of *T. solium* cysticercosis/taeniosis and human neurocysticercosis (Sreedevi and Hafeez, 2011). The use of neuroimaging and immune-diagnostic techniques in diagnosing neurocysticercosis has further improved the diagnostic accuracy (Brutto *et al.*, 2012). Nevertheless, the availability of these techniques is still a challenge in most low and middle economy countries (WHO, 2015).

An ideal disease reporting system and recording needs to be timely and perfect and should cover important aspects of the disease dynamics. Regular updating and improvement of the disease reporting system is important so that relevant data are timely made available (Janati *et al.*, 2015). However, *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis is one of the neglected tropical diseases and not reported (Roman *et al.,* 2000). This fact is reflected in the deficiency of data about the disease in most of European countries (Laranjo-gonzález *et al.*, 2017) and African countries (Melki *et al.*, 2018).

This study aimed at assessing *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis diagnosis and reporting in medical and veterinary health systems in selected regions in Tanzania. The results obtained are useful in identifying opportunities and challenges in both forms of the disease diagnosis and reporting in medical and veterinary sectors. In turn, this will help to address the challenges and improve disease diagnosis and reporting practice to get reliable and accurate data on the disease which will be used in setting disease control and elimination strategies in the country.

1.1 Problem Statement and Study Justification

There is a perceived inefficient *T. solium* cysitcercosis, taeniosis (including human neurocysticercosis) (TSCT) diagnosis and reporting in Tanzania. Personnel skills and accuracy of the diagnostic methods play key role in *T. solium* cysticercorsis/taeneosis and neurocysticercosis surveillance. The disease is not accommodated in the National Health Policy of 2017 (MoHCDEC, 2017) and it is also not certain whether the international health organizations guidelines for the diagnosis of the disease are adapted by the country to suit the local situation. A comprehensive systematic scoping review in Tanzania has revealed disease prevalence requiring public attention than it has been reported by the routine disease reporting systems currently in place (Ngowi *et al.*, 2019). This shows that there is a gap on either the way the disease is diagnosed at different levels of diagnosis in veterinary and medical health systems or the routine systems by which the disease is reported do not sufficiently accommodate necessary information concerning the disease. As a result, the data concerning the disease may not present the true disease burden. This study intends to identify the challenges and opportunities existing in the *T. solium* cysticercosis/taeniosis diagnosis and reporting to guide strategic allocation of resources to improve the disease diagnosis and timely reporting in Tanzania.

1.2 Study objectives

1.2.1 General objective

To evaluate the current status of diagnosis and reporting of *T. solium* cysticercosis/ taeniosis in Tanzania.

1.2.2 Specific objectives

i. To evaluate the diagnostic capacities, knowledge and practices on *T. solium* cysticercosis/taeniosis in medical and veterinary sectors in selected regions in Tanzania.

ii. To describe the *T. solium* cysticercosis/taeniosis reporting system in medical and veterinary sectors in selected regions of Tanzania.

1.3 Research Questions

The research was driven by the following key research questions:

1. What is the diagnostic capacitiy for *T. solium* cysticercosis and taeniosis in Tanzania?
2. Are *T.solium* cysticercosis and taeniosis cases adequately reported to reflect the true disease burdern?

1.4 List of Manuscripts

The dissertation is based on two manuscripts:

i. Diagnostic capacities, knowledge and practices of medical and veterinary officers on *T. solium* cysicercosis/taeniosis and human neurocyticercosis in Tanzania.

ii Taenia solium cysticercosis and taeniosis reporting in the current medical and veterinary diseases reporting systems in Tanzania.

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CHAPTER TWO

Diagnostic Capacities, Knowledge and Practices of Medical and Veterinary Officers on *Taenia Solium* Cysticercosis/Taeniosis in Tanzania

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Abstract

Taenia solium cysticercosis/taeniosis (TSCT) is a zoonotic disease caused by *T. solium* tapeworm. There is a perceived inefficient diagnosis of both forms of a parasitic disease in Tanzania. This study aimed at identifying the challenges of diagnosing both forms of the disease. A cross-sectional study was conducted between January and April 2020 in Babati, Mbulu, Kongwa, Mbinga and Nyasa districts in Manyara, Dodoma, Ruvuma, Arusha and Iringa regions using a structured questionnaire with closed and one open ended question and one on one in-depth interview using a checklist. A total of 152 officers in charge of primary health facilities and 108 meat inspectors were interviewed using a pre-tested questionnaire. Qualitative data on TSCT diagnosis challenges were obtained from 33 medical and veterinary officers. Quantitative data were analysed for proportions and compared using the Chi-square test in Statistical Package for Social Science (SPSS) software. Content analysis was used to analyse qualitative data using ATLAS.ti software. Results revealed inadequate availability of diagnostic facilities (54.6 %) and diagnostic personnel (100%) for taeniosis in primary health facilities (n=152). Secondary and tertiary health facilities were challenged by inadequate/unavailability of diagnostic imaging machines and physicians to diagnose neurocysticercosis/epilepsy. Inadequate qualified meat inspectors, slaughter slabs and inadequate facilitation challenged porcine cysticercosis diagnosis. Meat inspectors scored above average with respect to *T. solium* cysticerci knowledge (81.2%) compared to medical respondents who scored below average (57.9%). Nevertheless, 61.2% of medical respondents scored above average with respect to *T. solium* tapeworm knowledge while 57.4% of meat inspectors scored below average. Medical health respondents with clinical health medical training were more knowledgeable (P<0.017) about *T. solium* cysticerci than those with other medical professions. Those with longer working experience were much more aware about *T. solium* cysticerci (P<0.046) than those with shorter working experience. Meat inspectors who had professional backgrounds other than animal health profession were much more aware about *T. solium* tapeworm than those with animal health professional background (0.009). It is concluded that TSCT diagnosis capacity is low in medical and veterinary sectors. Strategic awareness creation to both medical and veterinary officers should be considered and facilitation of parasitic disease diagnosis in both sectors is of paramount importance.

2.0 Introduction

Taenia solium is a zoonotic tapeworm which is transmitted among humans and between humans and pigs (Parkhouse and Harrison, 2014). The parasite has an indirect life cycle, involving humans who are the definitive hosts and pigs which are intermediate hosts (Parkhouse and Harrison, 2014). Human gets infected by *T. solium* cysticerci through ingestion of food or water contaminated by infective *T. solium* eggs. Human infection by *T. solium* tapeworm is through consumption of improperly cooked pork infected by *T. solium* cysticerci (Weka *et al.*, 2019). Pigs get infected by *T. solium* cysticerci through scavenging on human faeces, feeds or water contaminated by infective *T. solium* eggs (Weka *et al.*, 2019). The prevalence of 17.4% has been reported in the northern highland district of Mbulu based on lingual examination method (Ngowi *et al.*, 2004). Recent study in the southern highland districts of Mbeya rural and Mbozi reported a prevalence of 9.2% in pigs, estimated through total carcass dissection (Kabululu *et al.*, 2020). The countrywide abattoir-based prevalence in pigs ranging from 0.0 and 18.2% has been reported in Tanzania (Ngowi *et al.*, 2019). In Tanzania, human taeniosis prevalence of 2.3% and 5.2% was estimated through Kato-Katz and copro antigen enzyme linked immunosorbent assay method, respectively (Ngowi *et al.*, 2019). Human cysticercosis prevalence of 16.0 to 17.0% has been reported based on antigen ELISA or neurocysticercosis IgG western bloat (Ngowi *et al.*, 2019). Parasite life cycle maintenance is attributed to poor sanitation, unhygienic practices in food preparation, improper handling of infected pig carcasses and poor pig husbandry practices (Kungu *et al.*, 2015). The cystic form of the parasite causes neurocysticercosis in human which is characterized by headache and epileptic seizures whose intensity and frequency depends on the size and location of the cyst in the brain (Delgado-garcía *et al.*, 2018). Neurocysticercosis accounts for 30.0% of all epileptic cases worldwide (Bruno *et al.*, 2013). A number of diagnostic methods for the disease have been recommended, and they range from macroscopic to microscopic techniques as well as serology, diagnostic imaging and molecular techniques (García, 2011). Tongue palpation for porcine cysticercosis diagnosis has a sensitivity of 16.0% (Phiri *et al.*, 2006) to 70.0% and specificity of 100.0% (Gonzalez *et al.*, 1990). Microscopic diagnosis of taeniosis in human has specificity ranging from 0.0% to 59.0% (Rodriguez-canul *et al.*, 2016) as eggs of *T. solium* and *Taenia saginata*, and sometimes their proglottids morphology look similar under the light microscope (Jabbar *et al.*, 2016). On the other hand, serological techniques for diagnosing the larval stage of the parasite have sensitivity ranging from 54.5% to 78.6% and specificity of 69.2% (Targonska *et al.*, 2009). Diagnostic imaging techniques such as computerised tomography (CT) scanners and magnetic resonance imaging (MRI) are efficient in identifying the cystic form of the tapeworm in the brain and provide accurate diagnosis of neurocysticercosis when used in combination with other techniques (García *et al*, 2011). Diagnosis of porcine cysticercosis/taeniosis in developing countries, particularly in sub Saharan countries, has been challenged by unavailability of sophisticated diagnostic tools with high sensitivity and specificity such as CT scanners, MRI and PCR machines (WHO, 2015) and neglected and hence maginalised status of the disease by medical school training (Pawlowski, 2008).

Strategies towards control and eradication of this disease rely on efficient and coordinated disease surveillance and monitoring system that enables reliable estimation of the disease magnitude in both pigs and humans (Braae *et al.*, 2020). Tanzania, like other low and middle income countries, is likely to be facing some challenges in diagnosing *T. solium* cysticercosis/taeniosis (TSCT) in pigs and human, though little is known in this aspect. This study aimed at assessing the diagnostic capacities of both medical and veterinary health facilities, practitioners' knowledge and practices towards diagnosis of *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis in Tanzania to identify opportunities and challenges in the surveillance of this important disease complex.

2.1 Material and Methods

2.1.1 Study area

Large part of the study was conducted in three regions of Tanzania namely: Ruvuma (southern Tanzania), Dodoma (central Tanzania) and Manyara (northern Tanzania). It involved five districts namely Babati and Mbulu (Manyara region), Kongwa (Dodoma region) and Mbinga and Nyasa districts (Ruvuma regions). The study districts were purposively selected based on the reported prevalence of porcine cysticercosis of 12% or more by previous studies (Ngowi *et al*., 2019). Two more regions namely Iringa (southern) and Arusha (northern) were purposively selected based on the fact that they had livestock diseases investigation and surveillance centres and laboratories for livestock diseases diagnosis (Fig. 2.1). The two regions were strategically included in the study to capture officers in charges' opinions about the role their animal diseases investigation and laboratory centres are playing in the diagnosis and surveillance of TSCT.

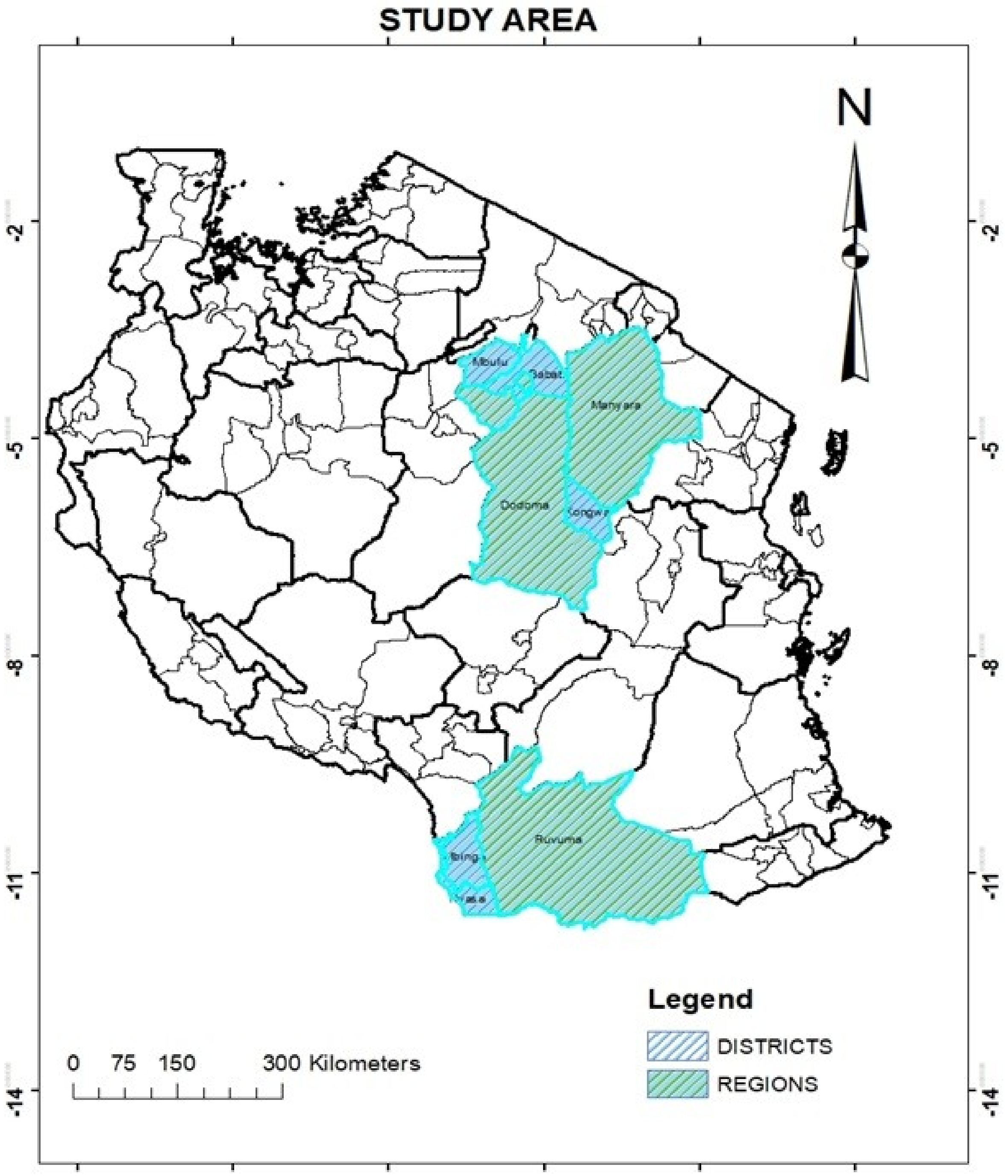

Figure 2.1: The map of Tanzania showing the study districts and regions

2.1.2 Study design

This was a cross-sectional study involving qualitative and quantitative methods of data collection for triangulation purposes. One on one in depth interview with key informants was used to collect qualitative data and close-ended questionnaires were used to collect quantitative data from officers in charge of primary health facilities and meat inspectors whereby each respondent was interviewed once (Table 2.1).

2.1.3 Sample size and sample selection

2.1.3.1 Sample for qualitative data

Respondents were purposively selected to target key informants with expertise in specific topics to answer the research questions in both medical and veterinary sectors at district, regional and national levels. This qualitative research intended to interview 37 participants from different sectors (livestock, health) and levels (district, regional, national) regarding *T. solium* taeniosis, cysticercosis and human neurocysticercosis diagnosis and reporting in Tanzania. In addition to district and regional respondents, one respondent was interviewed from the ministry responsible for livestock and one from the ministry responsible for health. This was intended to capture the opinion of health experts from both ministries about TSCT diagnostic capacities as the overseers of the nationwide veterinary and medical health issues in the country. In addition, the fact that the disease is zoonotic necessitated a One Health approach in identifying diagnostic challenges from ground level of veterinary and medical health policy implementation to the highest level of experts who are also decision and policy makers in both veterinary and medical sectors. The coverage of both sectors ensured a One Health approach of this veterinary-public health problem (Table 2.1).

Respondents were District/Town Medical Officers of a respective District/Town Council, Regional Medical Officers and, a specialist in a particular regional or referral hospital dealing with neurocysticercosis or neurocysticercosis related conditions. In the veterinary sector, a District Veterinary Officer (DVO) or District Livestock and Fisheries Officer in the absence of the DVOs, Regional Veterinary Officer or Regional Livestock Advisers in absence of Regional veterinary Officers were interviewed. Officers in Charge of Zonal Veterinary Investigation Centre (ZVC), Tanzania Veterinary Laboratory Agency (TVLA) and Epidemiologist in the Epidemiology units of both the Ministry of Health and Ministry of Livestock and Fisheries were also interviewed (Table 2.1).

2.1.3.2 Sample for quantitative data

Purposive sampling approach was used to select regions and districts in which to conduct the research. Before the sample size was calculated a researcher contacted the District/Town Council Medical and Veterinary Officers (or District/Town Council Livestock officers in absence of Veterinary Officer) in the respective five districts to get the total number of primary health facilities and extension officers in their districts or town council from which to calculate the sample size.
The sample size for the number of questionnaire interviews to be done in each sector was calculated from the formula; $n=N/(1+N(e)^2)$, (Yamane, 1973).

Where: n = study sample size, N = study population size and e = level of precision. In livestock sector a total of 130 respondents from 5 districts were obtained using the above formula, n= $192/1+192(0.05)^2$, where N=192 and *e* = 0.05. In medical sector a sample size of 167 respondents from the same 5 districts was obtained from the calculation, n = $286 /1+ 286 (0.05)^2$, whereby N=286 and *e* = 0.05.

The number of respondents included in the study from each district was determined based on the proportional to size sampling approach. The number of livestock and agricultural field officers doing meat inspection in wards and villages in veterinary sector were recruited into the district sample size based on the proportion each of the two strata contributed to the total number of extension officers in each district. Both, meat inspectors and officers in charge of primary health facilities were randomly selected from the list of meat inspectors and primary health facilities in the district provided by Districts Veterinary or Livestock Officer and District Medical Officer. Table 2.1 indicates the distribution of the study and sample population by administrative levels and institutions.

Table 2.1: Distribution of the study population and sample size by administrative levels and institutions

Variable	Targeted number of respondents (n)	
	Medical respondents	**Veterinary respondents**
Region		
Manyara	63	44
Dodoma	37	37
Ruvuma	67	49
District		
Babati	38	23
Mbulu	25	21
Kongwa	37	37
Mbinga	46	30
Nyasa	21	19
Sample size		
Targeted study population size for quantitative data	286	192
Sample size calculated and selected	167	130
Distribution of the qualitative sample size by administrative and institutional levels		
Districts/Town councils	8	8
Regional administrative secretariat	3	3
Zonal Veterinary Investigation Center		3
Tanzania Veterinary Laboratory Agency		3
Regional Referral Hospitals	3	
Zonal Referral Hospital	3	
National Referral Hospital	1	
Ministerial level	1	1

2.1.4 Data collection

2.1.4.1 Qualitative data collection

One to one in-depth interview with the respondents was conducted using an interview guide with questions which were pre-arranged to focus on the known diagnostic approaches to specific disease conditions as stipulated in the WHO/OIE/FAO standard guidelines for the diagnosis of specific diseases and diseases surveillance (Dorny *et al.*, 2005). The interviews lasted 35 for minutes on average and were recorded using an audio recorder following verbal consent by the respondent. The researcher interviewed a total of 33 participants from different sectors (livestock, health) and levels (district, regional, and national) regarding *T. solium* taeniosis, cysticercosis and human neurocysticercosis diagnosis. Of the 33 respondents interviewed, 16 were medical officers and 17 were veterinary/livestock officers at different administrative levels and institutions. Male respondents were 28 (84.5%) reflecting the male dominance in the targeted professions.

(i) Assessment of diagnostic capacity for human taeniosis, neurocysticercosis and epilepsy

A total of 16 medical health respondents (eight from District and Town Council hospitals, one from the district private referral hospital (Faith Based Organisation), three from the regional hospitals, three from the Regional Administrative Secretariat and one from the Ministry of Health) out of 19 targeted were interviewed to assess their perceptions on the diagnostic capacity for human taeniosis, neurocysticercosis and epilepsy in the health facilities they were working and those below or above them.

Before assessment of diagnostic capacity availability of any disease condition, the researcher ensured that the respondent was referring to the disease condition in question by introducing the topic to the respondent before the actual interview. Also respondent's responses to follow up questions further highlighted that the respondent was referring to the disease in question. When the researcher noted unawareness regarding the condition (as it was common for neurocysticercosis) no further questions were asked on that disease. This was the case with neurocysticercosis in which most respondents appeared to be more used to epilepsy which is the manifestation of neurocysticercosis than neurocysticercosis itself. Thus, epilepsy was later on included in the diagnostic capacity assessment after realising that many respondents were mostly reflecting to it when neurocysticercosis (NCC) issues were discussed and the fact that epilepsy is the main manifestation of NCC. Questions on availability of taeniosis diagnostic capacities demanded the respondent to give his/her general opinion about the primary health facilities and district hospital capacity to diagnose taeniosis. Questions on availability of neurocysticercosis or epilepsy diagnostic capacity demanded the respondent to give his/her opinion about the presence of neurocysticercosis or epilepsy diagnostic capacity in the health facility he or she was currently working. Availability was assessed in terms of presence of functional diagnostic equipment, presence of a professional technician as well as presence of qualified medical personnel.

(ii) Assessment of diagnostic capacity for *Taenia solium* porcine cysticercosis

A total of 17 respondents (eight from district / town council livestock and fisheries offices, three from regional administrative secretariat, three from Zonal Veterinary Investigation Centers, two from Tanzania Veterinary Laboratory Agency and one from the Ministry of Livestock and Fisheries) out of 18 were interviewed to capture their perceptions on porcine cysticercosis diagnostic capacity in their respective working stations and those below them. Questions about the availability of *T. solium* porcine cysticercosis diagnostic capacity demanded the respondent to give his or her opinion about the availability of porcine cysticercosis diagnostic capacity in terms of presence of meat inspectors, adequacy of meat inspectors in the respective district which was measured based on the respondent's perceptions on the number of villages/wards in relation to the availability of meat inspectors in the respective villages/wards, skills of meat inspectors in terms of proper training in meat inspection, presence of pig slaughter house/slaughter slabs and whether or not these meat inspectors were facilitated in their routine meat inspection duties. Respondents from TVLA were interviewed to capture their perceptions about the role their laboratories were playing in the diagnosis of porcine cysticercosis.

2.1.4.2 Quantitative data collection

Data were collected using Afyadata application (Karimuribo *et al*, 2017) installed in one tablet and one smart phone in which the two questionnaires were digitalized. All respondents gave their verbal consents to participate following the briefing of the research purpose and importance by the researcher.

The questionnaires had close-ended questions written in English and administered by a researcher and trained enumerator by reading and explaining the questions and responses to the respondents in Swahili. A respondent had to choose response(s) that he/she thought they best describe the phenomenon in question from the responses provided. The questionnaires were pre-tested on 10 respondents (five primary health facilities and five meat inspectors, each sector with a specific questionnaire) and adjustments were made to questions that needed to be edited. The researcher collected data from health sector respondents while a trained enumerator collected data from meat inspectors. Questions were read and answers selected and filled in the digitalized forms according to the responses given by the respondents.

(i) Assessment of knowledge and practices regarding diagnosis of *T. solium* taeniosis, cysticercosis, neurocysticercosis and epilepsy

A close-ended structured questionnaire comprised of important demographic features was used to collect quantitative data from the officers in charge of primary health facilities. Questions relevant to the research questions included: the type of a primary health facility (health centre or a dispensary), presence or absence of a functioning laboratory with ability to test taeniosis, their awareness about *T. solium* tapeworm and *T. solium* cysticerci. For those who had a working laboratory, further questions on tests they prescribed for tapeworm confirmation were asked. Those who didn't have a working laboratory, questions about the means they use to diagnose taeniosis were asked using multiple choice questions. A similar approach was used to inquire on issues related to epilepsy in their settings.

Respondents' knowledge on *T. solium* tapeworm and *T. solium* cysticerci were assessed by firstly asking them if they knew any of the two aspects. Those who replied 'yes' to this first question were further probed to describe each of the aspects that they claimed to know including: the number and types of hosts of the *T. solium* tapeworm, description of the tapeworm and tapeworm cysticerci morphology and the mechanisms by which human gets infected by *T. solium* cysticerci by selecting correct answers from the list of answers provided.

(ii) Assessment of knowledge and practices regarding diagnosis of porcine cysticercosis

To assess porcine cysticercosis diagnosis, a questionnaire was prepared with questions regarding pork inspection designed to align with FAO standard meat inspection guidelines (FAO, 2019). General demographic data concerning sex, academic professional background and working experience of the meat inspectors were also collected. Presence of pork slaughter houses/slabs and their number within the ward/villages were inquired to capture the presence/absence of catchment area to which meat inspectors were capable of inspecting pork. Meat inspectors' knowledge about *T. solium* tapeworm and *T. solium* cysticerci was assessed by firstly asking the respondents if they knew any of the two aspects. Those who replied 'yes' to these first questions were further probed by questions which required them to describe the morphology of each by selecting the correct answers from the list of the tapeworm and tapeworm cysticerci descriptions which were read to them by the enumerator. Respondents were further required to tell the number and types of the tapeworm hosts, the mechanisms by which human gets infected by the *T. solium* cysticerci and the risk factors for the *T. solium* tapeworm life cycle maintenance. This was achieved by providing them with a list of descriptions of the items from which they had to select the correct answers.

2.1.5 Data analysis

2.1.5.1 Qualitative data

Audio recorded transcripts were transcribed and translated into English in Microsoft Word document. The collected data were analysed using ATLAS.ti qualitative data analysis software. Content analysis was used to analyse the transcripts and it involved both deductive and inductive approaches which involved extensive reading of each transcripts to grasp concepts discussed by the respondents. This was followed by creation of codes to capture each important concept discussed after reading each transcript several times. To avoid mixing up of codes during coding, quotation reporting and creation of output of codes, each code was anchored by a specific short (sub) research question for each research question. A total of 148 free codes were created and defined. This was followed by importation of the 33 interview transcripts. The imported transcripts were grouped by respondents' sectors (health, livestock) as well as by other factors found necessary during the analysis. Each quotation addressing a concept of interest within the transcript was highlighted and coded deductively by a respective code. The analysis involved reading back and forth the transcripts and on the way removing, adding or sometimes editing some codes as new concepts emerged through the process. A particular quotation was counted once per respondent. Therefore, the number of quotations per concept represents opinions from different respondents. A concept was considered to be a theme (important) idea if it reached a cut-off point of at least 50%. Thus at least 50% of the respondents to the particular question mentioned the concept.

2.1.5.2 Quantitative data

Collected data were cleaned and coded in Microsoft Excel. The coded data were imported into SPSS software for analysis. Data were analyzed for frequency and proportions to determine the number and percentage of responses towards a variable of interest. Regarding taeniosis, neurocysticercosis/epilepsy diagnoses, the following variables were analyzed: Number and type of the primary health facilities, number and professional background of the officers in charge of the primary health facilities and meat inspectors, the presence and number of working laboratories with a capacity to diagnose taeniosis. Regarding *T. solium* porcine cysticercosis diagnosis, the following variables were analyzed: number and professional backgrounds of the meat inspectors, presence and number of pig slaughter houses/slabs in areas served by interviewed meat inspectors. The questionnaire had one open ended question on knowledge of meat inspectors in inspecting pork for porcine cysticercosis. The respondents had to describe briefly how they do meat inspection to diagnose *T. solium* porcine cysticercosis. The responses were analyzed as follows: The responses were copied from excel to word document to create transcripts. Their responses were read several times to understand key issues/steps described followed by creation of codes for important ideas described. A total of 110 transcripts were imported in ATLAS.ti software from which an excel output of the analysis was generated. Total scores of each respondent were converted into percentages and compared to pork inspection guidelines. The scores were grouped into four based on the range in which the respondents had scored as follows, excellent (more than 70%), good (between 60% and 69%), average (between 50 and 59%) and poor (below 50%).

In addition, data about the knowledge of officers in charge of primary health facilities were analyzed for proportions of officers in charge of primary health facilities with knowledge about *T. solium* tapeworm, *T. solium* cysticerci and neurocysticercosis/epilepsy. Likewise, data about the knowledge of meat inspectors were analyzed for proportions of meat inspectors with knowledge about the *T. solium* tapeworm and the larval stage of the tapeworm. This is because both categories of respondents require adequate knowledge about the parasite tapeworm biology and epidemiology in their daily practices as medical officers and meat inspectors.

Respondents' knowledge about the tapeworm was analyzed for *T. solium* tapeworm and *T. solium* cysticerci correct descriptions, neurocysticercosis correct definition, the number and types of tapeworm hosts, mode of human infection by the *T. solium* cysticerci and risk factors for human infection by *T. solium* cysticerci. Descriptive statistics particularly for frequencies and percentages of correct responses selected were generated. Respondent's knowledge was then categorized into four groups, based on the total scores of the response per respondent as follows: excellent (more than 70%), good (between 60% and 69%), average (between 50 and 59%) and poor (below 50%).

Because the respondents selected had different working experience and professional backgrounds, with some not specifically gone through medical or animal health clinical training *per se*, association between professional background and working experience of the respondents and correct responses were analyzed using the Chi square test and p values of less than 0.05 ($p < 0.05$) were considered statistically significant.

2.2 Results

2.2.1 Qualitative results

A total of 33 respondents were interviewed. Table 2.2 summarizes the distribution by administrative level, institutions and demographic characteristics of the interviewed respondents.

Table 2.2: Demographic characteristics of respondents of a study to assess *T. solium* taeniosis, cysticercosis and neurocysticercosis diagnosis

Factor	Number of respondents
Sex	
Male	28
Female	5
Region	
Manyara	3
Dodoma	5
Ruvuma	3
Iringa	2
Arusha	1
Districts	
Babati	4
Mbulu	5
Kongwa	2
Mbinga	4
Nyasa	2
Occupation	
Medical doctor	15
Nurse	1
Veterinary doctor	9
Animal scientist	5
Veterinary paraprofessional	2
Work station	
District hospital	8
Regional hospital	6
Missionary referral hospital	1
Zonal Veterinary Investigation Centre (ZVC)	3
Tanzania Veterinary Laboratory Agency (TVLA)	2
District Livestock and Fisheries Office	8
Regional Administrative Secretariat	4
Ministry of Livestock and Fisheries Development	1
Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDEC)	1
Sector	
Health	16
Livestock	17
Level of healthcare facility	
District hospital	8
Regional hospital	5
District referral hospital (Faith Based Organisation)	1

A total of 14 respondents (eight from district hospitals and six from regional hospitals) were interviewed to assess their perceptions on taeniosis diagnostic capacity in primary health facilities and in hospitals. A total of 12 quotations were captured with regard to presence of a qualified laboratory technician for taeniosis diagnosis in the study area. Out of these, seven admitted the lack of competent laboratory technician in most of the primary health facilities as exemplified by the following quotation: *['The challenge also is staff knowledge, because even if these laboratory technicians were there, still, I don't know what kind of college did they go through, just to keep an eye, to prepare a specimen and say this is certain worm many people still fail, different from our times, so personnel capacity in identification of those kind of things is still low, they are used to just saying 'worms' only',* Male, District Medical Officer*]*. In addition, out of the 11 quotations regarding availability of diagnostic facilities for taeniosis, five indicated that they are completely unavailable while six indicated that diagnostic facilities are inadequately available in primary health facilities and district hospitals *['The challenge with taeniosis diagnosis is the deficiency in laboratory and technicians in health facilities specifically at dispensary',* Male, District Medical Officer*]*. Furthermore, three out of four quotations admitted that the diagnostic personnel, which include clinical officers, assistant medical officers and medical officers were not sufficiently available in health facilities and district hospitals *['If you tell someone to diagnose Taenia in the diagnosis or taeniosis while he is not laboratory expert and he doesn't have laboratory, they are just medical attendants and others are just nurses it is difficult',* Male, District Medical Officer*]* (Table 2.3).

Table 2.3: ***T. solium*** **taeniosis diagnostic capacity as perceived by respondents in district (DH) and regional (RH) hospitals**

Factor	DH quotations (theme)	RH quotations (theme)	Total quotations (theme)
Availability of a competent laboratory technician for taeniosis diagnosis			
Available	2	0	2
Inadequate	3	0	3
Unavailable	5 (theme)	2 (theme)	7 (theme)
Availability of diagnostic facilities for taeniosis			
Available	0	0	0
Inadequate	6 (theme)	0	6 (theme)
Unavailable	4	1 (theme)	5
Availability of diagnostic personnel (physician) for taeniosis			
Available	0	0	0
Inadequate	1	0	1
Unavailable	3 (theme)	0	3 (theme)

(i) **Diagnostic capacity for epilepsy and human neurocysticercosis as perceived by respondents in the study districts and regional hospitals**

A total of 14 respondents (eight from district hospitals and six from regional hospitals) were interviewed to assess how they perceived epilepsy diagnostic capacity in their health facilities and in their respective referral hospitals. All 10 quotations from the respondents admitted that diagnostic facilities for epilepsy were not available in their health facilities and in most of their respective referral hospitals *['Eeeh, the main challenge here is about diagnostic facilities, mmmh, if for example there was a plan for each region, for example each regional hospital to have CT scanner, because the regional hospital is nearby here, so even diagnosis of those kind of diseases would have been easier'*, Female, Town Council Medical Officer*]*. A total of three out of four quotations admitted that epilepsy diagnostic personnel, meaning physicians specialised in the central nervous system health, were not available in their health facilities *['Aaah, it is not that easy and I would still say doctors should be sensitized on that matter, … most of cases are treated symptomatically … but if they don't improve they refer them to higher referral hospitals with experts with advanced* *diagnostic equipment …, so even though worms are within top ten conditions but to think of worms in relation to epilepsy is very rare'*, Male District Medical Officer*]* (Table 2.4).

A total of 15 respondents (nine from district hospitals and six from regional hospitals) were interviewed to assess *T. solium* neurocysticercosis diagnostic capacity in their health facilities and their respective referral hospitals. Six out of nine quotations admitted that diagnostic facilities for human neurocysticercosis were not present in their health facilities and some of their respective referral hospitals *['No, it is not easy, you know, neurocysticercosis is something in advanced stage, so it needs advanced technology, for example you may need things like CT scanner, MRI, which we don't have it here, and I think throughout this zone we don't have CT scanner, so most likely we will depend on symptoms … '*, Male District Medical Officer*]*. A total of three out of five quotations admitted that diagnostic personnel for human neurocysticercosis, meaning medical physicians specialised in the central nervous system health were not present in most of the health facilities *['…,I have been here for a while now but I have never seen anybody reporting neurocysticercosis in his report. It is possibly there but people might be under diagnosing it, people may be having epilepsy and the like but they can't tell exactly what is it',* Male Regional Medical Doctor] (Table 2.4).

Table 2.4: Human epilepsy and neurocysticercosis diagnostic capacity as perceived by respondents in district hospitals (DH), regional referral hospitals (RRH), and regional hospitals (RH) and at national levels (MoHCDEC)

Factor	DH quotations (theme)	RH quotations (theme)	RRH quotations (theme)	MoHCDEC quotations (theme)	Total quotations (theme)
Availability of diagnostic facilities for epilepsy					
Available	0	0	0	0	0
Inadequate	0	0	0	0	0
Unavailable	8 (theme)	2 (theme)	0	0	10 (theme)
Availability of diagnostic personnel for epilepsy					
Available	1	0	0	0	1)
Inadequate	0	0	0	0	0
Unavailable	2 (theme)	1 (theme)	0	0	3 (theme)
Availability of diagnostic facilities for neurocysticercosis					
Available	0	1 (100.0)	1 (100.0)	0	2
Inadequate	0	0	0	1 (theme)	1
Unavailable	4 (theme)	2 (theme)	0	0	6 (theme)
Availability of diagnostic personnel for neurocysticercosis					
Available	0	0	1 (100.0)	0	1
Inadequate	0	1 (theme)	0	0	1
Unavailable	2 (theme)	1 (theme)	0	0	3 (theme)

(ii) Diagnostic capacity for *T. solium* porcine cysticercosis as perceived by livestock sector respondents

A total of 17 respondents (eight from district / town council livestock and fisheries offices, three from regional administrative secretariat, three from Zonal Veterinary Investigation Centers, two from Tanzania Veterinary Laboratory Agency, one from the Ministry of Livestock and Fisheries) were interviewed to capture their perceptions on porcine cysticercosis diagnostic capacity in their respective working stations and those below them. The respondents were asked on the availability of *T. solium* porcine cysticercosis diagnostic capacity in terms of presence of meat inspectors and adequacy of meat inspectors in their respective districts. This was measured based on the respondent’s perceptions on the number of villages/wards in relation to the availability of meat inspectors in the respective villages/wards, skills of meat inspectors in terms of proper training in meat inspection, presence of pig slaughter house/slaughter slabs and whether or not these meat inspectors were facilitated in their routine meat inspection duties. Respondents from TVLA were interviewed to capture their perceptions about the role their laboratories were playing in the diagnosis of porcine cysticercosis. Four out of 7 quotations admitted that there were no official pig slaughter slabs or slaughter houses *[‘Do you know what the problem is? There is no slaughter house for pigs. Do you know that in many places in Tanzania, there are no specific slaughter slabs for pigs, do you know that?',* Male, District Livestock and Fisheries Officer*]*. Ten out of 12 quotations admitted that meat inspectors were not adequate *['Aah, as we are talking now, I need to ask for a permit to allow those who have retired from their public service to be allowed to work and do meat inspection, for those who have certificate or diploma or Bachelor of Veterinary Medicine in animal health to be doing meat inspection and animal health service delivery. That is because we have high deficiency with animal health extension officers,…',* Male District Livestock and Fisheries Officer*]*. In addition, eight out of 15 quotations admitted that some of the meat inspectors were not trained for the job *['Exactly, so sometimes he may decide to take the photo and post on WhatsApp group and may be the expertise in the respective sector are in the field and didn’t have a look on the WhatsApp and it is until they have a look on WhatsApp….. but unfortunately you see the photo at 6 or 9pm ....and then you tell him that this carcass had cysticercosis challenge, and he replies that they have already eaten’* Male, Ag District Livestock and Fisheries Officer*]* and 12 out of 14 quotations admitted that meat inspectors were not facilitated, meaning that they were not provided with necessary working tools and the means of transport to reach various locations to inspect meat *[‘Because every time he works he doesn't have working facilities, he has to take a motorcycle and go, he has to pay some money out of his pocket …, you see?, so ... um ... that’s the challenge, these guys don’t have even working tools, so, mmmh ... really ... not so much,’* Male, District Livestock and Fisheries Officer*]*. Furthermore, three out of five quotations from TVLA respondents admitted that porcine cysticercosis was largely diagnosed visually at postmortem meat inspection *['The main point is like I said before, it is due to the nature of this disease, its nature, according to the laboratory we have there is no diagnostic technique that can detect beyond meat inspection technique with which they are directly seen by naked eyes, and you can say this is T. solium, so there is no need to seek for another technique, for example you may have molecular technique which are very expensive, now the laboratory has no reason to go for the very expensive technique while the diagnosis can be done directly at meat inspection and it is reliable',* Male, Officer in Charge of TVLA*]* (Table 2.5).

Table 2.5: Diagnostic capacity for *T. solium* porcine cysticercosis as perceived by livestock sector respondents

Factor	DLO quotations (theme)	TVLA quotations (theme)	ZVC quotations (theme)	RAS quotations (theme)	MoLF Quotations (themes)	Total Quotations (theme)
Availability of official slaughter slabs for pigs						
Inadequate	2	0	1 (theme)	0	0	3
Unavailable	3 (theme)	0	0	0	1 (theme)	4 (theme)
Availability of meat inspectors						
Available	1	0	0	0	0	1
Adequate	1	0	0	0	0	1
Inadequate	7 (theme)	0	0	2	1 (theme)	10 (theme)
Availability of trained meat inspectors						
Some trained	1	0	1	3 (theme)	1 (100.0)	6
Some not trained	6 (theme)	0	2 (theme)	0	0	8 (theme)
All trained	1	0	0	0	0	1
Availability of facilitation of meat inspectors						
Available	0 (00.0)	0	0	0	0	0
Sometimes available	2 (theme)	0	0	0 (theme)	0	2
Unavailable	6 (theme)	1 (theme)	02 (theme)	3 (theme)	1 (theme)	12 (theme)
Availability of laboratory diagnosis for porcine cysticercosis						
Laboratory diagnosis costly	0	2	0	0	0	2
Disease diagnosed at abattoir	0	3	0	0	0	3 (theme)
Samples occasionally submitted	0	1	0	0	0	1

2.2.2 Quantitative results

A total of 260 participants, comprising of 152 officers in charge of primary health facilities and 108 meat inspectors were interviewed. Out of the 260 respondents interviewed 71.5% were males. Their demographic characteristics are summarized in table 2.6.

Table 2.6: Demographic characteristics of officers in charge of primary health facilities, meat inspectors, diagnostic facilities and slaughter houses/slabs

Variable	Number and percentage (%) of respondents	
	Officers in charge of primary health facilities	Meat inspectors
Region		
Manyara	53 (34.4)	38 (34.5)
Dodoma	36 (23.4)	26 (24.5)
Ruvuma	63 (42.2)	44 (40.9)
District		
Babati	30 (19.7)	22 (20.3)
Mbulu	23 (15.1)	16 (14.8)
Kongwa	36 (23.6)	26 (24.1)
Mbinga	42 (27.6)	28 (25.9)
Nyasa	21 (13.8)	16 (14.8)
Type of primary Health facility		
Dispensary	131 (86.2)	NA
Health centers	21 (13.8)	NA
Health facility ownership		NA
Private	36 (23.4)	NA
Public	118 (76.6)	NA
Clinical medical health against other profession		
Officers in charge with clinical medical health background	118 (77.6)	NA
Officers in charge with non-clinical medical health background	34 (22.4)	NA
Animal health profession against other profession		
Animal health	NA	44 (40.7)
Other background	NA	64 (59.3)

Number of pork slaughter houses/slabs		
Slaughter houses/slabs present	NA	20 (18.2)
Slaughter houses/slabs absent	NA	90 (81.8)

(i) Diagnosis of *T. solium* taeniosis and neurocysticercosis/epilepsy

Out of the 152 officers in charge of primary health facilities interviewed, 66.2% reported that the health facilities in which they were working had no laboratory with necessary equipment to do stool examination for *T. solium* tapeworm. With respect to this, 46.5% of the respondents relied on patients' explanation from the mother of a child that she has seen the tapeworm pieces in their stool to diagnose taeniosis.

Clinical signs were the major means of diagnosing epilepsy whereby 40.1% of the respondents said they diagnosed the disease clinically. With respect to clinical signs diagnosis, 23.7% of the respondents said they diagnosed one to five new epileptic cases in a year while 2.0% of the respondents diagnosed six to 10 new epileptic cases in a year (Table 2.7).

Table 2.7: Awareness and means of diagnosing *T. solium* taeniosis and epilepsy among officers in charge of primary health facilities

Variable	Number of responses (n)	Percentage
Awareness about *T. solium* tapeworm		
Yes	133	87.5
Number of hosts for *T. solium* tapeworm		
Two host	79	52
Other	73	48
The two *Taenia solium* hosts mentioned		
Pigs and human	62	40.8
Others	90	59.2
Presence of laboratory in the primary health facility		
Laboratory present	52	33.8
Laboratory not present	102	66.2
Taeniosis cases diagnosed per month		
Don't diagnose any case	132	86.8
1-5 taeniosis cases/month	19	12.5
>5taeniosis cases/month	1	0.7
Awareness about *T. solium* cysticerci		
Yes	72	47.4
Diagnosis of epilepsy		
Don't diagnose any case	88	57.9
Clinical signs	61	40.1
I don't know	3	2.0
Number of new epileptic cases diagnosed per year		
Don't diagnose any case	113	74.3
1-5 number of epileptic cases/year	36	23.7
>5 number of epileptic cases/year	3	2.0

Out of the 152 respondents interviewed, 87.5% agreed that they knew *T. solium* tapeworm and 47.5% agreed that they knew *T. solium* cysticerci. Out of those who said they know the tapeworm only 32.2% got all the tapeworm descriptions right and 32.2% got 75% of the descriptions right. In summary, 64.4% of respondents had excellent knowledge of *T. solium* tapeworm, 13.8% had average knowledge of the tapeworm and 21.7% had poor knowledge about the tapeworm. Generally, 77.8% of the respondents scored above average about description of the *T. solium* tapeworm and 21.7% scored below average (Fig. 2.2).

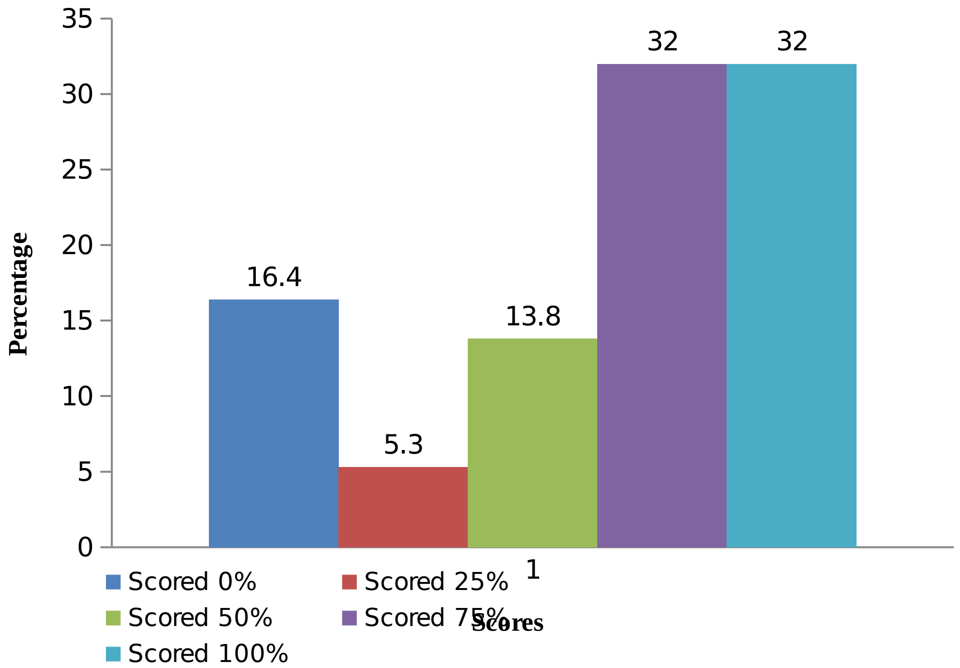

Figure 2.2: Percentage and scores of officers in charge of primary health facilities with correct description of *T. solium* tapeworm (n=152)

Among the respondents who said they knew *T. solium* tapeworm, 56.6% correctly mentioned the two tapeworm hosts, 29.6% mentioned only one correct host while missing on the other, and the remaining 13.8% wrongly mentioned the type of tapeworm hosts.

Respondents' knowledge about *T. solium* cysticerci were variable, with only 9.2% getting all (100%) descriptions correct, 18.4% getting 75% of the descriptions correct and 14.5% getting 50% of the descriptions correct. The remaining 57.9% of respondents scored below average. This resulted into classifying 27.6% of the respondents under 'excellent knowledge' of *T. solium* cysticerci, 14.5% under 'good knowledge' about *T. solium* cysticerci and 57.9% under 'poor knowledge' about *T. solium* cysticerci. In summary, only 42.1% of respondents scored above average while 57.9 of the respondents scored below average (Fig. 2.3).

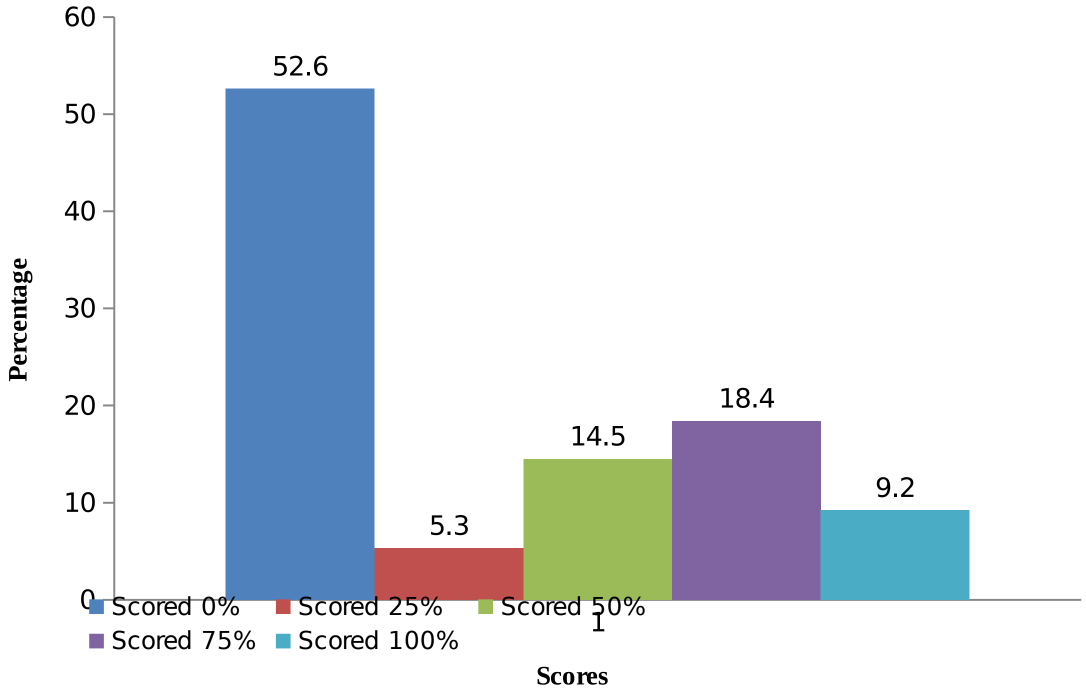

Figure 2.3: Percentage and scores of officers in charge of primary health facilities with correct description of *T. solium* cysticerci morphology (n=152)

Furthermore, 38.8% of the respondents correctly described the means by which human gets infected with *T. solium* cysticerci with 27.6% mentioning both eating of food and drinking of water contaminated by *T. solium* eggs and 11.2% mentioning of either drinking of water or eating of food contaminated by *T. solium* eggs. The remaining 61.2% of respondents mentioned consumption of pork as the source of human infection by *T. solium* cysticerci.

The study found that there was significant difference in awareness about *T. solium* tapeworm and neurocysticercosis among officers in charges of the primary health facilities. Those with clinical medical health professional training (MHP) were significantly more aware than the other professionals (OP), about *T. solium* tapeworm ($P<0.009$) and neurocysticercosis ($P<0.005$). Furthermore, there was significant difference among officers in charge of primary health facilities with different medical health professional backgrounds about correct description of neurocysticercosis ($P<0.017$). However, there was no significant difference in awareness about *T. solium* cysticerci, correct descriptions of *T. solium* cysticerci and *T. solium* tapeworm among officers in charge of primary health facilities with different medical professional backgrounds. The study also found no significant difference in knowledge about mechanisms by which human gets infected by *T. solium* cysticerci and the number and type of the tapeworm hosts among officers in charge of primary health facilities with different medical professional backgrounds (Table 2.8).

Table 2. 8: Association of background of medical officers in charge of primary health facilities and awareness on *T. solium* cysticerci taeniosis

Factor	MHP	OP	Pearson Chi-square	Likelihood ratio
Awareness about *T. solium* tapeworm				
Yes	112	6		P<0.009
No	21	13		
Awareness about *T. solium cysticerci*				
Yes	59	13	ns	
No	59	21		
Awareness about neurocysticercosis				
Yes	56	8		P<0.005
No	3	5		
Definition of neurocysticercosis				
Correct definition	34	3	P<0.017	
Wrong definitions	84	31		
Description of *T.solium* tapeworm				
A 4 meters long or more	69	14	ns	
A pigmented tapeworm with scolex (head)	86	19		
Made up of four suckers each consisting of double rows of hooks with which it attaches itself on the walls of the intestine	94	19		
Has proglottids which contain eggs	79	13		
Description of *T. solium* cysticerci				
Fluid filled sac	39	5	P < 0.019	
A 0.5 to 2cm in diameter	20	8		
A white – greyish coloured sac	47	10		
Resides in many tissues and organs including brain	54	9		
Human infection by *T. solium* cysticerci				
Eating food contaminated with T.solium eggs	47	9	ns	
Drinking water contaminated with T.solium eggs	35	10		
Number and hosts of *T. solium* tapeworm				
Human	70	16	ns	
Pig	102	21		

Large proportion of officers in charge of primary health facilities with less than 10 years working experience were aware about *T. solium* cysticerci than those with much more working experience (P<0.046)**.** On the other hand, there was no significant difference in awareness about *T. solium* cysticerci, correct descriptions of *T. solium* tapeworm and *T. solium* cysticerci among officers in charge of primary health facilities with different working experience. There was also no significant difference in knowledge about the mechanisms by which human gets infected with *T. solium* cysticerci and the number and type of the tapeworm hosts among officers in charge of primary health facilities with different working experience (Table 2.9).

Table 2.9: Association between working experience of the officers in charge of primary health facilities and awareness on *T. solium* cysticercercosis taeniosis

Factor	Experience defined by number of years in employment				
	0 -10 years	11-20 years	>20 years	Pearson Chi-square	Likelihood ratio
Awareness about *T. solium* tapeworm					
Yes	100	15	18		ns
Awareness about *T. solium cysticerci*					
Yes	48	11	13	P < 0.046	
Awareness about neurocysticercocis					
Yes	42	11	11		ns
Description of *T. solium* cysticerci					
Fluid filled sac	30	6	8	ns	
A 0.5 to 2cm in diameter	19	5	4		
A white – greyish coloured sac	36	9	12		

Resides in many tissues and organs including brain	42	9	12	
Human infection by *T. solium* cysticerci				
Eating food contaminated with *T. solium* eggs	37	8	11	ns
Drinking water contaminated with *T. solium* eggs	29	7	9	
Description of *T. solium* tapeworm				
A 4 meters long or more	61	12	10	ns
A pigmented tapeworm with scolex (head)	76	14	15	
Made up of four suckers each consisting of double rows of hooks with which it attaches itself on the walls of the intestine	87	11	15	
Has proglottids which contain eggs	66	11	15	
Number and hosts of *T. solium* tapeworm				
Human	70	13	11	ns
Pig	91	14	18	

(ii) *T. solium* porcine cysticercosis diagnosis

Out of the 108 interviewed meat inspectors, 59.3% were not trained in animal health at any level and neither had they had formal meat inspection training course. Pig slaughter slabs were said not to be present by 90.7% of the respondents interviewed and there was a total of only 20 pig slaughter slabs in areas where the respondents were working. Furthermore, 75.0% of the respondents had graduated their field extension training professions 11 to 20 years ago and only 7% had attended formal short course training about meat inspection (Table 2.10).

Table 2.10: Awareness about *T. solium* tapeworm, *T. solium* cysticerci, presence of slaughter slabs, time passed since graduation/short course training on meat inspection and the number of porcine cysticercosis cases diagnosed

Factor	Number of responses	Percentage
Awareness *about T. solium* tapeworm		
Yes	88	81.5
Presence of pig slaughter slabs		
Yes	10	9.3
The two *Taenia solium* hosts mentioned		
Human and pigs	74	68.5
Other	34	31.5
Awareness about *T. solium* cysticerci		
Yes	107	99.1
Total number of pig slaughter slabs	20	
Porcine cysticercosis cases diagnosed per month		
Don't diagnose any case	72	66.7
1-5 porcine cyst	34	31.5
5-10 porcine cyst	2	1.9
Years passed since graduation of meat inspectors		
0-10 years	8	7.4
11-20 years	81	75.0
> 20 years	19	17.6
Short course training on meat inspection		
No	101	93.5
Yes	7	6.5
Time passed since last training		
Never attended meat inspection short course	101	93.5
12-60 months	3	2.8

61-120 months	1	.9
>120 months	3	2.8

Out of the 108 meat inspectors interviewed 87.5 agreed that they knew *T. solium* tapeworm and 99.1% agreed that they knew *T. solium* cysticerci. Those who said they know the tapeworm, only 6.5% got all (100%) tapeworm descriptions right and 17.6% got 75% of the description right. The remaining 18.5% respondents got 50% of the descriptions correct, 17.6% got 25.0% of the descriptions correct and 39.8% got all of the descriptions wrong. In summary, 24.1% of respondents had excellent knowledge of *T. solium* tapeworm, 18.5% had average knowledge of the tapeworm and 57.4% had poor knowledge about the tapeworm. Only 42.6% of meat inspectors scored above average and 57.4% scored below average (Fig 2.4).

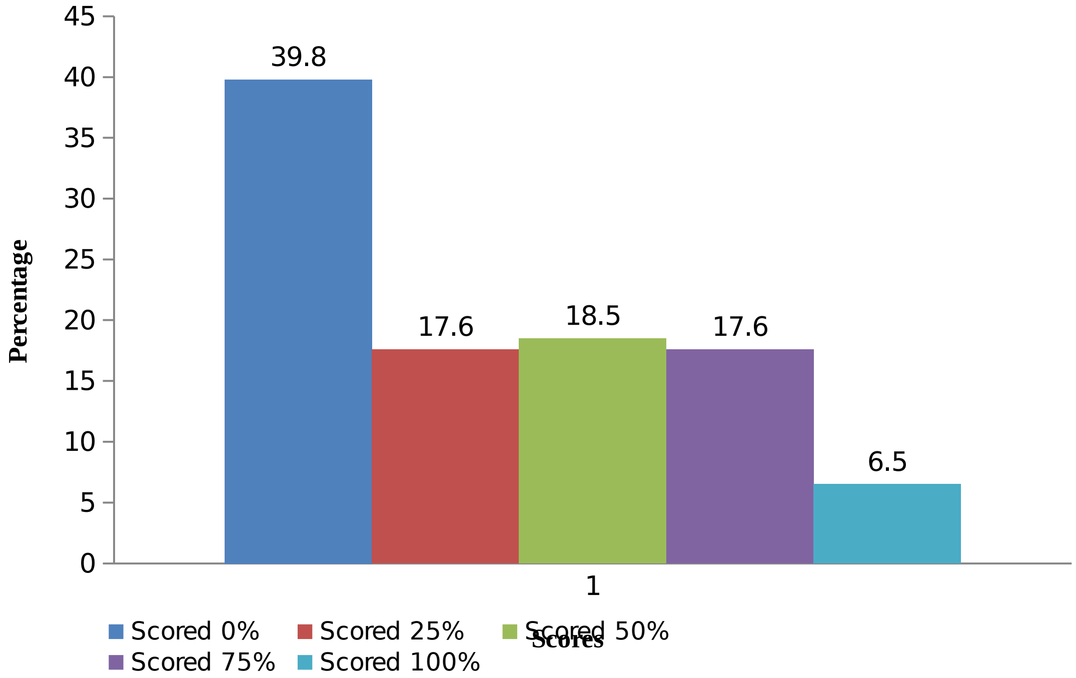

Figure 2.4: Percentage and scores of meat inspectors with correct description of *T. solium* tapeworm (n=108)

Meat inspectors' responses towards tapeworm hosts were varying, with 68.5% correctly mentioning the two tapeworm hosts while 13% mentioned only one correct host and the remaining 18.5% wrongly mentioned the tapeworm hosts.

Respondents' knowledge about *T. solium* cysticerci were varying, with only 7.4% getting all (100%) of the descriptions correct, 28.7% getting 75% of the descriptions correct and 45.4% getting 50% of the descriptions correct. The remaining 15.7% of the respondents scored below average. This resulted into classifying 36.1% of the respondents under 'excellent knowledge' of *T. solium* cysticerci, 45.4% under 'good knowledge' about *T. solium* cysticerci and 2% under 'poor knowledge' about *T. solium* cysticerci (Fig 2.5). In summary, out of the 108 meat inspectors, 81.2% scored above average and 28.5% scored below average.

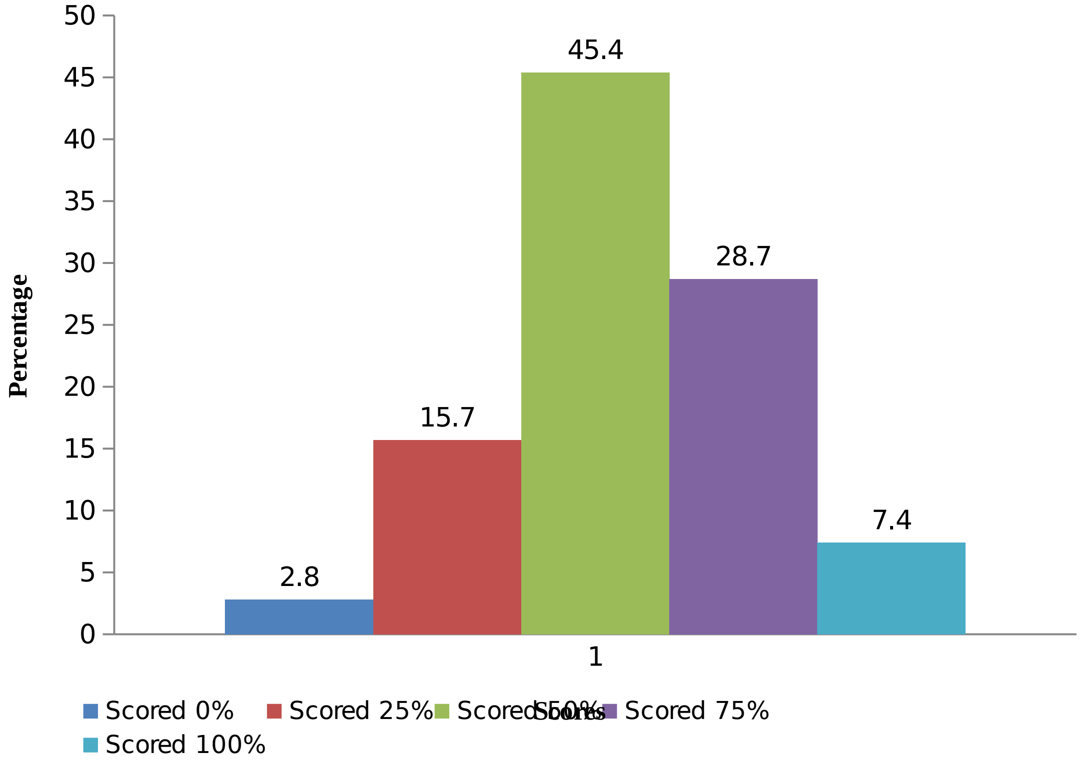

Figure 2.5: Percentage and scores of meat inspectors with correct description of *T. solium* cysticerci (n=108)

Meat inspectors had also varying knowledge about the risk factors for *T. solium* tapeworm life cycle maintenance with 26.9% correctly mentioning all (100.0%) of the risk factors for tapeworm life cycle maintenance and 23.1% correctly mentioning 80.0% of risk factors for the tapeworm life cycle maintenance. The remaining 15.7% of the respondents correctly mentioned 60.0% of the risk factors and 11.1% correctly mentioned 20.0% of the risk factors (Fig 2.6).

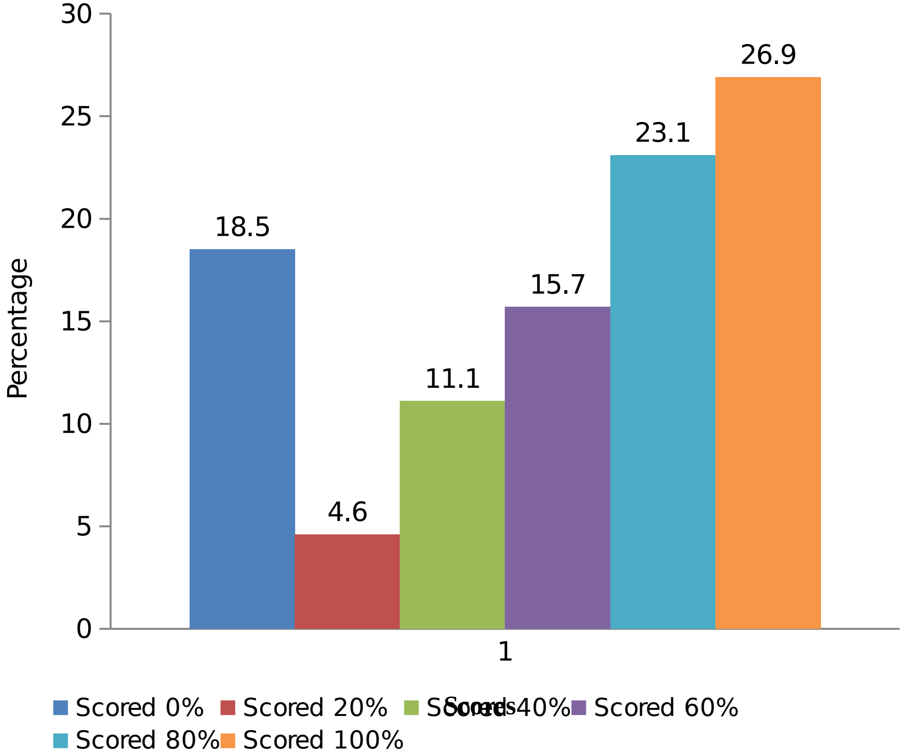

Figure 2.6: Percentage and scores of meat inspectors with correct explanation of the risk factors for *T. solium* life cycle maintenance (n=108)

This resulted into classification of meat inspectors into different levels of knowledge about risk factors for *T. solium* tapeworm life cycle maintenance (Fig 2.7).

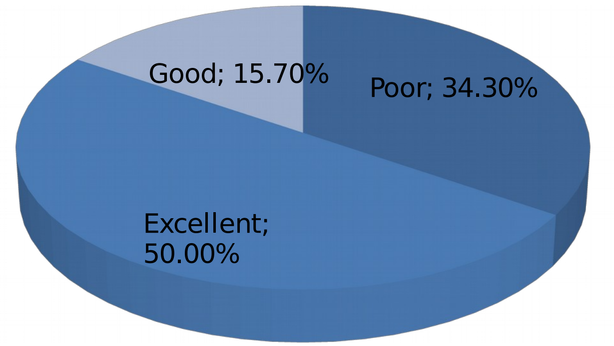

Figure 2.7: Distribution of meat inspectors with respect to their level of knowledge on risk factors for *T. solium* (n=108)

Out of 110 respondents, 65.7% scored above average on their knowledge about risk factors for *T. solium* tapeworm life cycle maintenance. Furthermore, respondents had varying knowledge regarding *T. solium* porcine cysticercosis risk based meat inspection (Fig. 2.8).

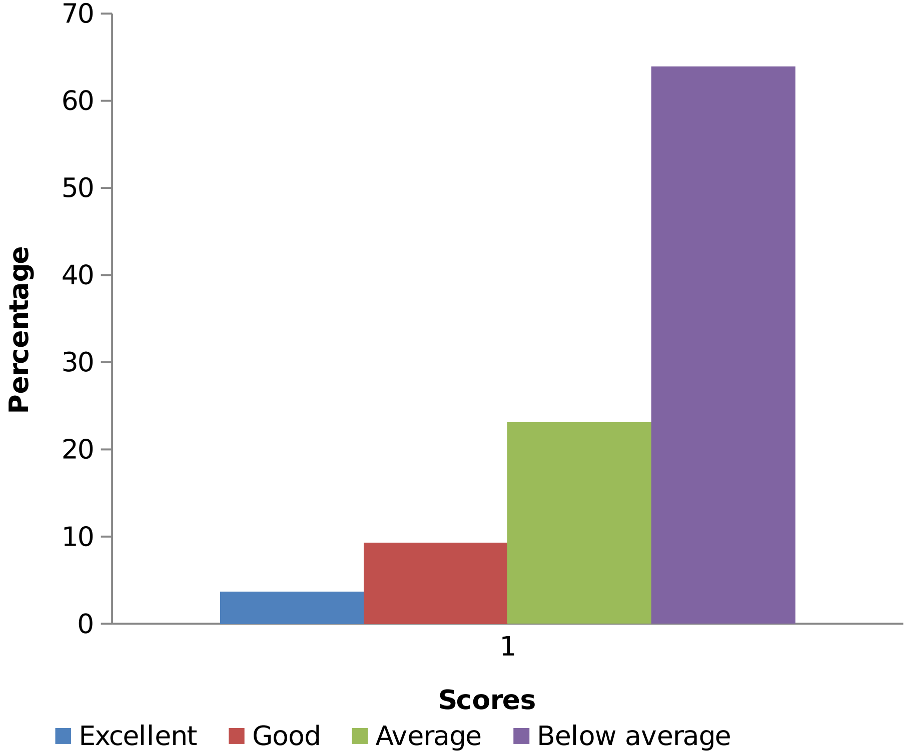

Figure 2.8: Distribution of meat inspectors with respect to their level of knowledge about *T. solium* porcine cysticercosis risk based meat inspection

Regarding the sites most likely to diagnose porcine cysticercosis, most respondents said that they normally inspect the tongue (17.6%), masseter muscles (15.1%), leg muscles (14.2%), heart muscles (13.6%) and psoas muscles (10.9). Other organs mentioned were neck muscles, rib muscles, liver, abdominal muscles and bladder, intestines and stomach (Figure 2.9).

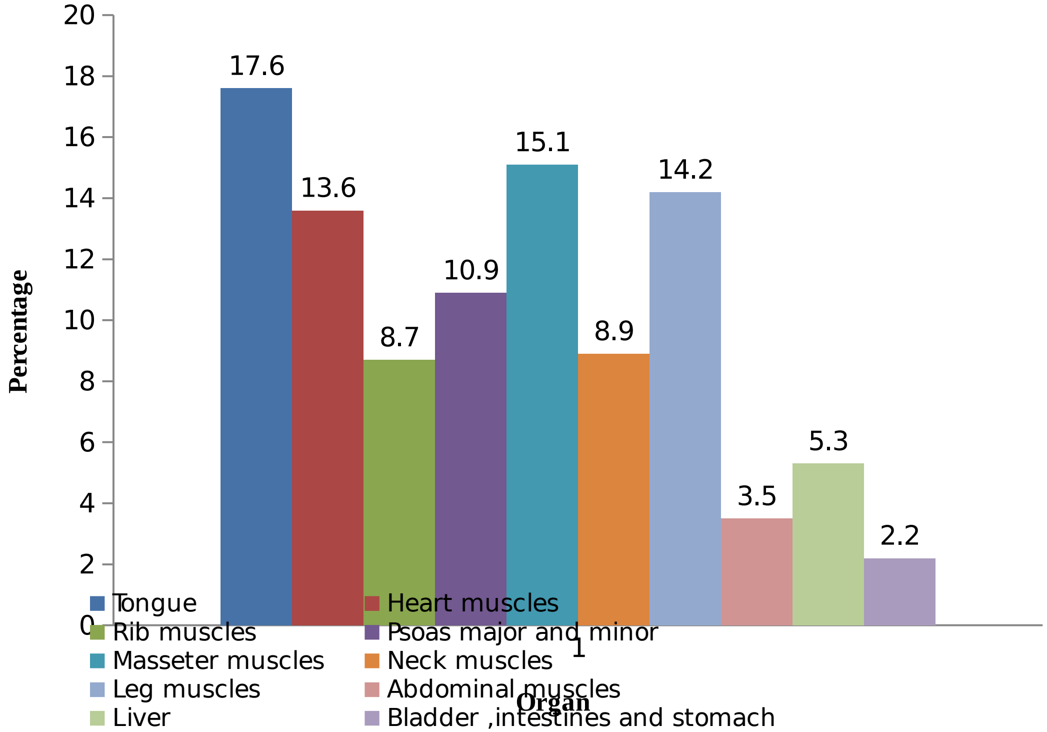

Figure 2.9: Common organs targeted for diagnosis of *T. solium* by meat inspectors (n=550)

The study found no significant difference in awareness about *T. solium* cysticerci between meat inspectors with animal health professional background and those with different professional backgrounds. There was also no significant difference about the correct descriptions of *T. solium* tapeworm and *T. solium* cysticerci among meat inspectors with different professional background. Furthermore, there was no significant difference in knowledge about the mechanisms by which human gets infected by *T. solium* cysticerci and risk factors for the parasite life cycle maintenance among meat inspectors with different professional background. Nevertheless, the study found that large proportion of meat inspectors with professional background other than animal health appeared to be aware about *T. solium* tapeworm than those with animal health profession ($p<0.009$) (Table 2.11).

Table 2.11: Awareness and association between professional background of the meat inspectors and correct descriptions of *T. solium* tapeworm, *T. solium* cysticerci, ways of human infection by *T. solium* cysticerci and risk factors for *T.solium* life cycle maintenance

Factor	AHP	OP	Chi-Square	Likelihood ratio
Awareness about *T. solium* tapeworm				
Yes	41	47	P<0.009	
No	3	17		
Awareness about *T. solium* cysticerci				
Yes	44	63		ns
No	0	1		
Description of *T. solium* tapeworm				
A 4 meters long or more	8	10	ns	
A pigmented tapeworm with scole (head)	24	26		
Made up of four suckers each consisting of double rows of hooks with which it attaches itself on the walls of the intestine	21	19		
Has proglottids which contain eggs	17	19		
Description of *T. solium* cysticerci				
Fluid filled sac	24	24	ns	
A 0.5 to 2cm in diameter	6	10		
A white – greyish coloured sac	39	53		
Resides in many tissues and organs including brain	34	50		
Human infection by *T. solium* cysticerci				
Eating food contaminated with *T. solium* eggs	29	46	ns	
Drinking water contaminated with *T. solium* eggs	29	43		
Risk factors for *T. solium* life cycle maintenance				
Improper handling of cysticerci infected pork	36	42	ns	
Unhygienic preparation of food	23	24		
Improper use of latrines	31	36		
Drinking of unsafe water which may be contaminated by eggs of *T. solium*	29	38		
Negligence to treatment of the infected patient	33	33		

The study found no significant difference among meat inspectors with different working experience on correct descriptions of *T. solium* tapeworm and *T. solium* cysticerci. There was also no significant difference among meat inspectors with different working experience on their awareness about *T. solium* tapeworm and *T. solium* cysticerci. Furthermore, there was no significant difference on correct descriptions about risk factors for the tapeworm lifecycle maintenance and the number and type of the tapeworm hosts among meat inspectors with different working experience (Table 2.12).

Table 2.12: Association of working experience of meat inspectors and their **awareness on *T. solium* tapeworm and *T. solium* cysticerci**

Factor	**Experience defined by number of years in employment**				
	0-10 years	**11-20 years**	**>20 years**	**Pearson Chi-square**	**Likelihood ratio**
Awareness about *T. solium* tapeworm					
Yes	8	64	16		ns
Awareness about *T. solium* cysticerci					
Yes	8	81	18		ns
Human infection by *T. solium* cysticerci					
Eating food contaminated with *T.solium* eggs	37	8	11	ns	
Drinking water contaminated with *T.solium eggs*	29	7	9		
Risk factors for *T. solium* life cycle maintenance					
Unsafe disposal of cysticerci infected pork	7	55	16		ns
Unhygienic preparation of food	4	36	7		
Improper use of latrines	6	45	16		
Drinking of unsafe water which may be contaminated by eggs of *T.solium*	6	52	9		
Infected patients not treated	5	49	12		
Description of *T. solium* tapeworm					
A 4 meters long or more	61	12	10		ns
A pigmented tapeworm with scolex (head)	76	14	15		
Made up of four suckers each consisting of double rows of hooks	87	11	15		

Has proglottids which contain eggs	66	11	15	
Number and hosts of *T. solium* tapeworm				
Human	8	52	15	ns
Pig	8	63	16	
Description of *T. solium* cysticerci				
0.5 to 2cm in diameter	13	3		ns
Resides in many tissues and organs including brain	63	21		
A fluid filled sac	39	9		
A white – greyish colored sac	67	25		

Respondents had various responses concerning the decisions they make once they diagnose *T. solium* cysticerci in pork carcass with majority doing total condemnation and burying the carcass (41.2%) while others were opting for burning the carcass (24%). However, some respondents allowed the carcass to be eaten under condition that it should be thoroughly cooked (6.6%) and others passed the carcass if the cysticerci are less than 5 (1.6%) or 12 (1.1%), (Fig. 2.10).

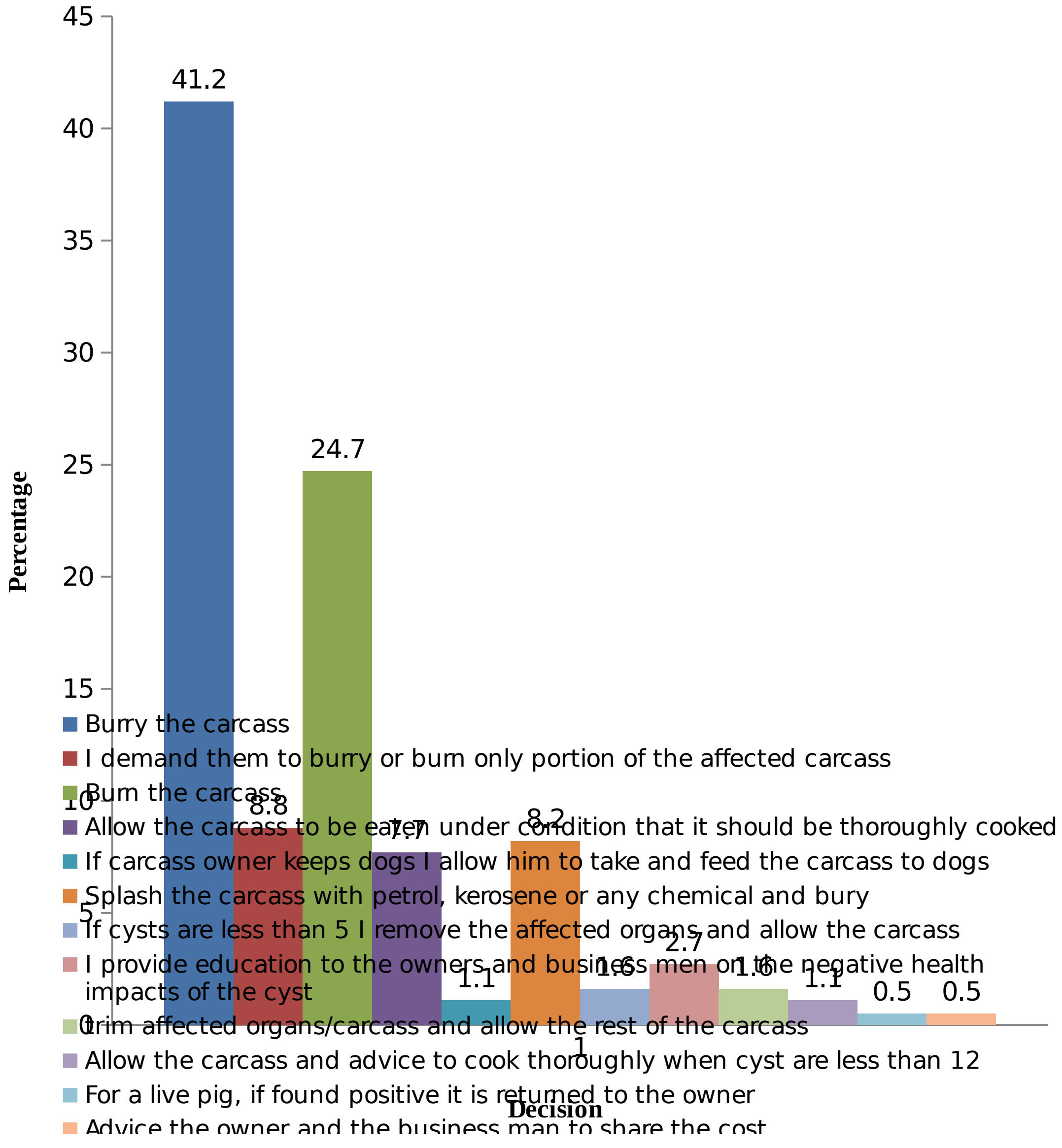
Percentage
45
40
35
30
25
20
15
10
5
0
41.2
8.8
24.7
7.7
1.1
8.2
1.6
2.7
1.6
1.1
0.5
0.5
1
Decision
Burry the carcass
I demand them to burry or burn only portion of the affected carcass
Burn the carcass
Allow the carcass to be eaten under condition that it should be thoroughly cooked
If carcass owner keeps dogs I allow him to take and feed the carcass to dogs
Splash the carcass with petrol, kerosene or any chemical and bury
If cysts are less than 5 I remove the affected organs and allow the carcass
I provide education to the owners and business men on the negative health impacts of the cyst
trim affected organs/carcass and allow the rest of the carcass
Allow the carcass and advice to cook thoroughly when cyst are less than 12
For a live pig, if found positive it is returned to the owner
Advice the owner and the business man to share the cost

Figure 2.10: Decisions made by meat inspectors on cases which are positive for *T. solium* porcine cysticercosis

2.3 Discussion

To the best of my knowledge this is the first study conducted in Tanzania to assess the TSCT diagnostic capacities of veterinary and medical health facilities and medical practitioners and veterinarians' knowledge and practices towards diagnosis of TSCT. The study findings have highlighted the challenges that need to be addressed to enable efficient disease diagnosis in both veterinary and medical health facilities. In addition, the findings have realized the need and importance of One Health approach to ensure efficient disease diagnosis, particularly in primary health centers and at meat slaughter slabs/houses for optimum countrywide disease magnitude estimation to create the base for TSCT control or eradication strategies.

In this study 71.5% of the respondents were males (Table 2.6). The reasons behind more participation of males than females in both medical and veterinary sectors can be explained by the fact that more males than females are enrolled in medical and veterinary colleges in Tanzania. More officers in charge from dispensaries were involved in the study than officers in charges from health centres because there were more dispensaries than health centres in the general population in the study area (Table 2.6). In both medical and veterinary sectors, less than the calculated sample size of respondents were interviewed because some of the health facilities and meat inspectors' geographical locations were unreachable because the roads were destroyed by heavy rains during data collection period.

The study found that there were many challenges which limit effective diagnosis of *T. solium* taeniosis and neurocysticercosis/epilepsy in medical sector and porcine cysticercosis in veterinary sector (Tables 2.3, 2.4 and 2.5). The use of both qualitative and quantitative data collection approaches provided room for triangulation of responses. Key informant interviews supplemented most of the information which could otherwise not be captured through questionnaire alone as the two categories of respondents had different levels of knowledge and working coverage. Medical and Veterinary/Livestock Officers from district to national levels had broader working coverage and were in position to provide informative responses concerning the topic. Not only did their responses complement questionnaire responses but also provided additional information on the topic. It is in our opinion that the two approaches complimented and supported one another.

T. solium taeniosis diagnosis challenges differed between primary and other levels of health facilities. Primary health facilities had much more challenges than other levels of health facilities in diagnosing taeniosis (Table 2.7). The lack of diagnostic laboratories and laboratory technicians made most helminthosis and taeniosis diagnosis difficult and the clinicians had to rely mostly on clinical presentation and the patient's history. Lack of clinicians in some of the primary health facilities further incapacitated the primary health facilities to diagnose the disease. With these challenges it is difficult to confidently quantify the magnitude of the disease basing on diagnosis results at primary health facilities because most helminthosis abdominal clinical presentation are not specific and patient's history may be too obscured to rely on (Craig and Ito, 2007).

Primary health facilities are the first health centers to which most of the resource poor individuals seek health consultation in most of developing countries (Maeseneer and Twagirumukiza, 2010). This makes them to be important catchment areas to capture community health status of a particular disease. The fact that only 33.8% of the primary health facilities in the study districts had laboratories with capacity to diagnose helminthosis (Table 2.7), hinders efficient diagnosis of taeniosis. It is difficult to quantify *T. solium* taeniosis under this situation with insufficiently supportive diagnostic infrastructures and personnel to diagnose not only taeniosis but also other helminthosis diseases.

Lack of diagnostic facilities and diagnostic personnel to diagnose *T. solium* neurocysticercosis contributed much to obscured data about the disease magnitude in the study regions despite the fact that epileptic cases were frequently identified. While it was possible to diagnose an epileptic patient at primary and districts hospitals, it was difficult to confirm the exact cause of the epilepsy when connection to heredity and accidents related causes was loose. Zonal tertiary hospitals to which some epileptic cases could be referred to for confirmatory diagnosis were lacking CT scanners and MRI machines, further making the diagnosis of neurocysticercosis and associated clinical manifestations difficult. This is in line with WHO report about *T. solium* neurocysticercosis diagnosis challenges in most of sub Saharan countries whereby absence of advanced diagnostic equipment has been mentioned among the contributing factors (WHO, 2015).

Diagnostic facilities for neurocysticercosis/epilepsy were limited to some of the tertiary hospitals resulting into reduction of diagnostic services coverage. The fact that *T. solium* neurocysticercosis is the disease associated with poverty further reduces accessibility of the diagnostic services due to high service and travelling costs (Pal *et al.*, 2000). As such, what is currently known about the disease burden is likely to be less than what is actually the disease status in the community.

Challenges facing *T. solium* porcine cysticercosis diagnosis included inadequate pig slaughter houses/slabs, inadequate meat inspectors, inadequate knowledge on *T. solium* porcine cysticercosis risk based meat inspection among meat inspectors and the lack of facilitation in the day to day inspection activities (Tables 2.5 and 2.10: Fig. 2.8). Absence of transport facilitation reduced meat inspectors' mobility to provide meat inspection services to wider geographical area. This provides higher chances of leaving some areas unattended and thus greater risk of people eating uninspected pork and more chances of being exposed to infested products and thus developing taeniosis.

Inability of meat inspectors to efficiently move around to provide meat inspection services poses a risk of a significant number of pig carcasses going uninspected as a result of failure of meat inspectors to reach the slaughter slabs on time or not appearing at all for meat inspection. Likewise, in a study done to compare operations and challenges of pig butchers in rural and peri-urban settings of western Kenya it was reported that pork meat inspection by state meat inspectors was lately done or not done at all in some days (Levy *et al.*, 2014). This resulted into some pig carcasses going uninspected, posing risk of taeniosis infection to pork consumers. This finding explains common challenges in meat inspection sectors with the common reasons being inadequate number and mobility of meat inspectors in respective areas to provide meat inspection service. This results into inadequate data about *T. solium* porcine cysticercosis being captured and most importantly is the fact that under this situation the public health is jeopardized as most of uninspected pork is consumed in places where inspection service is either lately provided by meat inspectors or sometimes not available at all.

Inadequate slaughter slabs provides room for home slaughter of pigs (Table 2.10). Similar to our findings, in a study intended to assess knowledge and practices related to *T. solium* cysticercosis-taeniasis among smallholder farmers it was found that majority of farmers practiced home slaughter of pigs (Maridadi *et al*, 2016). Under this situation meat inspection became more difficult because despite having no transport to move around the scattered houses to do meat inspection he or she will sometimes never know houses/homes which have slaughtered pigs to inspect. This increases the chances that the population in the surveyed community is eating uninspected pork with higher risk of getting exposed to taeniosis infection (Meester *et al.*, 2019).

Majority of meat inspectors (59.3%) do not have formal training on meat inspection, with the majority being graduates in various disciplines other than animal health (Table 2) with below average knowledge on *T. solium* porcine cysticercosis risk based pork inspection practices. This further exposes the served community into greater chances of exposure to improperly inspected pork carcasses and higher chances of developing taeniosis and neurocysticercosis. This is because despite the challenges facing efficient and reliable pork inspection practices, the meat inspection procedures itself is reported to lack sensitivity to detect all porcine cysticercosis cases (Sithole *et al.*, 2019). This means that under this situation, eating porcine cysticercosis free pork is not guaranteed in the surveyed areas.

Improper porcine cysticercosis risk based pork carcass inspection observed in the study districts has consequent potential to public health threat. This is evidenced by the study findings whereby 63.9% of meat inspectors scored below average on *T. solium* cysticercosis risk based pork carcass inspection (Fig. 2.8). This may be explained by the fact that majority of meat inspectors (59.3%), had no animal health training background with high possibility that their meat inspection skills could be much lower than those with the training. The fact that some meat inspectors passed for human consumption the perceived lightly porcine cysticercosis infected pork further exposes the community to taeniosis infection. It appears that some meat inspectors confuse decisions meant for *T. saginata* cysticerci positive cases with those for *T. solium* cysticerci positive cases by conditionally passing the *T. solium* cysticerci perceived lightly infected pork for human consumption (Fig. 2.10). This may have been caused by the fact that there is no current Tanzania meat inspection guideline which specifically describes *T. solium* porcine cysticercosis risk based pork carcass inspection. The animal diseases regulations of 2007 only provide guideline for *T. saginata* cysticerci risk based meat inspection. Nevertheless, the guideline provide for total condemnation of pork carcass whenever *T. solium* cysticerci is diagnosed during postmortem pork inspection for localized and generalized infection (MoLF, 2007).

Some respondents perceived *T. solium* porcine cysticercosis as a commonly and well known parasite with higher chance that an experienced field livestock extension officer will diagnose the parasite. While this may be true especially with the fact that resources are limited in Tanzania and in most of the sub Saharan countries where the disease is endemic it is contrary to the findings by Sithole *et al*., (2019) who reported low sensitivity of postmortem pork inspection for diagnosing porcine cysticercosis.

The fact that some meat inspectors were passing for consumption the perceived lightly *T. solium* porcine cysticerci infected pork on condition that it should be thoroughly cooked further exposes the community to infection by taeniosis and increased risk of developing neurocysticercosis. This is because it is very unlikely that everyone will cook or treat the pork to a recommended temperature and time enough to kill the infective cysticerci in most of the rural communities of Tanzania and other low and middle economy countries (Okello and Thomas, 2017).

There was varying degree of knowledge/awareness on various aspects of *T. solium* taeniosis and neurocysticercosis/epilepsy. Out of 87.5% officers in charge of primary health facilities who agreed to know *T. solium* tapeworm, 78.2% (64.4% categorized under excellent scores and 13.8% categorized under average scores) scored above average in describing the *T. solium* tapeworm (Fig. 2.2). This could be attributed to the fact that being medical clinicians they have been taught about the tapeworm in their medical schools as one of worms of medical importance. Also the fact that they are medical practitioners increases their chances to encounter the parasite in some of their patients in their routine working environment. Contrary to this, out of 47.5% officers in charge of primary health facilities who agreed to know *T. solium* cysticerci, only 42.1% got above average score on correct description of *T. solium* cysticerci and only 38.8% correctly described the mechanisms by which human gets infected with

T. solium cysticerci. This could be attributed to the fact that the level of the diagnostic capacity of the health facilities they were working was too low to diagnose this stage of the parasite in their daily working environment.

There was significant difference in awareness about *T. solium* tapeworm (P<0.009), neurocysticercosis (P<0.005), correct definition of neurocysticercosis (P<0.017) and correct description of *T. solium* cysticerci (P<0.019) among officers in charge of primary health facilities with different professional background (Table 2.8). This might be explained by the fact that different health professional backgrounds exposed different respondents differently into health training courses, with those taking clinical medical health training being much more likely to be exposed to clinical courses and thus more likely that they were taught about the tapeworm biology in their medical training than those taking other types of health courses.

There was no significant difference in awareness and knowledge about *T. solium* tapeworm and mode of transmission in human among officers in charge of primary health facilities with different working experience (Table 2.9). This may have been contributed by the fact that given the time they have worked in the primary health facilities with most of them lacking diagnostic facilities, they may have come to a level of common understanding of the parasite given common working environment with common diagnostic challenges. However, the fact that large proportion of officers in charge of primary health facilities with less than 10 years working experience were aware about *T. solium* cysticerci than other categories (P<0.046) may be attributed to the fact that this age experience category were many in number than other categories (Table 2.9).

Although majority of meat inspectors (81.5%), agreed to be aware about *T. solium* tapeworm with 68% correctly mentioning the number and type of the tapeworm host, 57.4% scored below 50% on describing the tapeworm morphology (Fig. 2.4). Scoring below average on morphological description of the parasite could be attributed by the fact that their daily meat inspection and animal health service provision activities do not expose them to this adult stage of a parasite for them to sufficiently describe its morphological structure. Also, the fact that 59.3% of meat inspectors do not have animal health training background increases the chances that they do not know the parasite as they may have not been trained in their respective academic programs. This is supported by the fact that the same meat inspectors scored above average on questions that required them to describe the larval stage of the tapeworm which they frequently encounter in their daily ante and post mortem pig carcass inspection.

Large proportion of meat inspectors with professional background other than animal health appeared to be aware about *T. solium* tapeworm than meat inspectors with animal health profession (P<0.009). This could be contributed by the fact that there were many meat inspectors with non-animal health profession in the study sample than meat inspectors with animal health profession (Table 2.11). Absence of significant difference in awareness about *T. solium* cysticerci could be attributed to the exposure time during which meat inspectors with different professional background have been encountering the *T. solium* cysticerci in their daily meat inspection activities and *T. solium* cysticercosis is known to be endemic in the study districts. Likewise, insignificant difference about correct description of the *T. solium* cysticerci, mechanism by which human gets infected by the larval stage of the parasite and the risk factors for the parasite life cycle maintenance among meat inspectors with different professional background (Table 2.11) is attributed to the fact that both categories of respondents have been exposed to the parasite for a considerable period of time in their daily meat inspection activities to know the *T. solium* cysticerci. On the other hand, insignificant difference in awareness and knowledge about *T. solium* cysticerci, risk factors for the tapeworm lifecycle maintenance and human infection by the larval stage of the parasite among meat inspectors with different working experience can be explained by the fact that the tapeworm cysticerci is endemic in the study areas and the meat inspectors regularly encounter the cysticerci in their daily meat inspection activities. Thus it is easier for them to know the parasite within short period of time. It could otherwise be expected that those with many years of working in the field to be more knowledgeable about the parasite than those with shorter working experience. Insignificant difference in awareness and knowledge about *T. solium* tapeworm among meat inspectors with different working experience could be attributed to the fact that their daily meat inspection activities do not expose them to the adult stage of the parasite. This makes no difference in their knowledge about the tapeworm regardless of the time they have worked in the field.

In a study aimed at assessing physician awareness about *T. solium* taeniosis and the potential it has in infecting pregnant women it was found that 14.5% of respondents answered correctly that cysticercosis is acquired through ingestion of the parasite eggs in contaminated human stool, (Hall *et al.*, 2017). Our study found that 38.8% correctly answered that human gets infected by *T. solium* cysticerci through ingestion of the tapeworm eggs in contaminated food or water. This difference could be contributed by the fact that respondents interviewed in the previous study were specialized in gynecology while the respondents in this study were not working in a specialized medical career. This difference makes gynecologists much more likely to miss correct answers to questions with aspects they don't frequently encounter in their daily practices than officers in charge of primary health facilities who meet many patients of different categories in the first place before referring them to different specialists according to the symptoms each patient presents (Maeseenar and Twagimurukiza, 2010).

A smaller proportion of officers in charge of primary health facilities were knowledgeable about *T. solium* cysticerci (42.1%) than meat inspectors (71.5%) (Figs. 2.3 and 2.5). This could be caused by the fact that with the level of their health facilities, officers in charge of primary health facilities are less exposed to this larval stage of the parasite than meat inspectors. This is different from meat inspectors whose daily meat inspection activities expose them to *T. solium* cysticerci cases and thus many of them are aware and knowledgeable about the parasite larval stage. The difference could also be explained by the fact that taeniosis and the parasite biology are marginalized health problems in medical training (Pawlowski, 2008). On the other hand, the number of officers in charge of primary health facilities with knowledge about *T. solium* tapeworm was higher (77.8%) than that of meat inspectors (42.6%) (Figs 2.2 and 2.4). This could be explained by the fact that officers in charge of the primary health facilities are more likely to encounter this stage of the parasite in their daily activities. Also this is one of the parasites of medical importance taught in their medical schools, further contributing to many of them being knowledgeable of the tapeworm than meat inspectors counterparts.

Our study found that taeniosis was not diagnosed in primary health facilities due to inadequate diagnostic facilities and personnel. However, in a study conducted to evaluate porcine cysticercosis control integration within Indian agricultural, medical, food safety and public health system it was found that taeniosis diagnosis by medical doctors was not compulsory. This indicates differences in challenges hindering efficient diagnosis of the adult stage of the parasite in different countries. While it was more of financial constraints to provide for efficient diagnosis of taeniosis in our study, it appears that it was a neglected status of the disease that hindered its efficient diagnosis in India (GALV*med*, 2017).

In this study, a considerable knowledge on the *T. solium* tapeworm and *T. solium* cysticerci has been shown despite difference in knowledge regarding the two stages of the parasite between the study groups of officers in charge of primary health facilities and meat inspectors. This is similar to the findings from a study done to assess computer based *T. solium* health education knowledge uptake among health professions which found that health professions had considerable more knowledge about *T. solium* parasite (Ertel *et al.*, 2015).

The study findings are limited by the fact that it excluded laboratory personnel who were not officers in charge of primary health facilities and therefore didn't capture their knowledge and opinions particularly on taeniosis diagnosis. However, given the lower number of primary health facilities with laboratory facilities, their responses would not have significant contribution on the research objective. Inclusion of respondents with different levels of expertise, working in different levels of the health facilities served to mitigate this challenge.

The study was also challenged by Corona Virus Disease 2019 (COVID 19) pandemic and impassable weather roads which were destructed by heavy rains during data collection period. This limited access to some health facilities and meat inspectors in some wards and villages for data collection and resulted into lower than expected number of respondents for qualitative data to be collected.

2.4 Conclusion

T. solium taeniosis, neurocysticercosis and porcine cysticercosis diagnosis remain to be a challenge in both medical and veterinary sectors. The two forms of the disease in man bring about differences in magnitude of diagnostic challenges. While taeniosis diagnosis challenge is mostly at the level of primary health facilities, neurocysticercosis diagnosis challenge is mostly at the level of tertiary hospitals most of which diagnostic neuroimaging machines are lacking. Primary health facilities have a potential of serving large rural community which in most cases is at higher risk of taeniosis and neurocysticercosis infection. They need to be capacitated with diagnostic facilities and laboratory technicians to effectively serve taeniosis surveillance and help predicting neurcosticercosis vulnerable population countrywide. Porcine cysticercosis diagnosis challenge is more about inadequate trained meat inspectors with inadequate facilitation mostly in terms of mobility. In addition, both medical and veterinary practitioners' knowledge on the parasite needs to be improved through a One Health approach.

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CHAPTER THREE

Taenia solium Cysticercosis and Taeniosis Reporting in the Current Medical and Veterinary Disease Reporting Systems in Tanzania

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Abstract

Taenia solium taeniosis and cysticercosis (TSCT) are two forms of a zoonotic disease caused by *T. solium* tapeworm. There is perceived inefficient TSCT and human neurocysticercosis reporting in both medical and veterinary sectors in Tanzania. The study aimed at identifying the challenges in

TSCT reporting in the medical and veterinay sectors. A cross-sectional study was conducted in Babati, Mbulu, Kongwa, Mbinga and Nyasa districts in Manyara, Dodoma, Ruvuma, Arusha and Iringa regions using qualitative and quantitative research between January and April 2020. We interviewed 154 officers in charge of primary health facilities and 110 meat inspectors for quantitative data and 33 medical and veterinary officers for qualitative data about challenges facing TSCT reporting. Quantitative data were analysed for proportions using Statistical Package for Social Science (SPSS). Content analysis was used to analyse qualitative data using ATLAS.ti software. It was found that *T. solium* taeniosis and neurocysticercosis were not reportable diseases in the current medical disease surveillance and reporting system. The livestock diseases reporting system accommodated porcine cysticercosis reporting provided that the meat inspectors were able to diagnose it. Nevertheless, there was inadequate facilitation in the general livestock diseases surveillance and reporting system that hindered efficient reporting of *T. solium* porcine cystiecercosis among others and the reports were incomplete, submitted late or not submitted at all. It is concluded that both forms of the disease were not reported in the medical sector because they were among the neglected diseases and thus not reportable. Porcine cysticercosis was inadequately reported because the whole livestock diseases reporting system was inadequately facilitated for efficient diseases reporting. Zoonotic challenges of TSCT demands one health approach to improve disease reporting in both sectors, with medical sector revising their priority reportable diseases to include TSCT whereas adequate facilitation in livestock diseases reporting system should be considered for efficient porcine cysticercosis disease reporting among others.

3.0 Introduction

Taenia solium human and porcine cysticercosis is an infection of human and pigs by a larval stage of a zoonotic tapeworm called *T. solium* which is transmitted among humans and between humans and pigs (Pondja *et al*., 2010). When human accidentally ingests the parasite eggs through contaminated foods or hands he/she develops cysticercosis and when he/she eats improperly cooked *T. solium* cyst infected pork he/she develops taeniosis. Infection of the central nervous system by *T. solium* larvae causes neuryocysticercosis. Pigs get infected by the larval stage of the parasite through ingestion of the tapeworm eggs in contaminated feeds and water or when scavenging on human faeces (Devleesschauwer *et al.*, 2015). *T. solium* neurocysticercosis is the clinically important disease and the most common cause of epileptic seizures in the world (Reddy and Ii, 2017). In human, it is estimated that neurocysticercosis accounts for 30.0% of all epileptic cases worldwide (Bruno *et al*., 2013).

Porcine cysticercosis is an economically important pig disease accounting for economic losses to resource poor communities resulting from total carcass condemnation of *T. solium* porcine cysticercosis positive cases (Nkwengulila, 2014). The prevalence of 17.4% has been estimated from community based studies in pigs on the disease in northern highland district of Mbulu based on lingual examination method (Ngowi *et al*., 2004). Kavishe *et al*. (2017) reported a prevalence of 13.0%, 25.0% and 8.2% in Babati based on tongue palpation, Ag-ELISA and abattoir records respectively. A study in the southern highland districts of Mbeya rural and Mbozi reported a prevalence of 9.2% in pigs, estimated through total carcass dissection (Kabululu *et al.*, 2020). An abattoir based prevalence of 0.0 to 18.2% in pigs has been reported (Ngowi *et al.*, 2019). In Tanzania, human taeniosis prevalence of 2.3% and 5.2% estimated through Kato-Katz and coproantigen enzyme linked immunosorbent assay method has been reported respectively. Cysticercosis prevalence of 16.0 to 17.0% has been estimated based on antigen ELISA or neurocysticercosis IgG western bloat (Ngowi *et al.*, 2019).

Successful control and eradication of the disease in both humans and pigs requires adequate and reliable knowledge on the magnitude and distribution of the parasite in both pigs and human (Braae *et al.*, 2017). On the other hand, the reliable knowledge on the disease magnitude and distribution relies on efficient and coordinated reporting of the identified/diagnosed cases of the disease in both medical and veterinary sectors (GALVmed, 2017). Braae *et al.* (2019) recommend monitoring and reporting of both porcine cysticercosis and human neurocysticerocis and taeniosis notification among important elements to effective control *T. solium* taeniosis/cysticercosis among others. However, *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis are the neglected tropical diseases and are not reportable in many countries (Roman *et al.*, 2000). This fact is reflected in the deficiency of data about the disease in most of European (Laranjo-gonzález *et al.*, 2017) and African (Melki *et al.*, 2018) countries. Janati *et al.* (2015) recommend a disease reporting system which is timely and perfect, covering important aspects of the disease dynamics with regular updating and improvement of the disease reporting system for collecting relevant data and timely report submissions.

In Tanzania, much of what is known about *T. solium* taeniosis, neurocysticecosis and porcine cysticrcosis national status in both medical and veterinary sectors is through report findings from various research progrommes conducted in various areas within the country (Ngowi *et al*., 2019).

The aim of this study was to assess how *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis diseases are accommodated in the routine national disease surveillance and reporting systems in both medical and veterinary sectors. The study findings would be used to identify opportunities and challenges for the disease reporting in the existing routine diseases surveillance and reporting systems to generate reliable and accurate data on nation-wide disease status on which to base disease control and eradication programs.

3.2 Materials and Methods

3.2.1 Study area

The study was conducted in five districts namely, Babati, Mbulu, Kongwa, Mbinga and Nyasa in three different regions namely; Ruvuma (southern Tanzania), Dodoma (central Tanzania) and Manyara (northern Tanzania) that were purposively selected based on the reported prevalence of porcine cysticercosis of 12.0% or more by previous studies. Two more regions of Iringa (southern Tanzania) and Arusha (northern Tanzania) were purposively selected based on the fact that they had animal diseases investigation and surveillance centres and laboratories for animal diseases diagnosis. They were strategically included in the study to capture officers in charges' opinions about the role their animal diseases investigation and laboratory centres are playing in the diagnosis and surveillance of TSCT (Fig. 3.1).

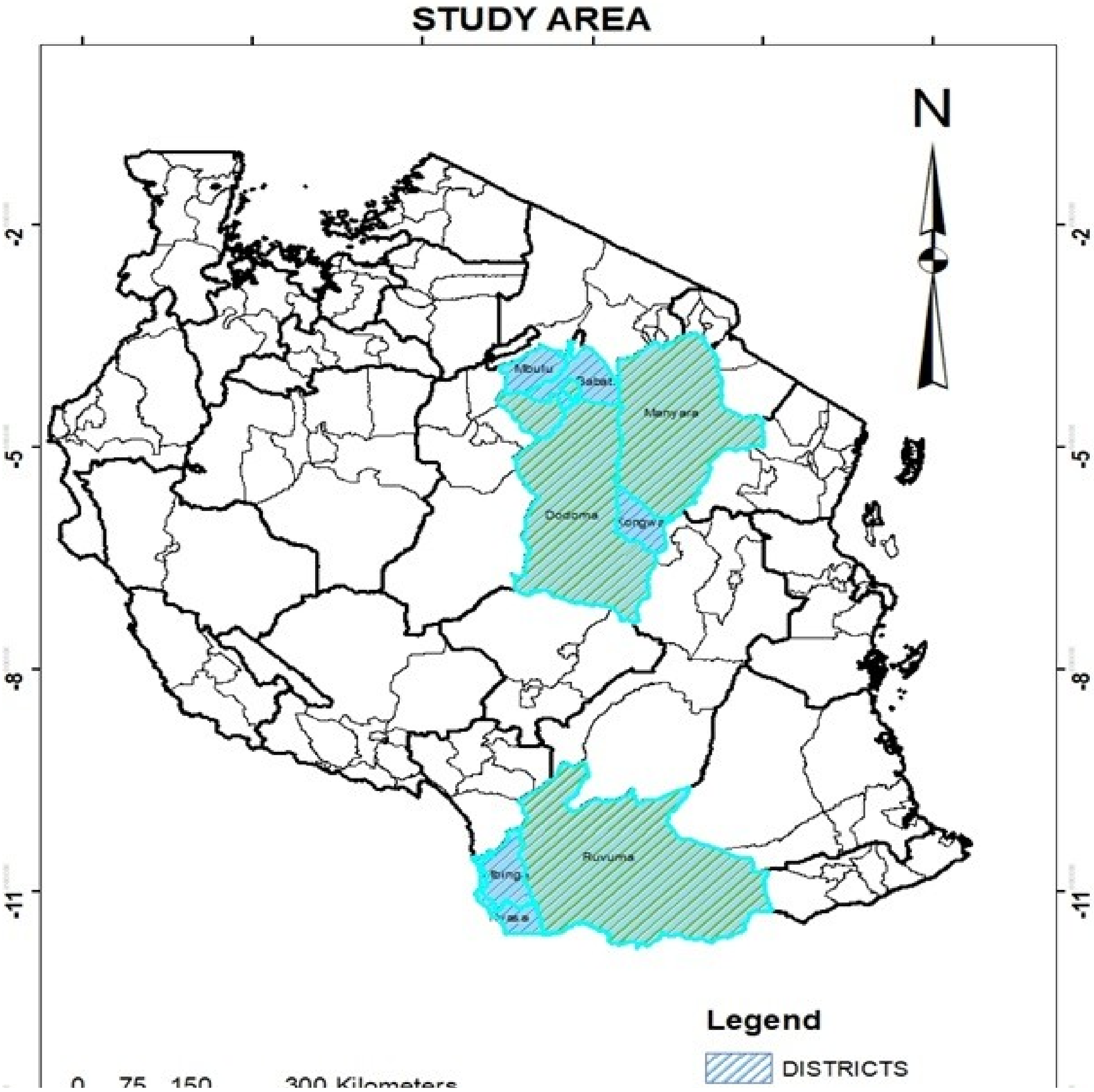
STUDY AREA
N
-2
-5
-8
-11
Mbulu
Manyara
Dodoma
Ruvuma
Legend
DISTRICTS
0 75 150 300 Kilometers

Figure 3.1: The map of Tanzania showing study districts and regions

3.1.2 Study design

This was a cross-sectional study with both qualitative and quantitative components of data collection for triangulation purposes. Using a checklist, one to one in depth interview with key informants was used to collect qualitative data. Structured questionnaires were used to collect quantitative data from officers in charge of primary health facilities and meat inspectors whereby each respondent was interviewed once (Table 3.1).

3.1.3 Sample size and sample selection

3.1.3.1 Sample for qualitative data

Respondents were purposively selected to target key informants with expertise in specific topics to answer the research questions in both medical and veterinary sectors at different levels, from district, regional and national levels. This qualitative research intended to interview 37 participants from different sectors (livestock, health) and levels (district, regional, and national) regarding *T. solium* taeniosis, cysticercosis and human neurocysticercosis reporting in Tanzania. In addition to district and regional respondents, one respondent was interviewed from the ministry responsible for livestock and one from the ministry responsible for health. The mixture of respondents enabled the analysis of the situation using One-Health approach of this veterinary-public health problem (Table 3.2).

Respondents were included in the study if they were either District/Town Medical Officers or Acting District/Town Medical Officer of a respective District/Town Council, Regional or Acting Regional Medical Officer of a particular region, A specialist in a particular regional or referral hospital on a particular topic of interest (neurocysticercosis or neurocysticercosis related conditions in this case), District Veterinary Officer or District Livestock and Fisheries Officer in the absence of District Veterinary Officer, Regional Veterinary Officer or Regional Livestock Adviser in the absence of Regional Veterinary Officer, Officer in Charge or an acting Officer in Charge of Zonal Veterinary Investigation Centre (ZVC) and Tanzania Veterinary Laboratory Agency (TVLA) and an Epidemiologist in the Epidemiology unit of both the Ministry of Health and Ministry of Livestock and Fisheries.

3.1.3.2 Sample for quantitative data

Before sample size was calculated a researcher communicated to District/Town Council Medical and Veterinary (or District/Town Council Livestock officers in absence of Veterinary Officer) Officers in the respective five districts to get the total number of primary health facilities and extension officers in their districts or town council from which to calculate the sample size.

A total of 286 primary health facilities and 192 extension officers were obtained from list provided by the District/Town Council Medical and Veterinary Officers (Livestock and Fisheries Officers in absence of District Veterinary Officers). Sample size for a number of questionnaire interviews to be done at each group category was calculated from the formula; $n = N/(1+N(e)^2)$, (Yamane, 1973). Where:

n = study sample size, N = study population size and e = level of precision.

In the livestock sector a total of 130 respondents from 5 districts were obtained using the above formula, n= $192/1+192(0.05)^2$, where N=192 and *e* = 0.05. In medical sector a sample size of 167 respondents from the same 5 districts was obtained from the calculation, n = $286/1+286(0.05)^2$, whereby N=286 and *e* = 0.05. The number of respondents each district contributed in the study sample size was determined using proportional to size sampling approach.

Both, meat inspectors and officers in charge of primary health facilities were randomly selected from the list of meat inspectors and primary health facilities in the district provided by the Districts Veterinary or Livestock Officer and Medical Officers (Table 3.1).

Table 3.1: Distribution of the study population and sample size by administrative levels and institutions

Variable	**Targeted number of respondents (n)**	
	Medical	**Veterinary**
Region		
Manyara	63	44
Dodoma	37	37
Ruvuma	67	49

District		
Babati	38	23
Mbulu	25	21
Kongwa	37	37
Mbinga	46	30
Nyasa	21	19
Sample size		
Targeted study population size for quantitative data	286	192
Sample size calculated and selected	167	130
Distribution of the qualitative sample size by administrative and institutional levels		
Districts/Town councils	8	8
Regional administrative secretariat	3	3
Zonal Veterinary Investigation Center		3
Tanzania Veterinary Laboratory Agency		3
Regional Referral Hospitals	3	
Zonal Referral Hospital	3	
National Referral Hospital	1	
Ministerial level	1	1

3.1.4 Data collection

3.1.4.1 Qualitative data collection

One to one in-depth interviews with the respondents were conducted using an interview guiding questions which were pre-arranged to focus on the diseases surveillance and reporting approaches as stipulated in the WHO/OIE/FAO guidelines for effective diseases surveillance and reporting

(Dorny *et al.*, 2005). Each interview was conducted in an average of 35 minutes. The interviews were recorded using an audio recorder following verbal consent of the respondents.

Questions on taeniosis, neurocysticercosis, epilepsy or porcine cysticercosis reporting wanted the respondent to give his/her general perceptions about the presence of disease reporting routine and specific reporting format for the disease. The questions also wanted the respondent to give his or her perception on the need and facilitation for report preparation and submission to the relevant authorities. Questions on the general disease reporting quality assessed the respondent's perception on the quality of the general disease reporting in terms of completeness, report quality and timely submission. Questions on facilitation and sufficiency of meat inspectors and slaughter houses/slabs were asked to veterinary professionals to explore their perceptions on the supportive working environment for effective disease reporting.

3.1.4.2 Quantitative data collection

Data were collected using *Afyadata* application (Karimuribo *et al.*, 2017) installed in one tablet and one smart phone in which the two questionnaires were digitalized. All respondents gave their verbal consents to participate following the researcher’s briefing of the research purpose and importance.

The questionnaires had closed ended questions written in English and administered by a researcher and trained enumerator by reading and explaining the questions and responses to the respondents in Swahili. A respondent had to choose response(s) that he/she thought they best describe the phenomenon in question from the responses provided. One day before the actual questionnaire interview, questionnaires were pre-tested on 10 respondents (five primary health facilities and five meat inspectors each sector with a specific questionnaire) and adjustments were made to questions that needed to be edited. The researcher collected data from health sector respondents while a trained enumerator collected data from meat inspectors. Questions were read and answers selected and filled in the digitalized forms according to the responses given by the respondents.

A total of 264 respondents were interviewed of which 73 were female and 191 were males. Out of 264 respondents 154 were officer in charges of medical health primary facilities out of which 133 were from dispensaries and 21 from health centres. In addition, out of 154 respondents, 56 were females and 98 were males. The remaining 110 were meat inspectors in wards and villages of which 17 were female and 93 were men.

(i) *T. solium* taeniosis, epilepsy and neurocysticercosis reporting

A questionnaire interview prepared in English with questions regarding taeniosis, epilepsy and neurocysticercosis was administered to the respondents by a researcher through reading and explaining the questions and responses from which he/she had to choose the responses that applies to his/her situation. Question about the availability of taeniosis/epilepsy reporting was asked to the respondent and they had to give a ‘no’ or ‘yes’ responses. This was followed by questions of whether there was specific reporting format present for taeniosis/epilepsy only within their routine disease reporting. General information filled in the routine disease reporting system was asked to see if there was any means by which taeniosis/epilepsy were captured even within the routine disease reporting system they use. Questions on the presence and areas of facilitation in report preparation and submission were asked to rule out the possibility of having taeniosis/epilepsy diagnosed but not reported due to failure of the officer in charge to submit the reports for financial/office consumable reasons. This was then followed by a question about where and how the reports were submitted and at which frequency. The respondents were also asked on how they got feedback on whether the reports had reached the intended destination followed by a question as to whether they were able to meet deadline for report submission and if no what was the reason for the delay.

(ii) Assessment of porcine cysticercosis reporting

Porcine cysticercosis reporting assessment was done using questionnaire interview. A question on the presence of specific reporting format for porcine cysticercosis was asked to know if the disease details were specifically reported to cover important epidemiologic information about the disease. In addition, questions about reporting contents, the means of report submission and whether or not they were able to submit the reports on time were asked to know how their routine disease reporting system enabled them to send the reports on time. Respondents were further asked on the presence of reporting preparation and submission facilitation to know whether delay or on time reporting could have been attributed to the individual respondent’s willingness to report or there were reasons beyond meat inspector’s control.

3.1.5 Data analysis

3.1.5.1 Qualitative data

Qualitative data were collected in Swahili and saved using an audio recorder. Audio data were then transcribed and translated into English transcripts. The collected data were analysed using ATLAS.ti qualitative data analysis software. Content analysis was used to analyse the data and it involved both deductive and inductive approaches which involved extensive reading of each transcripts to grasp concepts discussed by the respondents. This was then followed by creation of codes to capture each important concept discussed after reading each transcript several times. To avoid mixing up of codes during coding, quotation reporting and creation of output of codes, each code was anchored by a specifically short (sub) research question for each research question. A total of 148 free codes were created and defined. This was followed by importation of the 33 interview transcripts into ATLAS.ti. The imported transcripts were grouped by respondents' sectors (health, livestock) as well as by other factors found necessary during the analysis. Each quotation addressing a concept of interest within the transcript was highlighted and coded by a respective code. The analysis involved reading back and forth the transcripts and on the way removing, adding or sometimes editing some codes as new concepts appeared to emerge on the way throughout the process. A particular quotation was counted once per respondent. Therefore, the number of quotations per concept represents opinions from different respondents. A concept was considered to be a theme (important) idea if it reached a cut-off point of a least 50%, that is, at least 50% of the respondents to the particular question mentioned the concept.

3.1.5.2 Quantitative data

Collected data were cleaned and coded in Microsoft excel. The coded data were then transferred into SPSS data analysis software. Data were analyzed for frequency and proportions to know the number and percentage of responses towards a variable of interest. Regarding taeniosis, neurocysticercosis/epilepsy and porcine cysticercosis reporting, the following variables were analyzed: Presence of reporting format and specificity in reporting of taeniosis, neurocysticercosis/epilepsy and porcine cysticercosis. Availability of reporting facilitation to officers in charge of primary health facilities and meat inspectors, timeliness in report submission, completeness in reporting and means of sending and getting the reporting feedback.

3.2 Results

3.2.1 Qualitative results

A total of 33 people were interviewed. Table 3.2 summerises the demographic characteristics of the respondents. Three of the five districts had two councils, district council and town council, each with a district and town medical doctor. This accounted for a total number of eight districts and town councils' medical and veterinary doctors interviewed.

Table 3.2: Demographic characteristics of respondents of a study to assess *T .solium* taeniosis, cysticercosis and neurocysticercosis reporting in Tanzania, January-April 2020

Factor	Number of respondents (n)
Sex	
Male	28
Female	5
Occupation	
Medical doctor	15
Nurse	1
Veterinary doctor	9
Animal scientist	5
Veterinary paraprofessional	2
Work station	
District hospital	8
Regional hospital	6
Missionary referral hospital	1
Zonal Veterinary Investigation Centre (ZVC)	3
Tanzania Veterinary Laboratory Agency (TVLA)	2
District Livestock and Fisheries Office	8
Regional Administrative Secretariat	4
Ministry of Livestock and Fisheries Development	1
Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDEC)	1
Sector	
Health	16
Livestock	17
Level of healthcare facility	
District hospital	8
Regional hospital	5
District referral hospital (Faith Based Organisation)	1

(i) *Taenia solium* taeniosis reporting

A total of 12 health personnel (eight from district/town council hospitals, three from regional hospitals, one from Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDEC) were interviewed to capture their perceptions on the availability of *T. solium* taeniosis reporting routine. Sixteen quotations admitted that taeniosis disease was not specifically reported in isolation from other worm infestations. Rather it was reported under a group of 'intestinal worm' in general *['… If you go into the register book you may specify either the doctor has diagnosed which type of worms but the challenge comes in the tallying book ,where you have to write worms, you only have to write intestinal worms it doesn't say whether it is a tapeworm, hookworm or ascaris or what is it, so it will go that way up the end of the month, … so at that point you have already lost someone to know the report whether it was tapeworm , hookworm, or what kind of worm was it, that is where there is a challenge',* Female, HIMS Regional focal person*]*. In addition, nine quotations admitted that there was no format for reporting taeniosis disease meaning that there was no reporting format specifically designed to report taeniosis only *['it has been grouped in intestinal worms, it doesn't have its separate reporting format*', Female Ag. District Medical Doctor*] (*Table 3.3).

(ii) Epilepsy reporting

A total of 14 health respondents (eight from district/town council hospitals, five from regional hospitals, one from MoHCDEC) were interviewed to capture their perceptions on the availability of epilepsy reporting routine. Seven out of eight quotations admitted that epilepsy was not reported to the level of identifying a specific cause *['Yes, it is there, if we get time we shall access the system and see although they don't appear as they are, you will find it in general as epilepsy',* Male, District Medical Officer*]*. In addition, all 7 quotations admitted that there was no any format for epilepsy disease reporting, meaning that there was no reporting format specifically designed to report epilepsy cases only *[‘Epilepsy is there with other diseases, it appears as epilepsy in general’*, Male, District Medical Officer*]* (Table 3.3).

(iii) Neurocysticercosis reporting

A total of 14 health respondents (eight from district/town councils and six from regional hospitals) were interviewed to capture their perceptions on the neurocysticercosis reporting routine. Four out of five quotations admitted that there was no specific reporting for neurocysticercosis [‘*Aaah, that cysticercosis, first of all it is among the neglected diseases, why am I saying so? That disease is not reported anywhere in the disease reporting systems of the Ministry of Health, we are talking about the health sector….. so very little is known about it, individual health expert may encounter it in his routine treatment activities, but if you ask me on the magnitude of the disease challenge I can’t tell you exactly because we don’t have data on that, we don’t have routine surveillance on that, but on research based, in research you will find that someone has collected samples and analyzed and found the presence of that disease and he/she will know the magnitude of the disease’,* Male Epidemiologist at MoHCDEC*]* while one quotation admitted that neurocysticercosis disease was specifically reported as it is. In addition, there were three quotations all admitting the lack of format for neurocysticercosis disease reporting, meaning that there was no reporting format specifically designed to report neurocysticercosis cases only *[‘There is a place for example, if we look at this book, this is a comparable counterpart book, you see, there is a first place, date, number of attendances (it will be written as a new case or an old case) there is patient name, place of domicile, age, after attending the patient what tests you called upon, what are the test results, diagnosis, treatment and what did you do? Treated him and has gone home, you* *admitted the patient or he/she died or you referred the patient… and you fill in the comments. So if it is the case of taeniosis or cysticercosis it means it will be written in the diagnoses,* Male, District Medical Officer*]* (Table 3.3).

(iv) General disease reporting in the medical sector

A total of 14 health officials (eight from district/town councils, six from regional hospitals) were interviewed to capture their perceptions on general disease reporting routine in the medical sector, particularly, report completeness, reporting facilitation, report quality check and timeliness. Ten out of 12 quotations admitted that there was reporting facilitation which included among others, provision of reporting tools and bus fare for submitting the reports *[*'*Yeah, he has it, he has it because the government is sending money to all health providing facilities direct and they are the signatories themselves, so they have it in the budget, bus fare to submit the report, stationaries, adequately, so they have that. So they will buy reams, they buy everything, so they have got it*', Male District Medical Officer*]* while seven out of 13 quotations admitted that reports were timely submitted *[*'*Yeah, in our case, they submit on time, the good thing with us is, that behavior of giving someone who is coming to headquarters saying you go to town please send my report too we have discouraged and stopped that long time ago', Male, Town Council Medical Doctor]* and nine out of 15 quotations admitted that almost all health facilities submitted the reports *[*'*almost 100%, 100% of health facility submit the reports'*, Regional Medical Doctor, Male*]* and six out of 15 quotations admitted that the reports were checked for quality before submission (Table 3.3).

Table 3.3: General disease reporting system in the medical sector as reported by respondents from District Hospital (DH) Regional Medical Officers (RMO) Regional Referral Hospital (RRH) and Epidemiologist from the Ministry of Health (MoHCDEC)

Factor	DH quotations (theme)	RMO quotations (theme)	RRD quotations (theme)	MoHCDECquotations (theme)	Total quotations (theme)
Specific to neurocysticercosis					
Available	1	0	0	0	1
Unavailable	2 theme)	0	0	1 (theme)	4 (theme)
Availability of format for neurocysticercosis reporting					
Available	0	0	0	0	0
Unavailable	2(theme)	0	0	1 (theme)	3 (theme)
Availability of specificity in epilepsy reporting					
Available	1	0	0	0	1
Unavailable	4 (theme)	2	0	1 (theme)	7 (theme)
Availability of format for epilepsy reporting					
Available	0	0	0	0	0
Unavailable	4 (theme)	2 (theme)	0	1 (theme)	7 (theme)
Availability of format for taeniosis reporting					
Format present	0	0	0	0	0
No format	6 (theme)	2 (theme)	0	1 (theme)	9 (theme)
Availability of specificity in taeniosis reporting					
Disease specific	0	0	0	0	0
Not disease specific	10 (theme)	5 (theme)	0	1 (theme)	16 (theme)
Availability of reporting facilitation					
Available	8 (theme)	2 (theme)	0	0	10 (theme)
Unavailable	1	1	0	0	2
Timeliness in disease reporting					
Timely reported	4	3 (theme)	0	0	7 (theme)
Sometimes delayed	5 (theme)	1	0	0	6
Report submission rate and quality check					
All submit the report	6 (theme)	3 (theme)	0	0	9 (theme)
Report quality checked	5	1	0	0	6

(v) General livestock disease reporting

Fifteen respondents (eight from district / town council livestock and fisheries offices, three from regional administrative secretariat, three from ZVC, one from the Ministry of Livestock and Fisheries) were interviewed to capture their perceptions regarding livestock disease reporting in general. A total of 11 out of 15 quotations admitted that reports were always submitted after submission deadline *['Aaah, not easy, we can't, because our reporting depends on our extension officers, now you can call someone… because he knows fully that Wednesday is the day for report submission he may choose not to pick your phone call the whole day, so you can find yourself forced to send the report on Thursday sometimes up to Sunday, hahaha, eeeh until Sunday you find yourself saying let me just log into the system, just send those which have been submitted, eeeh you send',* Female, Acting District Livestock and Fisheries Officer*]* while eight out of nine admitted that sometimes reports were not submitted at all *['Something that goes together with meat inspection is under reporting, and in most cases, inspection of pork meat, it is very few districts which are reporting concerning porcine carcass inspection, very few departments report about pork carcass meat inspection, even in areas known to have porcine cysticercosis disease we don't get pork inspection reports from those districts, we mostly get of….there in Hanang, Mbulu and the like…we don't get the inspection reports from those areas',* Male, Veterinary Doctor, In Charge, ZVC*]*. Fourteen out of 15 quotations admitted that there was no any facilitation in disease report preparation and submission *['Aaah, there is no specific facilitation to people working in the field for report submission, for those working in the field this is one of their responsibilities, meaning that, for everything they are doing in the field they have to provide the report'*, Male, Veterinary Doctor, In charge, ZVC*]* while five out of six quotations admitted that there was no consistence in disease reporting among meat inspectors *[I have something here it's about underreporting, I had a seminar here, the main challenge I have here is underreporting,* *it's until you call them, begging them to send the report. It's very challenging honestly'*, Male, Regional Veterinary Doctor*]*. Furthermore, all two quotations regarding completeness of the reports admitted that there was no any completeness in disease reporting *['You see, or sometimes the report are submitted in different qualities, no uniformities in report quality'*, Male, Veterinary Doctor, In charge ZVC*]* (Table 3.4).

Table 3.4: General disease reporting system in the veterinary sector

Factor	DVO/DLO quotations (theme)	RAS quotations (theme)	ZVC quotations (theme)	MoLF quotations (theme)	Total quotations (theme)
Timeliness report submission					
Always delayed	5(theme)	3 (theme)	2 (theme)	1 (theme)	11 (theme)
Sometimes delayed	3	0	1	0	4
Report submission rate					
Sometimes not submitted	4 (theme)	1 (theme)	2(theme)	1 (theme)	8 (theme)
Not submitted at all	0	0	1	0	1
Availability of reporting facilitation					
Inadequate	1	0	0	0	1
Unavailable	7 (theme)	3 (theme)	3 (theme)	1 (theme)	14 (theme)
Availability of consistence in reporting					
Available	1 (theme)	0	0	0	1
Unavailable	0	4 (theme)	1 (theme)	0	5 (theme)

(vi) Porcine cysticercosis reporting

Fifteen respondents (eight from district / town council livestock and fisheries offices, three from regional administrative secretariat, three from ZVC, one from the Ministry of Livestock and Fisheries) were interviewed to capture their perceptions on porcine cysticercosis reporting along the livestock sector disease reporting system. Among the aspects assessed were presence of format for reporting porcine cysticercosis and whether the reporting format was specific for porcine cysticercosis or not. A total of five quotations: one from the district livestock officer, two from the regional livestock advisors and two from the officers in charge of the zonal veterinary investigation center admitted that porcine cysticercosis reporting was not disease specific meaning that the reporters did not report the specific parasitic worm which was connected to porcine cysticercosis. On the other hand, a total of ten quotations: five from the district livestock officers, two from the regional livestock advisors and three from the officers in charge of zonal veterinary investigation center admitted that there was no format for porcine cysticercosis disease reporting. Furthermore, a total of five quotations: three from the district livestock officers, one from the regional livestock advisor and another from the officer in charge of the zonal veterinary investigation center admitted carrying out of quality check on submitted reports before submitting them to the subsequent higher reporting authority. However only two quotations: one from the regional livestock advisor and another from the officer in charge of the zonal veterinary investigation center admitted that only occasionally there was completeness in disease reporting. Five out of six quotations admitted that porcine cysticercosis reporting was disease specific meaning that the reporting allowed the reporter to name the disease specifically as he or she has diagnosed it *[' This format is self-sufficient, because it is the matter of the extension officers to identify the cyst and report it, but if the extension officer has got no ability to identify then that is a challenges',* Male, Regional Veterinary Doctor*]* while one of quotations admitted that there was no specific porcine cysticercosis reporting, meaning that the reporter would just write cyst without telling which kind of cyst exactly is he or she referring to. In addition, there were 10 quotations which admitted that there was no format for porcine cysticercosis reporting meaning that porcine cysticercosis had no independent format for disease reporting instead it was reported together with other diseases *['I haven't seen it in this district, let me say this,…we don't have specific format for porcine cysticercosis reporting, but in meat inspection they may say they have slaughtered and inspected several pigs and saw these* *challenges, but I have never seen cases of porcine cysticercosis being reported',* Male, District Veterinary Doctor*]*.

Five quotations admitted that there was quality check of disease reports before submission to the next reporting level *['We say one of our responsibilities here is to collect and disseminate the reports, that is, after receiving the data collected, you process, one can say he has seen taenia in chicken, so you start to think is possible to get taenia in chicken? You may need to call to verify, you ask, "I can't understand the report you have sent me". You are trying to triangulate the information',* Male, Veterinary Doctor, ZVC*]*.

3.2.2 Quantitative results

Out of 264 respondents interviewed 154 were officers in charge of medical health primary facilities out of which 133 were from dispensaries and 21 from health centres. In addition, out of 264 respondents, 72.3% were males (Table 3.5).

Table 3.5: Demographic characteristics of officer in charges of primary health facilities and meat inspectors

Variable	Number and percentage (%) of respondents	
	Officers in charge of primary health facilities	Meat inspectors
Region		
Manyara	53 (34.4)	38 (34.5)
Dodoma	36 (23.4)	27 (24.5)
Ruvuma	65 (42.2)	45 (40.9)
District		
Babati	30 (19.5)	22 (20.0)
Mbulu	23 (14.9)	16 (14.5)
Kongwa	36 (23.4)	27 (24.5)
Mbinga	44 (28.6)	28 (25.5)
Nyasa	21 (13.6)	17 (15.5)
Type of primary Health facility		
Dispensary	133 (86.4)	NA
Health centers	21 (13.6)	NA
Health facility ownership		NA
Private	36 (23.4)	NA
Public	118 (76.6)	NA
Clinical medical health against other profession		
Officers in charge with clinical medical health background	119 (97.3)	NA
Officers in charge with non-clinical medical health background	35 (22.7)	NA
Animal health profession against other profession		
Animal health	NA	43 (39.1)
Other background	NA	67 (60.9)
Number of pork slaughter houses/slabs		
Slaughter houses/slabs present	NA	20 (18.2)
Slaughter houses/slabs absent	NA	90 (81.8)

(i) Assessment of *Taenia solium* taeniosis and epilepsy reporting

The study found that 100% of primary health facilities had a register book called Health Management Information System (HMIS) for registering all cases attended at a particular health facility with all necessary details about the disease and patient being filled. However, 100% of respondents said there was no specific reporting format specifically designed to report taeniosis or epilepsy. In addition, 92.2% of respondents said that they were facilitated in many aspects in report preparation and submission and 83.8% were capable of submitting the reports to the respective authority on time. The remaining 16.2% of the respondents who could not submit reports on time had various reasons for the delay with 51.3% of the respondents admitting that they were overwhelmed by health services provision duties (Fig. 3.2).

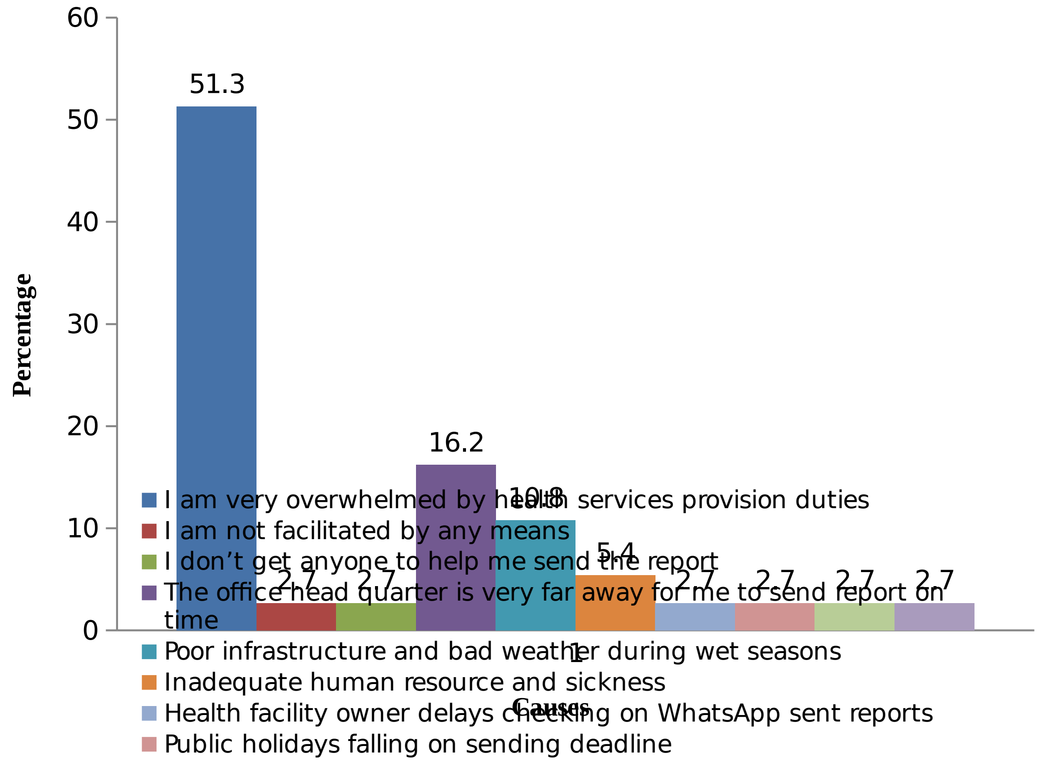

Figure 3.2: Causes of delay in report submission (n=37)

Regarding the means of sending the reports, 43.8% of the respondents said they normally send the repots physically while the rest were sending them via other methods whereby 22.3% were sending using phone text message, 14.8% were sending via someone they knew or trusted and 18.8% were sending reports using email or Health Management Information System (HMIS).

Concerning feedback in reporting, 43.8% of the respondents said that because they send reports in person they were sure that the reports had reached the respective offices on time and had no reason for report receipt feedback, while 19.4% of the respondents said they had to call to ask if the reports had reached the respective officer and 14.8% said that the headquarter people would call or write a text message to acknowledge receipt of the reports if they had sent via other methods than in person or electronic (Fig. 3.3).

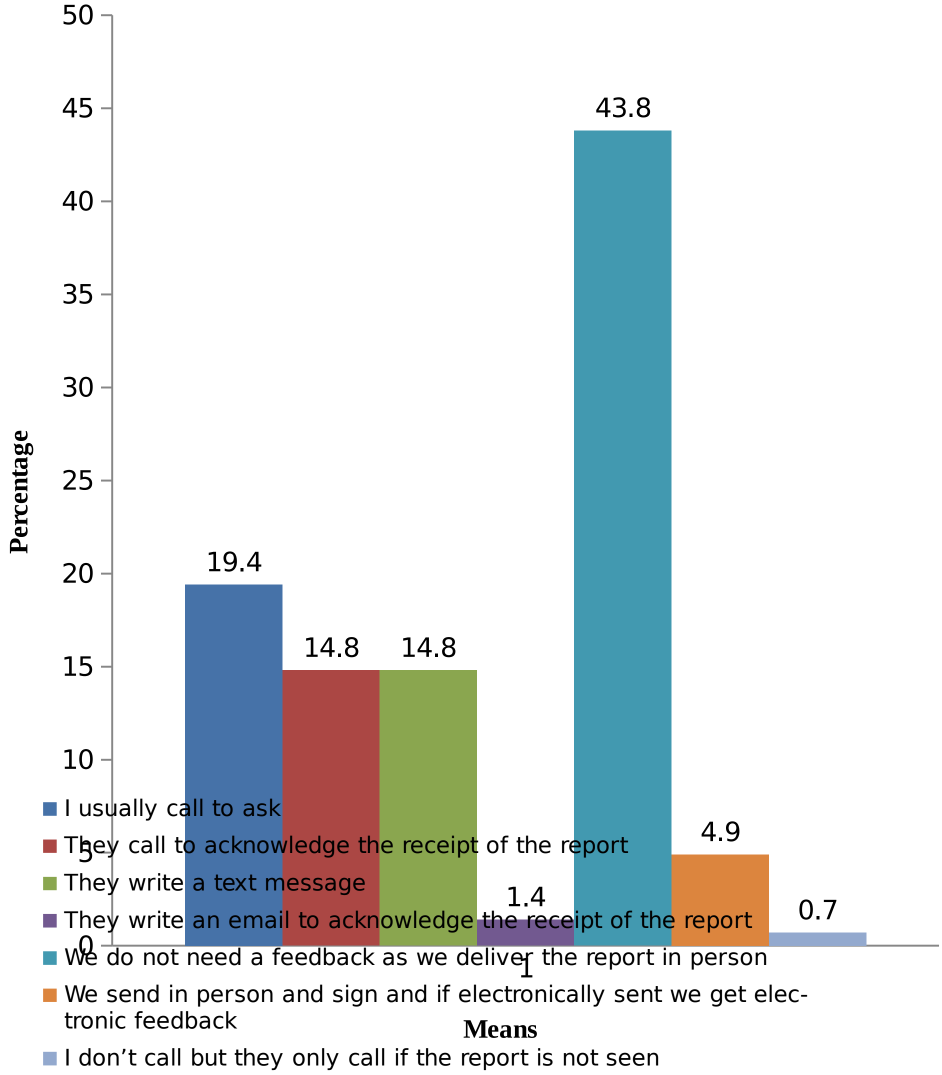

Figure 3.3: Means by which officers in charge of primary health facilities were getting reporting feedback (n=283)

(ii) Porcine cysticercosis reporting

The study found that most meat inspectors had no specific register book to record daily pig inspection findings. Each meat inspector had his own means of recording meat inspection findings whereby 54% of meat inspectors used notebooks to record the findings (Fig. 3.4).

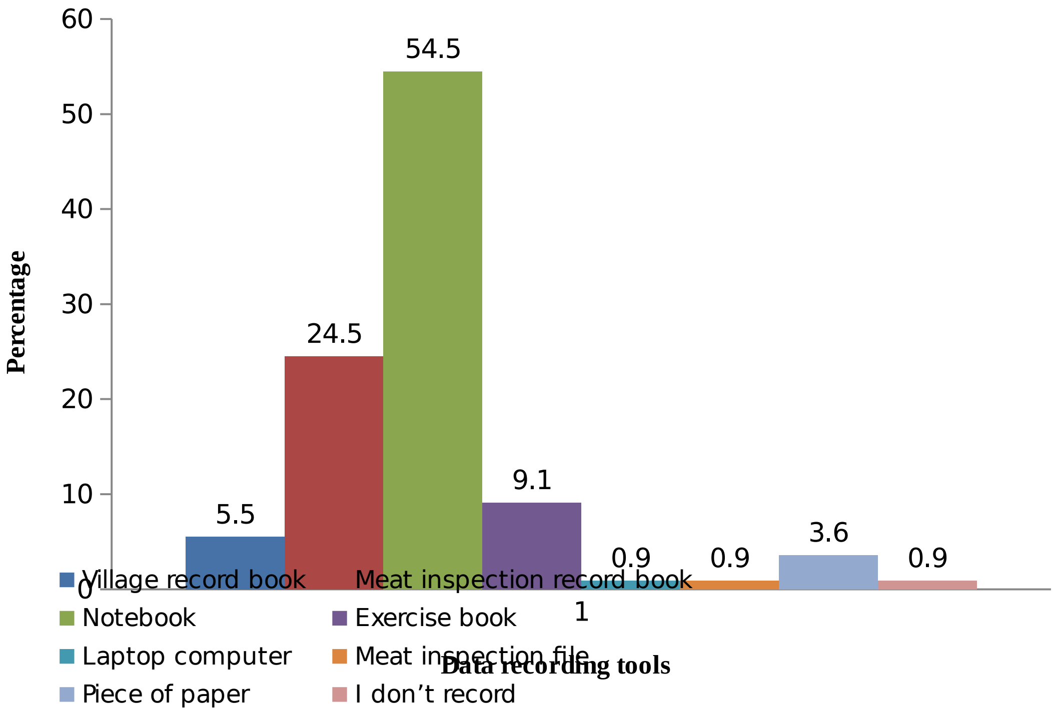

Figure 3.4: Means by which meat inspectors were recording pork inspection findings (n=110)

Out of 110 respondents interviewed 91.8% said that there were no specific reporting forms for porcine cysticercosis. In addition, 77.3% of the respondents said that there was no reporting facilitation, with 18.2% of those facilitated being facilitated mainly by the DLFO office, of which 70% were facilitated mostly in terms of stationeries (Table 3.6).

Table 3.6: Porcine cysticercosis reporting by meat inspectors

Variable	Number of responses (n)	Percentage
Presence of reporting facilitation		
Not applicable (Excluded from previous responses)	2	1.8
Yes	23	20.9
No	85	77.3
Timely report submission		
Yes	55	50.0
No	10	36.4
Not applicable (Excluded from previous responses)	15	13.6
Presence of porcine cysticercosis specific reporting format		
Yes	9	8.2
No	101	91.8
Sources of facilitation		
Not facilitated	87	79.1
DLFO	20	18.2
DLFO and NGOs	1	0.9
Ministry of Livestock	2	1.8
Aspects of reporting facilitation		
Given stationeries	21	70.0
Air time bundles	1	3.3
Given motorcycle	5	16.7
Fuel	2	6.7
Given portable computer	1	3.3

Out of the 110 meat inspectors interviewed, 44.5% used Agriculture Routine Data System (ARDS) forms to report porcine cysticercosis and other livestock diseases, 26.4% used locally designed abattoir reports and 8.2% used abattoir diseases surveillance forms. The remaining 20.9% prepared reports using various other methods including: both ARDS and diseases surveillance forms, any forms at their convenience, and some were admitting that they were not sending abattoir or any disease report at all. Furthermore, 87.3% of the respondents said that they used to send the reports direct to District Livestock and Fisheries Office (DLFO). Out of the remaining respondents, 12.7% mentioned several other routes through which the reports were channeled before reaching the DLFO office. In addition to that, 49.4% of meat inspectors said they physically submit the reports and 31.9% used the people they knew or trusted to send the report to DLFO office. The remaining respondents sent the reports using either phone text message, WhatsApp, phone calls or physically sent when they had other personal agenda at the district headquarters.

Regarding reporting feedback, 37.9% of the respondents said they were sure that the reports had reached the respective office because they sent them in person and therefore there was no need to find other ways to confirm while 25% of those who sent through other means had to call to the office to be sure that the reports had reached the respective office among other means (Fig. 3.5).

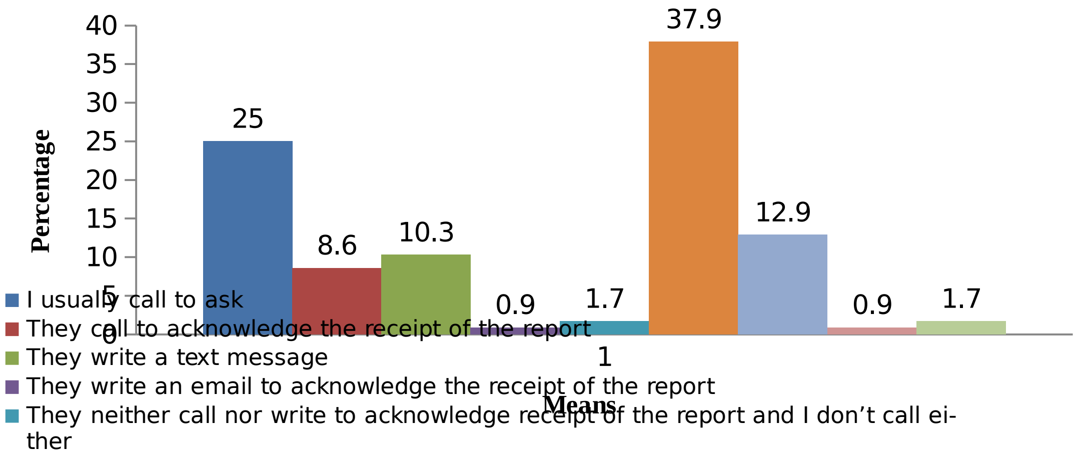

Figure 3.5: Means by which meat inspectors were getting reporting feedback (n=116)

Respondents who could not submit reports on time had various reasons for reporting delay with 41.8% of the respondents saying that they were too much overwhelmed by field activities to get time to write the report, 14.5% said they were not facilitated by any means and 9.1% said that bad weather and infrastructures during rainy season made them to delay in sending the report (Figure 3.6).

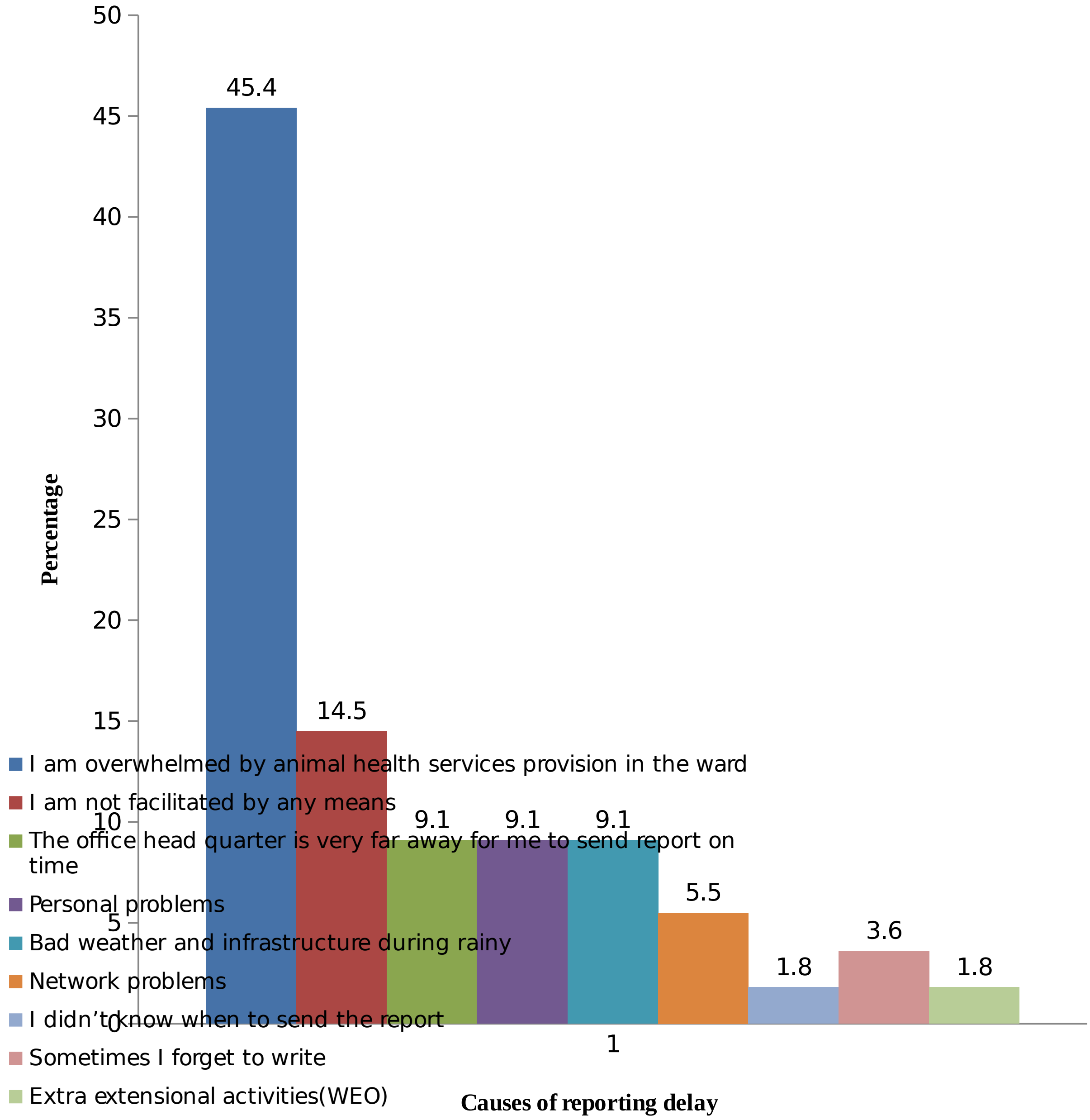

Figure 3.6: Causes for porcine cysticercosis reporting delay by meat inspectors (n=55)

3.3 Discussion

To the best of my knowledge, this is the first study conducted in Tanzania to assess the TSCT reporting in the current medical and veterinary diseases reporting systems. The study findings have highlighted the challenges that need to be addressed to enable efficient disease reporting. In addition, the findings have realized the need and importance of One

Health approach to ensure that sufficient data about the disease magnitude and epidemiology are collected countrywide to create the base for TSCT control or eradication strategies.

In this study 71.5% of the respondents were males (Table 2.6). The reasons behind more participation of males than females in both medical and veterinary sectors can be explained by the fact that more males than females are enrolled in medical and veterinary colleges in Tanzania. More officers in charge from dispensaries were involved in the study than officers in charges from health centres because there were more dispensaries than health centres in the general population in the study area (Table 2.6). In both medical and veterinary sectors, less than the calculated sample size of respondents were interviewed because some of the health facilities and meat inspectors' geographical locations were unreachable because the roads were destroyed by heavy rains during data collection period.

The study involved both qualitative and quantitative research approaches for triangulation purposes. Key informant interviews supplemented most of the information which could not be collected using structured questionnaire as the two groups of respondents had different level of knowledge and working coverage area. While District Medical and Veterinary/Livestock and Fisheries Officers with higher exposure and overseers of medical and veterinary matters within the districts provided broader understanding of the medical and veterinary matters within the districts, officers in charge of primary health facilities and meat inspectors provided the individual primary health facility and meat inspection status and challenges associated with operations in their working settings regarding *T. solium* taeniosis, neurocysticercosis/epilepsy and porcine cysticercosis reporting respectively. In most cases, much of the information in primary health facilities and meat inspector's respondents were reflected by responses from the respondents of one to one in depth interview who had wider working coverage and understanding. It is therefore in our views that the two approaches complimented and supported one another.

Overall, the study findings show that *T. solium* taeniosis, neurocysticercosis/epilepsy and porcine cysticercosis reporting faces many challenges to enable collection of sufficient epidemiologically important data about the disease to influence policy and decision makers to strategize towards control and possible eradication of the disease in the country in both intermediate and definitive hosts.

The national medical health disease surveillance and reporting systems are well structured, coordinated and optimally financed to support smooth health surveillance data reporting from the primary health facilities to the national level (Table 3.3). Nevertheless, *T. solium* taeniosis had no place to be reported within the surveillance and reporting systems and neither were *T. solium* neurocysticercosis/epilepsy. While it was impossible to find the term 'neurocysticercosis' in the reporting forms, epilepsy which is the main clinical presentation of neurocysticecosis, was reported as 'epilepsy' and as such the one whom the report is intended for could not tell the exact cause of epilepsy even when a physician in a well-equipped hospital with advanced diagnostic facilities could diagnose the exact cause of epilepsy (Table 3.3). This poses difficultness in estimating the magnitude of any primary cause of the disease, be it *T. solium* neurocysticercosis or else against which to strategize towards control or elimination.

The study also found that *T. solium* taeniosis and neurocysticercosis national status could not be estimated. This was contributed by the fact that the disease does not get reported as a standalone reportable disease in the national medical health surveillance and reporting system. The reason was pointed out to be the fact that the disease was considered less important and one of the neglected diseases in the country.

Comparing the general medical health and veterinary disease surveillance and reporting systems, it is found that medical health disease surveillance and reporting system is by far much more efficient in some aspects of ideal diseases surveillance and reporting (Table 3.3) compared to the veterinary disease surveillance and reporting systems (Table 3.4). This is probably due to the fact that the medical health disease surveillance and reporting system is adequately supported in terms of resources and infrastructures as was found out by this study than the veterinary animal disease surveillance and reporting system (Tables 3.3 and 3.4). Therefore, it is evident that *T. solium* taeniosis and neurocysticercosis could be equally and efficiently reported by the health facilities if it were given a priority and included among the reportable medical diseases. On contrary, despite the fact that most animal diseases reporting forms provide for *T. solium* porcine cystiecercosis reporting, the general animal diseases surveillance and reporting system is not adequately facilitated to support efficient reporting of the *T. solium* porcine cysticercosis disease among others.

A scoping review study to document taeniosis and cyticercosis in Tanzania reported *T. solium* neurocysticercosis to be contributing about 7.4% ($p<0.0000$), 3.3% ($p<0.0001$) and 1.1% ($p<0.04$) prevalence of epileptic cases in Mbozi, Mbulu and Hai districts respectively (Ngowi *et al.*, 2019). These data were from research findings from specific studies done in the respective districts and not from the routine national disease surveillance and reporting system. This fact further supports our findings that the current national diseases surveillance and reporting system is not supportive enough to quantify taeniosis, neurocysticercosis and porcine cysticercosis.

Absence of specificity in helminthosis/taeniosis reporting as was found out by this study further intensifies the difficultness in quantifying taenioisis cases in at any level of health facility. This finding is in line with systematic review studies by (Laranjo-gonzález *et al.*, 2017; Trevisan *et al.*, 2019) which were aimed at establishing epidemiology of *T. solium* taeniosis and cysticercosis in Western and Eastern Europe in which they both reported that among the challenges in estimating the disease magnitude was absence of species specificity in reporting identified taeniosis cases. However, different from our study findings, (Laranjo-gonzález *et al.*, 2017; Trevisan *et al.*, 2019) reported some initiatives in reporting taeniosis and cysticercosis cases in European countries than it was in our study regions. Nevertheless, similar to our study, both studies show that taeniosis and human cysticercosis are still neglected and marginalized diseases in the existing diseases surveillance and reporting systems resulting in under reporting and obscured data on the disease prevalence.

The livestock disease surveillance and reporting systems allowed livestock diseases to be reported the way they were diagnosed by field veterinarians. This provided equal chance for *T. solium* porcine cysticercosis reporting as long as the field extension worker was knowledgeable and capable of diagnosing the disease. Absence of uniformity and consistence in report content and quality is explained by the lack of general disease reporting facilitation (Table 3.4).

It is generally realized from this study that *T. solium* porcine cysticercosis adequate reporting relies on the efficiency of the general livestock diseases surveillance and reporting system as there is no specific reporting or surveillance plan for the disease currently in place. However, the general livestock reporting system is not adequately supportive to enable efficient reporting of livestock diseases. This is evidenced by inadequate material and financial support to the whole surveillance and reporting system, including inadequate facilitation to extension workers in the field for data gathering and reporting (Table 3.4).

Inadequate meat inspectors and absence of facilitation to livestock extension officers working in the field and along the reporting chain was found to be one of the limiting challenges for effective porcine cysticercosis and other livestock diseases reporting in general. This is similar to the study done in Uganda which was aimed at assessing stakeholders' perceptions on livestock diseases surveillance system in Uganda. The study reported inadequate number of staff, poor motivation and communication along surveillance chain among the contributing factors for inadequate performance of the diseases reporting (Namayanja *et al*., 2019).

In a study aimed at assessing endemicity of *T. solium* taeniosis and cysticercosis in Europe it was found that fewer reports for porcine cysticercosis in most of the Western European countries studied was partly contributed to by the absence or fewer porcine cysticercosis cases diagnosed resulting from an improved management and confinement of pigs with improved sanitary conditions (Devleesschauwer *et al.,* 2017). This was different from our findings whereby underreporting of the disease in the study areas was contributed by inadequate number of meat inspectors to diagnose and report *T. solium* porcine cysticercosis positive cases, reluctance of some field officers to report cases and inadequate facilitation of the livestock field officers, reporting staff and the livestock diseases surveillance and reporting system in general.

One Health approach is currently advocated for successful control and eradication of *T. solium* taeniosis and neurocysticercosis (Devleesschauwer *et al.*, 2015). However, this study found unequal level, capacity and priorities of the existing diseases surveillance and reporting systems within and between medical health and veterinary sectors towards *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis reporting. This challenge has a potential of decelerating the efforts towards one health approach in controlling the disease within the country.

While *T. solium* taeniosis reporting in medical sector was limited by the lack of specific disease reporting in the routine health reporting system (Table 3.3) and, porcine cysticercosis reporting was limited by inadequate general livestock disease reporting support and facilitation in most of the important aspects of livestock diseases surveillance and reporting along the reporting chain among other factors. This fact has a potential of creating limitation of implementing one health approach in combating *T. solium* nuerocysticercosis with strategies towards controlling *T. sollium* taeniosis and porcine cysticercosis as the easiest measurable variables than targeting neurocysticercosis itself (Braae *et al.*, 2020).

Corona virus disease 2019 (COVID 19) outbreak during data collection period limited access to some health facilities for data collection. This resulted into lower than expected number of respondents for qualitative data to be collected. However, the amount of data already collected before the lock down for COVID 19 pandemic outbreak mitigation were adequate for analysis and report preparation.

3.4 Conclusion

Different levels of stakeholder’s engagement provided adequate insight of *T. solium* taeniosis, nuerocysticercosis and porcine cysticercosis reporting with qualitative and quantitative data collection approaches complementing one another. Routine diseases surveillance and reporting systems in both medical and veterinary sectors do not support effective *T. solium* taeniosis, neurocysticercosis/epilepsy and porcine cysticercosis reporting. Inadequate support in livestock diseases surveillance and reporting system was reflected in *T. solium* porcine cysticercosis under reporting whereas difference in priorities for surveillance and reporting of medical diseases with *T. solium* taeniosis and neurocysticercosis being less privileged was reflected by the absence of reporting of *T. solium* taeniosis and neurocysticercosis. The disease was neglected and therefore not a priority in the current medical health surveillance and reporting system. With current emphasis on One Health approach in addressing *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis, priorities need to be revised, with strategies towards optimizing sufficient epidemiologically important data collection for the disease are put in place for successful disease control and eradication.

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CHAPTER FOUR

4.0 General Conclusions and Recommendations

4.1 Conclusions

Different levels of respondents' engagement provided adequate insight of *Taenia solium taeniosis*, nuerocysticercosis and porcine cysticercosis diagnostic capacity and reporting in medical and veterinary health sectors with qualitative and quantitative data collection approaches complementing one another. The results of this study have shown that *Taenia solium* taeniosis and neurocysticercosis diagnosis capacity in the study areas was insufficient.

Taenia solium taeniosis diagnosis capacity is challenged by inadequate availability of diagnostic facilities with most of primary health facilities lacking laboratory and laboratory technicians with capacity to diagnose the disease. What is known about taeniosis prevalence will remain to be grossly under-estimated as long as primary health facilities are not facilitated to perform their roles as focal points to test and confirm taeniosis infection at wide coverage.

Like in most lower and middle income countries, neurocysticercosis diagnosis remains to be challenged by the lack of advanced diagnostic equipment in most of tertiary hospitals which are the referral hospitals for the disease. All regional hospitals visited lacked imaging machines like CT scanners and MRI. This limits accessibility of diagnostic services to patients most of which have lower financial capacity.

It is found in this study that porcine cysticercosis diagnosis capacity is challenged by inadequate competent meat inspectors with proper training in providing meat inspection services. Absence of transport facilitation further reduced mobility and scope of meat inspection service delivery creating more chances of exposing more community members to taeniosis infection.

Routine diseases surveillance and reporting systems in both medical and veterinary sectors did not support effective *Taenea solium* taeniosis, neurocysticercosis/epilepsy and porcine cysticercosis reporting. In medical sector the main challenge was the fact that the disease is among the neglected and is not reportable. Porcine cysticercosis reporting was challenged by inadequate number of properly trained meat inspectors and inadequate facilitation of the livestock disease surveillance and reporting system at all reporting levels. Generally, inadequate support in livestock diseases surveillance and reporting system was reflected in *Taenia solium* porcine cysticercosis insufficient data on the disease despite the fact that livestock diseases surveillance and reporting system provided room for disease reporting as long as it was diagnosed by meat inspectors.

Taenia solium taeniosis and neurocysticercosis are not priority diseases in the medical surveillance and reporting system. This was reflected by the absence of reporting of *Taenia solium* taeniosis and neurocysticercosis at any reporting authority level.

4.2 Recommendations

T. solium taeniosis, neurocysticercosis and porcine cysticercosis are all disease conditions that impart human health and economic wellbeing of the most vulnerable rural population in Tanzania. Control and eradication of both forms of the diseases in man as the definitive host and in pigs as intermediate host requires sufficient country wise data on the disease prevalence and epidemiology. The current national health policy plan 2017-2020 does not advocate control or eradication strategies on the disease. From the study findings it looks like this is contributed by the neglected status the disease has in the medical health sector point of view. This study finds that it is very possible that less is known by national health plan policy makers of the disease negative health and economic impacts. This is because the current health facilities from primary to tertiary level are not well facilitated to diagnose the disease to realize the seriousness of neurocysticercosis negative health impacts. In addition to that, the existing medical health diseases surveillance and reporting system does not accommodate taeniosis and neurocystiecercsis reporting making it difficult to capture data about the disease within the system and realize the disease magnitude national wide. In order to bring into decision and policy makers awareness of *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis of the disease negative health and economic burden the way forward should consider the following mitigation measures:

(i) Primary health facilities need to be facilitated to improve their capacity to diagnose taeniosis by facilitating them with laboratory facilities and professional laboratory technicians and medical health personnel. This will not only improve *T. solium* taeniosis confirmatory diagnosis of the patients but also help in assessing and predicting the success of neurocysticercosis control or eradication programs/initiatives than by testing of neurocysticercosis itself which are expensive.

(ii) The government should consider employing more animal health professionals into the livestock sector. This will not only improve animal health services delivery but also widen the coverage of meat inspection service in rural communities which are more vulnerable to taeniosis and neurocysticercosis resulting from insufficient and substandard meat inspection services.

(iii) In case employing adequate number of new animal health professionals is not practically possible then formal in-service training on meat inspection should be advocated to extension workers already in the field. The training should focus among other things, on *T. solium* porcine cystcirccosis risk based pig carcass inspection to ensure that the available extension officers are optimally working to provide meat inspection service and only safe pork is passed for human consumption.

(iv) It is a high time that the government considers improving regional referral hospitals with diagnostic imaging facilities like CT scanners and MRI to improve *T. solium* neurocysticercosis diagnosis among other health challenges. This will not only reduce diagnostic services accessibility barriers to epileptic patients and have their causes confirmed but also improve disease surveillance and our knowledge on the country disease magnitude.

(v) As we are looking on how to better facilitate diagnostic facilities in both medical and veterinary sectors to improve *T. solium* taeniosis, neurocysticercosis and porcine cysticercosis diagnosis, both health and veterinary professionals need to be updated of their current knowledge on the parasite biology and zoonoses nature. This will help improve their consciousness/suspicion index in the parasite diagnosis especially in the known endemic areas and think of better tests to confirm their diagnosis or where it is not possible provide referral to advanced health facilities.

(vi) *T. solium* taeniosis and neurocysticorcosis reporting should be declared mandatory in the country. This should go together with restructuring of medical health diseases surveillance and reporting system that accommodates taeniosis and neurocysticercosis/epilepsy reporting. This will help improve capturing of all epidemiologically important data about the disease to facilitate strategizing towards control and eradication of the disease in the country.

(vii) *T. solium* porcine cysticercosis reporting should be declared mandatory as well. This will create urgency and a sense of accountability to those who are expected to identify and report the cases.

(viii) Despite the fact that an efficient and active livestock diseases surveillance and reporting system is a function of good performance of many attributes put together, the role of livestock and agricultural extension officers who in most cases are the primary source of the reported data should never be underestimated. They need to be motivated and facilitated in many aspects although of particular importance is transportation. This will enable them to easily move around to provide meat inspection services among others and provide reliable data on porcine cysticercosis epidemiology and prevalence.