THE PREVALENCE AND ASSOCIATED RISK FACTORS FOR *TAENIA SOLIUM* TAENIASIS IN KIAMBU COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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DEDICATION

This work is dedicated to my parents for their support and encouragement throughout the study.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

CDC	Centers for Disease Control
FAO	Food and Agriculture Organization
FGD	Focused Group Discussion
ITFDE	International Task Force on Disease Eradication
KIIs	Key Informant Interviews
KNBS	Kenya National Bureau of Statistics
KVA	Kenya Veterinary Association
NACOSTI	National Council for Science, Technology, and Innovation
NCC	Neurocysticercosis
SPSS	Statistical Program for Social Sciences
UNEP	United Nations Environmental Program
UNICEF	United Nations International Children's Emergency Fund
W.H.O	World Health Organization

DEFINITION OF TERMS

Cysticercosis	It is an intestinal infection which is caused by larval cysts of a tapeworm known as the *Taenia solium*. The cysts larvae can affect different organs such as the muscles, the brain or other tissues
Neurocysticercosis	is a parasitic disease which is brought about by infestation with *T. solium* (the pork tapeworm). It results from the formation of larval cysts which grows in the brain and it causes symptoms such as epileptic seizures
Prevalence	Proportion of a disease found to be affecting a given population in a specific time. It is the comparison of the number found with the disease with the total number of people studied
Taeniasis	Parasitic disease due to infection with tapeworms belonging to the genus Taeniidae
T. saginata	also known as beef tapeworm, it is an animal and human parasite belonging to the order Cyclophyllidea and genus Taenia
T. solium	the pork tapeworm belongs to the cestodes cyclophyllid in the family Taenia Cyclophyllidea and genus Taenia

ABSTRACT

Taenia solium taeniasis is an intestinal parasitic disease caused by infection with *Taenia solium* is also referred to as the pork tapeworm. The main objective of this study was to determine the prevalence and the risk factors that may lead to *T. solium* taeniasis amongst the community in Thika Sub County. A cross-sectional study design was used to collect both qualitative and quantitative data. The study was carried out in Thika Sub-County from November 2016 to January 2017. The study population were members of the community. Cluster sampling was used with administrative wards as the clusters and households as the sampling units. Systematic random sampling was used to select the households which participated in the study. Primary data was collected using structured Questionnaires, focused group discussions (FGDs), key informant interviews (KIIs) and Observations. Stool samples were obtained from all the participants for parasitological laboratory analysis of *T. solium* eggs, scolexes or proglottids. The data was analyzed using SPSS version 20. The statistical analysis included proportions such as mean, median, frequency, and range. Chi-square was used to show the association of risk factors and occurrence of *T. solium* taeniasis. A total of 384 respondents participated in the study and the same number of stool samples were collected and analyzed. The point prevalence for *T. solium* was found to be at 6.8%. Prevalence was found to be significantly related to the ward of the respondent at $\chi 2= 7.153^{a}$, df=2, P=0.028 with respondents from Gatuanyaga showing a higher prevalence. The level of knowledge amongst the community on *T. solium* taeniasis was low and a majority 335 (87.20%) had never heard of it. Majority (380) of the respondents had latrines at 99.0%. The prevalence was significantly associated with having a latrine at $\chi 2=55.657^{a}$, df=1, p=0.000. Respondents from households which had no latrine were more predisposed to *T. solium* taeniasis. The relative risk was 17.2727; 95% CI; P < 0.0001. Lack of deworming was also found to be a risk factor to *T. solium* taeniasis with a relative risk of 1.5211; 95% CI; 0.5513 to 4.1970; P = 0.0418. The study recommends that the county government of Kiambu should address the high prevalence of *T. solium* taeniasis through the promotion of good hygiene and food safety and thorough pork inspection. The county government should educate the community through media and public rallies so as to create awareness on the *T. solium* taeniasis. The county government should sensitize the community through health promotion activities such as the building of latrines so as to address the risk factors associated with *T. solium* taeniasis. This study recommends further studies on the prevalence of *T. solium* taeniasis, the level of awareness amongst the community and the risk factors in other counties. The study also recommends further studies to establish other diseases which may be caused by the high prevalence of *T. solium* taeniasis such as neurocysticercosis and porcine cysticercosis.

CHAPTER ONE: INTRODUCTION

1.0 Background of the study

Taenia solium taeniasis is a parasitic disease caused by infection with *Taenia solium*, also referred to as the pork tapeworm. The pork tapeworm belongs to cyclophyllid cestodes and Taeniidae family. The parasite is found in many parts of the world especially the pork-consuming countries (Allan & Craig, 2006). *Taenia solium* taeniasis is an important zoonosis and a major public health concern across the world (Eshitera *et al.,* 2012). Globally, *T. solium* estimates stand at about 40 million cases (Schantz, 2002). *Taenia solium* taeniasis is often a neglected disease especially in developing countries such as African countries in the south of Sahara, countries in Latin America, and Asia. Thus there is little epidemiological data existing in these countries and the fact that the disease is assumed to be rare (Mutua *et al.,* 2010). Currently, the understanding of the status of *T solium* taeniasis as a severe and new concern to the environmental and public well-being of the population in Africa has been on the rise. However, data on the prevalence, risk factors and knowledge on *T. solium* taeniasis is not adequate. Data on the actual human cases is surprisingly scarce in most affected areas due to a lack of reporting procedures, inadequate form of disease surveillance and poor monitoring platforms (Eshitera *et al.,* 2012).

Pork tapeworm infection is associated with ingestion of undercooked or in some cases raw meat from an infected pig that contains a *T. solium* cysticerci (Allan & Craig, 2006). Other studies have found a connection of pork tapeworm infection with open defecation due to various reasons such as culture, poverty and subsequent consumption of human

excreta by un-confined pigs (Phiri *et al.*, 2003). Ngowi et al. (2009) pointed out that when an egg is transmitted from a human carrier of *T. solium* through autoinfection due to contaminated hands with own excreta, or any direct form of contact to another person who is a tapeworm carrier or through indirect forms such as taking of contaminated food, hands, or drinking water may also lead to human cysticercosis. This leads to the growth of tapeworm cysts larvae in the body organs such as the eyes, muscles and the central nervous system. Pigs may also ingest *T. solium* eggs from faeces of human carriers, which lead to porcine cysticercosis. Pigs can also get the parasite directly by ingesting fodder which is contaminated with feaces from a human carrier (Dorny *et al.*, 2004).

In Kenya, pigs are kept under the commercial intensive system with extensive management system being predominant in Nyanza and Western region (Eshitera *et al.*, 2012). In this system, pigs are free to scavenge a factor that offers a suitable condition for the spread of *T. solium* cycle (Mafojane *et al.*, 2003). There is little data on prevalence and predisposing factors to *T. solium* taeniasis in Kenya, therefore, this calls for a need for a study.

1.1 Problem statement

Taenias solium taeniasis remains a neglected zoonotic disease regardless of its serious consequences to the human health and pig production. The global estimate of about 40 million cases of *T. solium* taeniasis is alarming and calls for intervention (Schantz, 2002. The disease is prevalent in many parts of developing countries with estimated prevalence as high as 21% in some parts of sub-Saharan Africa (Gomes *et al.*, 2002).

The undiagnosed cases of the disease are a concern to the community and the healthcare system in the country due to the long-term effect of the disease. *Taenia solium* taeniasis is a major contributing factor to various concerns such as disability and the lost work productivity due to related epilepsy, incapacitation, and dependency by the infected people. There is also decreased productivity in the pig sector when the pigs are infected, school absenteeism due to the related illnesses, stigmatization and increased medical bills. *T. solium* taeniasis is also associated with neurocysticercosis which can be fatal (Mamkin *et al.,* 2007). There are concerns about the free-range keeping of pigs in Thika Sub-County which could predispose the community to the disease. Epidemiological information about *T. solium* taeniasis is needed for its monitoring and control. The study addressed issues related to *T. solium* taeniasis since it presents a major concern to the health of the community. The disease also presents a challenge in pig production which is an important economic activity in Kiambu County.

1.2 Justification of the study

Zoonotic diseases such as *T. solium* taeniasis still pose a major challenge to human health despite their recognition as important foodborne infections. Food safety is an important aspect of the human health and development. The high prevalence of *T. solium* taeniasis continues to affect a large number of the population (Gomes *et al.,* 2002). A good understanding of the prevalence and documentation of the issues contributing to the high prevalence is a prerequisite to the development of interventions on the disease. There was data gap in Kiambu County concerning *T. solium* taeniasis yet the county remains the biggest producer and consumer of pork in Kenya (Kagira *et al*., 2010). Understanding the

awareness and knowledge amongst the community concerning the disease is also an important aspect towards eradicating it. Practices which predispose the community to *T. solium* taeniasis also need to be established so as to create control measures for the disease. This information was not available since there was no previous study which had been done in the area. The results of the study are expected to bridge the current gaps in the prevalence, knowledge, and practices that predispose the communities to *T. solium* taeniasis. The results will also document various contributing issues and recommendations in the research area.

1.3 Research questions

The study questions of this research were as follows;

1. What is the prevalence of *T. solium* taeniasis amongst the community in Thika sub-County?
2. What is the level of awareness and knowledge of *T. solium* taeniasis amongst the community in Thika sub-County?
3. What practices are risk factors to *T. solium* taeniasis amongst the community in Thika sub-County?

1.4 Hypotheses

1.4.1 Null hypotheses

$H_0$1 There is a low prevalence of *T. solium* taeniasis amongst the community in Thika sub-County

$H_0$2 There is a low awareness and knowledge on *T. solium* taeniasis amongst the community in Thika sub-County

$H_0$3 There are no practices which are risk factors to *T. solium* taeniasis amongst the community in Thika sub-County

1.5 Objectives

1.5.1 Broad objective

To determine the prevalence and the risk factors that may lead to the occurrence of *T. solium taeniasis* in Thika Sub County, Kiambu County.

1.5.2 Specific objective

1. To determine the prevalence of *T. solium* taeniasis amongst the community in Thika sub-County
2. To establish the level of awareness and knowledge on *T. solium* taeniasis amongst the community in Thika sub-County
3. To assess the practices which may be risk factors to the occurrence *T. solium* taeniasis amongst the community in Thika sub-County

1.6 Delimitation and Limitations of the study

This study was limited to the population within Thika Sub-County. All administrative wards were represented in the sampling to ensure representation of the entire Sub County. Pre-tested questionnaires were used to capture data on the knowledge and practices while

laboratory analysis of stool samples was done to determine the incidence of *T. solium* taeniasis.

The incidence was determined using one stool sample drawn from each study participant while the *T. solium* eggs are shed periodically which could lead to low prevalence rate.

1.7 Conceptual framework

Socio-demographic factors, knowledge, and risk practices are predictors for the prevalence rates of *T. solium* taeniasis. However, there are intermediate variables that can influence the prevalence. They include; the existing interventions such as pork inspection, laws and policies, and interventions such as health promotion amongst the community on parasitic diseases.

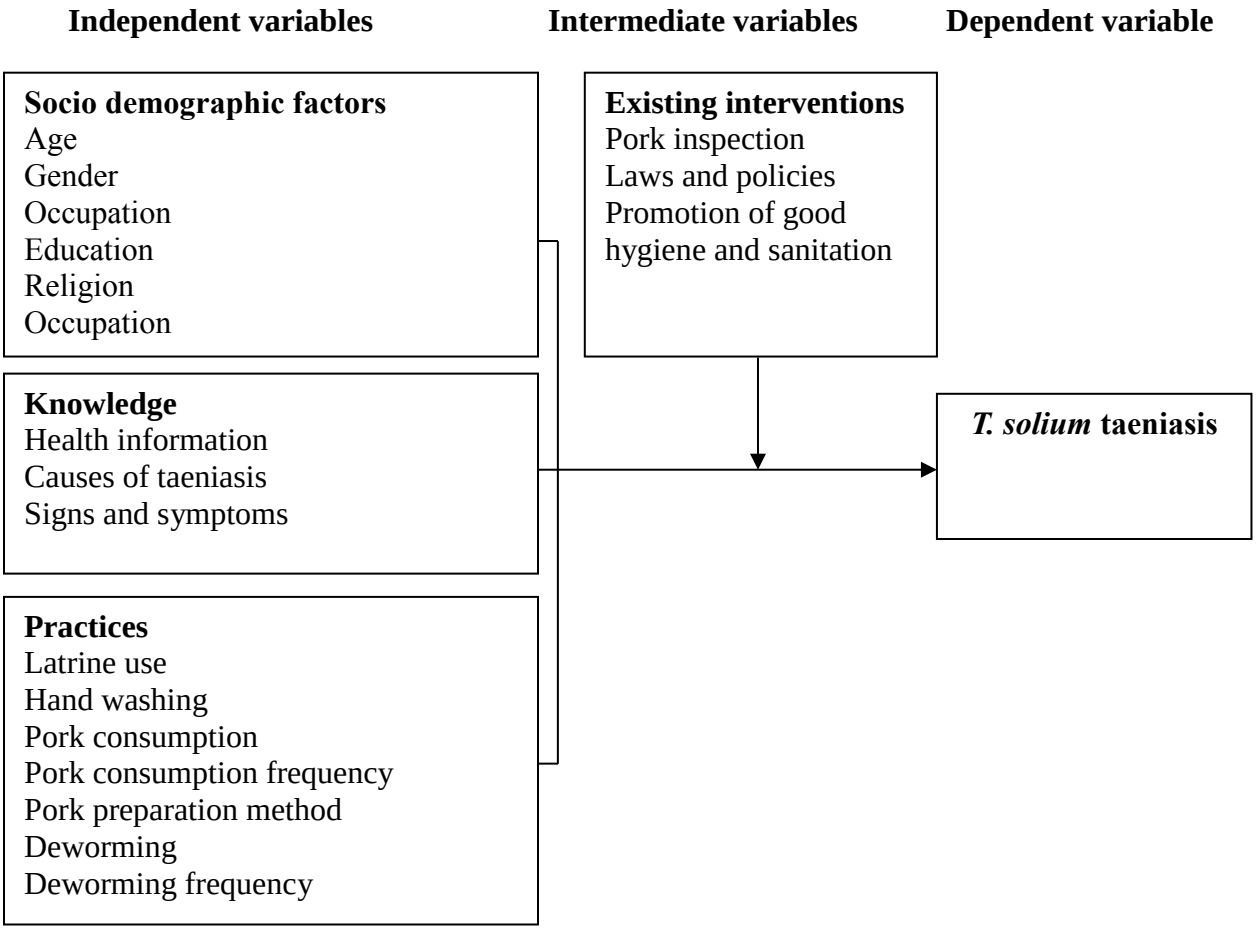

Figure 1.1: Conceptual framework

Source: Adopted and modified from FAO, (2010).

1.8 Significance and expected output

Despite increasing reports of *T. solium* taeniasis incidences across the globe, the prevalence has not yet been evaluated due to the missing data as a result of unreported *T. solium* taeniasis cases. Risk factors to *T. solium* taeniasis among the population infected have not been established. Baseline knowledge is important in addressing public health concerns (Pierson, 2012).

Therefore the study has documented the prevalence and the predisposing factors to *T. solium* taeniasis within the study area so as to provide essential knowledge for designing and monitoring of suitable and tailor-made interventions for *T. solium* taeniasis control. The interventions may include; pork inspection, public awareness, policies and improved sanitation for *T. solium* taeniasis control in Thika Sub County, Kiambu County. The beneficiaries of the study are the community through the interventions for control of *T. solium* taeniasis such as health education. The policy makers and researchers are also beneficiaries through the use of the data for policy making and baseline data respectively.

CHAPTER TWO: LITERATURE REVIEW

2.0 Global overview of *Taenia solium* taeniasis

Taenia solium taeniasis has been related to the human being for a period dating back to about 10,000 years due to the domestication of pigs and consumption of their meat (Sibat & Valdés, 2013). In the 16th century, a European pathologist found out that the condition was associated with a disease and explained the cause of as neurocysticercosis (NCC) in the brain (Torgerson *et al.,* 2015). The disease transmission remained unknown until around 1850 when Kuhenmeister found out the relationship on the linkage of the larval stages to the adult worm through various experiments done on humans and dogs (Lightowlers, 2013). Until today, the science has not given a better insight on the actual figure on the prevalence of both taeniasis and human Cysticercosis. International migration has led to the expansion of *T. solium* distribution incidences across the world (Thomas *et al.,* 2013).

Taenia solium taeniasis is ranked in the World Health Organization and FAO top ten list of the leading food borne parasites across the globe. The ranking is based on the associated effects of *T. solium* taeniasis such as porcine cysticercosis in the pigs and the detrimental concerns on human health such as NCC and related epilepsy (Torgerson *et al.,* 2015; Engels *et al.,* 2003). This led to recommendations towards a positive progress in diagnostic treatment and recognition of the importance of *T. solium*. Epilepsy, which is *T. solium* related and a burden since it is widely stigmatized has a negative impact in the population all across Sub-Saharan Africa (Carpio *et al.,* 1998; Eshitera *et al.,* 2012). The

recommendations have seen a positive trend towards NCC and epilepsy treatment especially in sub-Saharan Africa (Torgerson *et al.,* 2015).

In the year 1993, *T. solium* taeniasis was declared potentially eradicable by the international task force on disease eradication (ITFDE). This is due to the fact that the factors that favor its life cycle can be modified and practical interventions such as safe and effective drugs are available (Mwape *et al.,* 2012). However, the prevalence has been showing an increasing trend across the world due to the existing large treatment gap for *T. solium* taeniasis in developing countries (Torgerson *et al.,* 2015). Factors such as poverty, inadequate health care infrastructure and lack of medication are also challenges to the disease eradication (Mwape *et al.,* 2012). This shortcoming can be addressed through raising the priority of *T. solium* in the health care agendas as well as documenting *T. solium* taeniasis prevalence rates across the world and addressing key risk factors for the disease transmission (Sarti *et al.,* 2000).

The global distribution of *T. solium* taeniasis was reported by CDC (2016), as is shown in the map in Appendix I. The countries where *T. solium* taeniasis is endemic are southern Asia, South America and Central, Western, Eastern, and South Africa.

2.1 *Taenia solium* taeniasis transmission

Taenia solium taeniasis is a form of oral-faecal worm infestation of the digestive tract by parasitic pork tapeworm cestodes. It is transmitted by consumption of undercooked or raw pork that contains the *T. solium* larvae (cysticerci) (Schantz *et al.,* 1992). The larvae

can also be ingested from other foods, water or from the soil. Pigs acquire eggs by consuming feaces or contaminated feed from a human *T. solium* carrier and may result to porcine cysticercosis which is caused infestation by the larvae of *T. solium* tapeworm (Eckert, 2005). Cysticerci, the tapeworm eggs are present in human excreta of an adult tapeworm carrier which is as a result of ingesting cysts in a poorly cooked meat. *T. solium* life cycle is as illustrated in Appendix II and involves human host where the adult worm lives in the small intestines and pigs as the intermediate host. Cysticercus develops in the muscle and is ingested in raw or undercooked pork. Accidental intermediate host occurs when the eggs are ingested by the human. Cysticercus develops in muscle, skin, brain, eye or spinal cord causing a condition called human cysticercosis (Schantz *et al.*, 1992).

2.2 Clinical signs

The parasite is adapted to live in the human body while causing a minimal damage. Thus, the human carrier may harbor the parasite for a long period without any clinical signs and symptoms (Garcia *et al.*, 2014). *T. solium* taeniasis is normally asymptomatic in early stages but in advanced stages, signs include, weight loss, abdominal pains, dizziness, headaches, diarrhea, constipation, loss of appetite, indigestion, and nausea (Garcia *et al.*, 2014; WHO, 2014). Other signs and symptoms may include a mild gastrointestinal disturbance and presence of proglottids in the stool of the human carrier (Thomas *et al.*, 2013).

2.3 *Taenia solium* Treatment and prevention strategies

The fundamental prevention for *T. solium* taeniasis is generally proper hygiene and sanitation, meat inspection, pig confinement, health education, safe meat preparation, mass drug therapy treatment of human carriers (Torgerson *et al.,* 2015). High level of sanitation and prevention of human faecal contamination on pig feed and water plays a significant role in prevention (Eckert, 2005). Dirty hands are the primary causes of *T. solium* taeniasis transmission by the food handlers and it can be eliminated through improved sanitation and hand washing practices (Garcia *et al.,* 2014).

2.4 Global overview of *T. solium* taeniasis prevalence

Taenia solium taeniasis is emerging in more or less all the countries in the world with 1200 related deaths in the year 2010 up from 700 in the year 1990 (Garcia *et al.,* 2014; Zoli *et al.,* 2003). *Taenia solium* taeniasis prevalence has not been precisely determined across the globe due to the missing data since many cases of the disease go unreported due to lack of a proper surveillance system. However, in areas where its incidences are higher mostly the Asian, Latin America and African countries South of Sahara the prevalence is likely to be significantly high (Pondja *et al.,* 2012). In non-endemic areas, prevalence is also significant due to imported cases due to increasing international migrants out of regions which record high endemics (O'Neal *et al.,* 2011). A meta-analysis of epileptic cases across the world estimated that 30% of epileptic people have NCC (Pawlowski *et al.,* 2005). In a study that was done in the Democratic Republic of Congo based on the circulating antigen detection, the prevalence was found to be 21.6% while in Mozambique it was at 20.5% (this was based on specific antibody detection) and

7.4% in South Africa (Afonso, 2011; Eshitera, 2012). Mutua et al., (2010), found a prevalence of 6.5% in Teso district. This data highlights the need to conduct further studies so as to understand the overall burden within the contexts of each and every affected community (Kagira *et al*., 2010).

In Japan, Cysticercosis incidence was highest in 1936 and 1945 at 225 cases and drastically reduced in the year 1955 with 15 cases (Mwape *et al.,* 2011). *T. solium* is now being understood as one of the emerging diseases in developed countries too like the USA, Canada, and Europe because the pig keeping system is shifting from indoors to outdoors due to immigrants from other countries such as South America (Gilman, 2012). In a study on *T. solium* taeniasis in India and Nepal, the prevalence was found at 2% and 10% respectively with an unusual trend of low proportions among pork eaters. It was found that 95% of India's patients with NCC were vegetarians and did not consume pork. This trend can be attributed to other risk factors apart from the pork itself such as cross-contamination and poor hygiene (Amatya and Kimula, 1999). *Taenia solium* prevalence in Vietnam was found at 12% and 2.5% in Honduras, South America (Flisser *et al.,* 2013). This is a trend of concern since the prevalence is occurring in areas where there has been no *T. solium* taeniasis previously.

International travels are also a risk factor for *T. solium* distribution and prevalence (WHO, 2014). Increasing cases of cysticercosis are also being observed in children especially in developing countries (Mwape *et al.,* 2011).

2.5 Africa overview of *T. solium* taeniasis prevalence

A data gap exists on the prevalence of *T. solium* taeniasis in Africa especially the sub-Saharan part due to a missing epidemiological data of the disease, inadequate reporting, and the fact that the disease is often neglected (Thomas *et al.,* 2013). However, *T. solium* taeniasis appears to be present in all sub-Saharan African countries with an exception of a few non-pork eating countries (Mutua *et al.,* 2010). The prevalence of *T. solium* taeniasis in is estimated to range 2.4% to 10.8 % (Gomes *et al.,* 2002). As per the WHO requirement, data is needed for validation and control programs in terms of baseline data (Powlowski *et al.,* 2005).

In a study that was carried out in Tanzania, *T. solium* taeniasis prevalence was found at 17.4% (Boa *et al.,* 1995). In Uganda, the prevalence was found at 9.4% (Kisakye and Masada, 2002). In Burundi, the prevalence stood at 2.8%, and in Ghana 13.5% (Newel *et al.,* 1997). Prevalence in Cameroon was found at 4.6% in and 2.4% in the Africa Central Republic (Zoli *et al.,* 2003).

2.6 Prevalence of *T. solium* taeniasis in Kenya

Cysticercosis is a serious concern in Kenya and has had a detrimental impact on the pig production industry (Eshitera *et al.,* 2011). Data on porcine cysticercosis is not adequate in Kenya and *T. solium* taeniasis is a neglected disease and in some instances, its cases go unreported (Kagira *et al.,* 2010).

Kenyan pig farmers are raising pigs under the intensive system with the extensive system management system being predominant in some parts especially in Nyanza and the western regions (Mutua *et al.,* 2007). There is an emerging trend of free-range keeping especially in the informal settlement areas since it is assumed to cut down the cost of production (Ngowi *et al.,* 2009). This means that the pigs are free to scavenge thus exposing them to poor conditions that are suitable for *T. solium* cycle transmission.

A study in Busia County found a prevalence of 9%, 15% and 3% in Township, Funyula and Budalangi divisions of Busia district, respectively (Githigia *et al.,* 2006). World Health Organization and UNICEF Joint Monitoring Report, points out that only 32% of the Kenyans rural population uses improved sanitation facilities and 18% use open defaecation system without latrines (WHO & UNICEF, 2014). The findings highlight that the most affected areas are open defaecation regions with poor sanitation and areas where the pigs are not confined and graze extensively. This enhances the normal life cycle of the pathogen to flourish and thus a high prevalence (Flisser *et al.,* 2005).

2.7 Global picture of community knowledge and practices related to *T. solium* taeniasis

Pig production is fast growing within the livestock sector across the world and the projection is a continued growth due to the increasing demand for pork, short production cycle for the pigs and high returns to the farmers (Thomas *et al.,* 2013). However, pig production is faced with various challenges. These include; lack of enough feed sources, high costs of feed, lack of basic sanitation, bad husbandry practices, lack of sound

veterinary services and lack of proper meat inspection (Githigia *et al.,* 2006). All these factors influence practices that contribute to poor animal, public health and environmental health (Thomas *et al.*, 2013).

Taenia solium taeniasis is endemic in developing countries because the risk factors for the infection are poor sanitation and free roaming pig farming system (Murrel, 2005). Poor disease surveillance platforms result in underestimating of the epidemiological and the clinical effects of *T. solium* Taeniasis. This is due to the poor awareness of the infection and little familiarity with managing the disease. Cycle maintenance of *T. solium* in the peri-urban areas especially in the Latin America, Asia, and Sub-Saharan Africa is enhanced by cases of undercooked pork, free-ranging of pigs and inadequate sanitation (Githigia *et al.,* 2006).

2.8 Africa picture of knowledge and practices related to *T. solium* taeniasis

Concerns on an extensive-ranging system have proven a major contributing practice towards the spreading of *T. solium* taeniasis especially in sub-Saharan Africa (Flisser *et al.,* 2013). Other practices that have contributed to *T. solium* taeniasis incidences are; outdoor defaecation where pigs can access the human excreta, involvement of human *T. solium* carriers in the pig care and pork handling sector, use of raw sewage in areas where pigs pasture is grown and improper meat inspection (Githigia *et al.,* 2006; Ngowi *et al.,* 2009). Roasting of pork is an emerging trend in many parts of Africa. This raises concerns about undercooking of pork which could contribute to human infection from the pork (Pondja *et al.,* 2012).

2.9 Kenyan picture of knowledge and practices related to *T. solium* taeniasis

In some parts of Kenya, pig farming is small-scale holders industry with 1 to 10 pigs per household mostly under the free-ranging system (Kagira *et al.,* 2010). This pig keeping system entails pigs roaming extensively in large areas in search of food thus exposing them to conditions that could be suitable for the spread of *T. solium* (Thomas *et al.,* 2013). An inspection should be done to the pigs prior to slaughter as per the Meat Control Act Cap 356 (Eshitera, 2012). However, the pigs are sold to the local markets or butcheries without formal market chain (Kagira *et al.,* 2010). This contributes to a significant amount of pork entering the market without a proper meat inspection thus putting the consumers at risk of *T. solium* infection. Cysticercosis, which is caused by *T. solium* taeniasis, carries a great burden to the human health in form of resultant epilepsy and the related disabilities as well as the lost work productivity by the affected population (Githigia *et al.,* 2006).

There are knowledge gaps in Kenya regarding pork preparation and the risks associated with eating raw or undercooked pork. A common misconception that pigs are scavengers and literally feeds on garbage exists amongst a large population within the country (Mutua *et al.,* 2010). This translates to the pig keepers who often let the pigs roam freely in search of food and some instances feed them with swill, which could be a risk factor to *T. solium* taeniasis.

2.10 Summary of Literature review and the gaps that were addressed

Taenia solium taeniasis ranks among the top ten food-borne diseases across the globe with new cases being reported in developed countries due to international immigration (WHO, 2014). Prevalence in sub-Saharan Africa is estimated at 2.4 percent to 10.8 percent while the knowledge on *T. solium* Taeniasis is surprisingly low especially in endemic areas (Gomes *et al.*, 2002). Various studies have found a number of risk factors to *T. solium* taeniasis such as lack of latrine use, the free-range keeping of pigs, undercooking of pork and feeding of pigs with swill. There is a scarcity of data on the actual prevalence, knowledge and associated risk factors in sub-Saharan Africa and Kenya in particular. In Kiambu County, there was no research that had been done on *T. solium* taeniasis and associated risk factors. Therefore, this study sought to address the underlying knowledge gaps on the actual prevalence and the risk factors.

CHAPTER THREE: MATERIALS AND METHODS

3.0 Location of the study

Thika Sub-County is located at latitude 00 25’ and 10 20’ S of Equator and at longitude 360 31’ and 370 15’ East. Its area is 217.60 square kilometers and a population of 200,502 people (KNBS, 2016). It experiences a tropical moderate climate with an average temperature of 25 degrees Celsius. Thika Sub County has five administrative Wards namely; Township, Kamenu, Hospital ward, Gatuanyaga and Ngoliba. Thika Sub County is an industrial area with various processing industries dealing mainly in horticulture, fruits, coffee, cooking oils and animal feeds processing. Agriculture and livestock keeping is also predominant especially coffee, horticulture, fruits dairy farming, poultry and pig keeping (KNBS, 2016). The map of the study area is as shown in Appendix III.

3.1 Study design

A cross-sectional study design was used to collect the research data. The design entailed the use of both qualitative and quantitative data in evaluating the prevalence of *T. solium* taeniasis, and the risk factors that may lead to its occurrence in Thika Sub-County community, Kiambu County.

3.2 Variables

The study independent variables were socio-demographics, knowledge, and factors which may predispose the community to *T. solium* taeniasis. The factors were; latrine use, hand washing after using the latrine, pork consumption, pork consumption frequency, pork

preparation method and deworming. The dependent variable was the prevalence of *T. solium* taeniasis. Existing interventions such as pork inspection, laws and policies, and promotion of good hygiene practices were the intervening variables.

3.3 Study population

The study was done in Thika Sub-County, Kiambu County of Kenya, among the residents of Thika Sub-County in their respective households. Thika Sub-County has a total number of 16,708 households (KNBS, 2009). The study population comprised of individuals both male and females with a special interest in households where pigs are raised.

3.4 Sample size determination

The sample size determination was done in line with Fishers et al. (1998) formula of sample size determination which assumes that 50% of the study population has similar characteristics since there was no data to show the actual prevalence in the area. The sample size was calculated as shown;

$$n=z^2pq/d^2$$

Where;

n = Desired sample size (population> 10,000).

z = Standard normal deviation at the required confidence level (set at 1.96).

p = Since was no current data showing the prevalence in the area, the researcher made an assumption of 50% of the target population having similar characteristics.

q = 1 – p (1-0.5)

d = Level of statistical significance (usually 0.05)

$$n = \frac{(1.96^2)*(0.5)*(0.5)}{0.05^2} = 384$$

Thus, the sample size was 384 since the study population is more than 10,000 (KNBS, 2009).

3.5 Inclusion criteria

For a person to be included for sampling they were supposed to be residents of the study area for a period of more than 3 months. Pig keepers, handlers and the people who are involved with day to day keeping of the pigs were also included.

3.6 Exclusion criteria

The exclusion criteria were anybody who appeared to be mentally unstable as well as those who did not give consent to participate.

3.7 Sampling techniques

Cluster sampling technique was used to recruit participants for the household questionnaires. Clusters were formed from the five administrative wards of the Sub County. Two (2) - stage cluster sampling was used to form 3 clusters from the 5 administrative wards of the Sub County based on; the geographic location, total population, pig keeping, pig husbandry practices and water and sanitation. Cluster one comprised of Kamenu and the Hospital wards where Kamenu ward was randomly selected. The second cluster comprised Gatuanyaga and Ngoliba wards. Gatuanyaga was

randomly picked. Township ward formed the third cluster since it has unique characteristics. Households within the sampled clusters formed the sampling units. Systematic sampling was then used to select the household to participate in the study. The sampling interval was calculated as a proportion of the sample size from the study population such that every 12^{th} household was selected. In cases where the household declined to participate or there was no one at home, the next household was chosen. All the pig keeping households were purposively picked with the help of veterinary extension officers to give information on the keeping practices.

Table 3.1: Clusters and sample size as per the population proportions

S/n	Ward	Cluster	Total households	% of sampled households	Number sampled
1	Kamenu	1	2,944	63.5	244
2	Gatuanyaga	2	1038	22.4	86
3	Township	3	653	14.1	54
Total			5,091	100	384

3.8 Construction and Research Instruments

The research instruments were questionnaires, KIIs, FGDs, Observations and Laboratory analysis of stool samples. The questionnaires, KIIs, FGDs and Observation checklist were adopted and modified from (Murrel *et al.,* 2005; Pawlowski *et al.,* 2005; Kagira *et al.,* 2010) so as to ensure that they suited the study design, objects of measurements, data collection methodology, purpose of the study and resources.

3.9 Pretesting

Pre-testing of the research tools was done prior to data collection in Juja, Kiambu County. Juja was chosen since it has the same characteristics in terms of pork consumption and production.

Knowledge and practices were also assumed to be the same as in the study area. Ten (10%) of the sample size was used for the pretests. This comprised a total of 43 participants who met the inclusion criterion and were excluded from the actual study sample. Expert judgment and applicability of the questionnaire were sought and used to improve the quality of the data.

3.9.1 Validity

To avoid bias to the internal validity, accurate and appropriate tools for data collection procedures was achieved by familiarizing with the tools before the data collection and training research assistants who were involved in data collection. To ensure external validity of the study, variables were defined conceptually and operationally.

3.9.2 Reliability

Reliability was done to ensure that the data collection tool was stable and that it could produce results which were consistent. Pretests were done by administering the questionnaire repeatedly through the pre-testing and determination of its internal validity. Data obtained from the pretests were run through the reliability tests in the SPSS version

20 software. Cronbach Alpha coefficient was used to check the reliability. A correlation coefficient equal or greater than 0.75 was considered an indicator of validity.

3.10 Data collection techniques

Both secondary and primary data were used in the research; the primary data was useful in getting detailed and firsthand information that included qualitative facts. Secondary data were obtained from the review of related literature on the study topic. The purpose of the study was explained, and consent obtained prior to administering the questionnaire, Key Informant Interviews (KIIs) or Focus Group Discussions (FGDs).

3.10.1 Use of questionnaires

Primary qualitative data was collected through semi-structured questionnaires (Appendix VI). The questionnaire was written in English and translated into the local dialect by a trained research assistant. Research assistants were trained on how to introduce the research to the participants and how to administer the questionnaire. The questionnaires captured socio-demographic data, water and sanitation, pig husbandry and practices, pork consumption and awareness on *T. solium* taeniasis. The questionnaires were administered to the household head or any adult member of the household.

3.10.2 Use of key informant interviews

Additional qualitative data were collected through key informant interviews which were conducted to available members drawn from the study population. The key informers

were purposively drawn from public health officers, veterinary officers, agricultural extension officers, chiefs, prominent pig keepers, butchers and pork handlers.

3.10.3 Use of focused group discussions

Qualitative data was collected through FGDs which were conducted at the community level and moderated by a skilled facilitator. The discussions aimed at understanding the community opinions and perception on the risk factors, knowledge and practices that may lead to the occurrence of *T. solium* taeniasis.

3.10.4 Laboratory examination of stool samples

Prevalence of *T. solium* taeniasis was determined through laboratory parasitological evaluation of the fecal sample, one per individual of *T. solium* eggs or proglottids drawn from the person whom the questionnaire was administered to. A faecal collection tube for every participant was provided at the end of the interview and collected the following day.

Microscopic examination was done by the direct wet film and iodine staining procedures. The samples were examined of eggs, larvae, or scoleces of different types of microorganisms as well as helminths. Since *Taenia spp* eggs are identical, a follow-up procedure was done to all positive *Taenia spp* samples for species determination through sieving the samples to find proglottids or scoleces which were microscopically observed. Species determination samples were prepared with lactophenol (50/50 liquefied phenol crystals in lactic acid) and Indian ink injection was done for 30 minutes

and sandwiched between two glass microscope slides. Indian ink was then injected into the pores and the number of primary uterine branches was counted to determine the species (7-13 for *T. solium* and 12-30 for *T. saginata*). Laboratory examination of stool samples was done as per the (CDC, 2016) guidelines.

3.11 Data management and analysis

The first phase of data cleaning was done for every questionnaire to ensure that it was fully and correctly filled. Any incomplete or wrongly filled questionnaire was replaced.

The data from the FGDs and KIIs were entered in notebooks and then typed into MS word and analyzed based on emerging themes and categorizing it into meaningful sections. Qualitative pre-coded data was entered into Statistical Program for Social Science (SPSS) software, version 20 for analysis. After the entry, the second phase of data cleaning was done to ascertain correct entry of data using a basis of logic checks. The data operations were both analytical and descriptive. Proportions such as mean, median, frequency, and range were used. For bivariate and multivariate analysis, Chi-square was used to find associations.

3.12 Ethical considerations

This study was approved by the Kenyatta University Graduate School (Appendix VI) and reviewed by the Kenyatta University Ethical and Review Committee (Appendix X) and approved by the Ministry of Health, Kiambu County (Appendix VII). Permission to carry out the research was sought from the National Commission for Science and

Technology (NACOSTI) (Appendix VIII). All participants were provided a written informed consent (Appendix IV). All the participants were informed that the exercise was voluntary and one could decline or withdraw at any time during the study.

A brief health education was given to all the participating households as part of the engaging them and seeking consent. This consisted of a brief discussion of the *T. solium*, its lifecycle, its methods of prevention and the associated economic implications of healthy animals and people. Simple diagrams and pictures were used to explain *T. solium* and the life cycle and the different stages of infection were shown to create more insight on *T. solium* taeniasis. Brochures were made and distributed among the household for health education on *T. solium*. On confirming individual cases of *T. solium* infection, the households were contacted and the person was advised to seek medical treatment at Thika level five hospital or any other facility of their choice.

CHAPTER FOUR: RESULTS

4.0 Socio-demographic characteristics of the respondents

The socio-demographics describe the characteristics of all the 384 respondents who participated in the study. The majority were females at 221 (57.60%) while the minority was males at 163 (42.40%). On the education level of the respondents, those who were undergoing or had completed secondary education were the majority at 183 (47.70%) while those who had no formal education were the minority at 17 (4.40%). The religious affiliation of the respondents reported a Christian majority at 379 (98.70%) and a non-religious minority at 5 (1.30%). A majority of the respondents at 129 (33.60%) relied on animal husbandry as a source of income while a minority at 4 (1.0%) had no reliable source of income. On the marital status of the respondents, the majority at 299 (77.90%) were married while a minority at 6 (1.6%) were widowed.

Table 4.1: Socio-demographics characteristics of the respondents

Socio-demographics	Category	Number	Percentage
Gender	Male	163	42.4
	Female	221	57.6
Education	No formal education	17	4.4
	Primary not completed	101	26.3
	Secondary	183	47.7
	College	83	21.6
Religion	Christian	379	98.7
	Non-religious	5	1.3
Income Source	Salaried employment	99	25.8
	Business	59	15.4
	Casual labor	54	14.1
	Animal husbandry	129	33.6
	Crop farming	39	10.2
	Unreliable sources of income	4	1
Marital status	Married	299	77.9
	Never married	59	15.4
	Separated	14	3.6
	Widow	6	1.6

4.1 Prevalence of *T. solium* taeniasis

After the evaluation of the 384 stool samples from all the study participants, a total of 26 samples (6.77%) were found to be positive with *T. solium*. The point prevalence for *T. solium* was therefore found to be at 6.8%. A majority of the positive cases were from the Kamenu ward at 15 (3.90%) of the study participants from that ward, while a minority of the cases were from Gatuanyaga ward at 3 (11.50%). However, Township ward reported the highest prevalence at 30.8% while Kamenu ward reported the lowest at 3.9%. Prevalence was found to be significantly related to the ward of the respondent at $\chi 2= 7.153^{a}$, df=2, P=0.028 with respondents from Township ward showing a higher prevalence.

Table 4.2: Occurrence of *T. solium* per the wards/clusters of the respondents

Ward		The occurrence of *T. solium* in the sample				Total	P value
		Positive		Negative			$\chi 2=7.153^{a}$
		N	%	N	%		df=2
	Kamenu	15	3.90	229	59.60	244	P=0.028*
	Gatuanyaga	3	11.50	83	23.20	86	
	Township	8	30.80	46	12.80	54	
Total		26	6.77	358	93.20	384	

(Chi-square tests were done to find the relationships between variables P≤0.05, values with [*] are significantly associated).

Table 4.3: Multiple comparisons of the ward of the respondent and the occurrence of *T. solium* taeniasis

Dependent Variable: Occurrence of *T. solium* in the sample						
Tukey HSD						
(I) Ward of respondents	(J) Ward of respondents	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kamenu	Gatuanyaga	-0.03	0.031	0.661	-0.10	0.05
	Township	0.09*	0.037	0.049	0.00	0.17
Gatuanyaga	Kamenu	0.03	0.031	0.661	-0.05	0.10
	Township	0.11*	0.042	0.022	0.01	0.21
Township	Kamenu	-0.09*	0.037	0.049	-0.17	0.00
	Gatuanyaga	-0.11*	0.042	0.022	-0.21	-0.01

Based on observed means.
The error term is Mean Square (Error) = .060.
*The mean difference is significant at the 0.05 level.

The positives *T. solium* cases varied across the socio-demographics. Females recorded the highest number of cases at 14 (6.30%) while males reported the minority cases at 12 (7.40%). Respondents who had attained primary education reported the highest number of positive cases at 10 (9.90%) while those who had college education reported the least number of cases at 5 (6.00%). All the *T. solium* positive cases were from the Christians

who were also the majority respondents in the study area. The majority positive cases came from the respondents who were in salaried employment at 8 (8.10%) while there was no any positive case amongst the respondents who practiced crop farming and those who had no reliable source of income. Only the level of education of the respondent was found to be significantly associated with the occurrence of *T. solium* taeniasis at $\chi 2=18.982^{a}$, df=3, P=0.000*.

Table 4.4: Socio-demographic characteristics and the occurrence of *T. solium* taeniasis

Socio-demographics		**The occurrence of *T. solium* in the sample**				**Total**	**P value**
	Category	Positive		Negative			$\chi 2=0.157^{a}$ df=1 P=0.692
		N	%	N	%		
Gender	Male	12	7.40	151	92.60	163	
	Female	14	6.30	207	93.70	221	
Education	No formal education	5	29.40	12	70.60	17	$\chi 2=18.982^{a}$ df=3 P=0.000*
	Primary	10	9.90	91	90.10	101	
	Secondary	6	3.30	177	96.70	183	
	College	5	6.00	78	94.00	83	
Religion	Christian	26	6.90	353	93.10	379	$\chi 2=0.368^{a}$ df=1 P=0.544
	Non-religious	0	0.00	5	100.0	5	
Income source	Salaried employment	8	8.10	91	91.90	99	$\chi 2=7.041$ df=5 P=0.218
	Business	4	6.80	55	93.20	5	
	Casual labor	7	13.00	47	87.00	54	
	Animal husbandry	7	5.40	122	94.60	129	
	Crop farming	0	0.00	39	100.00	39	
	Unreliable sources	0	0.00	4	100.0	4	

(Chi-square tests were done to find the relationships between variables P≤0.05, values with [*] are significantly associated).

4.2 Level of knowledge on *T. solium* taeniasis amongst the community

The level of knowledge amongst the community on *T. solium* taeniasis was determined using three questions which served as the knowledge indicators. All the 'Yes' responses scored 1 while 'No' responses scored 2. The mean score of all the questions was 1.92 which indicated a low level of knowledge amongst the community.

Table 4.5: Mean on different questions to establish the level of community knowledge on *T. solium* taeniasis

	Mean	N	Std. Deviation	% of Total N
1. Knows any symptoms of *T. solium* taeniasis				
Yes	1.81	16	0.403	4.20
No	1.94	368	0.242	95.80
Mean score	1.87			
2. Heard of *T. solium* taeniasis				
Yes	1.96	49	0.2	12.80
No	1.93	335	0.258	87.20
Mean score	1.95			
3. Knows any symptoms of *T. solium* taeniasis				
Yes	1.92	52	0.269	13.50
No	1.93	332	0.249	86.50
Mean score	1.93			
Mean score (all the questions)	1.92			

(The level is indicated by the mean where 1.5 was the cutoff point between 'high' and 'low' level of knowledge. High knowledge ≤1.5; 1.5; moderate knowledge; Low knowledge ≥1.5).

A majority of the respondents did not know any symptoms of *T. solium* taeniasis at 368 (95.80%) while a minority at 16 (4.20%) knew symptoms of *T. solium* taeniasis. On whether the respondents had heard of *T. solium* taeniasis, a majority at 335 (87.20%) had never heard of it while a minority 49 (12.80%) had heard of it. Further, a majority of the respondents 332 (86.50%) did not know any symptoms of *T. solium* taeniasis while a minority of 52 (13.50%) at least one symptom of the disease.

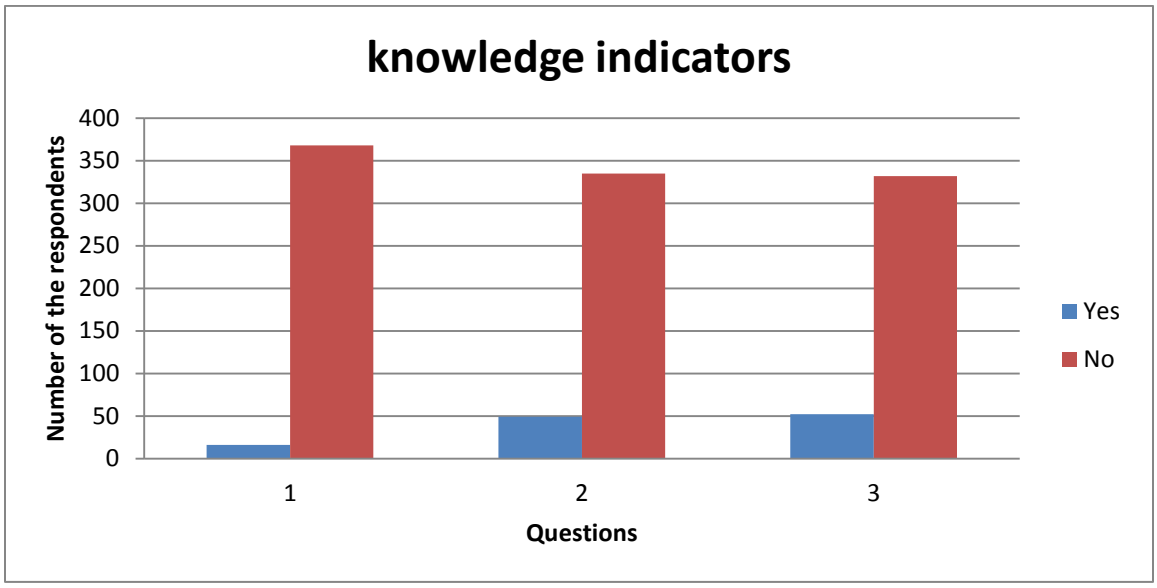

Figure 4.1: Knowledge indicators from the respondents

Majority of the positive cases 24 (7.20%), 22 (6.70%), and 23 (6.8%) were from the respondents who had never heard of *T. solium* taeniasis did not know the causes of *T. solium* taeniasis and who did not know any signs of *T. solium* taeniasis respectively. There was no any significant relationship between the occurrences of *T. solium* taeniasis with the questions on knowledge (Figure 4.1).

Table 4.6: Occurrence of *T. solium* taeniasis in relation to questions on knowledge

Question	Response	The occurrence of *T. solium* in the sample				Total	p-value
		Positive		Negative			
		N	%	N	%		
Heard of *T. solium* taeniasis	Yes	2	4.10	47	95.90	49	$\chi2=0.643^a$ df=1
	No	24	7.20	311	92.80	335	p=0.422
Knows causes of *T. solium* taeniasis	Yes	4	7.70	48	92.30	52	$\chi2=0.081^a$ df=1
	No	22	6.70	307	93.30	332	p=0.776
Knows any symptoms of *T. solium* taeniasis	Yes	3	18.80	13	81.20	16	$\chi2=3.795^a$ df=1 p=0.051
	No	23	6.80	358	93.20	368	

4.3 Risk factors to *T. solium* taeniasis amongst the community

On the risk factors to *T. solium* taeniasis, the majority of the respondents had latrine reported at 380 (99.0%). Majority of the respondents also reported hand washing after using the latrine at 342 (89.30%). Majority of the respondents were pork consumers at 351 (91.40%) while a minority 33 (8.60%) did not consume pork. A majority of the pork consumers 152 (39.60%) preferred roasted pork while a minority 35 (9.10%) preferred boiled pork. Among the pork consumers, a majority consumed the pork occasionally (every six months) at 138 (35.90%). A majority of the respondents reported that they deworm at 290 (75.50%). The deworming frequency varied amongst the respondents with a majority reporting that they deworm occasionally (every six months) at 138 (35.90%).

Table 4.7: Factors which may predispose the community to *T. solium* taeniasis

Risk factor	Response	N	Percentage
Latrine use	Yes	380	99.00
	No	4	1.00
Wash Hands	Yes	343	89.30
	No	41	10.70
Pork Consumption	Yes	351	91.40
	No	33	8.60
Pork Preparation	Roast	152	39.60
	Boil	35	9.10
	Fry	163	42.40
	Do not consume	34	8.90
Pork consumption frequency	Rarely	122	31.80
	Occasional	138	35.90
	Often	35	9.10
	Never	89	23.20
Deworming	Yes	290	75.50
	No	94	24.50
Deworming frequency	Rarely	122	31.80
	Occasional	138	35.90
	Often	35	9.10
	Never	89	23.20

Pork consumption frequency: Rarely (once a year) occasionally (every six months) often (every three months) Deworming frequency: often (3-4 months) occasional (4-6 months) rarely (beyond 6 months)

Majority of the positive cases were from the households which had latrines at 22 (5.80%) of all the respondents who had latrines. Worthy to note, all the households which had no latrine 4 (100%) reported a positive case. A significant relationship between a household having a latrine and occurrence of *T. solium* taeniasis was found at $\chi 2=55.657^{a}$, df=1, p=0.000. Those who had no latrines were more predisposed to *T. solium* taeniasis. A total of 22 (6.4%) positive cases were from the respondents who reported that they wash their hands after using the latrine. All the positive cases were from the respondents who consume pork. A majority of the positive cases were from the respondents who consume

pork occasionally at 20 (8.30%). A total of 14 (9.20%) of the positive cases were from the respondents who preferred the roasting type of pork preparation. There was a significant association between the pork preparation and the occurrence of *T. solium* taeniasis at $\chi 2=5.423^{a}$, df=2, p=0.066. Further, the majority of the positive cases 12 (4.10%) were from the respondents who reported that they deworm. There was a significant association between deworming and *T. solium* taeniasis at $\chi 2=13.101^{a}$, df=1, p=0.000. A total of 6 (4.30) positive cases were from the respondents who reported that they deworm frequently. The occurrence of *T. solium* taeniasis was found to be significantly related to deworming frequency at $\chi 2=14.831^{a}$, df=3, p=0.002. Univariate analysis shows that pork preparation method was a risk factor for *T. solium* taeniasis with those who preferred roasting and frying being more exposed. The results are as shown in Table 4.5. The deworming frequency was also risk factors since those who never dewormed or dewormed rarely were more predisposed. The results are as shown in Table 4.6.

Table 4.8: Occurrence of *T. solium* taeniasis in relation to risk factors

Risk factor		The occurrence of *T. solium* in the sample				Total	p-value
		Positive		Negative			
		N	%	N	%		
Household has a latrine	Yes	22	5.80	358	94.20	380	$\chi2=55.657^a$ df=1
	No	4	100.00	0	0.00	4	p=0.000*
Hand washing after using the latrine	Yes	22	6.40	321	93.60	343	$\chi2=0.648^a$ df=1 p=0.421
	No	4	9.80	37	90.20	41	
Pork consumption	Yes	26	100.00	325	90.80	351	$\chi2=2.622^a$ df=1
	No	0	0.00	33	100.00	33	p=0.105
Pork consumption Frequency	Rarely	0	0.00	7	100.00	7	$\chi2=3.065^a$ df=3 P=0.382
	Occasional	20	8.30	221	91.70	241	
	Often	4	5.90	64	94.10	68	
	Never	2	2.90	66	97.10	68	
Pork preparation method	Roast	14	9.20	138	90.80	152	$\chi2=5.423^a$ df=2
	Boil	5	14.30	30	85.70	35	P=0.066*
	Fry	7	4.30	156	95.70	163	
Respondent deworms	Yes	12	4.10	278	95.90	290	$\chi2=13.101^a$ df=1
	No	14	14.90	80	85.10	94	P=0.000*
Deworming frequency	Rarely	5	4.10	117	95.90	122	$\chi2=14.831^a$ df=3
	Occasional	6	4.30	132	95.70	138	P=0.002*
	Often	1	2.90	34	97.10	35	
	Never	14	15.70	75	84.30	89	

Pork consumption frequency: Rarely (once a year) occasional (every six months)often (every three months) Deworming frequency: often (3-4 months) occasional (4-6 months) rarely (beyond 6 months)

Different factors were found to be risk factors to *T. solium* taeniasis. Households which had no latrine were more predisposed to *T. solium* taeniasis. The relative risk was

17.2727; 95% CI; P < 0.0001. Lack of deworming was also found to be a risk factor to *T. solium* taeniasis with a relative risk of 1.5211; 95% CI; 0.5513 to 4.1970; P = 0.0418.

Table 4.9: Relative risk of factors which may predispose the community to *T. solium* taeniasis

Factor		Positive	Negative	Relative risk
		N	N	
The household has no latrine	Yes	22	358	17.2727
	No	4	0	95% CI
				P < 0.0001
Does not wash hands after using the latrine	Yes	22	321	0.2778
				95% CI
	No	4	37	0.1332 to 0.5795
				P = 0.0006
Respondent consumes pork	Yes	26	325	0.1953
	No	0	33	95% CI
				0.0122 to 3.1350
				P = 0.2489
Respondent does not deworm	Yes	12	278	1.5211
				95% CI
	No	14		0.5513 to 4.1970
				P = 0.0418

Table 4.10: Multiple comparisons between deworming frequency and the occurrence of *T.solium* taeniasis

(I) The frequency of pork consumption	(J) The frequency of pork consumption	Mean Difference	Std. Error	Sig.
Rarely	Occasionally	0.08	0.091	0.798
	Often	0.06	0.094	0.924
	Never	0.06	0.098	0.003*
Occasionally	Rarely	-0.08	0.091	0.798
	Often	-0.02	0.033	0.88
	Never	-0.02	0.043	0.005*
Often	Rarely	-0.06	0.094	0.924
	Occasionally	0.02	0.033	0.88
	Never	0	0.05	0.001*
Never	Rarely	-0.06	0.098	0.001*
	Occasionally	0.02	0.043	0.945
	Often	0	0.05	0.933

Pork consumption frequency: Rarely (once a year) occasionally (every six months) Often (every three months)

Table 4.11: Multiple comparisons between pork preparation method, the deworming frequency, and the occurrence of *T. solium* taeniasis

(I) Pork preparation prior to consumption	(J) Pork preparation prior to consumption	Mean Difference (I-J)	Std. Error	Sig.
Boil	Boil	0.05	0.044	0.49
	Fry	-0.05	0.027	0.159
Roast	Boil	-0.05	0.044	0.49
	Fry	-0.1	0.044	0.063
Fry	Boil	0.05	0.027	0.159
	Roast	0.1	0.044	0.063
(I) Deworming frequency	(J) Deworming frequency			
Rarely	Occasional	0	0.031	0.012
	Often	-0.01	0.048	0.99
	Never	.13*	0.035	0.001
Occasional	Rarely	0	0.031	0.012
		-0.02	0.047	0.988
	Never	.13*	0.034	0.001
Often	Rarely	0.01	0.048	0.990
	Occasional	0.02	0.047	0.988
	Never	.14*	0.050	0.002
Never	Rarely	-.13*	0.035	0.001

Pork consumption frequency: Rarely (once a year) occasional (every six months) often (every three months)

CHAPTER FIVE: DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.0 Prevalence of *T. solium* taeniasis

Summary draws information from socio-economic as well as knowledge, practices in relation to prevalence of *T. solium* taeniasis. The study found out that the prevalence of *T. solium* taeniasis was at 6.77% in Thika sub-county, Kiambu County, Kenya. The findings of this study concur with WHO, (2015) prevalence estimates of taeniasis by all tapeworm species which stand at 13.5% and a study carried out in Taiwan, on *T. solium* taeniasis prevalence which was found at 6%. Rodriguez et al. (1998) found a prevalence of *T. solium* taeniasis at 1.5% in Mexico while Sorvillo et al. (2007) found a prevalence of *T. solium* taeniasis at 1.1% in California, USA (using serum immunoblots). This is not consistent with the study findings owing to the fact that Mexico and USA are more developed than Sub Saharan African and that sanitation is likely to be more improved. The developed country is likely to have total latrine coverage amongst their population. Their health care system is also more improved and thus there is more treatment and deworming among the population. Garcia et al. (2003), in a study amongst rural populations in Peru found a prevalence of 6.2%, while Gomes et al. (2006) found prevalence at 8.6 in Brazil and Sakai et al. (2011) found a prevalence of 18.6% in north India (using species-specific DNA detection). This is consistent with the findings of this study since these are developing countries and the risk factors are not expected to be significantly different except for the Indian study whose high prevalence can be attributed to the fact that a more sensitive and specific method was used. Specific DNA detection is based on any exposure to the parasite at any point in the human life and thus it is likely to

give a higher prevalence as in the case of the Indian study. Prevalence in sub-Saharan Africa is estimated at 2.4 percent to 10.8 percent (Gomes *et al.*, 2002).

The findings of this study are consistent with the prevalence that has been found by other studies in sub-Saharan Africa. In Zambia, the prevalence was found at 6.3% (Mwape *et al.*, 2012). Wanjali et al. (2013) note that the prevalence in Burundi was 6.9%, and in Senegal was at 7.7% both estimated using a microscopic examination of stool. In Uganda, Kisakya and Masada (2002), found prevalence at 9.4%, and in Ghana, 13.5% (Newel, 2007). However, the findings of this study are not consistent with a study that was carried out in the Democratic Republic of Congo and found prevalence at 21.65% (using Ag ELISA) (Mwape *et al.,* 2012). The inconsistency in the results can be explained by the fact that a more sensitive and highly specific method was used. This means that the overall *T. solium* prevalence is likely to be underestimated due to the utilization of microscopy-based examinations whose sensitivity and specificity are low. Microscopy cannot detect intermittent proglottid shedding (Ng-Nguyen, 2017).

In Busia district of Kenya, Githigia et al. (2005) found a prevalence of 4-10% which is consistent with the study findings in Kiambu County. The findings of this study are also consistent with those found in endemic areas especially in Asia, Latin America and sub-Saharan Africa of between 2.4 percent to 10.8 percent (Gomes *et al.*, 2002).

5.2 Knowledge of *T. solium* taeniasis amongst the community

Knowledge findings on *T. solium* taeniasis amongst the community were consistent with (Garcia *et al.*, 2006). Those who had lower education level such as informal education were more predisposed to *T. solium* taeniasis. Garcia et al. (200) found out that educated people are more likely to engage in safe practices and thus they were less likely to be infected with *T. solium* taeniasis since they were more informed. The Education level of the respondent was found to be associated with the prevalence of knowledge on *T. solium* taeniasis was high with the education level. Gomes et al. (2000) and WHO (2014) points out that awareness on *T. solium* taeniasis is surprisingly low amongst communities living in endemic areas. Mutua et al. (2010) point out that a common misconception that pigs feed on garbage exists. He also points out that majority of pig farmers are not aware of signs and symptoms of pigs infected with pork tapeworm. This was evidenced amongst the study population. Kagira et al. (2010) found that low knowledge on husbandry and management exists amongst pig farmers. This concurs with the findings of this study that found that poor management practices in terms of the type of feeds used, veterinary inspections and deworming practices amongst the pig farmers.

5.3 Practices that may predispose the community to *T. solium* taeniasis

The findings of this study are consistent with findings from various studies. Motojane et al. (2003), Ngowi et al. (2009), Mwape et al. (2012) and Kungu et al. (2017) points out that lack of latrine use and outdoor defecation was a risk factor to *T. solium* taeniasis. Studies by Garcia et al. (2006), Motojane et al. (2003), Mwape et al. (2012) and Kungu et al. (2017) found out that lack of deworming and not adhering to the recommended

deworming frequency of three months was a risk factor to the occurrence of *T. solium* taeniasis. Undercooking of pork was a risk factor for the occurrence of *T. solium* taeniasis and suggests that roasting of pork is a form of undercooking in many cases (Githigia *et al.,* 2006; Pondja *et al.,* 2012; Mc Cleery *et al.,* 2013). The study found out that respondents who preferred the roasting and frying method of pork preparation were more predisposed to *T. solium* taeniasis. The recent study by Kungu et al. (2017) in Uganda found out that a majority of the respondents 94.1% dewormed. This is consistent with the findings of this study on the number of respondents who deworm.

5.4 Conclusions

1. The study found that *T. solium* taeniasis prevalence was 6.7% using the microscopic examination of stool samples in Kiambu County.
2. The study found that the level of community knowledge on *T. solium* taeniasis was low in Kiambu County. It also found that the majority of respondents had never heard of *T. solium* taeniasis.
3. The study found that risk factors to *T solium* taeniasis lack of latrine, the method of pork preparation, taking of deworming medication and frequency of taking deworming medication. Those who never dewormed or dewormed rarely were more predisposed to *T. solium* taeniasis. Roasting and frying methods of pork preparation was a risk factor.

5.5 Recommendations

5.5.1 Operational recommendations

1. The county government of Kiambu should address the high prevalence of *T. solium* taeniasis through the promotion of good hygiene and food safety and thorough pork inspection.
2. The county government should educate the community through media and public rallies so as to create awareness on the *T. solium* taeniasis
3. The county government should sensitize the community through health promotion activities such as the building of latrines so as to address the risk factors associated with *T. solium* taeniasis

5.5.2 Recommendations for further research

1. This study recommends further studies on the prevalence of *T. solium* taeniasis, the level of awareness amongst the community and the risk factors in other counties.
2. The study recommends further studies to establish other diseases which may be caused by the high prevalence of *T. solium* taeniasis such as neurocysticercosis and porcine cysticercosis.

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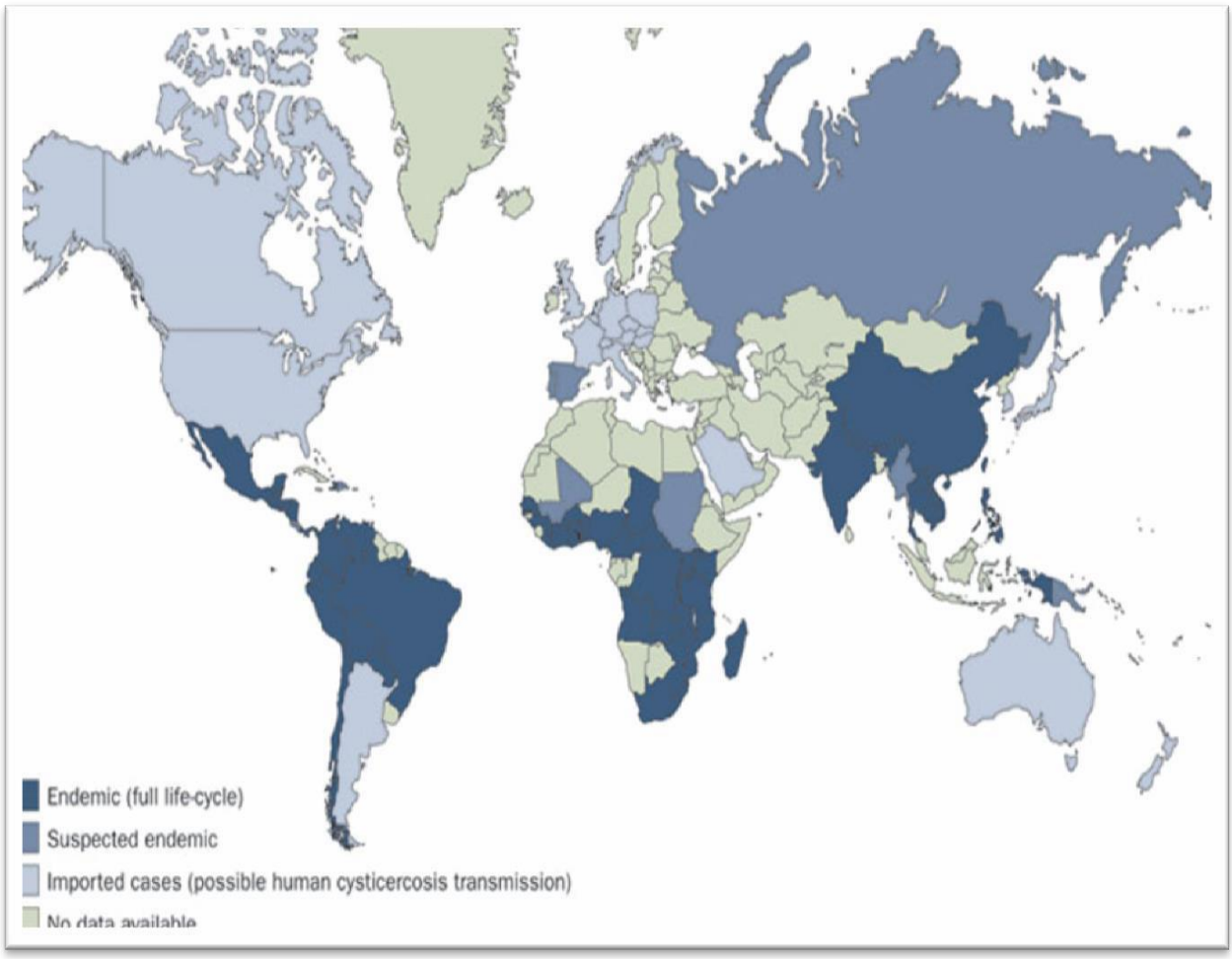
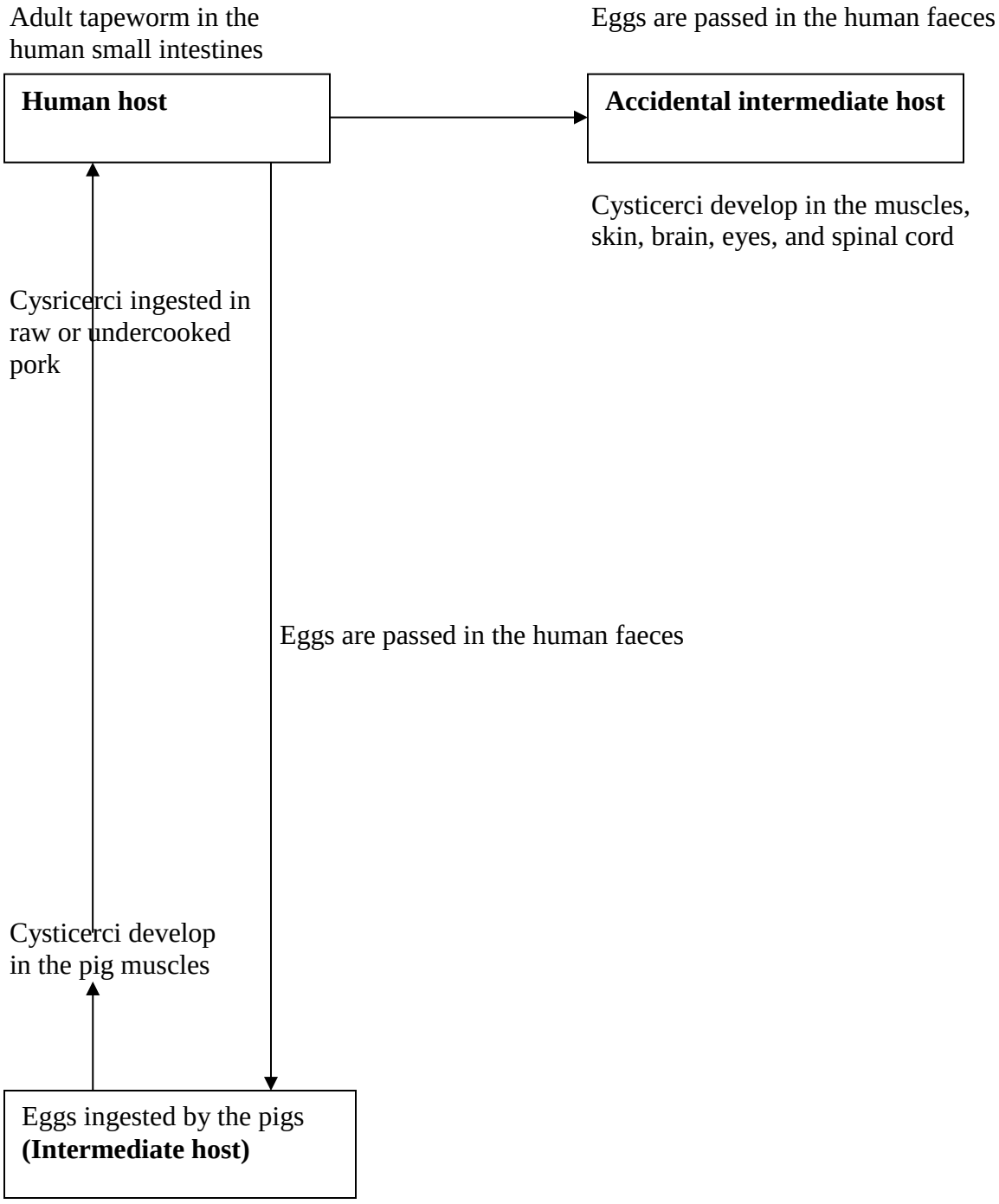
APPENDICES

Appendix I: World map showing global distribution of *T. solium* taeniasis



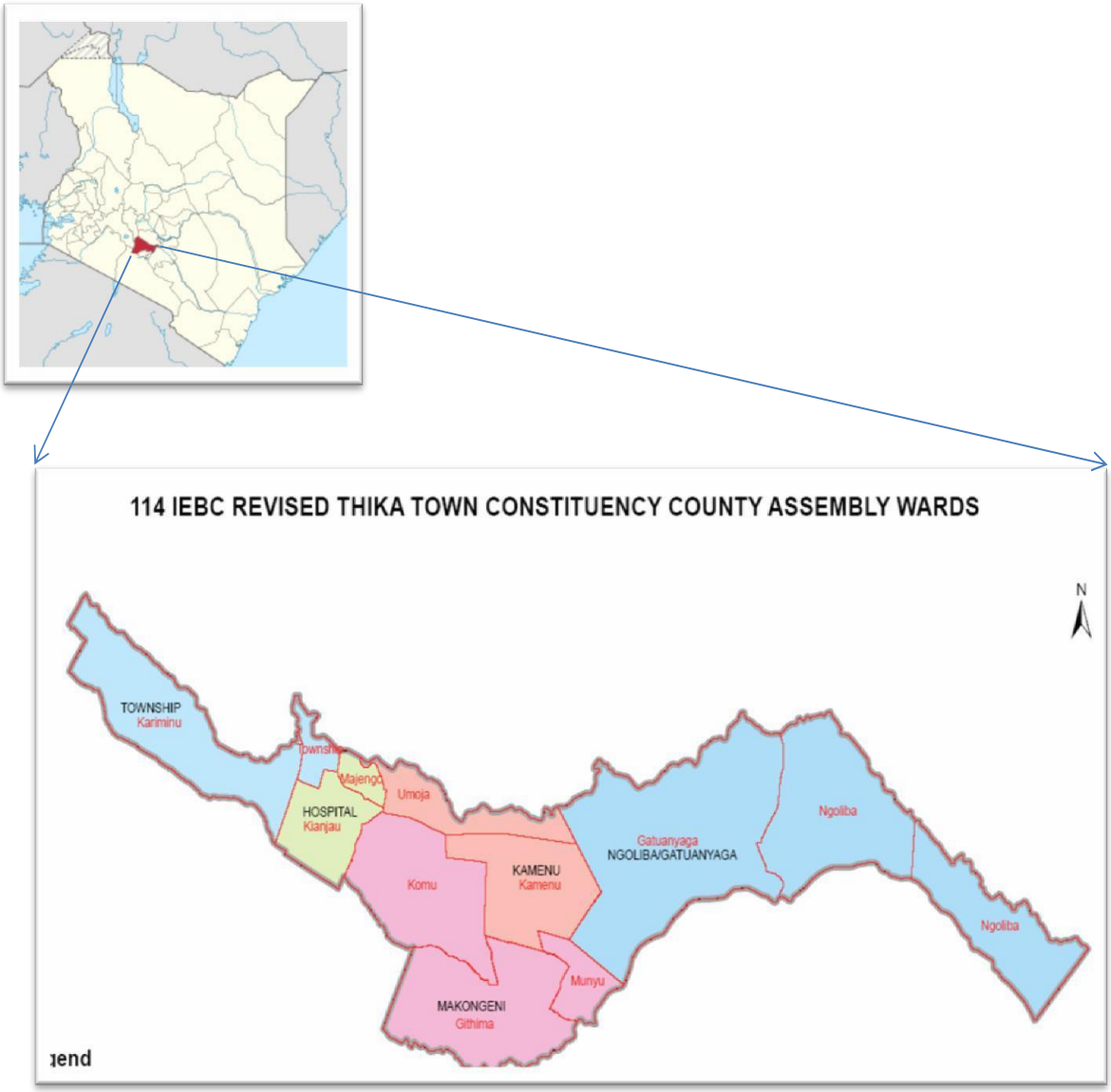
Adopted from CDC, (2016)

Appendix II: *Taenia solium* life cycle



Adopted and modified from CDC, 2016

Appendix III: Map of Kenya showing the study area



Source: Independent Electoral and Boundaries Commission, 2012

Appendix IV: The consent form

My name is David Mwikya Mbuvi; I am undertaking a Master degree in Environmental Health at Kenyatta University. I am undertaking a study a research on 'The prevalence and associated risk factors for *Taenia solium* taeniasis in Kiambu County, Kenya.' The information will be resourceful to various entities such as the ministry of health and medical services to formulate and/or to evaluate the effectiveness of the interventions on the disease.

Procedures to be followed

Participation in this study will involve answering some questions and also obtain a stool specimen from you, which will be examined in the laboratory for *Taenia solium* eggs, scolexes or proglottids. I will record your demographic information the questionnaire. You have a right to decline to participate in the study. Also, note that the participation in this study is entirely voluntary and you also free to ask any question related to the study at any time during the interview. You may also decline to answer/respond to any question that you feel unsuitable to you and you may withdraw from the interview at any time you wish.

Discomfort and Risks

The study may have questions that may intimidate you or sound embarrassing or make you uncomfortable. If this happens, you may refuse to answer these questions if you choose. You may also stop the interview at any time. The interview will take about 30 minutes.

Benefits

If you participate in this study you will learn how *Taenia solium* is transmitted and ways to its prevention. You will also receive laboratory results at no cost after the stool samples are analyzed. You will receive free medical advice in case you are found positive of the *Taenia solium.*

Reward

This interview is voluntary and no incentives whatsoever will be provided to the respondents.

Confidentiality

The interviews will be conducted at the place you feel convenient in the household and the samples will be analyzed within a private clinic setting. Your name will not be recorded in the questionnaires or the samples. The questionnaires will be kept safe and will only be used for the purpose of this study.

Contact information

If you have any questions regarding this study you may contact my supervisors:

1. Dr. Peterson Warutere, Kenyatta University. 0721 993 833
2. Dr. Purity Nguhiu, Kenyatta University. 0722 737 711.

   Email; nguhiupurity@yahoo.com

Or the Kenyatta university ethical review committee secretariat on

chairmn.kuerc@ku.ac.ke, secretary.kuerc@ku.ac.ke, secretariet.kuerc@ku.ac.ke

Participant's Statement

The above statement regarding my involvement in the study is clear to me. I have been given a chance to ask questions and my questions have been answered to my satisfaction. My participation in this study is entirely voluntary. I understand that the information will be kept in privacy and I can withdraw from the study at any time. I understand the benefits of the study and that no incentives will be given.

Name

Participant …….

Signature or Thumbprint……Date……...

Investigators statement

I, the undersigned, have explained to the participants in the language s/he understands the procedures to be followed in the study and the risks and the benefits involved.

Name

Interviewer.....

Signature or thumbprint.....Date.....

Appendix V: A sample household questionnaire

'The prevalence and associated risk factors for *Taenia solium* taeniasis in Kiambu County, Kenya'

Hello. I am David Mbuvi, a student at Kenyatta University undertaking a master's degree in Environmental Health. I am conducting a research on the above topic. I wish to request permission to interview you. You will also be required to provide a stool sample for laboratory analysis of *Taenia solium* (pork tapeworm). The sample can be collected later and the interview will take about 20 minutes. The information that you will provide will be used for the purpose of this study only and will be treated with privacy and confidentiality it deserves.

Accepted 1

Declined 2

Name of the interviewer Date

…… …….

Administrative ward (Circle which apply)

Kamenu 1

Gatuanyaga 2

Township 3

Demographic information

1. Gender of the respondent (circle which apply)

Male 1 Female 2

2. Age of the respondent (**Indicate age in years**)……..

3. Marital status

Married 1 Never married 2 Divorced 3 Separated 4 Widowed 5

Widower 6 Other (specify)……

4.The highest level of education (**Circle which apply**)

No formal education1 Primary not completed 2 Primary completed 3

Secondary not completed 4 Secondary 5 College 6 University7

5. Religion

Christian 1 Muslim 2 Hindu 3 Adventist 4

Not Religious 5 Other 6 (**specify**) ……

Section B: Socioeconomic data

1. What is the main source of household income?

Salaried employment 1 Business 2 Casual labor 3 Animal husbandry 4

Crop farming 5

Assistance/Handouts 6 No reliable source of income 7

Other 8 (**specify**) ……..…..

2. Does the household own livestock?

Yes 1 No 2 (**If No skip to 5**)

3. If yes in question 2 above, which ones does your household keep? (For each livestock owned indicate their number)

Poultry	1	numbers ……
Cattle `	2	numbers…….
Goat	3	numbers ……
Sheep	4	numbers ……
Pig	5	numbers ……...

4. Which is the household source for domestic water uses?

Tap (in the compound) 1 Public tap (outside the compound) 2 Dam 3

River 4 Well 5 Borehole 6 Water vendors 7

Other (specify) 8 ……

5. Does your household have a latrine?

Yes 1 No 2

6**.** If yes, which type?

Pit latrine 1 Flush 2

7. Do you wash your hands after using the latrine?

Yes 1 No 2

8. Do you wash hands after using the latrine?

Yes 1 No 2

Section C: Pork consumption practices and knowledge

1. Do you eat pork?

Yes1 No 2 (**If No skip to5**)

2. If yes, how often do you eat pork?

Rarely (months) 1 occasionally (few times in a month) 2

Often (once in a week) 3 never 4

3. How do you normally prepare the pork?

Roast 1 Boil 2 Fry 3 Other 4 **(specify**) …….

4. Where is the source of the pork that you consume?

(**Multiple responses**) own pigs1 friend/neighbor 2 other areas (not

within the sub-county) 3 other (specify) …….

5. Have you ever seen cysts in them eat?

Yes 1 No 2 (**If no skip to 8**)

6. If yes in question 6 above, where did you see the cysts?

(**Multiple responses**) Muscles 1 Intestines 2 Other

3 (**specify**)…… Not applicable 4

7. Do you know any signs and symptoms of a pig that is infected by a pork tapeworm?

Yes1 No 2 (**If No skip to22**)

8. Which are some of the signs and symptoms that you are aware of?

At least one sign 1 more than one sign 2

9. Where do the pigs normally get slaughtered in this area?

Slaughter house 1 Home 2 other 3 (**specify**)…….

10. What is your perception of the pigs?

They should be properly housed and take care of 1

They should be left free to scavenge 2

They are dirty animals and do not need much attention 3

They feed on garbage 4 Other 5 (**Explain**) ……

6. Are you aware of any pig infection in the area?

Yes1 No 2 **(If no skip to13**)

12. If yes in question 11 above, which ones do you know?

……

13. Do you normally take drugs for deworming?

Yes 1 No 2 **(If no skip to15)**

14. If yes how often?

Rarely (once in a year)1 occasionally (after six months) 2

Often (after every three months)3 Never 4

15. Have any of the family members had a history of the passing of a tapeworm?

Yes 1 No 2

16. Have you ever heard of *Taenia solium* taeniasis?

Yes 1 No 2

17. Have any of your family members had a history of taeniasis?

Yes 1 No 2

Appendix VI: Approval from graduate school

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 4150

Internal Memo

FROM: Dean, Graduate School

DATE: 09th December, 2016

TO: **David Mwikya Mbuvi**
C/o Environmental & Occupational Health Dept.

REF: Q23/27567/2014

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your revised Research Proposal as per our recommendations raised by the Graduate School Board of 10th November, 2016 entitled **"Prevalence of Taenia Solium Taeniasis and Associated Risk Factors in Kiambu County, Kenya".**

You may now proceed with your Data Collection, Subject to Clearance with Director General, National Commission for Science, Technology and Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

KENYATTA UNIVERSITY OFFICE OF DEAN 15 MAR 2017

GIDEON KAIMENYI
FOR: DEAN, GRADUATE SCHOOL

C.c. Chairman, Department of Environmental & Occupational Health

Supervisors:

1. Dr. Peterson Warutere
   C/o Department of Environmental and Occupational Health
   Kenyatta University

2. Dr. Purity Nguhiu
   C/o Department of Agricultural Resource Management
   Kenyatta University

GK/awn

Appendix VII: Clearance from county government of Kiambu

COUNTY GOVERNMENT OF KIAMBU
DEPARTMENT OF HEALTH SERVICES

All correspondence should be addressed to
HEAD HRDU – HEALTH DEPARTMENT
Email address: mndiritu@gmail.com
mkwasa@live.com
Mobile: 0721641516
0721974633

HEALTH RESEARCH AND DEVELOPMENT UNIT
P. O. BOX 2344 – 00900
KIAMBU

Ref. No: KIAMBU/HRDU/AUTHO/2016/08/30/Nguhiu PN Date: 30/08/2016

TO WHOM IT MAY CONCERN

RE: CLEARANCE TO CONDUCT RESEARCH IN KIAMBU COUNTY

Kindly note that we have received a request by Dr P. N. Nguhiu of Kenyatta University to carry out research in Kiambu County on *"Emergence of Cysticercosis, a neglected meat-borne notifiable zoonosis in Thika Sub County of Kiambu County, Kenya"*.

We have duly inspected her documents and found that she has been cleared by Kenyatta University ERC and National Commission for Science Technology and Innovation until 18th August 2017. She thus does not need any further clearance with another regulatory body in order to conduct research within the county of Kiambu.

However, it is incumbent upon the institution where she is carrying out research to ensure that she receives adequate supervision during the process of conducting the research. This note also accords her the duty to provide a feedback on her research to the county at the conclusion of her research.

DR. M. NDIRITU NDIRANGU
COUNTY HEALTH RESEARCH DEVELOPMENT UNIT
KIAMBU COUNTY

Appendix VIII: NACOSTI permit for the project

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. NACOSTI/P/16/19194/13155

Date: 18th August, 2016

Dr. Purity Nyambura Nguhiu
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Emergence of cysticercosis, a neglected meat-borne nitifiable zoonosis in Thika Sub County of Kiambu County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Kiambu County** for the period ending **18th August, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Kiambu County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kiambu County.

The County Director of Education
KiambuCounty.

THIS IS TO CERTIFY THAT:
DR. PURITY NYAMBURA NGUHIU
of KENYATTA UNIVERSITY, 76033-508
NAIROBI,has been permitted to conduct
research in *Kiambu County*

on the topic: *EMERGENCE OF CYSTICERCOSIS, A NEGLECTED MEAT-BORNE NITIFIABLE ZOONOSIS IN THIKA SUB COUNTY OF KIAMBU COUNTY, KENYA.*

for the period ending:
18th August,2017

.....
Applicant's Signature

Permit No : NACOSTI/P/16/19194/13155
Date Of Issue : 18th August,2016
Fee Recieved :ksh 5000

.....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

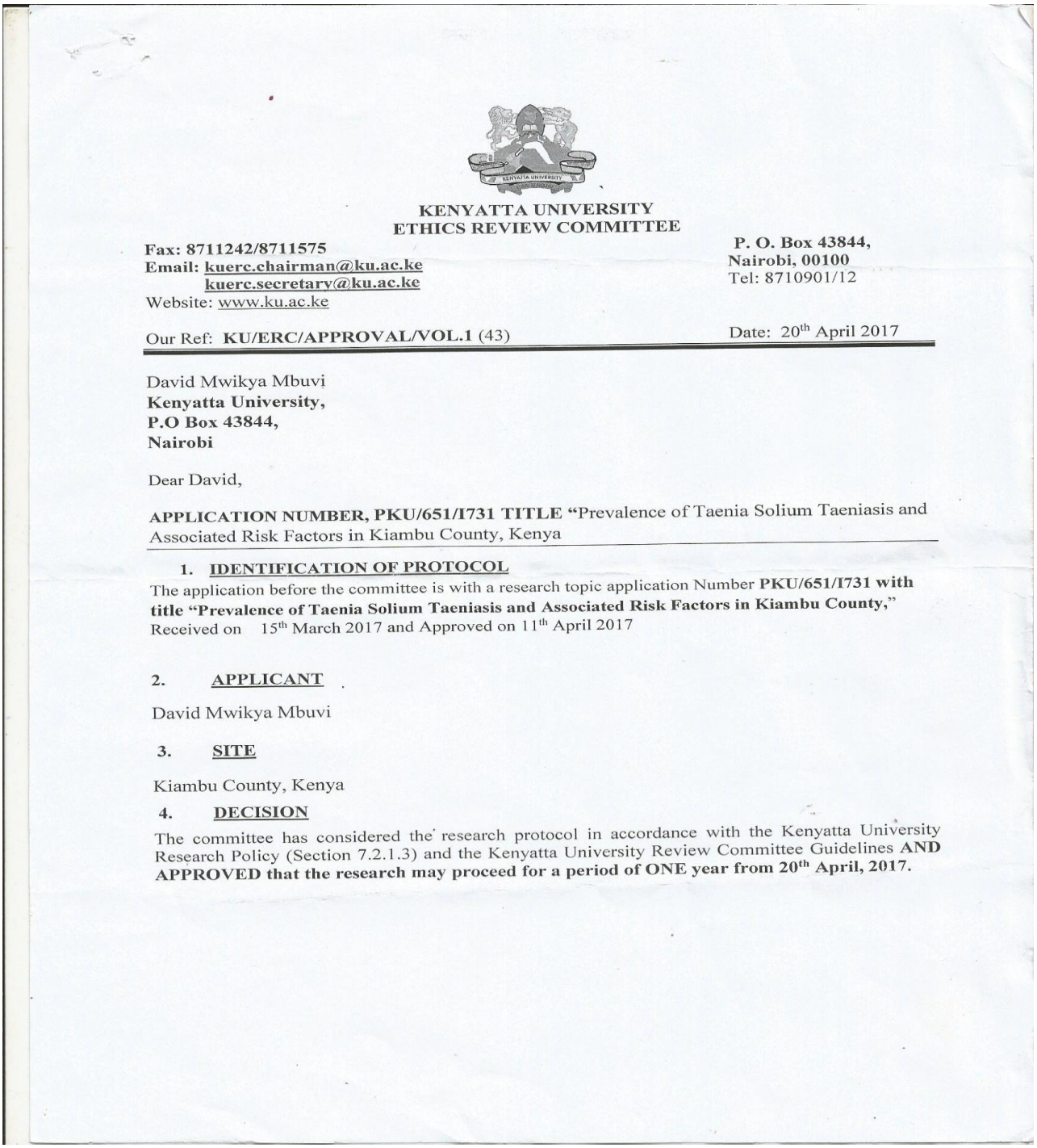
National Commission for Sc
Technology and Innovati

RESEACH CLEARANC
PERMIT

Serial No.10676

CONDITIONS: see back pag

Appendix IX: Ethical clearance from Kenyatta University Ethical Review Committee



KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Fax: 8711242/8711575
Email: kuerc.chairman@ku.ac.ke
kuerc.secretary@ku.ac.ke
Website: www.ku.ac.ke

P. O. Box 43844,
Nairobi, 00100
Tel: 8710901/12

Our Ref: **KU/ERC/APPROVAL/VOL.1** (43) Date: 20th April 2017

David Mwikya Mbuvi
Kenyatta University,
P.O Box 43844,
Nairobi

Dear David,

APPLICATION NUMBER, PKU/651/I731 TITLE "Prevalence of Taenia Solium Taeniasis and Associated Risk Factors in Kiambu County, Kenya

1. **IDENTIFICATION OF PROTOCOL**

The application before the committee is with a research topic application Number **PKU/651/I731 with title "Prevalence of Taenia Solium Taeniasis and Associated Risk Factors in Kiambu County,"** Received on 15th March 2017 and Approved on 11th April 2017

2. **APPLICANT**

David Mwikya Mbuvi

3. **SITE**

Kiambu County, Kenya

4. **DECISION**

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (Section 7.2.1.3) and the Kenyatta University Review Committee Guidelines **AND APPROVED that the research may proceed for a period of ONE year from 20th April, 2017.**

ADVICE/CONDITIONS

i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
ii. Serious and unexpected adverse events related to the conduct of the study are reported to this committee immediately they occur.
iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above.
If you accept the decision reached and advice and conditions given please sign in the space Provided below and return to KU-ERC a copy of the letter.

KENYATTA UNIVERSITY
THE OFFICE OF THE CHAIRMAN
21 APR 2017
ETHICS REVIEW COMMITTEE
P.O. BOX 43844 - 00100 NAIROBI

DR. TITUS KAHIGA.
CHAIRMAN ETHICS REVIEW COMMITTEE

I DAVID MWIKYA MBUVI accept the advice given and will fulfill the conditions therein.

Signature..... Dated this day of... 21st APRIL .....2017.

cc.
DVC: Research Innovation and Outreach