NEUROCYSTICERCOSIS: A POSSIBLE CAUSE OF EPILEPTIFORM FITS IN PEOPLE RESIDING IN VILLAGES SERVED BY THE BETHANIE CLINIC IN THE NORTH WEST PROVINCE

By

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DEDICATION

I dedicate the success of this research study to my parents, Masego and Mantsoaki, who taught me how to overcome my fears, and experience freedom and true happiness.

I also dedicate the success of this research to my daughter Motheo and wife Bontle, who were my source of inspiration throughout the process of my school days.

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SUMMARY

NEUROCYSTICERCOSIS: A POSSIBLE CAUSE OF EPILEPTIFORM FITS IN PEOPLE RESIDING IN VILLAGES SERVED BY THE BETHANIE CLINIC IN THE NORTH WEST PROVINCE

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A study to detect human taeniasis and cysticercosis was conducted in four village communities served by the Bethanie clinic in the North West Province. It was selected because of reports of people being diagnosed with epileptiform episodes (fits/seizures). The total population of the four villages is estimated at 13 947 and many house holders rear pigs in small numbers for both meat and an immediate income.

The primary aims of the work were to conduct in the study area a census of all small scale pig producers and a survey of rural village consumers – both by means of a structured questionnaire. In the former, to review pig husbandry practices, slaughter and marketing of pigs and in the latter, to provide information on pork consumption, sanitation as well as people's knowledge of *Taenia solium*. From the questionnaires the total number of patients with recorded seizures in the study area, within the selected time frame were determined. Stool samples from consenting participants were screened for *T. solium*. A descriptive analysis of retrospective data was conducted to determine the proportional morbidity of neurocysticercosis from the medical records of

patients diagnosed with seizures in an attempt to establish possible sources of infection and routes of transmission.

Secondary objectives were to determine more accurately the total pig population in the study area and to determine the prevalence of cysticercosis in pigs through inspection of those slaughtered at an approved abattoir – surprisingly all found to be negative.

The questionnaires revealed a poor understanding of the disease, poor sanitation and hygiene, poor methods of pig husbandry and poor meat inspection and control in rural smallholder communities. There was no significant statistical difference in the proportion of households reporting evidence of epilepsy, between those who owned pigs and those that did not. The incidence of high risk behavior is common, and there is a strong evidence of a tendency towards an association between epilepsy, consumption habits and various epidemiological factors which were considered as possible risk factors. The fact that no *T. solium* proglottids were found in the faecal samples collected is elaborated on. It is considered unlikely, but possible that the consumer/farmer information days played a significant role in the outcome of this study.

Chapter 1

INTRODUCTION

Bethanie village is found in the Bojanala region of the North West Province, and is northwest of Pretoria. It has one clinic situated in the village and provides all the outpatient care for the Bethanie human population and three other populations in surrounding villages. The total population of the four villages is 13 947 according to Statistics South Africa Census 2001. Many householders rear pigs in small numbers, the animal constituting an important source, not only of meat, but also of immediate income. The rearing of free-ranging animals requires little investment for the rural poor.

Globally, parasitic diseases continue to be a major constraint for poor developing countries. They are rarely associated with high mortality and their effects are usually characterized by lower outputs of animal products, by-products, manure and traction - all contributing to affect food security (Eddie *et al*., 2003). Humans and animals have been living in close contact since domestication started nearly 10 000 years ago (Kachani and Carabin, 1998). This close contact between man and animals did not come without problems, especially from the health point of view. Animals will always be one of the major sources of food for mankind, being the largest source of protein to human nutrition. However, food of animal origin must not threaten human health. Domestic animals and man share several pathogens that could be transmitted between them and these could affect food safety.

The *Taenia solium* taeniasis/cysticercosis complex is associated with inadequate sanitation and hygiene, inferior methods of pig husbandry and substandard meat inspection and control. Ingestion of larvae (cysticerci) in raw or inadequately cooked pork results in human tapeworm infection (taeniasis). Domestic pig raising, taeniasis and cysticercosis are intimately inter-related. Many farmers in less developed countries cannot afford a cow, but can buy a varying but limited number of pigs.

These animals are relatively easy to maintain and readily marketable, becoming a convenient source of meat and money. Even better, no investment is needed to feed them, since free-range pigs roam around and eat pasture and garbage. In Africa cattle are highly prized, but it can be a problem protecting them from disease and theft and it requires health programmes, constant vigilance and round-the-clock surveillance.

Pigs, however, are comparatively easy to manage, and are therefore becoming increasingly more popular and important in society, especially in rural smallholder communities. The increasing number of pigs being kept in eastern and southern Africa is, however, raising its own set of problems, with a vicious cycle of infection (cysticercosis) and re-infection developing.

Informal interviews with pig owners in Bethanie have indicated that rural pork producers are not motivated to pass pork through meat inspection because of the threat of condemnation. Furthermore, local culinary habits facilitate the consumption of raw or partly cooked meat.

These factors could lead to transmission of the cysticercus from the pig to the human being in endemic areas (Carpio, 2002). According to Phiri *et al.* 2003, the majority of pig keeping in the eastern and southern African (ESA) region is free-range, but if housed, the housing is poorly built and allows pigs to break out at will. This is indeed a problem in the area chosen for this study. In the absence of sanitary infrastructure, people use open areas and fields for defaecation. Free ranging pigs thus have access to human faeces. If these people are carriers of the tapeworm, they will produce thousands of highly contagious eggs in their stool, which perpetuates transmission of the parasite from the human being to the pig. In areas where meat inspection and control is lacking, infected pigs are often slaughtered informally and the pork (pig meat) is eaten or sold for human consumption, thus completing the life-cycle.

Infection with *T. solium*, the pig tapeworm, is widely prevalent in human and pig hosts in many developing countries of Latin America, Africa and Asia (Sarti *et al.,* 1992). The cysticerci of *T. solium* may lodge in the human brain causing cerebral cysticercosis (neurocysticercosis), a very serious zoonosis causing headache, epileptic seizures, epilepsy, blindness, mental disturbance and even death (White, 2000). Neurocysticercosis is frequently found in epileptic individuals in

most developing countries, and is probably the major cause of seizures, epileptiform episodes and other neurological symptomatology (Garcia *et al.,* 1999).

In the next chapter, information on the *T. solium* taeniasis/cysticercosis complex is reviewed, with particular attention being given to epilepsy, epileptiform seizures and to neurocysticercosis. The cultural attitudes of rural village consumers and the characteristics of pig keeping by small scale pig producers will also be reviewed.

Chapter 2

LITERATURE REVIEW

2.1 The *Taenia solium* Taeniasis/Cysticercosis Complex

The zoonotic tapeworm *Taenia solium* has emerged as an important constraint for the nutritional and economic well-being of smallholder farming communities (Eddie *et al*., 2003). Cysticercosis, a disease classified in List B by the OIE, is one of the most important zoonotic diseases in the world. Approximately 50 million people are infected with the parasite and some 50 000 die of cysticercosis annually (Aubry *et al*., 1995).

T. solium is a major public health problem in most areas of Latin America, Africa and Asia. Geographically, it is generally considered that Latin America and the Far East are the most affected regions, but there is increasing evidence that also on the Indian subcontinent and in eastern and southern Africa, *T. solium* cysticercosis is a parasitic disease of public health concern. Especially in the latter area, increasing poverty and lack of grazing land for cattle seems to contribute to the increasing popularity of subsistence pig farming.

In developing countries, the demand for meat has grown rapidly over the past 20 years at a rate of 5.6% a year. Although the trend towards livestock product consumption is likely to continue at a slower rate during the next three decades, it is estimated that some 360 million cattle, 560 million sheep and goats and 190 million more pigs would be needed to satisfy the nutritional demands of the world (Summary Report of FAO 2015-30). The pig population in Africa has more than doubled in the last 30 years (FAO STAT, 2001). Pork is the most popular meat consumed in the world today.

A recent survey indicates that 44% of world meat protein consumption is derived from pork and pork products (FAO, 2001). Surveys carried out in Africa (Geerts, 1993), Asia (Ito *et al*., 2002) and Latin America (Garcia *et al*., 1999; Flisser, 2002) showed that cysticercosis is seriously affecting pigs and humans.

Poor hygiene and living conditions, allowing pigs access to human faeces, put people at risk of developing cysticercosis. In addition, it is also emerging as a serious public health risk, not only in these rural communities, but also in the urban areas where many infected pigs are transported and consumed. Its incidence is rising in the non-endemic areas because of rising rates of immigration from endemic countries (Del Brutto *et al*., 1988; Sorvilo *et al*., 1992; Shandera *et al*., 1994). The disease has food safety implications and a direct relationship to Veterinary Public Health. It also impacts on animal production seriously affecting food security, since most of the carcasses of affected animals must be discarded (Eddie *et al*., 2003).

According to Engels *et al.,* 2003, cysticercosis is related to a number of the most burning problems in the world today, namely, poverty in the marginal rural regions, subsistence animal husbandry and migration from rural to urban areas or from developing to developed countries.

Murrell (2005), Pawloski, Allan and Meinardi (2005), Kyvsgaard and Murrell (2005), summarise the major risk factors related to the transmission of eggs to pigs as follows:

- extensive or free-range pig rearing in households lacking toilets;
- outdoor human defaecation near or in pig rearing areas;
- allowing pigs to scavenge and eat human faeces (“sanitary policeman”);
- deliberate use of human faeces as pig feed;
- connecting pig pens to human latrines (“pig sty privies”); and
- human carriers involved in pig rearing and care

The risk factors important to the transmission of cysticerci to humans are according to Murrell (2005), Pawloski, Allan and Meinardi (2005), Kyvsgaard and Murrell (2005)

- lack of comprehensive and satisfactory meat inspection at pig slaughter;
- clandestine marketing of pigs to avoid inspection; and
- cultural preferences for eating raw or improperly cooked pork.

Studies have shown that the problems of illegal slaughter and marketing are widespread and their solution will require substantial efforts in veterinary control. The habit of eating raw or

improperly cooked pork is also a very intractable trait, but hopefully, this can change through education.

The most important risk factors involved in human-to-human transmission are according to Murrell (2005), Pawloski, Allan and Meinardi (2005), Kyvsgaard and Murrell (2005)

- Low economic status, low level of household sanitation and personal hygiene standards;
- History of passing proglottids by a member of a household or a member of the community in frequent contact with the household;
- Household or community food handlers and childcare givers (carriers) are potentially very high risk factors; and
- Frequent pork consumption

2.2 The *Taenia solium* Life Cycle

T. solium is the cestode parasite that causes porcine cysticercosis. The life cycle, illustrated in Figure 2.1, includes the adult stage, the egg and the larvae (Flisser *et al*., 2006). The transmission of *T. solium* to pigs, the essential partner in the pig-man-pig cycle, requires that pigs have access to human faeces and that people consume improperly cooked pork. The natural biological cycle of *T. solium* consists of two hosts and the environment. The proglottids of the adult tapeworm are released via the faeces and the eggs contaminate the environment. Human beings, the final or definitive host, harbour the adult tapeworm, which produces several thousand eggs daily for years (Carpio, 2002).

The human becomes infected by ingesting cysticerci in undercooked pork meat. In the human intestine, the cysticerci develop over two months into an adult tapeworm, which can survive for years. Cysts evaginate and attach to the small intestine by their scolex. The adults produce proglottids, which mature, become gravid, detach from the tapeworm, and migrate to the anus or are passed in the stool (approximately 6 proglottids per day). Adult tapeworms develop from 2 to 7 m in length and produce up to 1000 proglottids, each with approximately 50 000 eggs, and reside in the small intestine for years (http://www.dpd.cdc.gov/dpdx).

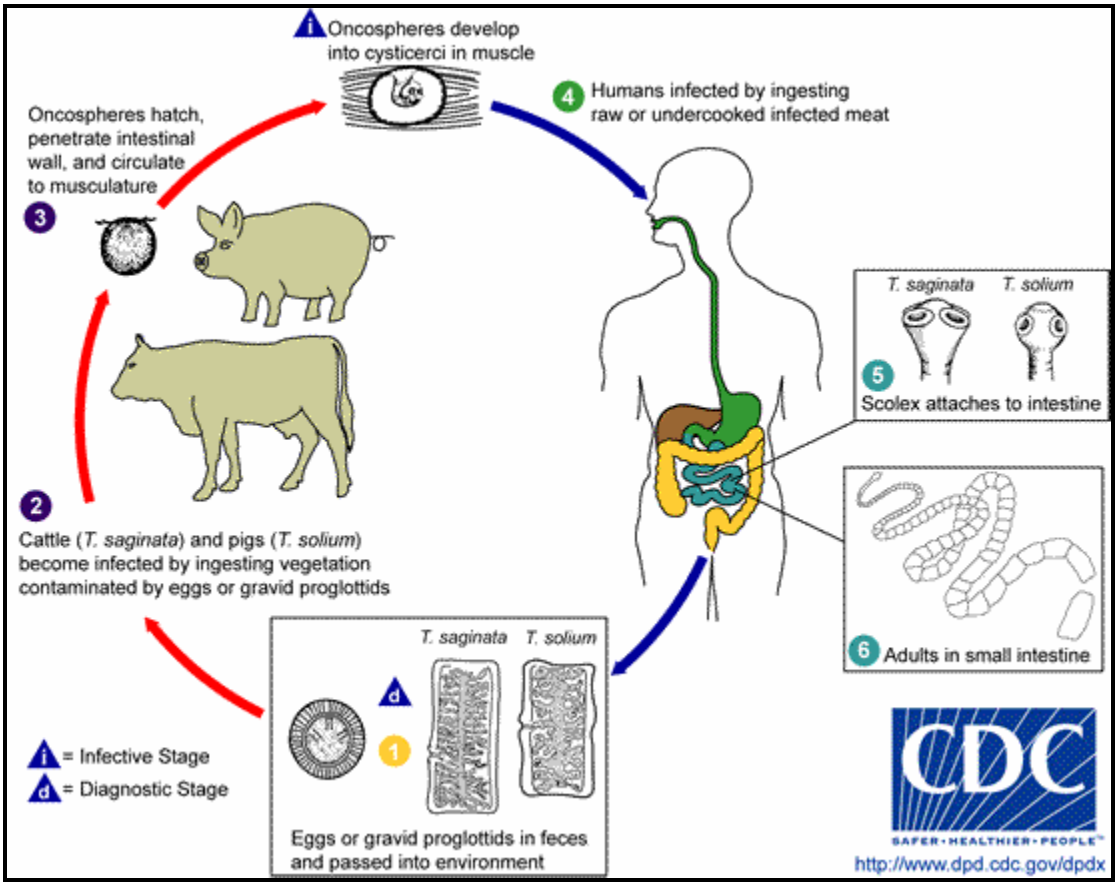

Figure 2.1: Life Cycle of *Taenia solium*

Eggs or gravid proglottids are passed with the faeces and the eggs can survive for days to months in the environment, depending on environmental factors. Ingesting vegetation contaminated with eggs or gravid proglottids infects the pig, the intermediate host.

In the animal's intestine, the oncospheres hatch, invade the intestinal wall, and migrate to the striated muscles as well as the brain, liver and other tissues where they develop into cysticerci. These, the larval form of the tapeworm *T. solium*, can survive for several years in the animal.

Humans can also be infected by *T. solium* eggs through auto-infection. A human infected with adult *T. solium* can ingest eggs produced by that tapeworm, either through faecal contamination or, possibly, from proglottids carried into the stomach by reverse peristalsis. Neglect of hygiene, such as hand washing after defaecation and before meals, is the main reason for auto-infection, which is an established route of self-infection. This can also result in infection of other humans through contact (e. g. shaking hands) or contamination of milk during hand milking by people with *T. solium*. In humans, cysts can cause serious sequellae if they localize in the brain, resulting in neurocysticercosis.

Krecek and Waller (2006) confirmed that humans acquire taeniasis when eating raw or undercooked pork contaminated with cysticerci, the larval form of *T. solium*. When ingested, the cysticerci establish as adult tapeworms in human intestines and produce eggs that are passed with faeces. Eggs can infect humans and pigs when ingested following direct contact with infected faecal matter, or by indirect contamination of water or food. Ingestion of eggs results in larvae migrating throughout pig and human tissues and eventually forming cysts.

As the life-cycle is complex but theoretically easy to control, the International Task Force has declared *T. solium* infection eradicable (Carabin *et al*., 2006). However, both infestation and the disease remain uncontrolled because of lack of information and awareness about the extent of the problem, and the absence of suitable diagnostic tools and intervention strategies appropriately adapted to Africa.

According to Eddi *et al*., 2006, *T. solium* can thus cause two distinct clinical presentations:

- Taeniasis, the presence of an adult tapeworm in the human small intestine
- Cysticercosis, the presence of larval stages in tissues of both pigs and humans

2.2.1 Taeniasis

Taeniasis occurs only in the human host, after ingestion of undercooked pork infected with cysticerci. Although cysticercosis has been known for ages, its relationship to the adult tapeworm was not clear until it was shown by Kuchenmaister in 1855, when he fed pig meat

condemned for cysticercosis to prisoners and recovered young tapeworm at human autopsy (Henneberg, 1912). In community settings many, if not most carriers of *T. solium*, will neither look for medical care nor notice the tapeworm segments in their stools (Pawloski and Schultz, 1972). Conversely, most patients infected with *Taenia saginata* notice the passage of proglottids, which are motile, more numerous and larger than those of *T. solium*. Identification of *T. solium* infection is important because of the risk of cysticercosis in the carrier or the immediate environment. The frequency of auto-infection in individuals with taeniasis is not known internationally (Pawloski and Schultz, 1972). Dixon and Lipscomb (1961) showed that nearly 25% of patients with neurocysticercosis either had harboured or were harbouring a tapeworm.

According to Eddi *et al*., 2005, the economic impact of taeniasis could be divided into three categories:

- Cost due to disease in humans
- Cost due to disease in animals causing production losses and/or condemnation at the abattoir.
- Cost of control programmes to reduce the occurrence

Taeniasis is characterized by either mild symptoms in the human or no symptoms at all. Abdominal pain, distension, diarrhoea, and nausea have been attributed to tapeworm infestation, but there are no data from controlled experiments that demonstrate any association, and most patients seem to be free of symptoms (Flisser, 1994).

Regarding diagnosis of taeniasis, visualization of taenia eggs by microscopy was the only diagnostic method available until the early 1990s (Garcia *et al.,* 2003). Two problems hamper the diagnosis of infection with *T. solium*, namely the poor sensitivity of stool microscopy, and the morphological similarity between the eggs of *T. solium* and *T. saginata (*Schantz *et al*., *1998).*

The best available diagnostic assay for intestinal taeniasis is a coproantigen ELISA, which detects taenia-specific molecules in faecal samples, demonstrating current tapeworm infection (Allan *et al*., 1990). It has a sensitivity of about 95% and specificity greater than 99% and is an

effective tool for epidemiological studies. Coproantigen assays confirmed that microscopy is poorly sensitive, missing 60-70% of cases.

There are two drugs available for the treatment of taeniasis, namely, niclosamide and praziquantel. Niclosamide is the drug of choice because it is not absorbed from the intestinal lumen (Pearson and Hewlett, 1985). With praziquantel there is a small risk that asymptomatic viable brain cysts are affected by the drug in the serum, causing neurological symptoms like headaches and seizures (Flisser *et al*., 1993). Both drugs are difficult to obtain and are expensive.

2.2.2 Cysticercosis

There are two major aspects in the burden due to *T. solium* cysticercosis. First of all, because of its localization in the central nervous system, it is estimated to cause an important disease burden, particularly in terms of late-onset epilepsy (Engels *et al*., 2003). As the parasite requires pigs as intermediate hosts to complete its life-cycle, its consequences can also have a potentially large impact in terms of food safety and economical consequences. Carabin *et al*., 2006, showed that the monetary burden to the Eastern Cape in South Africa for the agricultural losses was estimated to be an average of 5.0 million US dollars. In humans, cysticercosis can affect many anatomical areas like muscles, subcutaneous tissues and eyes, but it becomes prominent in the central nervous system (CNS), causing what is known as neurocysticercosis (NCC), (Eddie *et al*., 2006).

Neurocysticercosis (NCC) is known to be a common cause of late-onset seizures in regions where *T. solium* is endemic, accounting for 30-50% of all cases (Engels *et al*., 2003). The invasive oncospheres (embryos) in the eggs are liberated by the action of gastric acid and intestinal fluids and actively cross the bowel wall, enter the blood stream, and are carried to the muscles and other tissues (Nash and Neva, 1984). At small terminal vessels, they establish and encyst as cysticerci, reaching their definitive size of about 1 cm in 2-3 months (Yoshino, 1933). Clinical manifestation will depend on the affected organ; neurocysticercosis and ophthalmic involvement are associated with substantial morbidity.

Outside the central nervous system, cysticercosis causes no major symptoms. Subcutaneous cysticercosis presents small, movable, painless nodules that are most commonly noticed in the

arms or chest. After a few months or even years, the nodules become swollen, tender, and inflamed, and they then gradually disappear (Dixon and Smithers, 1934). Subcutaneous cysticercosis is rare in Latin America, but very common in Asia and Africa.

Although ophthalmic cysticercosis is much less common than neurocysticercosis (occurring in 1-3% of all infections), *T. solium* is the most common intra-orbital parasite (Rahaltar *et al*., 2000). Intraocular cysts are most frequently found floating freely in the vitreous humour or in the sub retinal space. Visual disturbance is related to the degree of damage to retinal tissue or the development of chronic uveitis. Cysticercosis may also be present in the anterior chamber or affect the conjunctiva or extra ocular muscles. Visual loss can also be related to cerebral cysticercosis causing pappiloedema hydrocephalus or chiasm compression (Chang and Keane, 2001).

2.2.3 *Taenia solium* and neurocysticercosis

As referred to above, cysticercosis in humans can affect many anatomical areas, but tends to become more prominent in the central nervous system (CNS), causing what is known as neurocysticercosis (Eddie *et al*., 2006).

Neurocysticercosis (NCC), an infection of the human brain by the larvae (*Cysticercus cellulosae*) of the pork tapeworm *T. solium*, is considered to be the most important parasitic infection of the central nervous system (Del Brutto and Sotelo, 1988). It is also interesting to note that different names have been used by various authors to describe/refer to this disease, and these include amongst others Swiss cheese brain (Jackson *et al.,* 1992); you drive me crazy (Shriqui and Milette, 1992); and gutless flatworm (Desowitz, 1978). The tapeworm that causes cysticercosis is found worldwide and it is found mostly in rural developing countries with substandard hygiene, poor pig management practices and no meat inspection and sanitary control. In addition, it is also emerging as a serious public health risk, not only in these rural communities, but also in the urban areas where many infected pigs are transported and consumed.

Cysticercosis is related to a few of the most burning problems in the world today:

- Poverty in the marginal rural regions;
- Subsistence animal husbandry; and
- Migration from rural to urban areas or from developing to developed countries.

There are no data for identifying population groups with a higher risk of acquiring cysticercosis, or risk factors that influence the manifestation of the disease. The prevalence or incidence of epilepsy associated with *T. solium* in South Africa is also unknown (Mafojane *et al*., 2003). A study of crude figures in one area relating numbers of each tribe involved with numbers infected, suggests that it is twice as common among the Xhosa people as in other groups, possibly owing to the commonness of the free ranging pigs in Transkei and Ciskei (Campbell and Farrell, 1987). Neurocysticercosis is commonly associated with seizures, headache and focal neurological deficits, and can have long-term neurological sequelae such as epilepsy, hydrocephalus and death (Carpio, 2002).

There are two commonly recognized ways in which person- to person transmission can occur:

- the ingestion of eggs in contaminated food and water;
- the introduction of eggs from faeces into the mouth by contaminated hands.

Neglect of hygiene, such as hand washing after defaecation and before meals, is the main reason for auto-infection, which is an established route of self-infection. Most worrying is the fact that people do not have to eat pork or to keep pigs to become infected with cysticercosis. They can be exposed to the eggs from a human tapeworm carrier. This can result in infection of other humans through contact (e. g. shaking hands) or contamination of milk during hand milking by people with *T. solium*.

Thus, vegetarians and other people who do not eat pork can acquire cysticercosis (Schantz *et al.,* 1992). Water, wind, flies and other indirect means of infection play little part in transmission (Martinez *et al*, 2000). Internal auto-infection by regurgitation of proglottids into the stomach in taeniosis has been proposed, but not proven. The lifespan of the adult *T. solium* is also unknown. According to (Richards and Schantz, 1985), parasitology textbooks and reviews cite

20-25 years, on the basis of ancestode cases. Age specific data from later studies suggest a much shorter lifespan, probably less than 5 years (Garcia *et al*., 2003).

After entering the central nervous system, cysticerci are viable and elicit few inflammatory changes in the surrounding tissues. Cysticerci may remain for a long time in this stage, protected by the blood-brain-barrier and active immune-evasion mechanism by the cysticerci (Carpio, 2002).

After a variable but unknown time, estimated to be several years on the basis of classic studies in English soldiers returning from India, the parasite degenerates with associated immune-mediated inflammation (Dixon and Hargreaves, 1944). Cysticerci cause symptoms because of mass effect or blocking the circulation of cerebrospinal fluid, but most symptoms in neurocysticercosis are the direct result of inflammatory process that accompanies cyst degeneration.

The clinical manifestations of neurocysticercosis (NCC) largely depend on the number, type, size, localization and stage of development of cysticerci, as well as on the host immune response against the parasite. There are no pathognomonic features or a typical NCC syndrome (Takayanaqui and Jardim, 1983; Sotelo *et al.,* 1985; Del Brutto *et al.,* 1998; Garcia and Del Brutto, 2003; Fleury *et al*., 2004; Hawk *et al*., 2005).

Neurocysticercosis affects both males and females, indiscriminately; some studies have shown that the disease tends to be more severe in women than men (Rangel *et al.,* 1987), possibly promoted by the female sex steroid levels (Fleury *et al*., 2004). Neurocysticercosis is of great economic relevance, resulting from the cost of medical treatment, lost working days, and losses due to livestock condemnation. A minimum estimate of the cost of admission to hospital and wage loss for neurocysticercosis in the United States (a non-endemic country) was $8.8 million annually, whereas estimated treatment costs in Mexico were $89 million and Brazil $85 million (Roberts *et al*., 1994). Carabin *et al*., 2006 showed that the overall monetary burden (in million of US$) to Eastern Cape, South Africa was estimated to vary from US$ 18.6 to US$ 34.2 million depending on the method used to estimate productivity losses.

2.2.4 Clinical manifestations of neurocysticercosis

a. Asymptomatic neurocysticercosis

Asymptomatic individuals are occasionally detected at autopsy and in serological surveys by enzyme-linked immunotransfer blot (EITB), but their real frequencies remain unknown (Takayanaqui and Odashima, 2006).

b. Symptomatic neurocysticercosis

The clinical signs and symptoms are varied and non-specific. Seizures are widely reported to be the most common symptom, occurring in 50-90% of patients (Del Brutto *et al*., 1992; Del Brutto *et al.,* 1998; Garcia and Del Brutto, 2003; Pal *et al*., 2000). Partial seizure, with or without secondary generalization, predominate in most cases (Takayanaqui and Jardim, 1983; Carpio and Hauser, 2002). When cysticerci lodge within the ventricular system (10-20% of cases) life-threatening acute intracranial hypertension secondary to hydrocephalus may develop.

It is directly related to obstruction of the flow of CSF by the cyst or by inflammatory reaction of ependyma (Pitella, 1997). Acute intermittent hydrocephalus, with violent headache, attacks of positional vertigo or loss of consciousness induced by abrupt movements of the head (Bruns' syndrome), or even sudden death, may result if a mobile ventricular cyst is present (Del Brutto *et al*., 1998; Hawk, 2005; Pitella, 1997).

In approximately 50-60% of the cases, there is an obstruction of the CSF circulation, resulting in hydrocephalus and progressive intracranial hypertension and mortality of over 20% of cases (Pitella, 1997). In endemic regions, recent onset of seizures in otherwise healthy teenage young adults, or middle aged individuals strongly suggests neurocysticercosis (Garcia *et al*., 1991). Most of these patients are normal on neurological examination.

2.2.5 Diagnosis

Diagnosis using serology relies on finding eosinophils in the cerebrospinal fluid, which suggests a diagnosis of neurocysticercosis. Other routine laboratory tests scarcely contribute diagnostically in cysticercosis, and thus the diagnosis rests on serology and neuro-imaging (Garcia *et al.,* 2003). Because the important features are the number, size and location of lesions, radiography has always been crucial for diagnosis of neurocysticercosis (McArthur, 1934). Lately, computer based imaging procedures (neuro-imaging) have enabled visualization of the brain and other intracranial soft structures. An example of this is shown in Figure 2.2. Currently used techniques include CT (computed tomography) and MRI (magnetic resonance imaging).

According to Nash and Neva (1984), CT has been claimed to have sensitivity and specificity of over 95% for the diagnosis of neurocysticercosis, although CT images are rarely pathognomonic for this disease. MRI is the most accurate technique to assess the degree of infection, the location and the evolutionary stage of the parasite. CT, however, is more sensitive for the detection of calcification. The main disadvantage of MRI is its high cost and scarce availability.

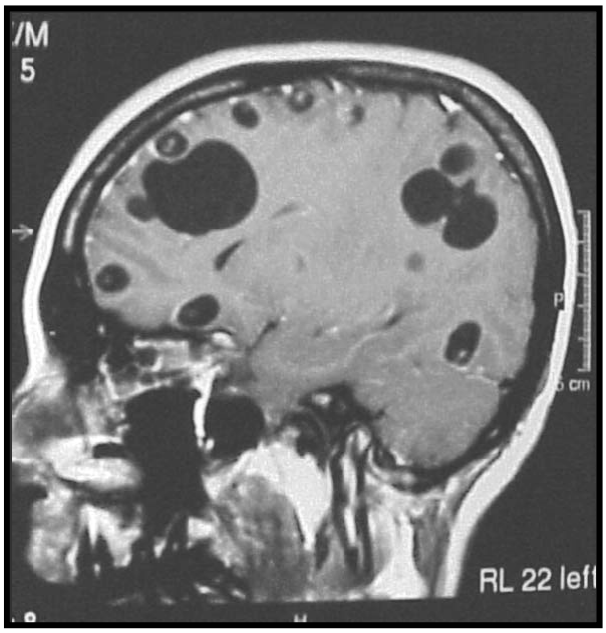

Figure 2.2: Massive Cysticercosis (sourced from Garcia and Del Bruto, 2003)

Cysticercosis outside the nervous system is a benign disorder and does not merit specific treatment. Neurocysticercosis, however, is associated with substantial morbidity and mortality. Management of NCC should be individualized according to the clinical syndrome, degree of neurological impairment, number, location and viability of the cysts, and the host immune response (Takayanagui and Odashima, 2006). Until 1978, the only treatments available were surgery for cyst excision or ventricular stunts or steroids to decrease infection.

Praziquantel, first used in cysticercosis, was the first effective specific antiparasitic drug (Sotelo, *et al*., 1984). Nowadays, albendazole (ABZ) is considered the medication of choice for antiparasitic therapy of NCC, in a regimen of 15mg\kg\day divided into two doses every 12 h for 8 days (Takayanagui and Odashima, 2006).

2.3 Epilepsy and Cultural Attitudes

Epilepsy is a chronic disorder characterized by recurrent seizures and also by a variety of medical and psychosocial consequences (Zielinski, 1988). Generally epilepsy has been understood as a medical problem to be dealt with by a medical doctor. Recent literature describes epilepsy not as a single disease, but as a symptom of a wide variety of neurological disorders (Rodin, 1987). A medical definition of 'the epilepsies' (as they have come to be known) sees them as being characterized by recurrent seizures which occur in an apparently spontaneous fashion, and are the product of abnormal, paroxysmal discharges of cerebral neurons. The epilepsies may manifest in various ways; the seizures may appear as disturbances of behaviour, emotion, motor function or sensation (Chadwick, 1990).

An infected patient with epilepsy may seek treatment by indigenous healers and faith healers. African patients make use of a variety of healing systems including biomedicine (Shorvon and Farmer, 1988). Major problems with the biomedical treatment of epilepsy in Africa are those of cost and difficult access to treatment. Patients may present late for treatment both because of access problems and because of beliefs not in keeping with the biomedical view (Pefile, unpublished Masters Dissertation, 1993). Traditional health care is utilized by the majority of the population in Southern Africa; this is especially true of treatment for mental health problems. This is partly due to a severe lack of facilities for treatment of mental disease in the Western

health care system, but also because these diseases in their cultural context are better handled by a traditional healer.

In many African cultures, diseases, mental or otherwise, are largely believed to be the result of a disregard for ancestors, who in turn are believed to inflict an individual with illness as punishment (Stafford *et al*., 2005). Cultural attitudes and beliefs about epilepsy vary widely in South Africa. Often there is a fear of, and stigma attached to, epilepsy, with widely held beliefs that it is caused by supernatural forces, or that it is contagious. For example, Eastman (2005), reported on a study conducted by Keikelane in 1998 in Khayelitsha Township, where the parents of epileptic children thought that their child's epilepsy was triggered by bewitchment (8.3%), fear (8.3%), upset (8.3%), or evil spirits (8.3%). Similarly, in a study conducted in 253 second year university students, approximately 30% believed epilepsy to be caused by witchcraft or evil spirits, 17% believed it to be contagious, 12% believed that an epileptic is a witch or wizard, and approximately 10% felt that an epileptic must be isolated from the rest of the society (Peltzer, 2001). Such beliefs affect how epilepsy is treated with many people consulting traditional healers.

In the study of Christianson *et al*., 2000, 22.5% of epileptic children received only traditional medical management, 22.5% received only western medical management, 20.4% received both forms of management and 34.6% received no treatment at all. Associated psychosocial problems have often been found to be more disabling than the seizures themselves (Beran, and Flanagan, 1987; Collings, 1990). Epilepsy is not unique among neurological disorders in having psychosocial consequences, but many myths, misconceptions and prejudices surround epilepsy, and persons with epilepsy face negative societal attitudes and discrimination (Schneider and Conrad, 1983; Shorvon, 1990).

Three areas of psychosocial adjustment were explored, these being the areas of health, vocational fulfillment and interpersonal adjustment (McQueen and Swartz, 1995).

a. Health

Dodrill *et al*., 1980 suggest that outside knowledge of their medical treatment affects their overall social functioning. Long term anticonvulsant medication is the central approach in the management of epilepsy, and approximately 80% of persons will have their epilepsy controlled by use of appropriate medication (Rimmer and Richens, 1988).

b. Vocational fulfillment

Vocational status is an important factor in adjustment (Dodrill *et al*., 1980) and may be linked to feelings of security, self esteem and independence (Levi, 1984). Unemployment and underemployment are more frequent in persons with epilepsy than in the general population. Employers' prejudice may result in the loss of jobs or the inability to find work. Children with epilepsy may have difficulties at school and may not complete their education, and so experience difficulty in becoming employed.

c. Interpersonal adjustment

Epilepsy is a life-long condition which requires daily drug treatment (with possible side effects), and the fear of another seizure is omnipresent. The experience of having a seizure in the presence of strangers can be embarrassing and alienating; outsiders may behave in a hurtful and hostile way (Craig and Oxley, 1988). Families may be over-protective, fearful and watchful; activities and friendship may thus be curtailed (Scambler, 1987). There is a lower rate of marriage among persons with epilepsy, with social withdrawal and isolation being common (Levin *et a*l., 1988). Fear, anxiety and low self-esteem among persons with epilepsy is common (Burden, 1981).

Three-quarters of the estimated 50 million people with epilepsy worldwide live in poor countries (Pal *et* al., 2000), where resources for care are extremely limited. In sub-Saharan Africa, although basic diagnostic services, such as neuro-imaging and electro-encephalography, were available in 70-80% of countries surveyed in 2004 (WHO, 2005), such services are located almost exclusively in urban areas, often in association with private hospitals, and are in fact, not available to most people with epilepsy (Birbeck and Munsat, 2002). Traditional medical systems

in such regions might be more adept at addressing these larger issues even if their treatments fail to improve seizure control (Baskind and Birbeck, 2005). According to Khan *et al*., 2004, traditional medicine, including Ayurveda in India, Kampo medicines in Japan, herbal medications in China and traditional herbs in Africa, have continued to play a significant role in the treatment of epilepsy and other medical disorders in many societies around the world.

Untreated seizures in low-income regions have significant consequences in terms of medical morbidity and mortality. Severe burns, fractures, and other seizure related traumas occur commonly, especially among individuals with long- standing untreated epilepsy (Birbeck, 2000). People with epilepsy in sub-Saharan Africa may have fewer educational, marital, and employment opportunities (Birbeck *et al*., 2006).

Epilepsy affects 5 to 10 persons per 1000 population throughout the world, with 75% of cases arising in childhood (Sander and Shorvon, 1996). Studies in the general population have reported a higher prevalence of epilepsy in blacks compared with whites and in lower socio-economic groups (Sander and Shorvon, 1987). In rural sub-Saharan Africa the prevalence of epilepsy varies from 0.22% (South Africa) to 5.8% (Cameroon) (Diop *et al*., 2003). NCC is known to be a common cause of late-onset seizures in regions where *T. solium* is endemic, accounting for 30-50% of all cases (Engels *et al*., 2003). In addition, a number of studies have shown a strong association (up to 50%) between late onset epilepsy and neurocysticercosis in areas endemic for *T. solium* (Garcia *et al*., 1995).

Serological studies in India (Chopra *et al.,* 1981), South Africa (Naidoo *et al*, 1987), Mexico (Schantz *et al*., 1994) and Peru (Garcia *et al*., 1993) suggest that higher rates of epilepsy are due mainly to neurocysticercosis. Epilepsy, similarly to neurocysticercosis is a largely unrecognized, but an increasing burden on welfare and economies of developing countries. There is little epidemiological data on risk factors for epilepsy in developing countries on which to base prevention strategies. The burden of epilepsy in South Africa is largely unknown, but it is likely to be as that typically found in developing countries (Eastman, 2005). In addition, neurocysticercosis represent a ‘silent epidemic’, with a sero-prevalence of, for example, 20% in the Eastern Cape (Mafojane *et al*., 2003). In a study of 578 black epileptic patients treated at the Ga-Rankuwa Hospital, Pretoria, 28% were shown to have neurocysticercosis using computed tomography scanning (Van As and Joubert, 1991).

2.4 Characteristics of Pig Keeping by Small-scale Pig Producers

2.4.1. Production systems and breeds

In the tropics pigs have been raised under various husbandry practices including free-range feeding and confinement (Kimbi *et al*., 2001). Free-range is practiced by small farmers mainly in rural areas in Africa, Latin America and South East Asia where pigs are fed mostly on grass, brewery cereal by-products or waste products and food remnants (Lekule and Kyvsgaard, 2003).

In most developing countries, pig production has not been fully exploited, among the reasons being poor sanitation, poor disease control practices and poor nutrition (Shrestha *et al*., 2002). Most of the pigs raised in the developing countries are crosses or local breeds raised under the traditional subsistence pig farming.

The broad genetic variability of indigenous livestock breeds in tropical African countries enables them to have valuable traits. These include disease resistance, high fertility, and low protein requirement. They survive under stressful environmental conditions including high disease incidence, poor nutrition, high temperature, all the qualities that form the basis for low input, sustainable agriculture (FAO, 1998 a, b). More productive exotic breeds on the other hand, are susceptible to harsh tropical conditions and dependant on high quality feeds.

2.4.2 Housing

Pigs are adversely affected by climatic factors namely, low environmental temperature (hypothermia), high environmental temperature (hyperthermia), high wind speed, wet floors, diseases, and energy intake (Shrestha *et al*., 2002). A suitable piggery should, therefore, have ample protection against environmental hazards and stress, good sanitation, and good hygienic condition, sufficient space, minimal feed wastage and be as cheap as possible.

However, Lekule and Kyvsgaard, 2003 showed that housing in most developing countries in the tropics is characterized by lack of wind protection, lack of bedding materials, poor sanitation, poor spacing and wet floors leading into disproportionate food wastage, physical damage through fighting, predisposition to rapid disease transmission, worm infestation and heavy losses of pigs.

2.4.3 Feeding the pigs

When the pig is kept enclosed all the nutrients have to be provided by the farmer. This is one of the challenges of intensive pig production in developing countries. Most of the time small-scale pig producers cannot purchase commercial rations. The challenge is to formulate alternative diets, which combine some commercial ingredients with other ingredients (Lekule and Kyvsgaard, 2003).

2.5 Justification

Naidoo *et al.,* 1987 quoted that 30% of epileptic cases in Durban proved to have cerebral cysticercosis, and even more so, children 5-10 years were the group with the highest frequency. In the study population conducted by Van As and Joubert (1991), neurocysticercosis accounted for 28% of black epileptic patients seen at the epilepsy clinic in Ga-Rankuwa Hospital. Their findings of a 28% incidence of CT-confirmed neurocysticercosis are similar to the 30% found in 77 epileptics in Natal. The above findings support the impression that neurocysticercosis is a major cause of epilepsy in South Africa.

Mafojane (1994) diagnosed 13 patients (0.006%) with NCC out of a population of 233 260 in Atteridgeville-Mamelodi townships in Gauteng, but for economic, social and other reasons that was only regarded as a rough estimate in particular since the census figures were not accurate. Although only people born in the Pretoria area were included, the source(s) of infection and routes of transmission were impossible to determine.

Mafojane *et al*., 2003, reported in the summary that Heinz and MacNab (1965) investigated the incidence of cysticercosis in rural and urban Africa. Their studies revealed that there is a considerable incidence of human and porcine cysticercosis in South Africa and that when comparing all pork eaters and non-pork eaters infected with cysticercus, it became evident that a non-pork eater has as great a chance of infection as a pork eater.

Schutte (1985) rightly mentions that information on the prevalence of porcine cysticercosis comes from abattoirs and this may not be a true reflection of the situation in rural areas.

Viljoen (1937) reported values of 0.5-25.1% while Heinz and MacNab, 1965 reported somewhat lower values of 0-9%. Up to 2003 there had been surprisingly few epidemiological studies conducted on porcine cysticercosis in spite of strong evidence indicating that *T. solium* is an important pathogen of poor, black South Africans (see Table 2.1 below).

Table 2.1: Results of prevalence studies on porcine cysticercosis conducted in Eastern and Southern Africa countries (Table from Phiri *et al*., 2003).

Country	Porcine cysticercosis prevalence (%)	Number of pigs surveyed	Type of survey[a]	Area surveyed	Reference
Tanzania	0.04-4.9 4.5-37.7 3.2-46.7 0-26.9	45 794 83 770 1789	P P L L	Mbulu District Northern Highlands Mbulu District Southern Highlands	Nsengwa(1995) [b] Boa *et al*.,(1995) Ngowi, (1999) Boa, (2001)
Kenya	10.0-14.0	407	L	Busia and South Nyanza Districts	Githigia *et al*., (2002)
Uganda	33.7-44.5 0-33.7[c]	600 297	P P	Moyo District Central and Northern Districts	Anyanzo (1999) Kisakye and Masaba (2002)
Zambia	20.6-56.6 8.2-20.8	1316 249	S, P L, S	Lusaka Eastern and Southern Provinces	Phiri *et a*l., (2001) Phiri *et al*., (2002)
Zimbabwe	0.03-4.3 2.7-28.6	1 000 000 99 525	P P	National Western Region	Robinson (1978) Matenga *et al*., (2002)
Mozambique	6.5-33.3	387	S	Tete Province	Afonso *et al*., (2001)
South Africa	0.5-25.1	> 100 000	P	National	Viljoen (1937)
	0-9.1	28 242	P	National	Heinz and MacNab (1965)

[a] P = post-mortem, L = lingual examination, S = serological.

[b] Survey conducted from 1985-1989.

[c] Eight foetuses from a positive slaughtered sow were all found to be infected with cysticercosis.

Kriel and Joubert (1996) and Kriel (1997) reported the alarming information that unqualified, self taught healers (so- called evil sorcerers or “baloi”) use *Taenia* segments and their contents as treatment in cases of severe intestinal tapeworm infections. Besides this practice, the malevolent use of *T. solium* segments is added to beer as punishment. According to (Shasha *et al*., 1986), cysticercosis is endemic in South Africa, but the extent to which it is a public health problem has not been determined in the context of prevalence, geographical distribution and other important variables.

Phiri *et al*., 2003, concluded in their findings that there has been almost complete absence of recent data on human cysticercosis in the eastern and southern African (ESA) countries and the general lack of knowledge on the *T. solium* taeniasis/cysticercosis complex among policy makers, medical doctors and the general community. Therefore this study of the taeniasis/cysticercosis complex was carried out in humans and pigs with the aim of quantifying the extent of the problem and investigates risk factors in order to allow the formulation of recommendations on control.

Mafojane *et al*., (2003) highlighted the need for studies to be undertaken, including those that are community based, to establish the levels of human and porcine cysticercosis in Africa. Carabin *et al*., (2006), quoted from the work of Krecek *et al*., (2004) in which it was shown that an early report from slaughter houses in South Africa indicated that 0.50 – 25.7% of pigs were infected. The same authors asserted that, more recently hospital surveys utilizing serological and radiological diagnostic techniques have indicated that 28 – 50% of epileptics, predominantly African and many children, were positive for this parasite.

The research questions thus arising are

- Can the consumption of pork from pigs raised and consumed in rural areas contribute to the incidence of neurocysticercosis in the selected population residing in the villages served by the Bethanie clinic in the North West Province; and
- Can free-range pig farming be related to this as a public health concern?

2.6 Aims and objectives:

Primary objectives:

i. By means of a structured questionnaire, survey pig land owners to provide information on pig husbandry practices, slaughter and marketing of pigs

ii. By means of a structured questionnaire, conduct a survey of consumers to provide information on pork consumption, sanitation as well as people's knowledge of *T. solium.*

iii. Screen by means of a stool sample, each consenting consumer from the survey for *T. solium*.

iv. To determine the total number of patients with recorded seizures in the study area, within the selected time frame.

v. Through retrospective study of clinic records, establish possible sources of infection and routes of transmission in patients diagnosed with epilepsy (seizures/neurocysticercosis) and the consumption of pork infected with cysticerci within the study area.

Secondary objectives:

i. To determine more accurately the total pig population in the defined study area, as current estimations are of a speculative nature.

ii. To determine the prevalence of cysticercosis in pigs through inspection of formally slaughtered pigs from the study area.

2.7 Benefits arising from the investigation

The benefits arising from the project will be to:

- Provide data leading to a possible intervention strategy aimed at the control of cysticercosis through health education and an understanding of the risk factors.
- Provide essential information on the incidence/prevalence of *T. solium* in different villages / areas.
- Formulate a surveillance and control plan for *T. solium*.
- Collate evidence for decision and policy makers to use when making priority assessment with regard to allocation of resources.
- Assist in developing a programme, leading to improved pig health and production.

- Assess the occurrence of cysticercosis/taeniosis in humans, with a view to establishing control measures which can be applied in a sustainable manner, and promoting agricultural development in general.

2.8 Outline of research

- Develop a farmer and consumer questionnaire
- Do a census of all pigs in the selected study area
- Obtain data from Bethanie clinic
- Collection of faecal samples for screening for worm proglottids
- Slaughter a random sample of pigs in the selected study area to test for cysticercosis
- Do risk assessment and develop an extension campaign

Chapter 3

MATERIALS AND METHODS

3.1 Model system

Preliminary consultation was done with the community health workers (nurses) with a view to finding out what the predominant community problems were in the villages served by the Bethanie clinic in the North West Province of South Africa. A number of health problems were considered, with mental disorder and epilepsy *inter-alia*, appearing to be a problem. Four villages in the magisterial district of Rustenburg were involved namely, Bethanie, Modikwe, Makolokwe and Berseba. The emphasis was to be on those cases with epileptiform-like seizures which were referred to the Ga-Rankuwa hospital for confirmation of diagnosis.

A structured questionnaire was designed and completed with farmers by personal interview to survey pig farming methods after pre-testing the content of the questionnaire on a peer group (Annexure A).

A structured questionnaire was designed and completed with consumers by personal interview to survey pork consumption habits after pre-testing the content of the questionnaire on a peer group (Annexure B).

In addition to the questionnaires, those consumers consenting to participate were provided with a sampling bottle and instructed on how to collect a stool sample for *T. solium* screening.

A descriptive analysis of retrospective data was conducted to determine the proportional morbidity of neurocysticercosis from the medical records of patients diagnosed with seizures (McCrindle *et al*., 1996).

3.1.1 Time constraints associated with the development of the model system

A letter of authorization from the Provincial Department of Health to investigate and conduct a retrospective analysis of cases presented at the Bethanie clinic and Ga- Rankuwa Hospital was requested by the researcher. As this was crucial for the investigation, co-operation and authorization for the participation of the investigator was requested. The request further highlighted that the investigator would not seek insight into the personal history files of individual patients, but rather information relating to cases referred to the hospital as outlined in the protocol. A year later without any success, the same request was directed to the Regional Manager, Community Health Services requesting approval and support to approach individuals under his control in order to obtain information as outlined in the protocol.

On the 14 July 2004, the Regional Manager kindly wrote a letter of approval in which he gave the project his blessing and approval. This approval was retracted and permission had to be obtained from the Head of the Health Department of the Province, through the Regional Manager's office. The Regional Manager was once again requested to support the project and to recommend approval by the Head of the Health Department of Province for the investigator to approach individuals and organizations to obtain information as outlined in the protocol.

The Animal Care and Ethics Committee of the University of Pretoria and the Ethics committee at Medunsa would have to approve the protocol, prior to the work commencing. Seemingly this attempt was not successful at Medunsa, since we were advised not to go ahead with a retrospective analysis of records because in the majority of cases the key words relating to a specific diagnosis were not specific enough. The protocol for this research was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, and that committee and the Animal Care and Ethics Committee of the Veterinary Faculty at Onderstepoort have granted written approval.

On the 21 September 2005, Professor Veary attended a meeting of the Faculty of Health Sciences Ethics committee and resulting from that meeting, changes were made to the project protocol.

The Research Co-ordinator, North West Department of Health required in addition to the changes, ethics clearance from the University of Pretoria before final permission could be granted for this research to be conducted.

In order to obtain this, permission must be obtained for the investigator to access patient information at the Bethanie clinic from the Director: Bojanala Health District in terms of the promotion of Access to Information Act, No 2 of 2000. On the 24 October 2005, three years after attempting to start with the project, a letter of authorization and approval was granted to conduct the study.

3.2 Study area/population

Bethanie clinic is situated in the village of Bethanie in the Bojanala region of the North West Province and was selected because of reports by the local clinic and the provincial department of health of people with epilepsy in the surrounding four villages. The clinic provides all the outpatient care for the Bethanie human population and three other populations in surrounding villages. The total population of the four villages was 13 916 according to Statistics South Africa census 2001. It is currently undergoing a rural-urban transition, and has a population pyramid resembling that of a developing community. The field work was conducted from July to November 2005 by a team of six field assistants led by the researcher.

Authorization was also requested from the Bakwena-ba-Mogopa tribal authority requesting involvement of the tribal office to start with a community-based research project in four of the communities belonging to the tribal authority. In essence, this required the co-operation of both pig farmers and members of the community who eat pig meat to complete a structured questionnaire. It also required the willingness of the village leaders to co-operate in the study.

Pig keeping is a traditional activity amongst Bakwena-ba-Mogopa families in this area and is practiced by about 35 (0.25%) of village families, but the actual number fluctuates according to circumstances. Historically, four in five house-holds in these communities farmed with pigs and ate pig meat during ceremonies, for example, weddings and traditional ceremonies, or as normal consumption practice. The pigs were kept in the back yard and fed mostly on grass, brewery waste products and food remnants. Indigenous, crossbred and improved pigs are all

raised at present, although cysticercosis is reputed to be more common in the hardier indigenous pigs which often wander freely through villages.

Most pigs are raised and then slaughtered and self-consumed or sold informally, with little or no sanitary inspection. The preliminary interviews showed that pig owners in Bethanie and the other three surrounding villages have indicated that rural pork producers are not motivated to sell pigs through recognized abattoirs and meat inspection services because of the risk of losing all through condemnation of the carcasses. For these rural livestock keepers, their losses are threefold:

- Low income they expect to receive from the sale of their pigs;
- They and their families lose a valuable protein source when the pig carcasses are condemned, thus increasing the likelihood of family malnutrition; and
- Own health and productivity are at risk from cysticercosis infected carcass

3.3 Sampling Methods (Selection of populations)

3.3.1 Household survey (Adequate survey of consumers)

A sample of 1042 families (7.5%) was selected through a stratified non-probability purposive method from all the families identified in the community census to complete a structured questionnaire. A census completed in 2001 before this study began, identified that the population comprised 1570 people in Berseba, 1662 in Makolokwe, 3498 in Modikwe and 7186 in Bethanie respectively. The following number of households was also revealed in the census, namely 459 in Berseba, 549 in Makolokwe, 1003 in Modikwe and 2392 in Bethanie.

An epidemiologist from the Faculty of Veterinary Science (University of Pretoria) was consulted on a grid random sampling procedure and numbers generated on a 50% presumption of pork consumption and a 95% confidence level. The following randomly generated numbers were selected for each village.

Table 3.1: Randomly selected numbers from village populations

Name of village	Number of households	Sample size (95% CL)
Berseba	459	207
Makolokwe	549	226
Modikwe	1003	278
Bethanie	2392	331
Total	**4403**	**1042**

3.3.2 Census of farmers (Pig farming communities)

On the 24 October 2004 prior to the commencement of the project, a meeting was convened in the form of a K. Birch sponsored farmer's information day on taeniasis/cysticercosis complex in order to identify pig farmers from within villages under investigation. The meeting determined who farms with pigs and where their farms/areas are situated (n=35). The resultant purposive sampling method was used to select all the farmers to complete a structured questionnaire.

3.3.3 Sampling for the baseline survey

At a planning meeting of the research team, the Makolokwe village was identified for the pilot study for the project, based on the size of the settlement (549 households) and its geographical position. A grid analysis location mapping was performed to identify all households by streets and household numbers and to allocate areas of intervention by trained interviewers. The same principle was adopted in turn for the larger villages.

3.3.4 Baseline measurements

Before the baseline survey, an introductory visit was made to the village for observation purposes. The researcher was accompanied by the Community Liaison Officer, who provided the street maps of the area. After the exploratory visit, a meeting was held with the headman of the community to obtain consent for the project to be undertaken. For practical and logistical reasons, 226 households were selected at random for the baseline survey. Invitations were then hand delivered to the spokesperson of these randomly selected households.

When the selected household spokesperson was not found at home, two subsequent visits were made, if this procedure was unsuccessful a new household (systematic random sampling) was selected to replace this loss. A meeting was convened in the form of a K. Birch sponsored information day on taeniasis/cysticercosis complex to assess the local knowledge of both taeniasis and cysticercosis infestations (See Figure 3.1 below).

This intervention attempted to bring about a change in knowledge levels, attitudes and practices of community members by veterinary public health education with community participation. This was initiated by in-depth questionnaires developed by the researcher. Based on this data, an educational intervention was organized which included explanation of the life-cycle, the disease, the risk factors and the control measures.

Various participatory facilitating methods were used in the meeting, including data projector, overhead projector, posters and subject matter specialists. For the questionnaires, a total of 29 questions for consumers and 34 questions for farmers had to be completed by the six field assistants. A de-briefing session on the questionnaire was given to the field assistants every time prior to an information session to ensure a high and uniform standard of data capture and research.

Figure 3.1: Community participation: (Bethanie recreational hall)

3.4 Experimental design and procedure

A cross-sectional study was undertaken to estimate the prevalence of human taeniasis and porcine cysticercosis and to investigate risk factors.

3.4.1 Data collection (Study by structured questionnaire)

a. Farmer questionnaire

A census was conducted by structured questionnaire with the household spokesperson or in their absence any adult present, on the nature and extent of pig farming. This was designed to collect data on pig husbandry practices, slaughter and marketing of pigs and where possible, was verified by direct observation. Verbal informed consent was given by the participants. In pig-owning families, all the pig owners were sampled. The questionnaire was administered during farm visits and took 30 minutes to complete. Information was also gathered on the presence of toilet facilities and whether or not pigs have access to faeces. The type of pig house was assessed and types of feeds used for feeding pigs were noted during farm visits.

b. Consumer questionnaire

A survey of randomly selected households was conducted with the household spokesperson by structured questionnaire to determine the nature and extent of pork consumption and eating habits, sanitation practices and knowledge of *T. solium*. Written informed consent was given by the participants. As referred to above, a meeting was convened in the form of a K. Birch sponsored information day on taeniasis/cysticercosis and a questionnaire administered (Annexure C). The variables investigated included individual risk factors for cysticercosis.

c. Data storage and analysis

A qualified statistician from the University of Pretoria was contacted for analysis and interpretation of data input. Descriptive statistics (frequencies, means, standard deviation and confidence intervals) were determined. The chi-square test was used to determine the significant difference between categorical variables. Human and pig data were entered and analyzed in separate databases using a statistical package (SAS V8.2 and V9.1). The testing methods are summarized as follows:

- Using 2 way frequency tables, the association between a household factor and occurrence of seizures in the family was analysed within the sample size (SAS V8.2).

- SAS V9.1 survey means a procedure to estimate 95% confidence limits for the incidence of seizures in the whole population based on the sample surveyed.

If the confidence limits for two groups overlap, there is no statistical evidence of seizures in those two groups.

3.5 Sample Collection, Testing and Method of Diagnosis (Human Taeniasis)

For the detection of human taeniasis, faecal specimens from consenting consumers were collected in approved plastic specimen containers, stored on ice blocks and submitted to the University of Limpopo, Medunsa Campus, Department of Microbiological Pathology for *T. solium* screening after prior consultation.

The following tests were carried out as specified under Standard Operating Procedures (NHLS Dr George Mukhari Tertiary Laboratory, Department of Microbiological Pathology-QAM SFEC PS019, Edition 0.2)

a) Macroscopic examination

- The colour of the specimen was recorded
- The consistency, e.g., formed, semi-formed or liquid was recorded
- Whether specimens have mucus and or blood or segments of parasites, or nothing, was recorded.

b) Concentration method (Formalin-ether method)

- The centrifuge tube was labeled with the laboratory number
- A quantity of stool (approximately 1 g) was selected and placed in a centrifuge tube containing 7 ml of 10% formalin
- The faeces were emulsified in the formalin, filtered through a gauze into a marked conical centrifuge tube and 3 ml of ether was added
- The tube was closed with a rubber stopper and mixed vigorously by hand for 1 minute or mixed well on a vortex mixer for 15 seconds.
- The sample was centrifuged for 1 minute at 3000 rpm
- The fatty plug was loosened and the supernatant poured away by quickly inverting the tube.
- The fluid on the side of the tube was allowed to drain on to the deposit, mixed well and wet preparations prepared of the whole deposit for examination under the 10x and 40x objectives of light microscope for ova and cysts.
- The findings were recorded on the work sheet.

c) Direct microscopic examination (Wet preparation)

- A drop of saline or a drop of Lugol's iodine was placed on a microscope slide
- A small amount of specimen was emulsified in the drop, covered with a cover glass and the preparation was examined thoroughly under 10x and 40x objectives of ordinary light microscope
- The presence of pus cells, red blood cells, yeast cells, cysts, trophozoites, ova and larvae were recorded on the work sheet.

3.6 Pigs for Slaughter

On completion of interviews and the analysis of results, farmers were selected on a non-purposive sampling basis to negotiate the purchase of pigs for slaughter and formal meat inspection at an approved abattoir. The survey at hand consisted of sampling pigs from randomly selected villages. The sample size of pigs for slaughter was derived using the methodology of Canon and Roe (1982) for selection to determine disease, using the following formula: $n= [1-(1-a)^{1/D}] [N-(D-1)/2]$, where

n = the required sample size
a = probability (confidence level) of observing at least one diseased animal in sample when the disease affects at least D/N in population
D = number of diseased animals in population
N = population size

3.7 Retrospective Descriptive Analysis of Medical Records

Prior to review of the medical records at the Bethanie clinic, a letter of consent and co-operation was required from the Provincial Department of Health, through which patient and family protection through a statement of confidentiality was ensured at the clinic.

A retrospective analysis was undertaken in the Bethanie clinic of the medical records of patients with the diagnosis of epilepsy from 1 January 1999 to 31 December 2003. Age, sex, origin, clinical manifestation, treatment, referral, neuro-imaging (computed tomography or magnetic resonance imaging) were all identified, summarized and analyzed.

Chapter 4

RESULTS AND DISCUSSION

4. OVERALL ANALYSIS OF THE QUESTIONNAIRES

4.1 Respondents

A total of 1042 households and 1031 people, including farmers, were sampled in the human taeniasis/cysticercosis study with (1.1%) refusing to participate. Community participation was good, as more than 95% of the families agreed to give information requested in questionnaires.

4.1.1 Characteristics of respondents

The results indicated that the majority of respondents were women, (n=583 or 56.5%) *vis-à-vis* men (n=448 or 43.5%) of the household and an age distribution of: 18-30 years (180), 31-40 years (186), 41-50 years (205), 51-60 (149), > 60 (311), and mostly (Se) Tswana speaking (92.61%).

4.1.2 Education level

The education level of respondents varied as indicated in Table 4.1. It is interesting that only 52 (5.0%) did not attend school at all.

Table 4.1: Education level of participants

Education level	Number of participants	Percentage
Primary school	284	28
Secondary school	383	37
Matriculation	226	22
Tertiary institution	86	8
None	52	5
Total	**1031**	**100%**

4.1.3 Source of income

Respondent's main source of income is indicated in Table 4.2. Makgatho (2004) showed that men get social grants for example, pensions from the age of 65, while women receive this benefit from 60 years of age.

Table 4.2: Main source of income for participants

Income source	Number of participants	Percentage
Pensioners	313	30
Own business	24	2
Municipality/NGO	14	1
Mining	59	6
Industry/State	102	10
None	519	51
Total	**1031**	**100%**

The majority of the participants fall within this age group range, so pension money is the other source of income for them. The socio-economic status in general was characterized by unemployment, namely, n=519 or 51%. The result of this is poorer villages are reliant on local meat which may have cysticerci, thus predisposing to higher levels of taeniasis.

4.1.4 Water supply

An analysis of the water source available to the respondents indicates that the majority of the households 92% (n=948) have tap water supplied by the relevant municipality. However, 105 received their main water supply from boreholes that are driven by electricity. Therefore some people have more than one source of water supply.

4.1.5 Toilet facilities

Of a total of 1031 participating households, it is evident that the type of toilet system used by the majority of the respondents is the pit toilet (n=1004 or 97%), while only 27 (or 3%) use waterborne toilet facilities or a combination of both because some people have more than one type of toilet facility at their disposal.

4.2 Results of the household survey (Consumer questionnaire)

4.2.1 Cross-factor association analysis relating to the occurrence of seizures

The association between a household factor and the occurrence of seizures in the families surveyed was analysed using 2 way frequency tables. In the instances highlighted below, there is a distinct tendency for an epidemiological factor to be associated with a higher percentage of seizures within household units. In all the cases surveyed, however, the 95% confidence limit testing does not provide statistical support for these trends.

4.2.2 Number of people per dwelling

Table 4.3: Household Size

Number of people	History of Seizures	
	Yes	**No**
1 – 5	61 (7.34%)	770 (92.66%)
6+	19 (9.74%)	176 (90.26%)
Total	**80**	**946**

From Table 4.3, it can be seen that 19 or 9.74% of the participants reported seizures in households with a family size of 6 or more (considered to be crowded), compared to 61 or 7.34% with a family size ranging from 1 - 5 (considered to be normal). The tendency is thus for a higher percentage of seizures in crowded households. Widdowson *et al*., 2000 showed that crowded households may be a marker for poorer socio-economic conditions and added problems of personal hygiene.

Table 4.4: 95% Confidence Limits for Household Size

Number of inhabitants	Seizures	Sample size	Mean (Population)	95% CL for population Mean	
1 - 5	YES	61	0.067931	0.04909704	0.8676475
6+	YES	19	0.109316	0.05753727	0.16109445

Table 4.4 indicates that for normal households (in the whole population), the proportion of seizures (estimated from the sample) is 4.9% - 8.7%. For crowded households the proportion is 5.8% - 16.1%. These 95% confidence limits for seizures overlap, which indicates that there is no statistically significant difference between the proportions of seizures in these two groups. From the households sampled, we can estimate that normal and crowded households in the whole population will report a statistically similar proportion of seizures.

4.2.3 Number of people per education level

From Table 4.5 it can be seen that, 6 or 11.54% of participants surveyed with no formal education reported seizures in the family, while only 2.33% with tertiary education reported a few cases of seizures in the family. The table indicates a tendency for a higher percentage of seizures in consumers with no formal education, probably due to lack of knowledge or understanding. In other words, the incidence of seizures decreases with higher levels of education, but this was again not supported statistically.

Table 4.5: Education Level

Education Level	History of Seizures	
	Yes	No
None	6 (11.54%)	46 (88.46%)
Primary	26 (9.1%)	257 (90.81%)
Secondary	29 (7.65%)	350 (92.35%)
Matriculation	17 (7.52%)	209 (48%)
Tertiary	2 (2.33%)	84 (97.67%)
Total	**80**	**946**

4.2.4 Number of people passing proglottids

Questionnaires showed that a reliable diagnosis of taeniasis could be achieved by asking people if they had released tapeworm segments (Garcia *et al*., 1995; Garcia-Garcia *et al*., 2000; Sarti *et al*., 1992, 1997, 2000), thereby facilitating the identification and treatment of tapeworm carriers.

From Table 4.6 it can be seen that 10.26% of respondents reported seizures in a family that has seen tapeworm segments or has been treated for a tapeworm. In the group who have not seen tapeworm segments or have not been treated for a tapeworm 6.6% of respondents reported the occurrence of seizures in family members.

Table 4.6: Tapeworm Segments Seen/Persons Treated

Tapeworm Segments Seen/Treated	**History of Seizures**	
	Yes	**No**
Yes	20 (10.26%)	175 (89.74%)
No	51 (6.67%)	714 (93.33%)
Do not know	9 (13.85%)	56 (86.15%)
Total	**80**	**941**

The table indicates a tendency for a higher percentage of seizures in consumers that have seen or been treated for tapeworms, but this was again not supported statistically.

The case of consumers who were not sure if anyone in their families have a history of passing worms but where seizures have purportedly occurred, indicates a general lack of knowledge about tapeworms or the absence of a waterborne toilet facility where they could identify if they have worms or not.

4.2.5 Alternative medication

Table 4.7: Exposure to Alternative Medication

Exposure to Muti/Herbal Medication	History of Seizures	
	Yes	**No**
Yes	67 (8.4%)	731 (91.6%)
No	13 (5.75%)	213 (94.25%)
Total	**80**	**944**

Table 4.7 indicates that 67 or 8.4% of respondents reported seizures in a family that had been exposed to herbal medication or "muti", while only 5.75% thought seizures had occurred without exposure to herbal medication/muti. The table indicates a tendency for a higher percentage of seizures in consumers that had been exposed to muti, but this was not supported statistically.

4.2.6 No clear trends for epidemiological factors

If there is no support for the expectation from the tendency in a 2 way table because there was no clear association, it was considered unnecessary to give a 95% confidence limit or to discuss these potential epidemiological factors.

4.3 Trends within the census of pig farmers (Farmer questionnaire)

In this study, the owners of pigs within the four villages of the study area were personally interviewed by means of structured questionnaires. A complete census was conducted of the pig population throughout the villages, following which only 35 participants were considered to be actually farming with pigs. The sample size proved too small to allow for a meaningful statistical analysis of the outcomes. The trends that arise from the analysis of answers to questions in the questionnaire are discussed in the sections that follow.

4.4 Data on pig production and pig husbandry practices

4.4.1 Herd size, type and management of pigs

Respondents (n=35) kept in total 238 pigs with a range from 1 to 45 pigs kept by a single farmer (see figure 4.1).

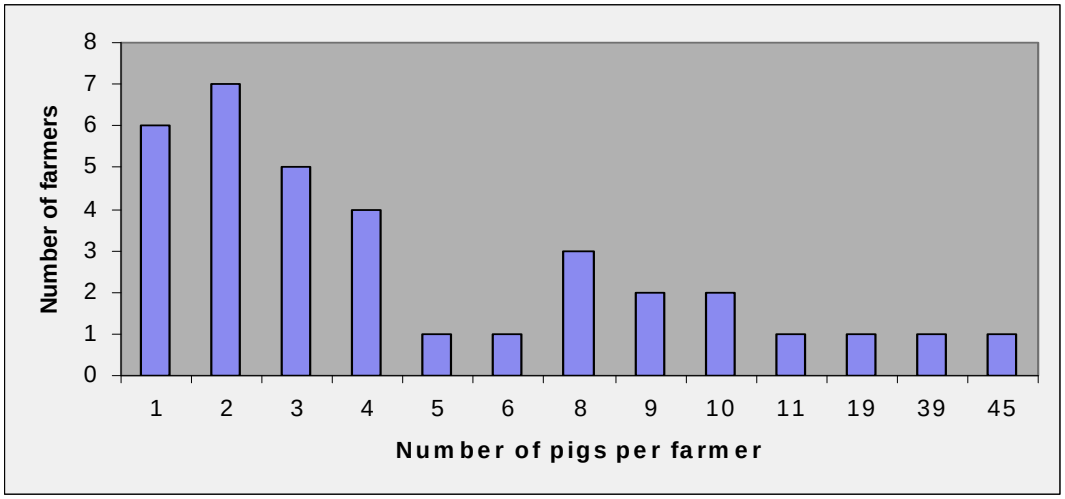

Figure 4.1: Number of pigs per farmer

Figure 4.2 shows the distribution of the total number of pigs per village.

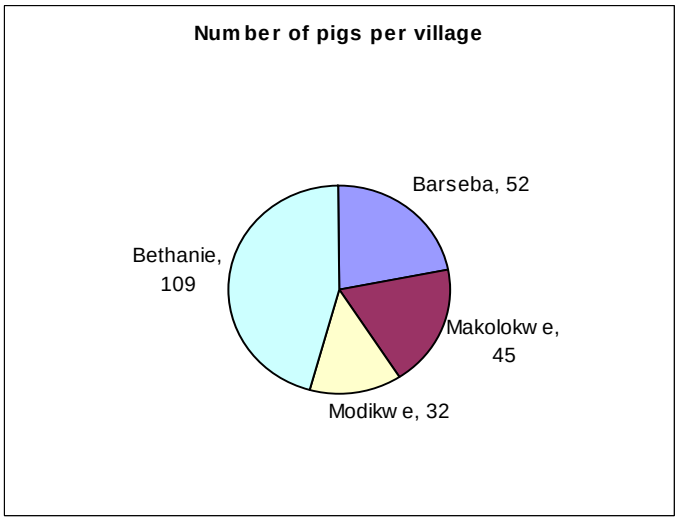

Figure 4.2: Total number of pigs per village

Most of the animals (75%) were small to medium in size and in a fair to good condition. One hundred percent of the pigs were kept for home consumption, but (n=10) farmers (28.6%) envisaged a future where it would be possible to expand into commercial pig farming. The stated intent of farming with indigenous, crossbred and improved pigs was not borne out by the survey which indicated that most of the farmers kept exotic pigs that were mainly crossbreed Large White and Landrace. Several authors (de Fredrick and Osborne, 1977 and Kumavongkrit and Heard, 2000) have indicated such breeds perform well under tropical conditions, if properly managed. However, it would appear that up to 40% of the farmers leave their pigs to wander freely, demonstrating that in these rural areas many pigs are maintained under extensive circumstances and allowed to roam freely among the households to scavenge for food. This picture is clouded as, arising from the questionnaire census, the impression is created that most farmers (n=32) feed their pigs with slurry/swill/husks, with at least 6 farmers supplementing their pig rations with commercial feeds (semel) that were not specifically formulated for pigs. This is indeed not surprising because there are no nearby co-operatives that sell pig feed.

Feeding food waste to swine helps producers save money and benefits the public and environment by reducing landfill use. Studies, however, indicate that unless the waste is cooked first, the spread of disease could result. Among the 35 pig owning households visited, 17 or 49% said that their pigs had access to human faecal material, and this is an indication of a poor standard of living infrastructure.

4.5 Data on Marketing

4.5.1 Purchasing of pigs

Table 4.8: Purchase of pigs

Place of purchasing	Number of participants	Percentage
Local	25	71.42%
Friends/Neighbour	4	11.42%
Commercial	7	20%
Total	36	

By far the majority of people interviewed (n=25) bought their pigs from the local farmer, four (4) bought from either a friend or a neighbour and seven (7) said that they bought their pigs from a recognized commercial farmer source.

4.5.2 Selling of pigs

Table 4.9: Selling of pigs

Place of selling	Number of participants	Percentage
Auction	1	2.85%
Abattoir	2	5.71%
Friend/Neighbour	8	22.83%
Locally	13	37.14%
Total	24	68.53%

It is noteworthy to mention that market expectations for the farmers is not high as pigs are rarely sold, and the only market available is to other local farmers. Only 24 farmers or 68.53% could give accurate information as to where they dispose of them outside of the village communities. Arising from the survey, the impression is that most of the farmers (n =13 or 37.14%) sell their pigs locally (see Table 4.9).

4.6 Data on Slaughtering of Pigs

4.6.1 Place of slaughter

Table 4.10: Place for pig slaughter

Place for slaughtering	Number of participants	Percentage
Abattoir	2	5.71%
Informal	26	74.28%
Total	28	80%

Again only 28 respondents or 80%, could give any information on where they dispose of their animals. Arising from the survey, the impression is that most of the respondents (n=26) said that they slaughter their animals informally and for local consumption, with only two of these respondents also using an approved abattoir on occasion for the slaughter of their pigs.

4.6.2 Meat inspection

By far the majority of respondents (n=25 or 71.42%) said that they do not subject their animals to formal meat inspection following slaughter. Two of these respondents who use an approved abattoir, were aware that their pigs were subjected to formal meat inspection. There is no meat inspection performed on carcasses of pigs slaughtered in the villages and in cases where the cysts are detected at slaughter, farmers said that the meat is well cooked and eaten, sold locally for consumption or used for soda soap processing out of the fat content for bathing or washing purposes. Asked why they would not subject their pigs to formal meat inspection, their reasons varied with the majority (n=25) indicating a lack of knowledge about meat inspection services. Nineteen (19) said that they do not have access to a meat inspection service.

4.7 Prevalence of Epilepsy

From 1031 records investigated for epilepsy, 80 individuals were found with a specific mention of an epileptiform insult having been diagnosed, a prevalence of 7.8% population. All the individuals lived in different villages with 14 or 6.76% in Berseba, 22 or 9.69% in Makolokwe, 22 or 7.91% in Modikwe, and 22 or 7.01% in Bethanie. The number of families with evidence of epilepsy was 3/35 for pig owning families. The retrospective study of clinic records as illustrated in Figure 4.3 below differs materially from the results obtained from the survey of the consumers by means of the structured questionnaire. Results from other endemic areas in Africa (Newell *et al*., 1997) have indicated a strong relationship between cysticercosis and epilepsy.

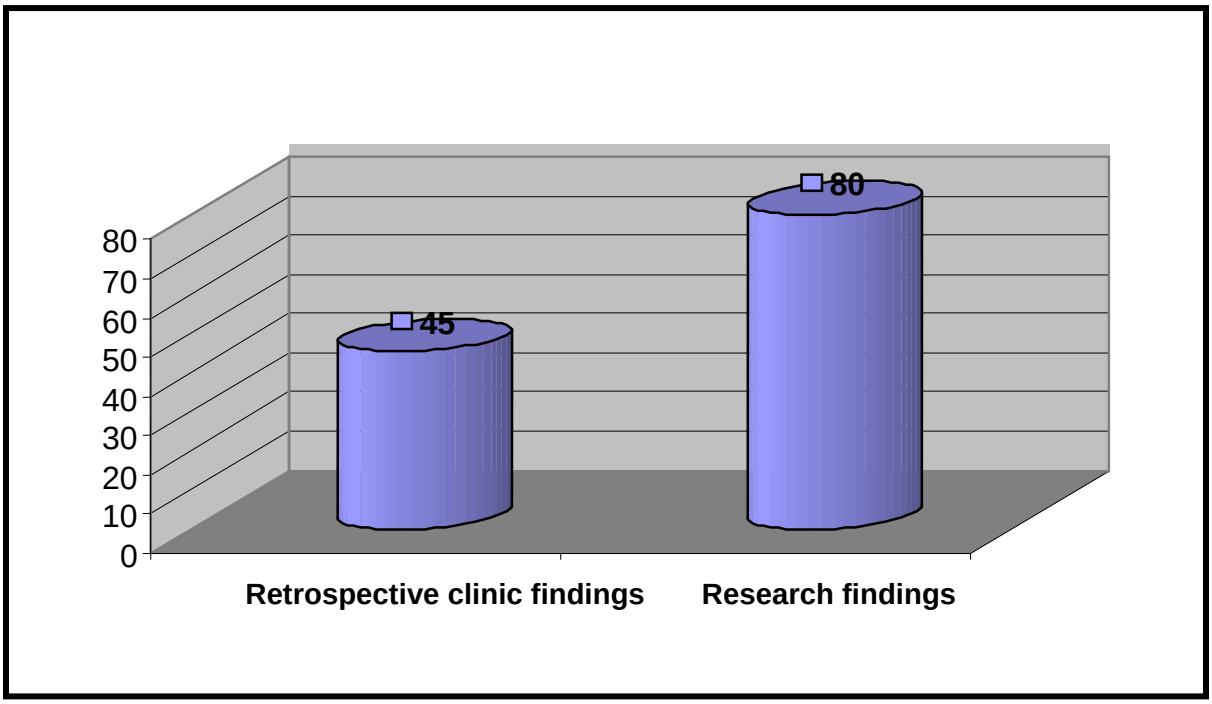

Figure 4.3: Comparison of prevalence of epilepsy within the study area

4.8 Prevalence of Human Taeniasis

From the community survey a total of 55 stool specimens was collected from four villages; 11 from Makolokwe, 21 from Berseba, 9 from Bethanie and 14 from Modikwe for microscopic examination of *T. solium*. Out of this total only 38 secimens were processed for microscopic examination for *T*. *solium* as 17 more specimens were lost or misplaced on referral to the contracted laboratory. Annexure E summarizes these results and it transpires that of these volunteers 32 had consumed pork originating from informal slaughter, 6 claimed that they did not eat pork at all and 6 had a house history of people having seizures and that pork had been consumed from informal slaughter.

Stool examination was negative for parasites or eggs (ova) in all patients. The latter results, however, have to be interpreted with caution due to the fact that, studies have shown that traditional laboratory diagnosis of tapeworm infection in humans has poor accuracy and modern coproantigen tests remain a research tool that has not been introduced to the market (Pawloski *et al*., 2005).

This is not necessarily unusual as a result as low as only 2% would be considered highly infected. Furthermore the specimens were collected only once in a day and not three times a day (personal communication, Mafojane). Carrique-Mas *et al*., 2001 showed that free treatment for taeniasis was given to the household as an incentive to participate in the survey, while in the present study no form of incentive whatsoever was given to the volunteers. It is also important to note from the survey that many household members with a history of passing segments said they would treat worms with pumpkin pips or drink a teaspoonful of petrol before eating. In this way the whole of the worm nest would be totally removed when defaecating.

4.9 Detection of *Cysticercus cellulosae* in Village Pigs

A sample of 34 pigs from ten households within the four villages was negotiated with the owners for slaughter and post-mortem examination by primary meat inspection at the local approved and registered abattoir. Routine primary meat inspection revealed that all 34 pigs were negative for cysticercosis (Table 4.11).

Table 4.11: Pigs Slaughtered

Localities/ Farms	No. of pigs slaughtered (n = 34)	Positive (%)
Berseba	10	Nil
Makolokwe	5	Nil
Modikwe	6	Nil
Bethanie	13	Nil

Whilst one household had 10 pigs sampled, it was difficult to persuade other farmers to honour the original agreement and make pigs available for slaughter, most households having only 1 or 2 pigs sampled. The project design was to sample pigs from all the selected farmers. From the formula, sixty pigs (n=60) were to be selected on a *pro rata* basis, and the proportion from each herd/village was to have been as follows:

Modikwe: 8
Makolokwe: 11
Berseba: 13
Bethanie: 28

An attempt was made to sample all pigs belonging to each household as required by this formula, but due to the following constraints, this was not always possible:

- Farmer has just started farming with too few pigs to sell
- The pigs have died in the interim
- The farmer ate or sold all the pigs
- In some cases the pigs were adult and the amount asked was unreasonable
- Sows were either lactating and feeding or pregnant
- Interval between negotiation and purchase was too long

Relatively few of the sampled pigs were of the indigenous unimproved breed of pig; with the majority being improved white-skinned breeds and crosses. It is interesting to note that free roaming pigs and pigs which were usually confined with no access to faecal material were not infected. This could probably be due to the fact that majority of the respondents have access to the toilet facilities, though it is worth mentioning that not everyone in the household will use a toilet (e.g., children) and may prefer to use the yard. Carrique-Mas *et al*., 2001 showed in their studies that there was a similar strength of association between free-ranging and pigs which were usually confined. This suggests that confinement is not secure or that household risk factors to which confined and free-ranging pigs are exposed may be more important in determining infection.

Phiri *et al*., 2002 used three different methods for the diagnosis of cysticercosis, namely, tongue palpation, meat inspection and the detection of circulating parasite antigen. In the present study only the standard prescribed meat inspection of the pig carcasses was used. Figure 4.4 below shows the marked variation in the size of the pigs that were slaughtered and contrary to expectation all the carcasses were negative for cysticercosis.

Figure 4.4: Post mortem results on carcasses with variation in size

4.10 Retrospective Descriptive Analysis of Clinical Data

Previous records of epilepsy were reviewed in the rural clinic from the study area. The observed clinical manifestations in the studied series are presented in (Annexure D). Also assessed was the degree of *T. solium* taeniasis/cysticercosis awareness amongst the community health workers in the study area. In this study (n = 45) patients were identified as epileptics. The age of these patients ranged from 10 to 71 years with an average age of 41.1 years with male patients marginally in the majority (51.1%). The female/male ratio was 21:23. The sex and age of one patient was not disclosed in the clinical records.

Thirty seven (82.2%) of the patients presented with epilepsy alone, 5 (11.1%) with epilepsy and psychosis, 2 (4.4%) with post traumatic epilepsy and 1 (2.2%) with long standing epilepsy. Only 3 (6.6%) patients had been referred for Computer Tomography. Permanent addresses could be found for 42 patients, (48.4%) were residents of Bethanie, (11.1%) from Makolokwe, (31.1%) from Modikwe and (2.2%) came from Berseba.

Most of the patients were from Bethanie and Modikwe respectively, and this is not surprising since they are the largest villages. Permanent addresses could not be found for 3 (6.6%) other patients. Noticeable in all the medical records was the lack of the use of more specific terms to describe the epileptiform seizures. All patients received anti-epileptic treatment even though in some cases more than one treatment was used for one patient. Some respondents said that their family members experienced seizures despite taking anti-epileptic drugs. The anticonvulsant being used included carbamazepine, phenytoin, tegretol, phenobarbitone, sodium valproate, chloropromadine, carbomoxypin, epamutin and thiamin.

However, Takayanagui and Odashima, (2006) showed that, most patients with NCC present with seizures and the administration of standard doses of single first-line anti-epileptic drugs, such as phenytoin or carbamazepine, usually results in adequate seizure control. Most had their blood taken to test the blood levels of the drugs, and doses of their drugs had been adjusted at various times. Majority of patients were unemployed and receive a state grant known as Disability Grant (DG) which precluded them from the possibility of full-time employment in the open labour market, but remain potentially economically active, and this emphasizes the impact this parasitic disease has on the labour market.

Interestingly, a shocking revelation of (n=82) cases of neurological deficit (psychosis) was a subjective observation as it was not the intention of this study to analyse them. In some cases, the medical records were incomplete. In this clinic, there were no records of human cysticercosis cases hence we could not determine the proportional morbidity of neurocysticercosis as advocated by (McCrindle *et al*., 1996) and community health workers exhibited no knowledge of cysticercosis.

However, Dorny *et al*., 2003, showed that access to imagery of the brain essential for the diagnosis of NCC, is lacking from several African countries. Ngowi *et al*., 2007, showed that consequently, data on the human aspect of the parasite is lacking in many endemic areas because most studies have only examined the livestock aspects of the parasites. The same author asserted that this has made it difficult to carry out a thorough economic analysis of the impact of *T. solium*. Carabin *et al*., 2006, showed that a recent analysis in the Eastern Cape Province, South Africa with imagery revealed an important economic burden to the country due to *T. solium* infestations.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This is the first community based survey of *T. solium* taeniasis/cysticercosis of pigs and humans in the communities served by the Bethanie clinic and in the North West Province. Statistics on the cysticercosis problem in the Republic of South Africa is derived from abattoir data on pigs which may not reflect the true situation in rural communities. The questionnaire census revealed poor pig husbandry practices, absence of meat inspection and control of informal slaughter in the surveyed villages. It was demonstrated that in these rural areas, pigs are generally maintained under extensive circumstances and allowed to freely roam among the households to scavenge for food. Most pig farmers did not seek extension information on pig farming and this might explain the poor pig management practices observed.

There is little or no meat inspection performed on carcasses of pigs slaughtered in the villages, and in the few cases where cysts are detected at slaughter the meat is eaten or sold for consumption. Rural areas in South Africa have never been serviced properly in terms of meat inspection as commercial slaughtering was done only in the urban areas. The Meat Safety Act, 2000 (Act No 40 of 2000), provides for measures to establish schemes for the improvement of meat safety of animal products. The law stipulates requirements for slaughter, but implementation will be difficult where previously it was not applied.

It is interesting to note that both free roaming pigs and pigs that are usually confined with no access to faeces were not infected. It is very difficult to conclude at this point if this is in any way due to an improvement in village pig husbandry practices. Undoubtedly, similar prevalence figures might not be found in many other pig rearing parts of the country where surveys have not yet been carried out.

There was no significant statistical difference in the proportion of households reporting evidence of epilepsy, between those who owned pigs and those that did not. Carique-Mas *et al*., 2001

showed that this is not surprising given the fact that there is a lot of social interaction between houses, with people visiting each other. It was also reported by people that pigs sometimes entered the yard of households which did not own pigs, in search of food. The fact that we cannot prove it statistically is because of the low number of households with a history of seizures, and we never anticipated finding a predominantly infested human population in the villages surveyed. The incidence of seizures among farmers was also very low because of the surprisingly small number of pig farmers in the selected community.

The incidence of high risk behaviour is common, and there is strong evidence of a tendency towards an association between epilepsy, consumption habits and various epidemiological factors which were considered possible risk factors. Multiple factors including pig husbandry practices, household and village factors were shown to be risk factors associated with the parasite transmission in the surveyed communities, and this could be summarized as follows:

5.1.1 Farming (pig factors)

a. Free roaming management of pigs is predominant in the communities surveyed and has been described as a major risk factor relating to the transmission of eggs (proglottids) to pigs (Eddi *et al*., 2006)

b. The majority of farmers feed slurry/swill and studies indicate that unless the waste is cooked first, the spread of disease could result, including cysticercosis (http;//www.aphis.usda.gov/vs/ceah/cadia/rarc2htm)

c. In the main poorly built pig containing structures allow pigs to break out at will.

5.1.2 Household (consumption factors)

a. There is a house history of taeniasis as evidenced by recognition of faecal excretion of proglottids (response from questionnaire).

b. There is a house history in many cases of epileptiform seizures.

c. There is a predominant consumption of uninspected pig meat from self-owned pigs which could well be a source of human taeniasis, not proven in this study due to the small sample size. As a result much pork infested with the larval stage of *T. solium* could well be consumed by the rural population, resulting in infestation with the adult tapeworm, as confirmed by the consumer survey.

d. Exposure to muti is admitted.

e. Living conditions reveal a considerable overcrowding of people within their homes.

5.1.3 Village factors

a. There is a lack of convenient slaughter facilities and consequently no well organized meat inspection.

b. The educational level is generally poor and a specific knowledge of the possibility of tapeworm infestation from affected pigs totally lacking.

The recent survey has clearly shown that many inhabitants of rural communities are generally ignorant of the danger to which they expose themselves by eating meat with cysticerci. Most of them did not understand the association between the presence of cysticerci in the meat of the animal and the tapeworm infection in man. The taeniasis/cysticercosis paradox is a disease waiting to happen in rural areas as typified by Bethanie and the other three surrounding villages, and unless properly dealt with by the authorities, the problem will continue. Since many people with epilepsy in the four villages do not seek medical care, the cases might not be

representative of the general population of epilepsy in the region. The apparently high occurrence of epileptiform seizures arising from our study is of particular concern. The incidence data for taeniasis/cysticercosis in humans is very limited owing to a lack of adequate surveillance, monitoring and reporting systems.

The lack of specialized personnel, particularly in neurology means that the accuracy of diagnosis cannot be confidently ascertained. The exact prevalence of NCC is difficult to ascertain, since the diagnosis can, in the living patient, only be conclusively confirmed by CT or Magnetic resonance imaging of the brain or biopsy. The use of different terminologies to classify seizures and epilepsy also hinders study comparison. Bearing in mind that our study was based upon black rural communities who have no immediate access to highly specialized investigations, we wonder what the prevalence of cerebral cysticercosis in the study area really is. We may be sitting upon a silent epidemic of potential epilepsy of some magnitude.

5.2 Recommendations

It would be interesting to do a case-control study because the random survey perhaps did not reveal more cases of seizures. The apparently small number of respondents with fits means that conclusions must be tentative, and further research is necessary. In fact, it would be commendable if the Provincial Department of Health could adopt a questionnaire similar to that used in this research work as a standard screening document for patients presenting to the clinic with epileptiform-like episodes. In order to reduce the infection risk, it is necessary to promote meat inspection, analyze the infection rate in pigs and determine the origin of pigs diagnosed locally. In other words the risk of disease should be mapped and an intervention strategy prioritized. A first step to short term action would be to document the public health and/or economic relevance of cysticercosis within the rural communities and to convincingly bring it to the attention of decision makers. Pig owners should be informed of the lifecycle and the health risks to their families and to the consumers of the meat they produce. Collection of data from hospital records and abattoirs (or traditional places of slaughtering) is essential to help define endemic areas of taeniasis/cysticercosis. Computed Tomography and Cerebro Spinal Fluid analysis must be regarded as important investigation methods in patients with epilepsy.

As for most zoonotic diseases, an interdisciplinary approach is needed, involving medical and veterinary workers as well as municipalities and farmers' organizations. Promote a co-operative action by the medical and veterinary institutions in the implementation of control measures. Institute a training programme for medical, public health and veterinary services personnel who will be involved in carrying out the control programme. Create a reporting system as simple as possible at all levels of existing medical (taeniasis/cysticercosis) and veterinary (cysticercosis) services. Ensure regular analysis of the incoming data and use the analysis for further decision making at the national or local levels. Establish a committee or a single person to be responsible for the implementation of preventive and control measures at various organizational levels (regional, national, district or community). Collect all possible medical information on taeniasis/cysticercosis in all the provinces, consider the economic importance of the disease in humans, establish a needs priority and determine the feasibility of undertaking control measures.

In terms of strategic approach, the following option can be used in which control is based on long term interventions:

- Veterinary Public Health education;
- Modernization of pig husbandry practices;
- More efficient and all inclusive coverage of meat inspection; and
- Establish active surveillance and treatment for taeniasis: detect and treat tapeworm carriers. According to Flisser *et al*., (2003), results of epidemiological studies indicate that control measures should be focused on the tapeworm carrier.

Free ranging of pigs is considered as one of the risk factors for porcine cysticercosis, and it is, therefore, imperative to find ways to keep the pigs enclosed. It is necessary to solve the feed problems before the farmer can be convinced that he should not let his pigs roam around freely.

The following scenarios have been proposed by Lekule and Kyvsgaard, (2003), as possible strategies for the development of the pig industry in resource poor communities and supported:

- Development of feed strategies for low income communities based on cheap feed stuff locally available such as leaf meals, grain by-products, etc.
- Dissemination of simple, relevantly designed pig house suited to and affordable for poor rural population i.e., cheap houses featured by ample sanitation, dry floor, dry bedding, good ventilation and hygienic conditions to control parasites and pathogens affecting pigs.
- Providing sufficient institutional support to the industry to ensure proper control programmes.

The same authors further asserted that, such support programmes should not only be limited to meat inspection, but should also include goodwill creating activities within the prevention of epidemic disease such as African swine fever.

Farmers need access to information regarding disease control and livestock management, supporting their ability to decide where to invest their resources to increase production-

productivity and improve veterinary public health. A pig training course needs to be offered to the farmers.

On the 24 October 2004 during a farmer's meeting, an action planning exercise was done on ways to educate farmers about control of the taeniasis/cysticercosis complex. The farmers chose this as a priority during a meeting that was an action planning workshop in terms of a participatory rural appraisal strategy advocated by McCrindle *et al*., (1994). Farmers were divided into five groups with a chairperson facilitator and a reporter. The facilitator then asked each person in the group to give one idea on the subject and this was written down by the reporter. This is the "brainstorming" session which makes sure everyone participates at least once. The reporter from each group reported back to a combined "plenary session". The ideas from each group were then crystallized out into objectives and prioritized into a way forward by means of a series of action plans.

Action Plan Group 1

WHAT	**WHO**	**WHEN**
Kraal erection	Owners	As soon as possible
Hygiene in place for pigs	Owners	As soon as possible
Sanitation- human toilets and basins	Owners	As soon as possible
Inspect kraals and animals	Owners	Weekly
Cook meat well	Everyone	Always

Action Plan Group 2

WHAT	**WHO**	**WHEN**
Fence	Owner	As soon as possible
Cook meat for $1^{1/2}$ hours	Everyone	Always
Must have toilets	Owners	Always
Clean hands	Everybody	Every time
Go to clinic	If infected	When clinic opens
Proper drainage for kraals	Owners	4 times a year

Action Plan Group 3

WHAT	WHO	WHEN
Proper kraals	Owner	Before you buy pigs
Inspect meat before slaughter	Owner	Prior to slaughter
Proper toilets	Owner	As soon as possible
Feeding pigs properly	Owner	Always
Buy inspected meat	Community	As much as possible
Cook well, boil then braai	Everyone	All the time
Clinic	Infected people	When clinic opens
Wash hands	Everyone	All the time

Action Plan Group 4

WHAT	WHO	WHEN
Proper fencing	Owner	When have pigs
Good nutrition and water for pigs	Owner	Always
Clean kraals	Owner	Always
Meat inspection	Meat inspector/ Veterinarian/ AHT	During slaughter
Wash hands	Everyone	Before working with food
Good cooking	Cooker	Every time

Action Plan Group 5

WHAT	WHO	WHEN
Kraals	Owner	As soon as possible
Inspect live pigs	AHT/Veterinarian	If suspect infection
Clinic	Everyone if suspicious	When clinic open
Submit stool sample	Everyone	When given bottle
Public toilets	Community	As soon as possible
Proper cooking	Community	Always
Wash hands	Community	Before eating

On completion of the “plenary session”, all participants were invited to brain storm the question “What must a veterinary official do to assist the community in the control of the taeniasis/cysticercosis complex?” Arising from this the final Action Plan was formulated as follows:

WHAT	**WHO**	**WHEN**
Regular visit to pig owners	Veterinary official	Monthly
Check infrastructure	Veterinary official	When necessary
Community workshops	Veterinary official Health officer	During community meetings held by tribal offices

Chapter 6

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ANNEXURE A: QUESTIONNAIRE FOR FARMERS

A. BASIC INFORMATION

FOR OFFICE USE ONLY

Respondent Number — V_1 ☐☐☐ 1-

		V_2 ☐ 4
Name of village	Barseba	1
	Makolokwe	2
	Modikwe	3
	Bethanie	4

Name & Surname of person

Gender — Male 1 | Female 2 — V_3 ☐ 5

Age……..Years — V_4 ☐☐ 6-7

		V_5 ☐ 8
What language do you speak? (Home language)	Setswana	1
	Xhosa	2
	Zulu	3
	Other	4

Person	No		
Adult Male(>18)		V_6	☐☐ 9-10
Adult Female (>18)		V_7	☐☐ 11-12
Boys		V_8	☐☐ 13-14
Girls		V_9	☐☐ 15-16
Babies		V_{10}	☐☐ 17-18

Number of persons in household

Highest educational level of respondent

1	2	3	4	5		
None	Primary School	Secondary School	Matric	Tertiary	V_{11}	☐ 19

Primary employment of respondent

1	2	3	4	5	6		
None	Full time farming	Own business	Mining	Industry/ State	Pension	V_{12}	☐ 20

Electricity

1	2
Yes	No

V_{13} [ ] 21

Waterborne toilet

1	2
Yes	No

V_{14} [ ] 22

Pit toilet

1	2
Yes	No

V_{15} [ ] 23

Water

1	2	3
Reticulated	Borehole	Surface

V_{16} [ ] 24

V_{17} [ ] 25

B. QUESTIONS

FOR OFFICE USE ONLY

Data on pig production

1. Do you keep pigs?

1	2		
Yes	No	V_{18}	26

2. If yes, how many?…… V_{19} 27-28

3. Number of years involved in farming?……years V_{20} 29-30

4. Who looks after the animals?

1	2	3	4	5		
Owner	Children	Wife	Other family member	Friend/neighbours	V_{21}	31
					V_{22}	32

5. What breed of pigs do you rear?

Duroc	1	V_{23}	33
Large white	2	V_{24}	34
Cole brook	3	V_{25}	35
Land race	4	V_{26}	36
Cross	5	V_{27}	37
Indigenous	6	V_{28}	38

6. Reasons for keeping pigs?

1	2	3	4		
Commercial sale	Tradition	Food security	Owning pigs	V_{29}	39
				V_{30}	40

7. Do they roam?

1	2		
Yes	No	V_{31}	41

8. What do you normally feed?

Commercial pig meal	1	V_{32}	42
Slurry/swill/husks	2	V_{33}	43

9. Do you buy extra feed for the pigs?

1	2		
Yes	No	V_{34}	44

10. If yes, what feed is given to slaughter pigs?

Grower meal	1	V_{35}	45
Finisher meal	2	V_{36}	46

11. Do you use medications?

1	2		
Yes	No	V_{37}	47

\kig23

12. If yes, what do you use?

Antibiotics	1	V_{38}	48
Vaccines	2	V_{39}	49
De wormer	3	V_{40}	50
Dips	4	V_{41}	51

13. If not why?

Too expensive	1	V_{42}	52
Not available	2	V_{43}	53
Not required	3	V_{44}	54
Money devoted to pig purchase	4	V_{45}	55

14. How many pigs died during last year? V_{46} 56

15. What did the pigs die of?

Malnutrition	1	V_{47}	57
Skin Conditions	2	V_{48}	58
Worms	3	V_{49}	59
Heat Stroke	4	V_{50}	60
Diarrhoea	5	V_{51}	61
Do not know	6	V_{52}	62

16. What happens to animals that have

People eat them	1	V_{53}	63
Dogs eat them	2	V_{54}	64
Bury them	3	V_{55}	65

Burn them	4	V_{56}		66
People sell the meat	5	V_{57}		67

Data on housing for pigs

17. What construction do you use for building a kraal?

Thorn bushes	1	V_{58}		68
Wood	2	V_{59}		69
Wire	3	V_{60}		70
Scrap iron	4	V_{61}		71
Rocks	5	V_{62}		72

18. Is it foolproof in preventing roaming?

1	2			
Yes	No	V_{63}		73

19. If no, do the pigs have access to human faeces?

1	2			
Yes	No	V_{64}		74

Data on Marketing

20. Do you buy pigs?

1	2			
Yes	No	V_{65}		75

21. From whom/ where do you buy pigs?

Commercial pig farmer	1	V_{66}		76
Local pig farmer	2	V_{67}		77
Auction	3	V_{68}		78
Friends	4			
Neighbour	5			

22. How many pigs did you buy over the last year?…… V_{69} | | | 79-80

1	2	V_{61}			86-87

23. Where do you sell your pigs?

Locally	1	V_{70}	81
Auction sale	2	V_{71}	82
Abattoir	3	V_{72}	83
Friend/Neighbour	4	V_{73}	84

24. How many pigs were sold during last year?

Number		V_{74}	85-86
Average price per head in ZAR	R	V_{75}	87-88

25. Do you think that the price of pigs is fair?

1	2		
Yes	No	V_{76}	89

26. If not, what do you think is a fair price in Rands?……R V_{77} 90-91

27. Do you want to sell more pigs?

1	2		
Yes	No	V_{78}	92

28. Is it difficult to sell pigs?

1	2		
Yes	No	V_{79}	93

29. What is you vision of owning pigs in the future?

More pigs	1	V_{80}	94
Better pigs	2	V_{81}	95
Stay as I am	3	V_{82}	96

30. Where do you slaughter pigs?

Informally	1	V_{83}	97
In abattoir	2	V_{84}	98

31. Any meat inspection?

1	2		
Yes	No	V_{85}	99

32. If no, for what reason

No access to meat inspection	1	V_{86}		100
Too far from abattoir	2	V_{87}		101
Abattoir condemns pigs	3	V_{88}		102
Lack of knowledge	4	V_{89}		103
Not important	5			

33. Do you sell pigs to specific people?

1	2			
Yes	No	V_{90}		104

34. If yes, to whom

Family	1	V_{91}		105
Friends	2	V_{92}		106
Neighbour	3	V_{93}		107
Villager	4	V_{94}		108
Stranger	5	V_{95}		109

ANNEXURE B: NON-INTERVENTION RESEARCH and CONSUMER QUESTIONNAIRE

Consumer Information Leaflet and Informed Consent

Title of Study

Neurocysticercosis: A Possible Cause of Epileptiform Fits in People Residing in Villages Served by the Bethanie Clinic in the North West Province

Introduction

You are invited to volunteer for a research study. This information leaflet is to help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved. You may at any time withdraw from this study.

The Nature and Purpose of this Study

The aim of this study is to evaluate the possibility that the consumption of pork from pigs raised and consumed in rural areas around the Bethanie clinic contributes to some people in the selected population suffering from seizures. Information will be collected leading to a possible health programme aimed at the control of the condition through an understanding of the risk factors.

Explanation of what Procedures will be followed

This study involves a survey by structured questionnaire. You will be asked some questions with regard to your consumption of pork and eating habits, sanitation practices and knowledge of the tapeworm. You will be asked to voluntarily collect a stool sample from yourself, which will be submitted for tapeworm screening by an expert.

Discomfort Involved

The only possible discomfort involved is in the collection of your own stool sample into the specimen container provided, a procedure that will be explained to you.

Benefits of this Study

The study will provide essential information on:

Whether or not the tapeworm is a problem in the different villages in the area where you live

How to educate people into protecting themselves against the tapeworm

Information

If you have any questions concerning this study, you should contact:

Professor Veary at telephone: 529 8015 or cell: 083 680 8285

Has the Trial Received Ethical Approval?

The Protocol for this research was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, and that committee has granted written approval.

What are my Rights as a Participant in this Trial?

Your participation in this trial is entirely voluntary and you can refuse to participate or stop at any time without stating any reason. Your withdrawal will not affect your access to medical care.

Confidentiality

All information obtained during the course of this study is strictly confidential. Data that may be reported in scientific journals will not include any information that identifies you as a volunteer in this project. Results will be published or presented in such a fashion that you remain unidentifiable.

Any information uncovered regarding your test results or state of health as a result of your participation in this project will be held in strict confidence.

Consent to Participate in this Study

You must confirm that you have read or have had read to you in a language that you understand the above information before signing this consent form. You must confirm that you have had the content and meaning of this information explained to you. You must confirm that you have been

given opportunity to ask questions and are satisfied that they have been answered satisfactorily. You hereby volunteer to take part in this study in the knowledge that once given, consent cannot be revoked as it will be non-traceable.

.....	.....
Volunteer signature	Date
.....	.....
Person obtaining informed consent	Date
.....	.....
Witness	Date

QUESTIONNAIRE FOR CONSUMERS

BASIC INFORMATION

FOR OFFICE USE ONLY

Respondent Number — V_1 [ ][ ][ ] 1-3

Name of village — V_2 [ ] 4

Barseba	1
Makolokwe	2
Modikwe	3
Bethanie	4

Name & Surname of person & house number……w……

Gender — V_3 [ ] 5

Male	1	Female	2

Age……Years — V_4 [ ][ ] 6-7

What language do you speak (Home language) — V_5 [ ] 8

Setswana	1
Xhosa	2
Zulu	3
Other	4

No. of persons in household

Person	No.		
Adult Male (>18)		V_6	[ ][ ] 9-10
Adult Female (>18)		V_7	[ ][ ] 11-12
Boys		V_8	[ ][ ] 13-14
Girls		V_9	[ ][ ] 15-16
Babies		V_{10}	[ ][ ] 17-18

Educational level of respondent

1	2	3	4	5		
None	Primary School	Secondary School	Matric	Tertiary	V_{11}	[ ] 19

Primary employment of respondent

1	2	3	4	5	6	7		
None	Full time farming	Own business	Mining/ Quarry	Industry/ State	Pension	Municipality/ NGO	V_{12}	[ ] 20

Electricity

1	2
Yes	No

V_{13} [ ] 21

Waterborne toilet

1	2
Yes	No

V_{14} [ ] 22

Pit toilet

1	2
Yes	No

V_{15} [ ] 23

Water

1	2	3
Reticulated	Borehole	Surface

V_{16} [ ] 24

V_{17} [ ] 25

QUESTIONS

FOR OFFICE USE ONLY

1. Were you a permanent resident of one of the following villages from 1999 to 2003?

Barseba	1	V_{18}		26
Makolokwe	2			
Bethanie	3			
Modikwe	4			

2. Have you left and stayed away from the village during this time? **[see now question 10]**

1	2			
Yes	No	V_{19}		27

3. If yes, how often?

Daily	1	V_{20}		28
Every week	2	V_{21}		29
Every month	3	V_{22}		30
Every year	4			
Frequently	5			
Sometimes	6			

4. If yes, for how long in days?

Daily the whole day	1	V_{23}		31-32
Every week……days	2	V_{24}		33-34
Every month……..days	3	V_{25}		35-36
Every year…….days	4			
Frequently…….days	5			
Sometimes	6			

5. If yes, why?

Work	1	V_{26}		37
Funerals/Weddings	2	V_{27}		38
Visit	3			
Holiday	4			
Church	5			
Illness	6			
School	7			

6. Do you or **any person in the household** eat pork?

1	2			
Yes	No	V_{28}		39

7. If Yes, where/from whom do you get the meat?

Own/Local slaughter	1	V_{29}		40
Street vended pork meat	2	V_{30}		41
Supermarket butcheries	3			

8. How many people in the household eat pork? V_{31} | | 42-43

9. How often do you or **any person in the household** eat pig meat?

Daily	1	V_{32}		44
Weekly	2			
Fortnightly	3			
Monthly	4			
Sometimes	5			

10. While away, did you eat pig meat from informal slaughter?

1	2			
Yes	No	V_{33}		45

11. How do you cook (prepare) your pig meat?

Raw	1	V_{34}		46
Undercooked	2	V_{35}		47

Boiling	3
Roasting	4

12. For how long do you cook/prepare your pig meat - time in minutes?

V_{36} [ ][ ][ ] 48-50

13. Have you seen 'water filled cysts' in pig meat?

1	2
Yes	No

V_{37} [ ] 51

14. If yes, what did you do with the meat?

Ate the meat	1	V_{38}	[ ] 52
Dogs ate the meat	2	V_{39}	[ ] 53
Discarded the meat	3		
Sold meat to other persons	4		

15. Do you buy vegetables?

1	2
Yes	No

V_{40} [ ] 54

16. If yes, where/from whom do you buy/get your vegetables?

Vegetable market	1	V_{41}	[ ] 55
Supermarket	2	V_{42}	[ ] 56
Own Grown	3	V_{43}	[ ] 57
Street vended	4		
Friends/neighbours	5		

17. Who usually prepares the food in the household/home?

Head	1	V_{44}	[ ] 58
Wife	2	V_{45}	[ ] 59
Son	3		
Daughter	4		
Brother	5		
Sister	6		
Parent	7		

Self	8
Daughter-in-law	9

18. How do you cook/prepare your vegetables?

Raw	1	V_{46}	60
Undercooked	2	V_{47}	61
Boiled	3		
Roasted	4		

19. Do you know what a tapeworm is?

1	2		
Yes	No	V_{48}	62

20. Has anyone in your family seen/been treated for tapeworm?

1	2	3		
Yes	No	Do not know	V_{49}	63

21. If yes, how many? V_{50} 64-65

22. Would you be prepared to collect your own stool sample to have it screened for tapeworms?

1	2		
Yes	No	V_{51}	66

23. Is there any history of seizures in your family members?

1	2		
Yes	No	V_{52}	67

24. If yes, how many people are affected?……..Number V_{53} 68-69

25. Did they ever go to Bethanie Clinic?

1	2		
Yes	No	V_{54}	70

26. Has this person ever eaten pork/pig meat?

1	2

Yes	No	V_{55}		71

27. Do you always wash your hands before eating?

1	2	3			
Always	Sometimes	Never	V_{56}		72

28. Have you ever been exposed to herbal medication/muti?

1	2			
Yes	No	V_{57}		73

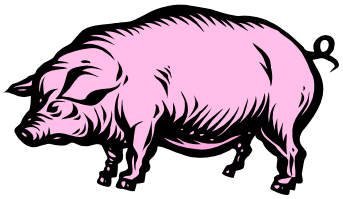
29. If yes, where do you get it?

Traditional healers	1	V_{58}		74
Prophets	2	V_{59}		75
Self-prepared	3			
Muti Shop	4			

2005/10/05

ANNEXURE C: INFORMATION DAY PROGRAMME

BETTER PIG FARMING



SAFER PIG MEAT

Date: Friday 25 November 2005

Venue: Bethanie Community Hall, Brits, North West Province

Sponsors: K. Birch Trust, Rand Merchant Bank

Programme:

Master of Ceremonies: Mr. Malebana/Mr Moloisane

10:00 -10:10:	Opening of farmers day by prayer
10:10 -10:25:	Introduction of Guests: Mr SN Manoto
10: 20 -10:35:	Opening: Mr. J Mamogale (Headman)
10:35 -10:45:	Purpose of the meeting: Mr. Manoto
10:45 -11:0:	Taeniasis/Cysticercosis: an overview of the disease: Professor CM Veary
11:00 -11:15:	Outline of the research project: Mr. Manoto
11:15 -14:00:	Completion of questionnaire
14:00 -14:40:	**LUNCH**
14:40 -14:45:	Vote of thanks: Mr. J Mamogale
14:45 -16:30:	Completion of questionnaire

ANNEXURE D: RETROSPECTIVE DESCRIPTIVE ANALYSIS OF MEDICAL RECORDS

PATIENT	PLACE OF ORIGIN	AGE (YRS)	SEX	OCCUPATION	CLINICAL PRESENTATION	TREATMENT	CT/MRI	REFERRAL/RECOVERY
1	Modikwe	56	F	Pensioner	Epileptic psychosis	Carbamazepine Tegretol		
2	Modikwe	53	F	N/A	Epileptic seizures	Carbamazepine Tegretol Phenytoin		
3	Modikwe	38	F	Unemployed	Epileptic seizures	Carbamazepine Tegretol		
4	Modikwe	23	M	N/A	Epileptic seizures	Carbamazepine Tegretol		
5	Modikwe	33	M	Unemployed	Epilepsy	Carbamazepine Tegretol		
6	Modikwe	47	F	N/A	Epilepsy	Carbamazepine		Death
7	Modikwe	36	M	Unemployed	Epilepsy	Carbamazepine Tegretol		
8	Modikwe	45	M	Unemployed	Epileptic psychosis	Tegretol		Brits Hospital
9	Modikwe	53	M	Unemployed	Post traumatic epilepsy	Phenytoin	CT scan No:4959/87	Ga-Rankuwa Hospital
10	Modikwe	60	F	N/A	Epileptic attacks	Phenytoin		
11	Modikwe	43	M	N/A	Epilepsy Psychosis Styphomania	Carbamazepine Tegretol		Ga-Rankuwa Hospital
12	Modikwe	32	M	Unemployed	Epilepsy Psychosis	Carbamazepine		From Brits Hospital

13	Makolokwe	42	F	Unemployed	Epilepsy	Carbamazepine Tegretol		Appears mentally retarded
14	Makolokwe	26	F	Unemployed	Epilepsy	Carbamazepine Tegretol S-Phenytoin		
15	Makolokwe	21		N/A	Epilepsy	Carbamazepine Tegretol		
16	Makolokwe	52	F	Unemployed	Epilepsy	Tegretol		Transferred from Brits Hospital
17	Makolokwe	51	F	Unemployed	Epilepsy Psychosis	Chloropromadine Carbamazepine		
18	Bethanie	54	M	N/A	Epilepsy	Carbamazepine Carbomoxypin		General practitioner Dr. H. H Wenhold Still gets epileptic seizures
19	Bethanie	16	F	Sholar	Epilepsy	Tegretol S-Carbamazepine		Had epileptic seizure at school
20	Bethanie	13	M	Scholar	Epilepsy	Phenobarbitone		
21	Bethanie	56	F	Unemployed	Epilepsy	Tegretol		
22	Bethanie	54	M	Pensioner	Epilepsy	Tegretol Carbamazepine		Transfer from Brits Hospital as an epileptic patient Repeated attacks
23	Bethanie	39	M	Unemployed	Epilepsy	Carbamazepine Tegretol		
24	Bethanie	44	M	Unemployed	Epilepsy	Phenytoin		
25	Bethanie	34	M	Unemployed	Epilepsy	Carbamazepine	Special investigation (brain) recommended CT scan	Back from Ga-Rankuwa Hospital

26	Bethanie	44	F	N/A	Epilepsy	Carbamazepine		Transfer from Brits Hospital
27	Bethanie	53	F	N/A	Epilepsy	Tegretol		
28	Bethanie	54	F	Unemployed	Epilepsy	Epamutin Phenytoin		
29	Bethanie	16	M	N/A	Epilepsy	Phenobarb		
30	Bethanie	55	M	Unemployed	OBS and Epilepsy	Carbamazepine Tegretol Thiamine		Referred from Sterkfontein
31	Bethanie	39	M	N/A	Epilepsy	Carbamazepine Phenobarb		Neurology clinic Ga-Rankuwa Hospital Brits Hospital for assessment Death of patient
32	Bethanie	19	F	Scholar	Epilepsy	Carbamazepine Phenobartone		
33	Bethanie	34	F	Unemployed	Epilepsy	Carbamazepine		
34	Bethanie	13	F	Scholar	Epilepsy	Sodium valproate		
35	Bethanie	43	M	Unemployed	Epilepsy	Carbamazepine		
36	Bethanie	N/A	M	Builder	Epilepsy	Phenytoin Tegretol		Back from Ga-Rankuwa Hospital for review of epilepsy
37	Bethanie	37	F	Unemployed	Epilepsy	Phenobarb Tegretol		
38	Berseba	49	M	Unemployed	Epilepsy	Epamutin Phenytoin		Referred from Brits Hospital for collection of treatment

39	N/A	50	M	N/A	Post traumatic epilepsy	Phenytoin		Neurology discharge from Ga-Rankuwa Hospital
40	N/A	10	F	N/A	Epilepsy	Carbamazepine Tegretol		
41	Bethanie	54	F	N/A	Long standing epilepsy	Carbamazepine	CT scan Brain- generalized atrophy	Ga-Rankuwa Hospital Neurology discharge form
42	Modikwe	71	M	N/A	Epilepsy	Tegretol		
43	Modikwe	36	M	N/A	Epilepsy	S-Carbamazepine		Defaulted
44	Bethanie	25	F	N/A	Epilepsy	Phenytoin		Defaulted
45	N/A	44	M	N/A	Epilepsy	Phenytoin		

ANNEXURE E: PREVALENCE OF HUMAN TAENIASIS

Stool Samples: Volunteers

Localities (n=4)	Subject number (=38)	Pork consumption status	Fits	*Taenia solium* ova
Makolokwe	053	Yes	No	Not observed
Makolokwe	105	Yes	No	Not observed
Makolokwe	116	Yes	No	Not observed
Makolokwe	145	Yes	No	Not observed
Makolokwe	146	Yes	No	Not observed
Makolokwe	168	Yes	No	Not observed
Makolokwe	171	Yes	No	Not observed
Makolokwe	186	Yes	No	Not observed
Berseba	022	Yes	No	Not observed
Berseba	025	Yes	Yes	Not observed
Berseba	029	Yes	No	Not observed
Berseba	047	No	No	Not observed
Berseba	063	No	No	Not observed
Berseba	070	Yes	No	Not observed
Berseba	075	No	No	Not observed
Berseba	097	No	No	Not observed
Berseba	102	Yes	Yes	Not observed
Berseba	103	Yes	No	Not observed
Berseba	108	No	No	Not observed
Berseba	121	Yes	No	Not observed
Berseba	138	Yes	No	Not observed
Berseba	143	Yes	No	Not observed
Berseba	166	Yes	No	Not observed
Berseba	167	Yes	No	Not observed
Berseba	189	Yes	No	Not observed
Berseba	198	Yes	No	Not observed
Berseba	200	Yes	Yes	Not observed
Berseba	201	Yes	No	Not observed
Berseba	202	Yes	No	Not observed
Bethanie	084	Yes	Yes	Not observed
Bethanie	107	Yes	Yes	Not observed
Bethanie	137	No	No	Not observed
Bethanie	141	Yes	No	Not observed
Bethanie	162	Yes	Yes	Not observed
Bethanie	194	Yes	No	Not observed
Bethanie	197	Yes	Yes	Not observed
Bethanie	223	Yes	No	Not observed