

## Neurocysticercosis: a possible cause of epileptiform seizures in people residing in villages served by the Bethanie clinic in the North West Province of South Africa

C M Veary<sup>a\*</sup> and S N Manoto<sup>a</sup>

### ABSTRACT

A study to detect human taeniasis and cysticercosis was conducted in 4 village communities served by the Bethanie clinic in the North West Province, based on reports of people being diagnosed there with epileptiform episodes. Many home owners in the villages rear pigs in small numbers for both meat availability and an immediate income from live pig or pig meat sales. The primary aim of the work was 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. The former reviewed pig husbandry practices, slaughter and marketing of pigs and the latter provided information on pork consumption, sanitation as well as people's basic knowledge of *Taenia solium*. Stool samples from consenting participants were screened by a contracted approved laboratory for *T. solium*. A descriptive analysis of retrospective data was conducted at the Bethanie clinic 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. In addition, the total pig population in the study area was determined more accurately and the prevalence of cysticercosis investigated in pigs subjected to meat inspection at an approved abattoir. 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 and owning pigs and those that did not. There is a strong evidence of a tendency towards an association between epilepsy, consumption habits and some identified epidemiological risk factors.

**Key words:** structured questionnaire survey/census, *Taenia solium*, cysticercosis, taeniasis, epidemiological risk factors, North West Province, South Africa.

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### INTRODUCTION

*Taenia solium* is a serious public health and agricultural problem in eastern and southern Africa (ESA)<sup>11</sup>. 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<sup>20</sup>. Its burden is counted in terms of human disease, mainly neurocysticercosis, a very serious zoonosis causing headache, epileptic seizures, epilepsy, mental disturbance and death<sup>17</sup>. Cysticercosis is endemic to 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 epidemiological variables<sup>21</sup>.

The actual prevalence of cerebral cysticercosis in South Africa is not known, but a study of crude figures in one area relating numbers of each tribe employed with numbers of cases suggests that it is twice as common among the Xhosa people as in other groups, possibly owing to the commonness of the free-ranging of pigs in Transkei and Ciskei<sup>2</sup>. Carabin and co-authors quoted an early report from abattoirs in South Africa indicating that 0.50–25.7 % of pigs were infected<sup>4</sup>. They also record that more recent hospital surveys utilising serological and radiological diagnostic techniques have indicated that 28–50 % of epileptics, predominantly African and many children, were positive

for this parasite<sup>4</sup>. The populations at highest risk are located in rural areas, where scavenging pigs have access to human faeces and people eat undercooked pig meat<sup>5</sup>. The *T. solium* taeniasis-cysticercosis complex is associated with poor sanitation and hygiene, poor methods of pig husbandry and poor meat inspection and control. The majority of pig keeping in the eastern and southern Africa (ESA) region is free-range but if housed, the housing is poorly built and allows pigs to break out at will<sup>16</sup>.

Krecek and Waller re-affirmed that humans acquire taeniasis when eating raw or undercooked pork contaminated with cysticerci, the larval form of *T. solium*<sup>10</sup>. 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. Human neurocysticercosis (NCC) occurs when the cysts develop in the brain<sup>11</sup>. This leads to blindness, epilepsy, madness and death. NCC can also occur in individuals that do not raise pigs or consume pork.

Mafojane *et al.* 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<sup>11</sup>. In response to this need, this community based study of the taeniasis-cysticercosis complex was carried out in humans and pigs in the selected populations with the aim of quantifying for the 1st time the nature and extent of the problem in the North West Province. It investigates risk factors in order to allow for the formulation of recommendations on appropriate control measures. The study area focused on the Bethanie clinic, situated in the village of Bethanie in the Bojanala region of the North West Province and selected because of reports by the health professionals of people with epilepsy in the surrounding 4 villages. The

<sup>a</sup>Department of Paraclinical Sciences, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort, 0110 South Africa.

\*Author for correspondence:  
E-mail: tubby.veary@webchamp.co.za

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clinic provides all the outpatient care for the human population in the 4 surrounding villages, where the total population according to Statistics South Africa census 2001 was 13 916. It is currently undergoing a rural–urban transition, and has a population pyramid resembling that of a developing community.

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, 4 in 5 households in these communities farmed with pigs and ate pig meat during ceremonies or as normal consumption practices. Most pigs are raised and then slaughtered for own consumption or sold informally, with little or no sanitary inspection. Preliminary interviews showed that rural pork producers in the villages are not motivated to sell pigs through recognised abattoirs with meat inspection services because of the risk of losing all through condemnation of the carcasses.

## MATERIALS AND METHODS

The study design involved a cross-sectional study, undertaken to estimate the prevalence of human taeniasis-cysticercosis and porcine cysticercosis by investigating identified epidemiological risk factors. The primary objectives were, by means of structured questionnaires, to conduct a census of land owners with pigs for information on pig husbandry practices, slaughter and marketing of pigs, and a survey of consumers for information on pork consumption habits, sanitation practices and consumer understanding of the potential public health implications of *T. solium*. Stool samples from consenting participants were screened by a contracted approved laboratory for *T. solium*. A descriptive analysis of retrospective data was conducted at the Bethanie clinic 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<sup>12</sup>.

For the household or consumer survey a sample of 1042 families, including farmers (7.5 %), was selected through a stratified non-probability purposive method from all the families identified in the community census 2001. This identified that the population comprised 1570 people in Berseba (459 households), 1662 in Makolokwe (549), 3498 in Modikwe (1003) and 7186 in Bethanie (2392) respectively. 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 randomly 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 and was based on a 50 % presumption of pork consumption and a 95 % confidence level. The following randomly generated sample sizes were selected for each village: Berseba 207, Makolokwe 226, Modikwe 278 and Bethanie 331 – totalling 1042 households.

Invitations were then hand delivered to these randomly selected households to attend a meeting convened in the form of a K. Birch Trust Fund (Veterinary Faculty, University of Pretoria)-sponsored information day on the taeniasis-cysticercosis complex to assess the local knowledge of both taeniasis and cysticercosis infestations. An educational intervention included explanations of the life-cycle, the disease, the risk factors and the control measures. The intention was to improve knowledge levels, attitudes and practices of community members by veterinary public health education with community participation. The meeting also determined who farms with pigs and where their farms were situated ( $n = 35$ ). The resultant purposive sampling method was used to select all the farmers for a census by a structured questionnaire.

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

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 selecting to determine disease<sup>3</sup>.

A retrospective descriptive 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 analysed. Descriptive statistics were determined and the chi-square test was used to determine the significant difference between categorical variables. 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).

## RESULTS

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

Cross-factor association analysis revealed some distinct tendencies for a factor to be associated with a higher percentage of seizures within household units, but the 95 % confidence limit testing did not provide statistical support for these trends. It was shown 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 with 61 or 7.34 % with a family size ranging from 1–5 (considered to be normal). For normal households (in the whole population), the proportion of seizures (estimated from the sample) is 4.9–8.7 %, but for crowded households the proportion is 5.8–16.1 %. This concurs with the findings of Widdowson *et al.* who showed that crowded households may be a marker for poorer socio-economic conditions and added problems of personal hygiene<sup>22</sup>.

The information given in Table 1 suggests a tendency for a higher percentage of seizures in consumers with no formal education, possibly due to a lack of knowledge or understanding of potential public health dangers of *T. solium*.

Questionnaires have shown that a reliable diagnosis of taeniasis can be achieved by asking people if they had passed tapeworm segments<sup>8,9,18,19,20</sup>,

Table 1: History of seizures according to 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

thereby facilitating the identification and treatment of tapeworm carriers. The results of this survey indicate a tendency for a higher percentage of seizures in consumers that have seen or been treated for tapeworms (10.26 %), but this was again not supported statistically. Also not supported statistically was the indication that a higher number of respondents (8.4 %) reported seizures in a family that had been exposed to herbal medication or 'muti', *vis-à-vis* those who had not.

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 thus too small to allow for a meaningful statistical analysis of the outcomes. There are trends that arise from the analysis of the response to questions in the questionnaire.

In an analysis of herd size, type and management of pigs it was found that a total of 238 pigs were kept by the 35 respondents, as indicated in Fig. 1. 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 10 farmers (28.6 %) envisaged a future where it would be possible to expand into commercial pig farming.

On visiting these rural areas, it would appear that up to 40 % of the farmers leave their pigs to wander freely (extensive circumstances) and scavenge freely amongst the households for food. The impression created by the response to the questionnaire, however, is that most farmers ( $n = 32$ ) feed their pigs with slurry/swill/husks, with at least 6 farmers supplementing their pig rations with commercial feed. Of the 35 pig-owning households visited, 17 or 49 % said that their pigs had access to human faecal material, substantiating a poor infrastructure and standard of living.

By far the majority of people interviewed ( $n = 25$ ) bought their pigs from the local farmer, 4 bought from either a friend or a neighbour and 7 said that they bought their pigs from a recognised commercial farmer source. Regarding the selling of pigs, it is noteworthy that market expectations for the farmers is not high as pigs are rarely sold commercially, with the only market available being to other local farmers or community members. Only 24 farmers or 68.53 % could give accurate information as to where they dispose of pigs outside of the village communities. Most of the farmers ( $n = 13$  or 37.14 %) sell their pigs locally (see Table 2).

Data on the slaughtering of pigs indi-

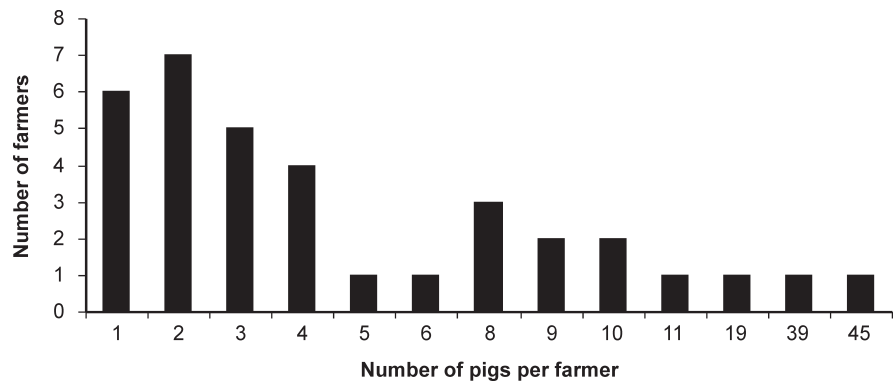


Fig. 1: Number of pigs per farmer ( $n = 35$ ).

Table 2: 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

cated that only 28 respondents or 80 % of the original owners of pigs could give any information on how they dispose of their animals. Only 2 of the respondents had sent pigs to an abattoir with 26 or 92.9 % slaughtering their animals informally for local consumption.

Only 34 pigs from 10 households within the 4 villages could be negotiated with the owners for slaughter and *post mortem* examination by primary meat inspection at a nearby approved and registered abattoir. Routine primary meat inspection revealed that all 34 pigs slaughtered were negative for cysticercosis.

From the community surveyed, a total of 55 stool specimens was collected from volunteers from the 4 villages. Of the volunteers, 32 had consumed pork originating from informal slaughter, but all of the submitted stool samples proved to be negative for parasites or eggs (ova) on microscopic examination as per the laboratory SOPs.

Of the 1031 individuals questioned during the survey, 80 admitted to having been diagnosed with an epileptiform type insult, a prevalence of 7.8 % of the population. These 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. Results from other endemic areas in Africa have indicated a strong relationship between cysticercosis and epilepsy<sup>13</sup>.

In a retrospective descriptive analysis of clinical data, previous Bethanie clinic records of epileptiform insults diagnosed

from the study area were reviewed. In this study 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 and with male patients marginally in the majority (51.1 %). The observed clinical manifestations revealed that 37 (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. Noticeable in all the medical records was the lack of the use of more specific terms to describe the epileptiform seizures. There were no specific records of human neurocysticercosis cases and the associated proportional morbidity could therefore not be determined<sup>12</sup>. On enquiry, all the community health workers at the clinic exhibited total ignorance of the public health significance of the taeniasis-cysticercosis complex.

## DISCUSSION

Statistics on the cysticercosis problem in South Africa are derived from abattoir data on pigs, which may not reflect the true situation in rural communities. Rural areas in South Africa have never been serviced properly in terms of meat inspection, as commercial slaughtering was carried out 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. The incidence data for cysticercosis-taeniasis in humans is very limited owing to a lack of adequate surveillance, monitoring and reporting systems.

It was demonstrated that in the rural areas in question, pigs are generally maintained under extensive circumstances and allowed to roam freely amongst the households to scavenge for food. 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. The questionnaire census revealed poor pig husbandry practices, absence of meat inspection and no control of informal slaughter in the surveyed villages. In cases where the cysts are detected at slaughter, the meat is well cooked and eaten, sold locally for consumption or used for soda soap processing out of the fat content. Asked why they would not subject their pigs to formal meat inspection, the majority ( $n = 25$ ) indicated that they do not have access to a meat inspection service.

Routine primary meat inspection revealed that all 34 pigs slaughtered were negative for cysticercosis. The project design was to sample pigs from all the selected farmers with 60 pigs ( $n = 60$ ) to be selected on a *pro rata* basis and proportionately from each herd/village. This did not happen as the interval between negotiation and purchase was too long, with farmers now having too few pigs to sell or the pigs having died in the interim, been eaten or sold.

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.* showed that this is not surprising given the fact that there is a lot of social interaction between houses, with people visiting each other<sup>3</sup>. 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 there was no specific diagnosis made from medical records, and secondly because of the low number of households with a history of seizures. It was never anticipated that a predominantly infested human population would be found in the villages surveyed.

However, 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.

Farming (pig factors) include the free-roaming management of pigs which is predominant in the communities surveyed and has been described as a major risk factor relating to the transmission of eggs (proglottids) to pigs<sup>7</sup>. 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. In the main, poorly built pig containing structures allow pigs to break out at will.

Household or consumption factors identified in the survey include a house history of taeniasis (as evidenced by recognition of faecal excretion of proglottids) and in many cases of epileptiform seizures. Furthermore, there is a predominant consumption of uninspected pig meat from self-owned pigs which is undoubtedly a major potential source of human taeniasis. Living conditions reveal considerable overcrowding of people within their homes and exposure to 'muti' is admitted, both factors increasing the risk of parasite transmission.

Village or community factors start with the perception that there is a lack of convenient slaughter facilities and consequently no well organised meat inspection. The educational level is generally poor and the majority of people interviewed are ignorant of the danger to which they expose themselves by eating meat with cysticerci. The taeniasis-cysticercosis paradox is a disease waiting to happen in rural areas as typified by Bethanie and the 3 surrounding villages, and unless properly dealt with by the authorities, the problem will continue.

From the community surveyed a total of 55 stool specimens proved to be negative for parasites or eggs (ova). This is not necessarily unusual as the specimens were collected only once in a day and not the preferred 3 times a day. A result as low as only 2 % positive cases would be considered as a highly infested population (N A Mafojane, University of Pretoria, pers. comm., 2004). The negative results do, however, have to be interpreted with caution due to the fact that studies have shown that traditional laboratory microscopy diagnosis of tapeworm infection in humans has a poor accuracy compared with modern copro-antigen tests. The latter remains, however, a research/diagnostic tool that has not yet been widely used for diagnostic purposes<sup>15</sup>. Free treatment for taeniasis has been given to the household as an incentive to participate in a survey, but in the present study no form of incentive whatsoever was given to the volunteers<sup>5</sup>.

The apparently high occurrence of epileptiform seizures arising from the retrospective descriptive analysis of clinical data at the Bethanie Clinic is of concern, particularly as many people with epileptiform insults in the 4 villages do not seek medical care. The exact prevalence of NCC is difficult to ascertain, since the diagnosis can, in the living patient, only be conclusively confirmed by com-

puter tomography, magnetic resonance imaging of the brain or biopsy. Access to imagery of the brain, so essential for the diagnosis of NCC, is lacking in several African countries<sup>6</sup>. Only 3 patients who did seek medical care at the Bethanie Clinic (6.6 %) had been referred for computer tomography. It has been shown that data on the human aspect of the parasite are lacking in many endemic areas because most studies have only examined the livestock aspects of the parasites<sup>14</sup>. This has made it difficult to carry out a thorough economic analysis of the impact of *T. solium*<sup>14</sup>. A recent analysis with imagery in the Eastern Cape Province, South Africa, revealed an important economic burden to the country due to *T. solium* infestations<sup>4</sup>.

The lack of specialised personnel at rural clinics, particularly in neurology, means that the accuracy of diagnosis cannot be confidently ascertained. The use of differing, vague terminology to classify seizures in patients also impedes study comparison. This study was based on black rural communities who have no immediate access to highly specialised investigations. The actual prevalence of cerebral cysticercosis in the study area could not be determined. Is the community sitting upon a silent epidemic of potential epilepsy of some magnitude?

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