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Original Article

An epidemiological survey of the magnitude and local perceptions of porcine cysticercosis by two methods in Nyaruguru district, Rwanda

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ABSTRACT

This study investigated the magnitude of porcine cysticercosis (PC), its risk factors, economic effects and the perceptions of 80 pig farmers from Nyabimata (n = 38) and Muganza (n = 42) and 20 registered butchers in the Nyaruguru district of Rwanda. January to December 2013 slaughter records from Kamirabagenzi market were also analysed for PC diagnoses based on the tongue test and meat inspection. During this period, the responding farmers' records showed a tongue test-based PC magnitude (3.9%, n = 984) which was lower than the collective tongue test-based PC magnitude of 9.2% (n = 1720) at Kamirabagenzi ($p < .05$). The overall magnitude of PC based on routine meat inspection diagnosis at Kamirabagenzi was 4%. The overall magnitude of PC for respondents using Free-range production systems (7.9%) was significantly greater than for those in Semi-intensive (2.1%) and Intensive production systems (1.5%) ($p < .05$). Though most farmers (90%) knew that PC is zoonotic, only 22.5% of the farmers opted for treatment of PC-infected pigs and 52.5% were willing to seek veterinary inspection while the rest (25%) opted to circumvent veterinary inspection ($P > .05$). Most butchers (70%) indicated they would circumvent veterinary inspection and continue to slaughter PC-positive animals whilst the rest (30%) indicated they would resell PC positive animals to defray costs ($P < .05$). The low sensitivity and specificity of methods used for PC detection in the study, implies that this may just be the tip of an iceberg and the actual magnitude is most likely to be much higher. In conclusion, PC is endemic in the Nyaruguru district of Rwanda with a high proportion of positive animals. The condition has public health implications and is worsening the economic plight of the impoverished Nyaruguru community.

1. Introduction

Pig production in Rwanda is largely subsistent but holds much promise (Mbuza et al., 2016). From 2000 to 2011 pork production in Rwanda has increased by 7.8% (FAO, 2014). However, increased production is seriously curtailed by factors such as feed shortage, poor genetics and the burden of diseases (Habarugira et al., 2016; Habarugira et al., 2014; Mushonga et al., 2017; Nzeyimana et al., 2015). Due to their high fecundity, a short generation interval and the possibility of large numbers being raised in a limited space, pigs have a great potential of contributing towards economic gain (Kohli et al., 2017; Mushonga et al., 2017).

Cysticercosis is one of the diseases that affect pig production and has major public health implications as a zoonosis (Johansen et al., 2017; Nsadha et al., 2014). Taenia solium, a cestode, and the causative agent for PC, has a complex two-host life cycle (Flisser et al., 2003). Pigs act as normal intermediate hosts while humans act as both aberrant intermediate hosts, harbouring the immature or larval stages (García et al., 2003; Mittal et al., 2008), as well as obligate definitive hosts harbouring the adult tapeworm in the small intestine (Garcia et al., 2014; Lightowlers et al., 2015).

Taenia solium is endemic in the developing world including Latin America, Asia and sub-Saharan Africa and has recently been classified as a re-immerging infection in the developed world due to immigration of human tapeworm carriers from poor endemic regions of the world (Flisser et al., 2003; Garcia et al., 2014; Pondja et al., 2015; Pray et al.,

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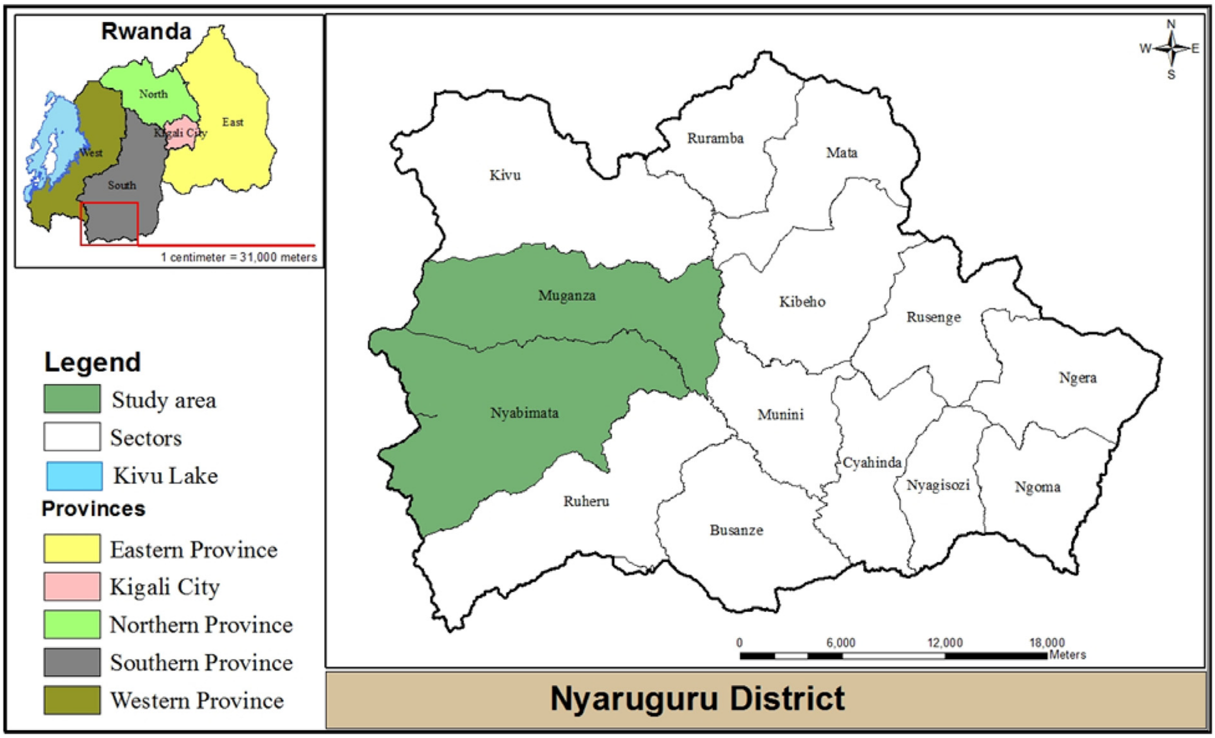

Fig. 1. Map of Nyaruguru district of Rwanda showing the study area (Map courtesy Itegere Basile: ArcMap 10.2).

2016; Trevisan et al., 2017).

Infection of humans with adult tapeworms (Taenia solium) is referred to as taeniasis and results from the ingestion of poorly cooked pork infected with viable cysticerci (Yamasaki et al., 2004). Cysticercosis is a condition that occurs in both pigs and humans. Infection of pigs occurs after ingestion of eggs of the tapeworm from faeces on pasture, contaminated water and other feed sources. In pigs the condition usually presents as an asymptomatic (especially in muscle) infection. Ingested eggs hatch in the host's intestines and release oncospheres, which penetrate the intestinal wall to travel through the bloodstream to striated muscles and sometimes to the brain, eyes, skin and other organs, where they develop into space occupying cysts known as cysticerci or bladder worms.

In humans, cysticercosis causes clinical signs depending on the number and location of cysts. The medical significance of PC is realised when a human accidentally ingests food contaminated with tapeworm eggs (Lightowlers and Donadeu, 2017). Cysticerci typically cause little or no observable clinical signs in pigs (Prasad et al., 2006).

PC causes economic losses as a result of condemnation of carcass parts, cost of treatment of the pigs, cost of treatment of humans for taeniasis/cysticercosis (Madinga et al., 2017) and the cost of freezing infected meat. It has been estimated that farmers lose 50–100% of the value of the animals when these are infected with PC (Trevisan et al., 2017).

Important risk factors for porcine cysticercosis include extensive production systems (in which pigs have access to human faeces on pasture), lack of or unwillingness to use latrines, open water sources (Mwanjali et al., 2013; Rottbeck et al., 2013), lack of or poor pig slaughter facilities (Krecek et al., 2012; Nsadha et al., 2014; Pondja et al., 2015; Trevisan et al., 2017) and lack of knowledge about transmission dynamics of the disease (Kungu et al., 2017). Other factors include presence of T. solium carriers in the vicinity (Pray et al., 2016) and the breed of pigs (Krecek et al., 2012). Previous studies have demonstrated that communal farmers have limited knowledge about the dangers of cysticercosis (Kungu et al., 2017).

The gold standard for diagnosis of PC is carcass dissection (Flecker et al., 2017; Lightowlers et al., 2015). Other PC diagnostic methods include routine necropsy (Carabin et al., 2017; Lightowlers et al., 2015; Singh et al., 2013), and routine post mortem meat inspection (Akoko et al., 2016). Tongue palpation is an accepted ante-mortem diagnostic technique in pigs (Alarakol et al., 2017; Braae et al., 2016; Guyatt and Fèvre, 2016; Komba et al., 2013; Krecek et al., 2012). Although examination of the tongue is an old technique with a wide-ranging sensitivity of 16% to 70% (Gonzalez et al., 1990; Lightowlers et al., 2015; Phiri et al., 2003), recent publications recommend it as an appropriate epidemiological tool when economics and the data that can be obtained are taken into consideration (Alarakol et al., 2017; Guyatt and Fèvre, 2016). The technique is cheap, rapid and simple and can be used by farmers, butchers and veterinarians alike (Guyatt and Fèvre, 2016).

Available prevalence figures for Porcine cysticercosis (PC) in the East African region (Kenya, Uganda and Tanzania) vary widely between 8.5 and 32% using various serological tests and; between 5.6 and 32% (Nsadha et al., 2014) with lingual examination test (Komba et al., 2013; Trevisan et al., 2017). Lightowlers et al. (2016) suggested that serological tests for PC are seriously flawed and therefore, in recent times, some workers have tended to disregard them.

The current study was conducted to establish the magnitude of porcine cysticercosis (PC) in two sectors of Nyaruguru district using routine post mortem and tongue examination methods. The study further aimed to determine the risk factors associated with PC and to draw inferences about the potential risk for human health and to determine the economic impact of PC in the two sectors of Nyaruguru district, Rwanda. Considering our less than perfect diagnostic methods, we have taken the conscious decision to deliberately restrict ourselves to the term "magnitude" rather than prevalence in this study.

2. Material studied, area description, methods and techniques

2.1. Area description

Nyaruguru District is one of the eight districts in the Southern Province of Rwanda and has a total surface area of 1010 km^2. It is comprised of 14 subdivisions called sectors (*imirenge*), each of which is made up of cells which are further subdivided into villages (*imidugudu*). There are 72 cells and 332 villages in Nyaruguru district. Muganza and Nyabimata are two of Nyaruguru district's 14 sectors (Fig. 1). Nyaruguru district is located 2°42″S and 29°31″E at an altitude of between 1600 and 1800 m above sea level. The annual average temperature is around 20 °C and the annual rainfall varies between 1000 and 1250 mm from March to May and from September to mid-January.

2.2. Study population

According to the 2012 census, the human population of Nyaruguru district was 293,424. Muganza and Nyabimata were home to 6.9% and 5.9% of the total population of Nyaruguru, respectively (DPP, Ministry of Local Government, Rwanda, 2013). According to the livestock census of September 2013, Muganza and Nyabimata had a combined total population of 200 pig farmers respectively contributing 9.7% and 5.2% of the total pig population of Nyaruguru (18,381), (DPP, Ministry of Local Government, Rwanda, 2013). For purposes of this study, three main systems of pig production were identified. Intensive pig production was characterised by well-maintained brick and concrete pig housing with fences to control entry and foot baths. These systems also reared pigs in batches with disinfection protocols in between batches. Pigs received routine veterinary care and were fed on commercial pig feed and had access to clean piped water. Semi-intensive systems were also fenced but were characterised by poorly-maintained brick and concrete housing with less restricted entry. Pigs in this system were reared in less-well-defined batches with ill-defined disinfection protocols and without well-defined veterinary care. Pigs were sometimes fed on commercial feeds but mostly on left overs and supplied with water from shallow wells. Free range systems reared pigs in make-shift housing made of mud, wood and sometimes galvanised sheets. These pigs were fed on left overs and left to forage and roam the neighbourhood during the day and penned at night. Pigs did not receive routine veterinary care. Assuming an infinite population of pig farmers, the sample size of pig farmers destined for interviews was determined by using the following formula; $n = Z^2pq/e^2$ (n = sample size of infinite population, Z = Z score, p = assumed maximum variability of population [0.5], q = 0.5 [1 − p], e = margin of error [0.05, based on 95% confidence level]). This sample size was then adjusted for a population of 200 using the following formula; sample size = $(n)/\{1 + [(n - 1)/200]\}$ and this equalled 80 pig farmers. A total of 80 pig farmers comprising of 60 males and 20 females were interviewed for this study. There was a total of 21 butchers in two sectors under study. Using the above-stated formulae for sample size, the adjusted required sample of butchers was 20. Thus, a total of 20 butchers were interviewed to establish what action butchers took in the event of positive diagnosis of porcine cysticercosis for carcasses. Kamirabagenzi is the largest of four markets in Nyaruguru district that the government improved and a destination for pigs from both Muganza and Nyabimata. To investigate the economic impact of porcine cysticercosis in Nyaruguru district, revenue losses resulting from condemnations due to cysticercosis at Kamirabagenzi market from January 2013 to December 2013 were retrospectively determined and analysed. A total of 500 households within the neighbourhoods (200 m radius) of the respondents were enumerated for the presence or absence of toilets.

2.3. Data collection and questionnaire survey

Meat inspection was conducted by a qualified meat inspector according to FAO meat inspection protocols (Herenda et al., 1994). Interviewed farmers participated voluntarily in the study and interviews were made in strict discretion between the interviewee and the researcher. All respondents' pig herds had monthly tongue inspections performed by trained para-veterinarians. The procedure was performed as described by previous workers (Dorny et al., 2004). Pigs were restrained in lateral recumbency, the head stabilized by holding the neck firmly behind the occipital protuberances with the forelimb pulled over the shoulder and firmly manually restrained. A wooden rod was used to pry the mouth open and the tongue was then gently pulled out with the aid of a cotton cloth. Para-veterinarians then examined the underside of the tongue for presence of T. solium cysts. The present study denoted all records reporting the presence of live cysts as porcine cysticercosis positive tongue inspections. Slaughter records from Kamirabagenzi were analysed for overall condemnations involving all the pigs brought between January 2013 and December 2013. All the respondents' records for the tongue test for porcine cysticercosis performed from January 2013 to December 2013 (n = 984) were also analysed retrospectively for proportional occurrence of PC-positive animals from these two sectors during this same period. These constituted 57.2% of the total number of slaughtered pigs at Kamirabagenzi between January 2013 and December 2013 (n = 1720). Revenue losses were calculated using market value of organs/carcasses condemned by measuring the weight of all condemned meat in kilograms (kg) and multiplying it by the average retail cost per kg.

2.4. Statistical analysis

The Statistical Package for Social Sciences (SPSS Version 25), (Gerber and Finn, 2013; Mehta and Patel, 2010; Weinberg and Abramowitz, 2016) was used for statistical analysis of the data. The Pearson Chi-square test of independence was used to examine differences between categorical variables and $p < .05$ was considered significant.

3. Results

3.1. Production systems and tongue test results

As shown in Table 1, the overall magnitude of positive PC tongue tests in the two sectors was 3.9%. Though the overall magnitude of positive PC tongue tests in Muganza (4.7%) was higher than those in Nyabimata (2.9%), was not statistically significant ($p > .05$). As shown in Table 2, an odds ratio of 1.7 (95% C.L: 0.86–3.35 at $p > .05$) showed that pigs in Muganza sector were 1.7 times more likely to be positive for the PC tongue test than those from Nyabimata sector. The

Table 1
Respondents' PC tongue test results according to sector between January and December 2013.

	Nyabimata		Muganza		
	PC-positive	PC-negative	PC-positive	PC-negative	Total
Production system					
Intensive	1 (2.1)[a]	47 (97.9)	2 (0.8)	149 (98.7)	199 (20.2)
Semi-intensive	3 (1.4)	213 (98.6)	7 (2.8)	244 (97.2)	467 (47.5)
Free-range	9 (4.7)	183 (95.3)	16 (12.7)	110 (87.3)	318 (32.3)
Overall	13 (2.9)	443 (97.1)	25 (4.7)	503 (95.3)	984 (100.0)

[a] % proportion.

Table 2
Comparison of positive PC tongue tests between pig-production systems of Muganza and Nyabimata.

Comparison of positive PC tongue tests	Odds ratio	95% Confidence Intervals	P-value
Muganza versus Nyabimata	1.7	0.86–3.35	0.09
Free-range versus semi-intensive system	3.9	1.85–8.24	0.00
Free-range versus intensive system	5.6	1.66–18.72	0.00
Semi-intensive versus intensive system	1.4	0.39–5.25	0.42

overall magnitude of positive PC tongue test in Free-range production systems (7.9%) was significantly higher than that in Semi-intensive (2.1%) and Intensive production systems (1.5%) ($p < .05$). An odds ratio of 5.6 (95% C.L: 1.66–18.72 at $p < .0001$) showed that pigs in Free-range production systems were 5.6 times more likely to test positive in PC tongue test compared to those from Intensive production systems. An odds ratio of 3.9 (95% C.L: 1.85–8.24 at $p < .0001$) showed that pigs in Free-range production systems were 3.9 times more likely to be positive in PC tongue test than those from Semi-intensive production systems. An odds ratio of 1.4 (95% C.L: 0.39–5.25 at $p > .05$) showed that pigs in Semi-intensive production systems were 1.4 times more likely to be PC tongue test positive than those from Intensive production systems.

3.2. Comparison of PC tongue test results and meat inspection condemnations at Kamirabagenzi market from January 2013 to December 2013

As shown in Table 3, the overall magnitude of positive PC tongue tests from January to December of 2013 at Kamirabagenzi slaughter market was 9.2%. This value was significantly greater than that of PC positive animals at meat inspection (4.0%) following slaughter of these tongue-tested animals. The total revenue losses from condemnation of pigs due to cysticercosis amounted to US$6434.01 during the same period.

3.3. Farmers' responses according to sector

The results in Table 4 show that, overall, the proportion of respondents that were aware of porcine cysticercosis as a zoonotic disease (90%) was significantly greater than that of those unaware of that fact (10%) ($p < .05$). The proportion of respondents that were unaware of cysticercosis as a zoonotic disease in Muganza (16.7%) was significantly greater than that in Nyabimata (2.6%) ($p > .05$).

Overall, a significantly greater proportion of respondents (52.5%) indicated a willingness to slaughter, under veterinary supervision, pigs diagnosed with PC in the herd at farm level than those willing to withdraw and treat PC positive pigs (22.5%) and those preferring to slaughter PC positive pigs without veterinary supervision (25%). A greater proportion of respondents from Muganza (45.3%), however, indicated a willingness to slaughter PC positive pigs without veterinary supervision than those from Nyabimata (2.6%) ($p < .05$).

Overall, a significantly greater proportion of respondents (52.5%) indicated a willingness to slaughter under veterinary supervision pigs diagnosed with PC at market level than those willing to withdraw and treat PC positive pigs (22.5%) and those preferring to slaughter PC positive pigs without veterinary supervision (25%). A greater proportion of respondents from Muganza (45.3%), however, indicated a willingness to slaughter PC positive pigs without veterinary supervision than those from Nyabimata (2.6%) ($p < .05$).

Overall, a significantly greater proportion of respondents (52.5%) indicated a willingness to slaughter under veterinary supervision pigs diagnosed with PC at pigs at market level than those willing to withdraw and treat PC positive pigs (22.5%) and those preferring to slaughter PC positive pigs without veterinary supervision (25%). A greater proportion of respondents from Muganza (45.3%), however, indicated a willingness to slaughter PC positive pigs without veterinary supervision than those from Nyabimata (2.6%) ($p < .05$).

3.4. Butchers' responses to diagnosis of PC in purchased pigs

Table 5 shows that 70% of the butchers indicated a willingness to slaughter PC positive pigs without veterinary supervision in comparison to those who indicated a willingness to seek veterinary advice and treatment of PC positive pigs (0%) and those who indicated they would resell infected pigs to defray cost (30%).

3.5. Pit latrine status in neighbourhoods within 200 m of respondents' homesteads

Enumerations of households for latrines revealed that 47.6% of the households inspected were from Nyabimata and the rest (52.4%) were from Muganza ($n = 500$). Overall, the proportion of households with latrines (96%) was significantly greater than that without latrines (4%) ($p < .05$). Availability of latrines between the Nyabimata and Muganza was similar ($p > .05$).

4. Discussion

This study reveals that the magnitude of PC by routine post mortem meat inspection at Kamirabagenzi was 4% (Table 3) and was 9.2% according to tongue examinations carried out before slaughter from January 2013 to December 2013 (Table 3). These figures are lower than the prevalence (20%) reported for Rwanda more than five decades ago (Zoli et al., 2003). However, since the methods used by Zoli et al. (2003) were not described, we cannot conclude that results of the present study confirm a definite decrease in the prevalence of PC. Furthermore, given that the sensitivities of both the tongue examination method and routine post mortem examination are low, our findings indicate a high prevalence of PC in the study area. Total carcass dissection is required to establish the true prevalence of PC in Nyaruguru district.

Although tongue palpation and inspection is an old method with a variable sensitivity of 16% (Phiri et al., 2003) to 70% (Gonzalez et al., 1990), there is renewed interest in its use as a screening tool because it is easy, cheap and rapid to implement (Alarakol et al., 2017; Guyatt and Fèvre, 2016). The fact that the tongue palpation test was undertaken by para-veterinarians might have underestimated the true magnitude of PC

Table 3
Proportions of Taenia solium cysticerci-infected pigs, resultant condemnations and revenue losses at slaughter at Kamirabagenzi market from January 2013 to December 2013.

Month	Animals slaughtered	PC positive tongue test	Condemnations at meat inspection	Revenue lost (US$)
January	147	15 (10.2)[a]	7 (4.8)	652.73
February	149	12 (8.1)	6 (4.0)	559.48
March	154	14 (9.1)	7 (4.5)	652.73
April	159	15 (9.4)	6 (3.8)	559.48
May	152	15 (9.9)	5 (3.3)	466.23
June	123	12 (9.8)	6 (4.9)	559.48
July	163	17 (10.4)	5 (3.1)	466.23
August	130	11 (8.5)	6 (4.6)	559.48
September	125	11 (8.8)	5 (4.0)	466.23
October	115	10 (8.7)	5 (4.3)	466.23
November	133	9 (6.8)	5 (3.8)	466.23
December	170	18 (10.6)	6 (3.5)	559.48
Overall	1720	159 (9.2)	69 (4.0)	6434.01

[a] % proportion.

Table 4
Proportional responses according to sector.

Response	Nyabimata Number of respondents	Muganza Number of respondents	Total
Awareness of cysticercosis			
Respondents aware	37 (97.4)[a]	35 (83.3)	72 (90.0)
Respondents unaware	1 (2.6)	7 (16.7)	8 (10.0)
Response after diagnosis of PC in herd at farm level			
Withdrawal followed by treatment	9 (23.7)	9 (21.4)	18 (22.5)
Slaughter with veterinary supervision	28 (73.7)	14 (33.3)	42 (52.5)
Slaughter without veterinary supervision	1 (2.6)	19 (45.3)	20 (25.0)
Farmers' likely response after diagnosis of PC in herd at market level			
Withdrawal followed by treatment	9 (23.7)	9 (21.4)	18 (22.5)
Slaughter with veterinary supervision	28 (73.7)	14 (33.3)	42 (52.5)
Slaughter without veterinary supervision	1 (2.6)	19 (45.3)	20 (25.0)
Farmer action after diagnosis of PC in pigs at market level			
Withdrawal followed by treatment	9 (23.7)	9 (21.4)	18 (22.5)
Slaughter with veterinary supervision	28 (73.7)	14 (33.3)	42 (52.5)
Slaughter without veterinary supervision	1 (2.6)	19 (45.3)	20 (25.0)
Overall	38 (47.5)	42 (52.5)	80 (100.0)

[a] % proportion.

Table 5
Butchers' responses to diagnosis of PC in purchased pigs.

Category	Number of respondents
Butchers' likely response after diagnosis of PC in purchased pigs	
Call the veterinarian for advice/treatment	0 (0.0)[a]
Slaughter without veterinary supervision	14 (70.0)
Resell infected animals	6 (30.0)
Overall	20 (100.0)

[a] % proportion.

in this study. Considering that diagnosis by complete dissection of the carcasses is the gold standard, results that arose from routine post-mortem meat inspection and tongue tests in this study are suggestive of a possible high PC infection burden in the district.

According to our survey results, the farmers in the district practice intensive, free-range and semi-intensive farming. Several studies list extensive production systems and lack of latrines as major risk factors for cysticercosis (Krecek et al., 2012; Nsadha et al., 2014; Pondja et al., 2015; Trevisan et al., 2017). The high magnitude figures for PC are in complete contrast with the high availability of toilets in the district since 96% of the households in the respondents' immediate neighbourhood had toilets (Table 5). However, other studies have reported a lack of association between availability of latrines and PC prevalence (Kavishe et al., 2017; Pouedet et al., 2002). It has been argued that availability of toilets does not necessarily imply that they are used as people with toilets have been found to defecate in the fields. In fact, some studies (Ngowi et al., 2004) have reported a negative association between availability of latrines and low prevalence of PC. The high proportions of PC-positive animals are supportive of a recent report from Rwanda (Rottbeck et al., 2013) which recorded a high prevalence of neurocysticercosis in humans in other sectors in the same province.

It is alarming that overall, 25% of the respondents at farm and market levels (Table 4), indicated they would still sell cysticerci-infected pigs for human consumption. Workers in Tanzania (Trevisan et al., 2017) have pointed out that farmers lose from 50 to 100% of the value of their animals when their animals are diagnosed with cysticercosis.

A surprising finding of the questionnaire survey is that overall, 22.5% of farmers who found that they had PC-infected pigs would seek treatment for the affected animals. It is necessary to point out that the only known effective treatment of PC with high dose (30 mg/kg) oxfendazole is not available in Rwanda but farmers (ignorant of this fact) somehow expect that veterinarians should be able to treat their animals. Even if the medication were available in Rwanda, it would certainly create further problems of high levels of drug residues in the meat after oxfendazole treatment. This would then entail observation of a mandatory 21 day withholding period (Moreno et al., 2012) for their pigs at a further inconvenience and cost!

Our results show that overall, 52.5% of the respondents at farm and market levels would withdraw their animals from the market and indicated that they would consult a veterinarian for the appropriate intervention measures. Butchers posed the greatest public health risk as all the interviewed butchers indicated they would not consult veterinarians nor withdraw cysticerci-infected pigs from the human food chain.

It is clear that farmers in the district have a high level of awareness of the public health implications of PC but economic consideration took precedence over public health considerations when it came to the fate of PC-positive pigs for these poor farmers. Improved general hygiene, though not specifically targeting PC, takes care of PC amongst a host of other diseases related to poor hygiene. Perhaps, the government should come up with more targeted interventions such as offering to compensate farmers that incur losses from cysticercosis-related condemnations to prevent farmers from selling cysticercosis-positive animals for human consumption or selling without veterinary inspection of carcasses. In addition, the government could also undertake subsidized treatment campaigns for both pigs and humans to further reduce PC in Rwanda. According to some reports (Kungu et al., 2017; Thys et al., 2015), knowledge about PC does not automatically translate into behavioural change. It is also important that awareness campaigns be carried out to promote behavioural change (of reporting and treating animals) when PC is diagnosed as reported.

Direct revenue losses amounting to US$ 6434.01 (Table 3) in 2013, though seemingly low, may represent a substantial revenue loss to the impoverished farmers of Nyabimata and Muganza. Indirect losses due to reduced productivity, treatment costs, time commitment and opportunity costs have not been included in the calculations. These losses also have public health implications if one considers the loss of protein, a nutrient which is already scarce in Rwanda particularly in rural areas like Nyaruguru; resulting in malnutrition of poor families in such areas.

5. Conclusions and recommendations

We conclude that pigs in Nyaruguru are at risk of PC and it is most likely that the actual magnitude of PC could be higher. Considering that stakeholders do not quite understand the disease and their attitudes towards it inadvertently increase the risk of cysticercosis in man, urgent positive steps such as increased meat inspection, confinement of pigs, encouragement of the use of latrines and proper cooking of pork must be implements to reduce the risk of spread of PC and investigations are warranted into the medical burden of cysticercosis in Rwanda. Further studies need to be undertaken in wider sections of the country (provinces) using the carcass dissection method to determine the actual prevalence of PC. A control program should be considered for reducing cysticercosis in Rwanda.

Ethical statement

Ethical approval (by official confirmation notice) for this study was obtained from Ethics Committee of the School of Animal Sciences and Veterinary Medicine, College of Agriculture, Animal Sciences and Veterinary Medicine of the University of Rwanda. All participants were adults and they provided informed oral consent for their responses to be used in our study. The participation to the interviews was voluntary and the privacy of the interviewees was strictly respected. The Institutional research board accepted oral consent and it was documented by way of each participant signing against a number assigned to him or her in the register for the sake of confidentiality. For the same reason names were not used or recorded Animal care and used protocol adhered to World Organisation for Animal Health (OIE) Terrestrial Animal Health Code 2012 (use of animals in research and education) (OIE, 2012). Meat inspection was conducted following all the standards meat inspection as described by Herenda et al. (1994). A map of the study area was drawn with ArcMap 10.2.

Conflicts of interest

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

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