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Full Length Research Paper

Targeting High-Impact Risk Factors for *Taenia saginata* Control: Applying Pareto Principles in Botswana

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Most available data on *Taenia saginata* taeniosis/cysticercosis risk factors in Botswana neither associate risk factors with Batswana's lifestyle nor rank risk factors' contribution to observed prevalence. This disconnect undermines usability of data for bovine cysticercosis control. This study identified bovine cysticercosis risk factors and quantitatively ranked risk factors' contributions to observed prevalence. Visual observation and interviews using Likert scale-formatted questionnaire was employed in collecting primary data from beef industry's stakeholders (149). Fourteen (14) out of eighteen (18) risk factors jointly predicted bovine cysticercosis prevalence (p <0.05), but the only factor of 'beef sold at non-licensed premises' predicted prevalence individually. Top 20% important risk factors were absence or distant pit latrines in farms (p <0.05; MD=1.288; CI: 1.15-1.43), proximity to uncontrolled human defecate (p <0.05; MD=1.184; CI=1.03-1.34), access to contaminated pasture (p <0.05; mean=4.13; MD=1.131), and failure to deworm herd boys (p <0.05; mean=4.10; MD= 1.097). Current prevention strategies in Botswana emphasizes proper disposal of human defecate. However, this study showed that minimizing butchers buying and slaughtering animals without proper ante-mortem and post-mortem examination would yield more efficient result. By adopting Pareto principle, this study modeled that controlling these top 20% important risk factors instead of targeting a repertoire of risk factors would result in 80% prevalence drop. Respondents showed greater consensus on risk factors with high odds to cause bovine cysticercosis. This consensus provides platform for driving attitudinal change, since risk factors were lifestyle-related. Associating people's lifestyle with risk factors of this zoonosis while targeting top 20% risk factors yields more efficient control outcomes.

Key words: Batswana"s lifestyles, Taenia saginata/cysticercosis, ranking risk factors, prevalence, Pareto principle, efficient control and prevention.

INTRODUCTION

Taenia saginata cysticercosis found in cattle, is caused by the larval stage of tape worm, *T. saginata* which resides obligately in human intestine (Urquhart et al., 1996). Bovine cysticercosis is an important food safety

issue with far reaching economic and public health implications in Botswana (Tshiamo, 2015). Beef from carcasses infested with bovine cysticercosis cannot be exported to the European Union, Botswana"s most lucrative market (Livestock and Meat Industries Act, 2007). This resulted in annual loss of export earnings of about one million (P1M; P1.00 = 0.5USD) in 1978 (Grindle, 1978). Bovine cysticercosis infested beef that could not be sold to EU markets worth P99.6M (P10.56 = 1USD) (IMF], n.d.) in 2009, P100M (P6.33 = 1USD) in 2010 and P83M (P7.78 = 1USD) in 2010 (Tshiamo, 2015).

Globally, improper disposal of human defecate has been identified as the most important risk factor of bovine cysticercosis (Filmer, 2012). The government of Botswana emphasizes mass campaigns on proper disposal of human faeces, to avoid pastures, feed and water contamination. Botswana advocated nationwide mass anthelmintic treatment for primary school children and enforced meat inspection, among other prevention and control measures (Neils and Murrell, 2005; Livestock and Meat Industries Act, 2007; Aganga, 2009). Despite these efforts, Botswana"s prevalence of bovine cysticercosis has been unsteady. It was 12 to 15% in 1985 (Mosienyane, 1986); 11.045% in 2008; 10.78% in 2009; 8.03% in 2010, to 13.5% in 2014 (Tshiamo, 2015) and 23% in 2014 in villages with high density of human population and poor hygiene status (Farmers" Magazine, 2016). Prevalence increases have led researchers and policy makers to question effectiveness of adopted control and prevention methods in addressing risk factors. It is probable that important risk factors were misdiagnosed, thus control and prevention methods targeted at identified risk factors were inadequate or there was mismatch between the risk factors and preventative strategies.

Preliminary investigation, which framed hypothesis for the present study showed that important risk factors of bovine cysticercosis in Botswana were behavioural, cultural and systemic. Published studies in other countries, just made a repertoire of identified risks (Flutsch et al., 2008; Verwoerd, 2017). These studies neither associated risk factors with lifestyles and cultures of locals nor ranked contributions of risk factors to recorded bovine cysticercosis prevalence. There are no known studies on risk factors of bovine cysticercosis in Botswana.

The purpose of this study was to identify bovine cysticercosis risk factors in Botswana, attempt to demonstrate that efficient control and prevention strategies must associate risk factors with lifestyles of individuals as well as emphasize corresponding attitudinal change. Furthermore, this study attempted to apply Pareto principles to model more efficient control and prevention methods.

MATERIALS AND METHODS

Data sources and data collection

Primary data were sourced through direct observation and face to face interviews using questionnaires structured in Likert scale format. The instrument was tested for validity using the Cronbach"s alpha and value calculated as 90%, before being used. Secondary data were sourced from relevant published and un-published documents available at Botswana University of Agriculture and Natural Resources (BUAN) Library.

Calculation of sample size

Formula for sample size calculation (Ama et al., 2008):

$$n = \frac{N}{N-1}\left\{\frac{Z^2 p(1-p)}{e^2}\right\} + \left\{\frac{Z^2 p(1-p)}{e^2}\right\}$$

where N = Population size, Z = Critical value of the normal distribution at the required confidence level, p = Sample proportion, and e = Margin of error.

N = Population size = 100,000 (since population size is large and not known and sample size does not change much for population larger than 100,000), Z = Critical value = 1.96 (at 95% confidence level, the critical value is 1.96), p = Sample proportion = 0.10, e = Margin of error = 5% = 0.05.

$$n = 100{,}000 \times \frac{1.96^2 \times 0.1 \times (1-0.1)}{0.05^2} / 100{,}000 - 1 + \frac{1.96^2 \times 0.1 \times (1-0.1)}{0.05^2}$$

= 144

Sample size of 144 was approximated to 150 respondents making allowance for non-responses

The questionnaire

The questionnaire was Likert-structured, which contained the question "*Which of these practices do you agree leads to spread of bovine cysticercosis? Please tick appropriately".* All respondents answered this question for each of the eighteen risk factors. Respondents answered one of five possible answers (strongly agree, agree, neutral, disagree, strongly disagree). (Appendix I).

Administration of questionnaire

The multistage sampling technique was used in this study to identify the animal holdings, because the population is officially stratified into regions, districts and animal holdings (Statistics

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Table 1. Sample size according to districts of respondents.

District	Sample size
North Central	30
Central + Kweneng	31
Kalagadi district.	36
Ghanzi	52
Total	149

Botswana, 2015b). Purposive sampling technique was used to select two agricultural regions; one with the highest cattle population, which was Central Region and another with the lowest cattle population, which was Western Region (Statistics Botswana, 2015a). From the Central region, the Central district with the highest cattle population and North East district with the lowest cattle population were selected. From the Western region, Ghanzi district with the highest cattle population and Kalagadi district with the lowest cattle population (Statistics Botswana, 2015a) were selected. Snow ball sampling technique was used to identify individual respondents because this population is sparse and there is no sampling frame available for this population (Naderifar et al., 2017). Questionnaire was administered to 149 respondent households (Table 1).

Data analysis

Descriptive statistics and Chi-square

Descriptive statistics (mean, median, quartiles) were used to describe the data. Analysis of median was used to determine the most probable response for a risk factor in population. Inter quartile range (IQR) determined the level of respondents" polarity about a particular risk factor. Chi-square test was used to test the contribution of each risk factor to bovine cysticercosis prevalence.

Application of regression

Binary logistic regression was selected as appropriate regression analysis because the dependent variable was dichotomous (binary). If we let P be defined as the probability of having bovine cysticercosis prevalence and 1-P, the probability of not having prevalence, then the ratio (P/1-P) defines odds in favour of having bovine cysticercosis. The binary logistic regression modelled natural log of odds ratio as a function of the independent variables:

$$\log\left[\frac{P}{1-P}\right] = \beta_0 + \beta_1 R_1 + \beta_2 R_2 + \beta_n R_n \quad (1)$$

where $\log$ is the natural log of odds ratio; n is the number of variables; β_0 is the intercept (constant) that gives the value of log of $\left[\frac{P}{1-P}\right]$ when the other factors are absent; β_1 to β_n represent the change in the dependent variable for a unit change in the independent variable given that other variables are constant; R_1 to R_n are the risk factors, which are listed in Tables 2 and 3. The multivariate logistic regression analysis determined both joint effects and individual effect of each of risk factors on bovine cysticercosis prevalence (Tables 5 and 6). The five-point Likert scale (Table 2) was consolidated to two answers, „agree", designated as 1 and „disagree", designated as 0 (Table 3).

Modelling Pareto principle

Pareto principle was modelled by separating and unpacking top 20% important risk factors. The "Pareto principle", or more commonly the "80/20" rule is a relation that describes causality and results. It claims that roughly 80% of output is a direct result of about 20% of the input (Kiremire, 2011). Pareto observed that by concentrating efforts on the top 20% important areas, and ignoring, eliminating or automating the rest many businesses achieved dramatic improvements in efficiency and profitability (Fabian et al., 2014).

In this study, Pareto Principle was applied in bovine cysticercosis prevention and control, in an attempt to not only explain observations in the field, but also to rank importance of each risk factor and in turn, fine tune prevention and control practices.

Firstly, contributions of each risk factor to the observed prevalence figures in Botswana were outlined using simple means. With test value (*t*) at 3, Chi-square was used to determine quantitative relevance of each risk factor in causing the observed prevalence of bovine cysticercosis in Botswana. Mean score of each risk factor was considered risk factor"s contribution (importance) to the observed bovine cysticercosis prevalence. Risk factors with mean score of 3.5 and above were considered important to bovine cysticercosis prevalence whereas risk factors with mean score less than or equal to 3.5 were considered unimportant. Following this ranking, the Pareto principle, was adopted to target the top 20% risk factors.

All analyses were carried out using Microsoft Excel and Statistical Package for Social Science (SPSS).

RESULTS

Fourteen of eighteen tested risk factors contributed significantly (p ≤0.05) to bovine cysticercosis prevalence (Tables 3 and 4). There was high consensus among respondents that important contributors to bovine cysticercosis prevalence were absence and/or distanced pit latrine in the farm (92.5%; IQR = 0), proximity to uncontrolled human defecation (90.8%; IQR = 0), access to contaminated pasture (89.0%; IQR = 0), access to contaminated water (88.7%; IQR = 0), failure to deworm herd boys (88.3%; IQR = 0), access to contaminated feed (78.7%; IQR = 0), and grazing of animal (78.3%; IQR = 0) (Table 3). There was low consensus among respondents that the other eleven (11) factors were important contributors to bovine cysticercosis prevalence (Table 3). Respondents disagree that risk factors of sharing of machineries (mean < 3), dairy female animals staying longer at farms (mean < 3), beef sold at non-licensed areas (mean<3), and butcheries procuring cheaper infested meat (mean< 2), and contributed to bovine cysticercosis prevalence (Table 3). Top 20% important risk factors were „absence and/or distanced pit latrine in the farm" [*P* <0.05; mean = 4.29; mean difference (MD) =1.288], „proximity to uncontrolled human defecation" (*P*<0.05; mean 4.18; MD=1.184), „access to contaminated pasture" (*P* <0.05; mean =4.13; MD=1.131), and„failure to deworm herd boys" (*P* <0.05; mean=4.10; MD= 1.097).

Table 2. Likert scale analysis of risk factors (%) of bovine cysticercosis in Botswana.

Likert scale	PRW	ADL	GRZ	ACP	SM	VIF	SFOM	PUHD	ACW	ACF	BF	BSNLP	ABMI	PIM	CPCUM	FD	PAC	NAFP
Strongly disagree	10.7	1.3	2.7	2.7	4.8	2.1	6.8	2.0	2.7	2.7	15.6	8.8	9.5	10.9	10.2	2.0	12.9	51.7
Disagree	9.4	5.4	14.3	6.1	36.1	26.0	27.9	6.8	7.5	13.6	38.1	35.4	32.0	34.7	28.6	8.2	21.1	19.0
Neutral	9.4	0.7	4.1	2.0	6.8	3.4	2.0	4.1	0.7	4.1	8.2	3.4	4.1	4.1	2.0	1.4	1.4	5.4
Agree	38.3	47.0	51.7	52.4	36.7	49.3	42.9	49.7	59.2	57.1	24.5	34.7	36.1	31.3	44.2	53.7	40.8	4.1
Strongly agree	28.9	43.6	24.5	35.4	12.2	14.4	16.3	37.4	26.5	18.4	7.5	14.3	15.6	16.3	13.6	33.3	21.1	17.0
Un-answered	2.0	0.7	2.7	1.4	3.4	4.8	4.1	0	3.4	4.1	6.1	3.4	2.7	2.7	1.4	1.4	2.7	2.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PRW = Preference of rare to well-done meat; ADL = absence or distance of pit latrine; GRZ = gazing of animals; ACP = access to contaminated pasture; SM = sharing machineries; VIF = visitors in the farm; SFOM = organic manuring; PUHD = proximity to uncontrolled human defecation; ACW = access to contaminated water; ACF = access to contaminated feed; BF = being female; BSNLP = beef sold in non-incensed places; ABMI = absence of meat inspectors; PIM = procuring of infected meat; CPCUM = consumer prefer cheap unfit meat; FD = failure to de-worm herd boys; PAC = poor awareness campaign; NAFP = non-adherence to fencing policy.

Table 3. Farmers views (Likert scale consolidated in agree and disagree) of risk factors as contributors to prevalence of bovine cysticercosis in Botswana.

Risk factor	Agree (%)	Disagree (%)	Median	IQR
Are the underlisted risk factors of bovine cysticercosis in Botswana	95.0	5.0	4.00	2
Preference of rare to well-cooked meat	69.4	30.6	4.00	2
Absence and or distanced pit latrine in the farm	92.5	7.5	4.00	0
Grazing of animal	78.3	21.7	4.00	0
Access to contaminated pasture	89.0	11.0	4.00	0
Visitors in the farm	66.9	33.1	4.00	2
Using sewage for organic manuring	61.7	38.3	4.00	2
Proximity to uncontrolled human defecation	90.8	9.2	4.00	0
Access to contaminated water	88.7	11.3	4.00	0
Access to contaminated feed	78.7	21.3	4.00	0
Poor awareness campaign about bovine cysticercosis to farmers and public	63.6	36.4	4.00	2
Non-adherence to fencing policy	72.7	27.3	4.00	2
Consumers prefer cheaper meat even unfit	58.6	41.4	4.00	2
Failure to deworm herd boys	88.3	11.7	4.00	0
Lack of or absence of meat inspections at butcheries or homes	53.1	46.9	4.00	2
Sharing of machineries and tractors	50.7	49.3	3.00	2
Being female (Diary animals slaughtered at very old age)	65.9	34.1	2.00	2
Beef sold at non-licensed areas	50.7	49.3	2.00	2
Butcheries procure cheaper meat which are more likely to be infested	49.0	51.0	2.00	2

Table 4. Chi-square determining quantitative relevance of each risk factor in causing the observed prevalence of bovine cysticercosis in Botswana.

One-sample test	N	Mean	Test Value = 3	Df	Sig. (2-tailed)	Mean difference	95% Confidence interval of the difference	
			T				Lower	Upper
Preference of rare to done meat	144	3.67	6.218	143	0.00	0.674	0.46	0.89
Absence and or distanced pit latrine in the farm	146	4.29	18.379	145	0.00	1.288	1.15	1.43
Grazing of animal	143	3.83	9.435	142	0.00	0.832	0.66	1.01
Access to contaminated pasture	145	4.13	14.647	144	0.00	1.131	0.98	1.28
Sharing of machineries and tractors	142	3.16	1.608	141	0.11	0.162	-0.04	0.36
Visitors in the farm	139	3.5	5.338	138	0.00	0.504	0.32	0.69
Using sewage for organic manuring	141	3.35	3.342	140	0.001	0.355	0.14	0.56
Proximity to uncontrolled human defecation	141	4.18	15.371	140	0.00	1.184	1.03	1.34
Access to contaminated water	142	4.03	13.287	141	0.00	1.028	0.88	1.18
Access to contaminated feed	141	3.78	9.192	140	0.00	0.78	0.61	0.95
Diary female animals stay longer	138	2.68	-2.997	137	0.003	-0.319	-0.53	-0.11
Beef sold at non-licensed areas	142	3.11	0.97	141	0.334	0.106	-0.11	0.32
Lack of or absence of meat inspections at butcheries or homes	143	3.17	1.531	142	0.128	0.168	-0.05	0.38
Butcheries procure infested meat because it's cheaper	143	3.08	0.685	142	0.495	0.077	-0.15	0.3
Consumers prefer cheaper meat even unfit	145	3.23	2.125	144	0.035	0.228	0.02	0.44
Failure to deworm herd *boys*	145	4.1	14.192	144	0.00	1.097	0.94	1.25
Poor awareness campaign about bovine cysticercosis to farmers and public	143	3.37	3.206	142	0.002	0.371	0.14	0.6
Non-adherence to fencing policy	143	3.66	7.179	142	0.00	0.664	0.48	0.85

Fourteen (14) out of eighteen (18) risk factors jointly significantly (p ≤0.05) determined bovine cysticercosis prevalence.

Going by Pareto principle eliminating these top 20% risk factors will result in 80% drop in bovine cysticercosis prevalence.

Other important risk factors were „access to contaminated water" (*P*<0.05; mean=4.03; MD= 1.028), „grazing of animals" (*P* <0.05; mean=3.83; MD=0.832), „access to contaminated feed" (*P* <0.05; mean=3.78; MD=0.78), „preference of fairly cooked to well cooked meat" (*P* <0.05; mean=3.67; MD=0.674), „non- adherence to fencing policy" (*P* <0.05; mean=3.66; MD=0.664) and „having visitors in the farm" (*P* <0.05; mean=3.5; MD=0.504). The rest 8 risk factors with mean ratings less than 3.5 were considered not important (Table 4). Disagreement among respondents that „dairy female animals staying longer in the farm" was important contributor to bovine cysticercosis prevalence was statistically significant (*P* <0.05; *t* = -2.997; CI: -0.53 to - 0.11) (Table 4).

Multinomial regression analysis showed that 14 variables jointly significantly (P<0.05) predicted the prevalence of cysticercosis (Table 4). However, only the factor „beef sold at non-licensed premises" significantly predicted bovine cysticercosis prevalence (*P* -value<0.05) as an individual variable (Table 5), holding the other factors constant.

Respondents who answered „yes" to preference for rare to well cooked meat were 1.71 times (SE=0.429) more likely to conceive preference for rare to well cooked meat as a risk factor than those who answered „No". Similarly, respondents who answered „yes" to absence or distanced pit latrines" and those who answered „yes" to „proximity of human defecate" were 2.28 (SE=0.321) times and 3.42 (SE=0.746) times, respectively, more likely to conceive these factors as risk factors of bovine cysticercosis than those who answered „No" (Table 6).

Model of natural log of odds of risk factors in favour of bovine cysticercosis prevalence = Ln

Table 5. Likelihood ratio tests of individual risk factors to cause bovine cysticercosis in Botswana.

Effect	Model fitting criteria	Likelihood ratio tests		Sig.
	-2 Log Likelihood of reduced model	Chi-square	df	
Non-adherence to fencing policy	128.156	0.639	1	0.424
Access to contaminated feed	129.049	1.532	1	0.216
Preference of rare to done meat	127.572	0.055	1	0.815
Absence and/or distanced pit Latrine in the farm	127.697	0.18	1	0.672
Grazing of animal	127.724	0.207	1	0.649
Access to contaminated pasture	127.992	0.474	1	0.491
Visitors in the farm	130.247	2.73	1	0.098
Proximity to uncontrolled human defecation	129.292	1.775	1	0.183
Sharing of machineries and tractors	129.098	1.581	1	0.209
Using sewage for organic manuring	127.518	0.001	1	0.973
Diary female animals stay longer	128.575	1.058	1	0.304
Beef sold at non-licensed areas	134.414	6.897	1	0.009*
Lack of or absence of meat inspections at butcheries or homes	128.39	0.873	1	0.35
Butcheries procure infested meat because it"s cheaper	128.237	0.72	1	0.396
Consumers prefer cheaper meat even unfit	127.563	0.046	1	0.831
Poor awareness campaign about bovine cysticercosis to farmers and public	127.998	0.48	1	0.488

*Beef sold at non-licensed areas significant at $p<0.05$ (p value =0.009).

(P/1-P) = -0.96 (SE =1.017) + 0.536PRW (SE=0.429) + 0.824ADL (SE=0.83) + 0.111GRZ (SE=0.507) + -0.982ACP (SE=0.716) + -0.759SM (SE=0.451) + -0.619VIF (SE=0.441) + 0.007SFOM (SE =0.038) + 1.232PUHD (SE =0.746) + 0.001ACW (SE =0.002) (Table 6).

DISCUSSION

Finding of this study that, absence or distant pit latrines in the farm is the single most important risk factor, followed by proximity to uncontrolled human defecation accurately describes risk factors scenario of bovine cysticercosis in Botswana. This is so because, in Botswana, open defecation is habitual among locals, particularly the Basarwa tribe (bushmen) of Ghanzi and Kalagadi district in Western region of Botswana (Richard and George, 2019). This tribe of nomadic cattle herders is unreceptive to technology and refuses to use basic amenities like, toilets. Ghanzi and Kalagadi districts have been identified as bovine cysticercosis hotspots in Botswana, with Makunda extension area in Ghanzi district topping the chart (Uchendu, 2020). Furthermore, over 85% of the nation"s cattle are reared through traditional free-range farming system (Statistics Botswana, 2016). Open grazing of animals in Botswana has political and socio-cultural driving forces, which must be preserved. For example, the EU, Botswana"s beef main market, insists on grass-fed beef, and for Botswana to maintain this market, cattle must graze openly (Uchendu, 2020). Thus, cattle are in constant contact with improperly disposed human defecate. This finding agrees with Filmer (2012) and WHO/DFID-AHP (2015) who ranked access to human faecal contamination as top risk factor of bovine cysticercosis. In addition to open defecation, pasture contamination, arises because sewage sludge is commonly used for manuring in Botswana. Furthermore, cattle have access to open and/or overflowing sewage dams.

Similarly, in Europe, bovine cysticercosis herd outbreaks arising from pasture contamination have been traced back to application of sludge on grazing fields (Kyvsgaard et al., 1991; Cabaret et al., 2002; Deschamps et al., 2013). Girma et al. (2012) noted that in Ethiopia, overflowing sewage and pit toilets serve as major exposure points for

Table 6. Logistic regression analysis determining joint significance (±SE) of risk factors of bovine cysticercosis.

Risk factor	B	S.E.	Wald	Df	Sig.	Exp.(B)	Probability
Preference for rare to well cooked meat	0.536	0.429	1.559	1	0.212	1.709	0.63086
Absence or distant pit latrine	0.824	0.83	0.985	1	0.321	2.28	0.695122
Grazing of animals	0.111	0.507	0.048	1	0.827	1.118	0.527856
Access to contaminated pasture	-0.982	0.716	1.882	1	0.17	0.375	0.272727
Sharing Machineries	-0.759	0.451	2.836	1	0.092	0.468	0.318801
Visitors in the farm	-0.619	0.441	1.971	1	0.16	0.538	0.349805
Organic farming	0.007	0.038	0.037	1	0.848	1.007	0.501744
Proximity to uncontrolled defecation	1.232	0.746	2.726	1	0.099	3.428	0.774164
Access to contaminated water	0.001	0.002	0.601	1	0.438	1.001	0.50025
Constant	-0.96	1.017	0.891	1	0.345	0.383	0.276934

spread of *T. saginata* oocysts in pastures around residential areas, more than in farms. This study agrees with Gajadhar et al. (2006) that feed contamination was an important risk factor of bovine cysticercosis. Gajadhar et al. (2006) traced contamination to employing *T. saginata* infested labourer in the farm. Interview results of this study agree with Dupuy et al. (2014) that other sources of *T. saginata* cysticercosis in farms are introducing already infested cattle into feedlot and introducing potential fomites into paddocks (Uchendu, 2020). However, Laranjo et al. (2016) ruled out migratory birds as major cause of feed contamination.

The ranking of risk factors" contributions to observed bovine cysticercosis prevalence agrees with the works of Murrell et al. (2005) who recognized open cattle grazing, more than contaminated feed and water, as major access of cattle bovine cysticercosis. Preference of rare to well done meat as an important risk factor is a recent but growing trend in Botswana. Consuming tender and rare done meet than well done meat seems more fashionable. This result re-echoes the findings of Seleshe et al. (2014) who claim that in Ethiopia, preference for rare to well done meat was common, with cultural, religious and dietary reasons. Although this study showed that „procuring infested meat because it is cheaper", „lack of or absence of meat inspections at butcheries", „beef sold at non-licensed areas", and „sharing of machineries and tractors" did not contribute significantly to bovine cysticercosis prevalence, Gajadhar et al. (2006) argue that virtually all human population, particularly beef-consuming population have direct association with bovine cysticercosis infestation. They described all forms of human population as a vital component to complete *T. saginata* cycle. In contrast to this study, Laranjo et al. (2016) categorize sharing machineries and having farm visitors, as risk factors, even though minor. Results that „procuring beef at non-licensed areas" and „consumers preference for cheaper unfit meat" were not significant contributors to prevalence of bovine cysticercosis is accurate about the risk factor scenario in Botswana. This is because, Botswana practices strict antemortem inspection especially in export abattoir, in accordance with the provisions of the Livestock and Meat Industries Act, 2007 (Engelen et al., 2013). In fact, the beef industry is Botswana"s third highest single foreign earner after diamonds and tourism. Consequently, there are rarely any non-licensed abattoirs in Botswana except in remote villages where meat inspectors cannot reach due to lack of access roads. Secondly, consumers hardly buy unfit beef because beef is ubiquitous and cheaply affordable in Botswana. Interestingly, unlike in most other countries of the world, where cattle farming is an exclusive occupation of few farmers, in Botswana, cattle ownership is a pride factor as every family owns cattle (Thornton et al., 2003; Patti et al., 2010). Dorny et al. (2002) agree with results of this study, which shows that majority of respondents do not consider dairy female animals staying longer in farms as important risk factor. Respondents" decisions may arise from ignorance of dairy operations because dairy farming is rare in Botswana (Moreki et al., 2011). Dorny et al. (2002) found that bovine cysticercosis was significantly more prevalent in feedlots and in traditional farming systems than in dairy farms. However, Zdolec et al. (2012) and Laranjo et al. (2016) disagree; claiming that female animals especially when used for breeding, stay longer than beef animals; thus, increasing probability of spreading infestation.

All risk factors jointly predicted bovine cysticercosis prevalence but the only factor of „beef sold at non-licensed premises" predicted bovine cysticercosis prevalence individually. This paradox is a case of multicollinearity. This means that some variables (particularly predictor variables) in the model are correlated with one another (Vatcheva et al., 2016). For example, „absence and/or distanced pit latrines in the farm" will cause „herd boys who are not dewormed" but „defecate indiscriminately", to result in „proximity of cattle to uncontrolled defecation,". Consequently, „unfenced", „grazing animals" will pick eggs when they „consume contaminated pastures" and „drink contaminated water". Broadly, bovine cysticercosis risk factors are categorized as animal-related or man-related, with factors on either

category co-related (Uchendu, 2020). Meat inspection provides control middle-point between both categories thus, individually predicts bovine cysticercosis prevalence. Prediction of this study holds because it identified „beef sold at non-licensed premises", a component of meat inspection, as predicting bovine cysticercosis individually. Therefore, although multicollinearity caused differences in p-values, it did not affect the overall fit or prediction of the model.

Literature is replete with repertoire of bovine cysticercosis risk factors (Flutsch et al., 2008; Calvo-Artavia et al., 2013). Some factors, either do not apply to Botswana or their contribution to bovine cysticercosis prevalence in Botswana is negligible. An efficient control and prevention strategy must focus only on important risk factors. Mean score of risk factor derived through Chi-square test was interpreted as its quantitative relevance in contributing to bovine cysticercosis prevalence. Going by Pareto principle, eliminating identified top 20% important risk factors is expected to cause 80% drop in bovine cysticercosis prevalence (Kenton, 2019).

Generally, respondents showed greater consensus in „agreeing" that the top 20% risk factors, contributed more to high bovine cysticercosis prevalence. This consensus, unlike when respondents were in disagreement, homogenizes respondents and provides a platform from which to drive an attitudinal change, as prevention and control strategy.

Conclusion

This study models and recommends that efficient control and prevention strategy of this zoonosis should interpret important risk factors in relation to people"s lifestyles. This provides a framework for policy advocacy for corresponding attitudinal change. By applying Pareto principle to focus efforts on mitigating the identified top 20% important risk factors showed to be more efficient control and prevention strategy rather than attempting to mitigate all identified risk factors. Existing prevention strategies in Botswana emphasizes proper disposal of human defecate. However, this study showed that minimizing „butchers buying and slaughtering animals without proper ante-mortem and post-mortem examination" would yield more efficient result. This study also recommends this methodological approach for control of bovine cysticercosis and other zoonotic diseases within and outside Botswana. Further studies to uncover novel risk factors of bovine cysticercosis in Botswana are also recommended.

Impact

This is the first study in Botswana that associated bovine cysticercosis risk factors with Batswana"s lifestyle and recommended for corresponding attitudinal change in locals.

This study ranked individual and joint contributions of important risk factors in leading up to observed bovine cysticercosis prevalence in Botswana.

By adopting Pareto principles, this study modelled that targeting top 20% important risk factors instead of mitigating a rapporteur of risk factors, would yield 80% desired (more efficient) control and prevention outcomes.

CONFLICT OF INTERESTS

There are no conflicts of interest in all the processes and documentation of this study. All the authors are in agreement with the paper"s content, reporting and submission for publication in your journal

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Appendix I: Questionnaire for collecting information about risk factor of *Cysticercus bovis*.
Which of these practices do you agree leads to spread of *Cysticercus bovis*? Please tick appropriately.

S/N	Question	S/DA	Disagree	Neutral	Agree	S/A
1	Preference for rare to well-done meat (colour of deep portion of cooked meat changes to greyish white)					
2	Absence/Distanced pit latrine in farm					
3	Grazing (Hoofing) of animal					
4	Access to contaminated pasture					
5	Sharing machinery or hiring contractors					
6	Having visitors on farm.					
7	Organic farming (effectiveness of sewage treatment)					
8	Proximity to uncontrolled human defecation					
9	Access to contaminated water					
10	Access to contaminated feed (issue with feedlot)					
11	Dairy animals/being female (being kept longer than beef)					
12	Beef sold at non-licensed shambles					
13	Lack of routine meat inspections at licensed abattoirs					
14	Butcheries procure infested meat because it is cheaper					
15	Consumers prefer to purchase cheaper meat without questioning its fitness					
16	Failure to de-worm herd boys and cattle keepers					
17	Poor awareness campaign to farmers and stake holders					
18	Non-adherence to fencing policy					

S/A= strongly agree; S/DA= strongly disagree.